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PROSPECTUS

Evolving Propylene Sources – Solution to Supply Shortages?

Nexant

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Solution to Supply Shortages?

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CHEMSYSTEMS – a brand owned by Nexant, Inc. that provides support to decision makers in the petroleum, chemical and petrochemical industries

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Section 1 Introduction

1.1 OVERVIEW

The entire petrochemical industry is based on a few, fundamental feedstocks. Propylene is perhaps one of the oldest of these crucial building blocks and one of the principal light olefins. From propylene, important industrial derivatives such as polypropylene, acrylonitrile, propylene oxide, 2-propanol, cumene/phenol, oxo-alcohols, isopropanol, acrylic acids, and oligomers are obtained. Various additional products use propylene as a feedstock. Hence, its use can be seen to span a wide span of end-use industries, from automotive and construction, to consumer durables, packaging, medical, and electronics.

Historically, propylene was readily available, either as a co-product of heavy liquids cracking or from refinery sources. Growth in demand for propylene derivatives has outpaced that for ethylene derivatives for several years. The higher propylene demand has largely absorbed readily available sources of propylene to yield, until now, a fairly balanced global market in terms of propylene supply and demand. However, an interesting dynamic is now unfolding in the United States whereby large amounts of natural gas from shale and other sources are being produced with their accompanying natural gas liquids (NGLs) such as ethane, propane and butanes. This additional NGL is being utilized in higher percentages in steam crackers, which in turn, is lowering available propylene supplies and changing the competitiveness of the North American ethylene chain.

With the recent discovery of U.S. shale gas reserves and the increase in ethane cracking currently taking place that is set to only increase exponentially in coming years, U.S. propylene supply tightened by large amounts. This is because the cracking of light feedstocks produces dramatically less propylene co-product than the cracking of heavy liquids. Consequently, propylene production in the United States from ethylene crackers has declined, and, for the first time in 20 years, propylene prices were higher than ethylene prices. This propylene supply/demand gap is projected to considerably widen in the next few years as propylene demand rises and even greater volumes of lighter feedstocks available from shale gas deposits rapidly replace heavy liquids in crackers. LPG cracking in Europe will have a similar impact, although the displacement of hydrocarbons liquids will not be nearly as pronounced as in North America. Hence, shortages of propylene feedstock are likely in these two regions – imbalances which will extend to other regions via higher propylene pricing.

To address these issues of propylene availability, Nexant has just published a new multi-client study which examines and compares the process technologies and economics of conventional as well as newer commercial technologies that may alleviate the shortage. Additionally, the report explores the causes and effects of the propylene shortage in North America, including ways in which new sources of propylene may replace conventional sources.

This multi-client report builds on Nexant's impressive array of intellectual capital in the area of propylene commercial information and production technology. In addition to our work in proprietary studies, Nexant has written extensively about propylene uses and availability. In 2003, Nexant analyzed the emerging technology of on-purpose propylene production in the

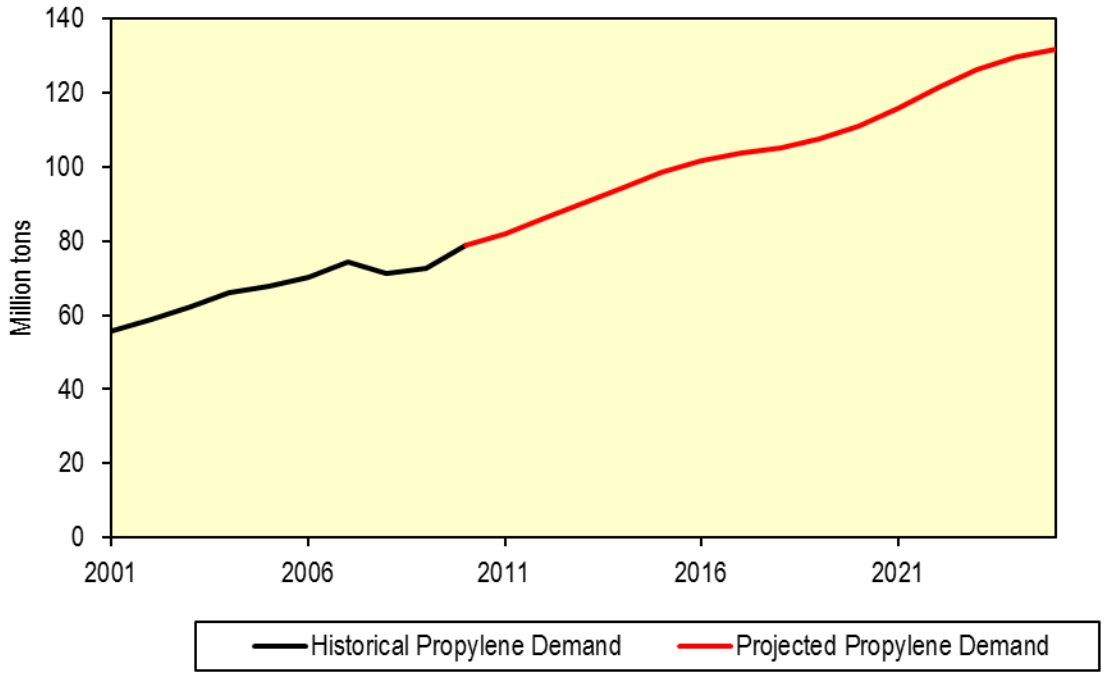
ChemSystems Process Evaluation/Research Planning (PERP) Program report, *Technology Developments in Propylene and Propylene Derivatives.* Several of the technologies covered have been commercialized in recent years due to the shortfall in conventional propylene capacity. In 2007, the severity of propylene demand exceeding capacity had not significantly abated and additional new technologies and feedstocks, as well as improvements to emerging technologies, were analyzed in a second PERP report entitled *Technology Developments in Propylene Production.*

This prospectus describes the background of why alternative propylene sources are one of the best solutions to current supply constraints, the scope of the analysis, the approach used, and Nexant's qualifications to perform such a study. The study was published in January, 2012 and is available immediately at the price of US$22,000 (twenty-two thousand U.S. dollars).

1.2 BACKGROUND

Global propylene demand increased at an Average Annual Growth Rate (AAGR) above six percent from 1995 to 2007, and is expected to continue increasing between 2005 and 2015 at an average yearly growth rate of 3.8 percent. From 2015 to 2025, this demand growth is expected to slow even more, to an average of 2.9 percent per year. The track of this demand growth is detailed in Figure 1.1, which shows that by 2025, demand would have increased 50 million tons from 2011 values to reach 132 million tons. This robust demand growth is mostly attributed to the demand for propylene used in derivatives, indicating that the majority of this demand will originate from developing regions such as Asia.

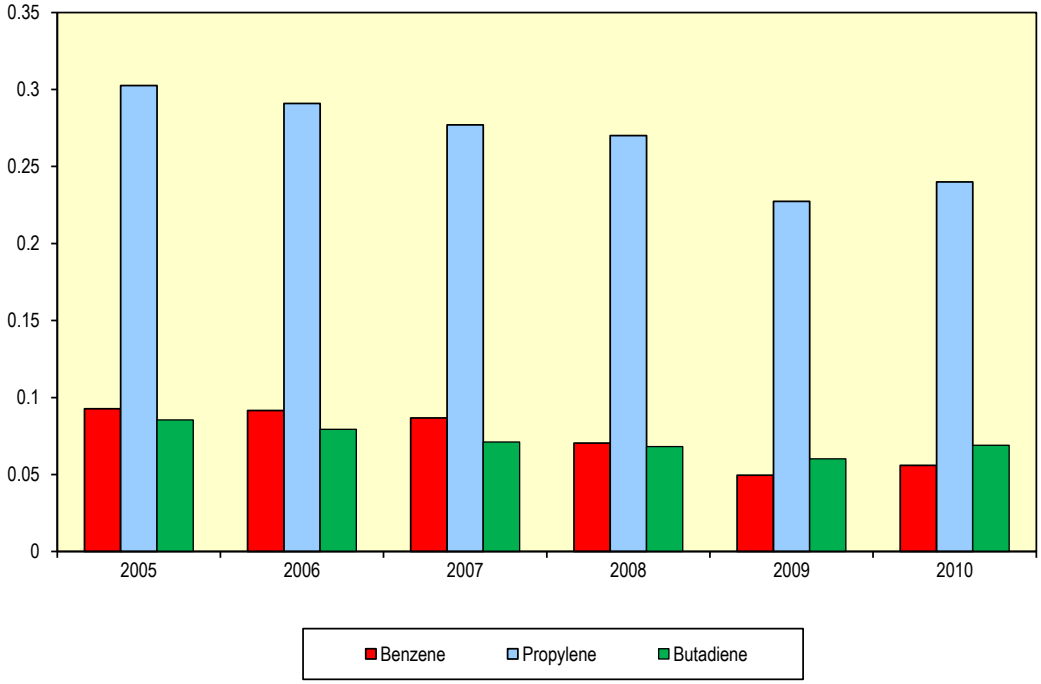
Figure 1.1 Global Propylene Demand
(Million Tons)



However, current tightness in propylene supply is only set to be exacerbated by this increase in demand.

The production of large volumes of shale gas in North America has already had the effect of dramatically reducing U.S. natural gas prices. Increased shale gas production, together with its associated gas liquids, and relatively high ethane prices have encouraged the recovery of even greater volumes of ethane. These abundant supplies of ethane have prompted increases in the use of lighter feedstocks in U.S. crackers which has the unintended effect of considerably reducing the amount of propylene obtained from steam crackers, as is illustrated in Figure 1.2. Indeed, the future outlook for rising volumes of ethane production from shale gas have already prompted a number of olefin producers to announce either significant U.S. debottlenecks or in the case of Chevron Phillips and Shell, construction of a new ethane cracker.

Figure 1.2 U.S. Steam Cracker Yields
(Tons per Ton Ethylene)



As ever increasing volumes of ethane are cracked in North America, accompanying propylene co-product production is reduced, further aggravating the supply/demand imbalance and pushing propylene prices even higher. As can be seen in Figure 1.3, in 2007 propylene pricing rose above ethylene prices, ending the historic relationship between these two critical olefins whereby propylene was priced at a slight discount to ethylene. Subsequently, propylene prices have continued to rise as cracker production levels have continued to fall. The impact of this ratio has already been felt, as some polypropylene end-users, facing rising polymer prices, have started to evaluate switching to HDPE or polystyrene.

Figure 1.3 USGC Propylene Price Relative to Ethylene
(Propylene to Ethylene Price Ratio)

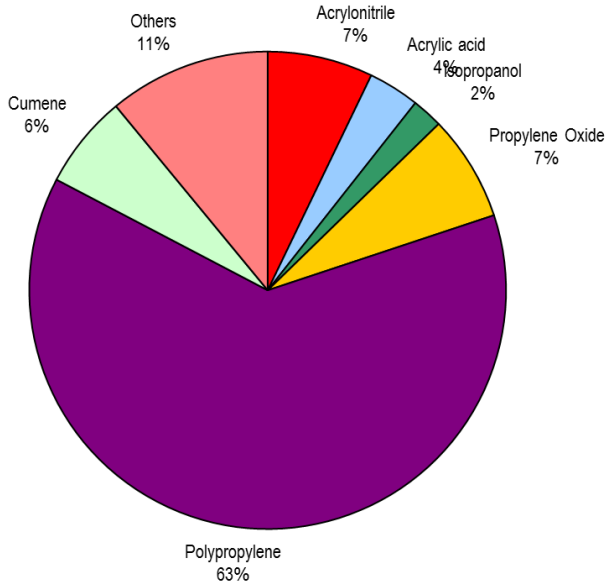
Further decreases in the amount of propylene produced in North America will only serve to push prices higher and further tighten supply. This ever increasing shortage in an important producing/consuming region will impact other regions as well through global pricing. Nexant's historic and forecast propylene prices, illustrated in Figure 1.4, have propylene prices remaining highest in the United States – a region that historically has had relatively abundant propylene supplies.

Figure 1.4 Global Propylene Prices
(Constant 2011 US Dollars per Ton)

Shortage of propylene supply and consequent continuously increasing prices will affect the global petrochemical market and propylene derivatives in a negative manner. Competition between propylene derivatives and similar chemicals will no longer be maintained at current levels, leading to widespread substitution or reduction in propylene derivative growth in response to rapidly rising propylene prices. Various propylene derivatives are indicated in Figure 1.5, which shows the 2011 global demand breakdown of propylene. These sectors will eventually experience a reduction in growth, especially if additional supplies of propylene cannot be found.

However, employment of emerging technologies such as propylene from biomass, increased production of propylene from direct sources like propane dehydrogenation or metathesis, and adoption of improvements in conventional technologies such as enhanced fluid catalytic cracking (FCC) may hold the key to relieving the tight propylene market and severity of consequences.

Figure 1.5 Global Propylene Demand by Derivative
(Percent)



Nexant's new report, ***Evolving Propylene Sources – Solution to Supply Shortages?,*** examines and compares the process technologies and economics of the commercially available and developing technologies for the production of propylene, both alone and as a co-product. Focus is maintained on alternate routes and feedstocks along with economic comparisons to conventional routes. Technology, economic and commercial evaluations are provided, as is an overview of global propylene supply/demand outlook by region, and a competitiveness analysis of all available routes in the current economic situation. Moreover, the report features a discussion on the current North American propylene crisis focusing on causation and outcome, as well as global consequences.

Section 2 Report Scope

The objective of this report was to evaluate and compare the technical, economic and commercial status of conventional, established propylene production routes with main alternative on-purpose methods in order to determine competitiveness and possible alleviation of supply shortages. In developing conclusions, an analysis of causation and consequences of the supply shortage is also presented.

This study covers:

- Assessment of the main alternative on-purpose technologies comprising a review of the technologies and licensors as well as commercial experience
- Technology, economic and commercial evaluation of alternative routes and feedstocks to propylene
- Comparison of the above two points
- Discussion of the current North American propylene shortage focusing on causation and consequences
- Global propylene supply/demand outlook

The study addresses the competitiveness of current and emerging production routes, with respect to a wide range of technical and economic assumptions, including: different feedstocks, regional feedstock prices and conversion costs, scale factors, and regional construction costs. Resulting production costs are compared to conventional propylene economics at different crude oil price levels to determine production competitiveness in global regions.

Technology Coverage

The report investigates and evaluates the following technologies:

- Conventional Technologies:
  - Conventional steam cracking
  - Off gases from Fluid Catalytic Cracking (FCC) units in refineries
  - Catalytic cracking: Selective Olefin Cracking, , Deep Catalytic Cracking
  - Enhanced (High Severity) FCC
- On-Purpose Technologies
  - Propane Dehydrogenation
  - Metathesis
  - Methanol to Olefins/Methanol to Propylene
- Bio-Propylene
  - Corn, Sugar or Switchgrass Fermentation (Ethanol based)
  - Fermentation to Propanol (Corn or Sugar based)
  - Biomass Gasification

The technology review for every method includes a description of the technology plus a flow-sheet, status of technology holders and licensors, cost of production development for what would be considered representative of each technology, and identification of the stage of process in commercial development. For secondary propylene technologies where other olefins are manufactured, competitiveness is determined using the effect of propylene-enhancing technologies on the cost producing ethylene. As a base, these fluctuations are measured from the costs associated with using a medium severity naphtha cracker with propylene to ethylene ratio of 0.50.

Economic and Commercial Coverage

The cost of production analyses were used to develop selected regional production and competitive dynamics, which ultimately affect the regional propylene demand and supply balance. The regions/locations analyzed are as follows:

- U.S. Gulf Coast
- North West Europe
- Coastal China
- Middle East (notionally Saudi Arabia)

As a measure of regional competitiveness, delivered costs of selected processes from all four regions are calculated for U.S. Gulf Coast, North West Europe and Coastal China. These delivered costs include total cost of production in addition to shipping charges.

The report also contains a section on sensitivities on pricing forecasts used by Nexant. The sensitivity compares 2016 cost of productions using Nexant's medium crude oil scenario to 2016 cost of productions utilizing Nexant's high crude oil scenario.

Due to the complicated economics resulting from comparing on-purpose technologies with those where propylene is one of many products, the report also contains return on investment comparisons that estimate and compare the economic viability on overall production (propylene plus ethylene) basis.

Market Geographical Coverage

In terms of market analysis, the study provides global coverage, with focus provided for the following markets:

- North America – this analysis also includes a discussion of the various factors that have led to the current propylene shortage and possible and current consequences
- Western Europe
- Asia Pacific
- Rest of World
- Global Summary

Feedstock Coverage

The report also evaluates the use of alternative feedstocks such as gas, coal, biomass, sugarcane, corn and switchgrass using only information that is in the public domain or developed by Nexant from non-confidential information.

Section 3 Report Table of Contents

The evaluations of conventional technology are based on Nexant's in-house information regarding process technology, augmented by contacts with licensors, engineering contractors and other experts in the industry. Analyses of emerging technologies are built up from reviews of patents, public domain information, and discussions with the technology development companies and engineering contractors.

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

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

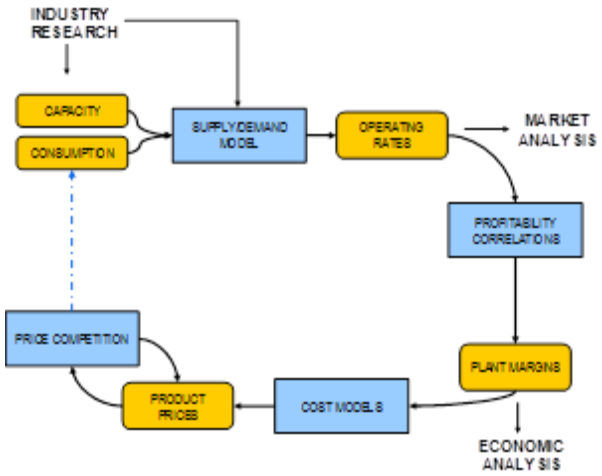
Market projections are developed with the aid of Nexant's supply/demand computer modeling systems such as Nexant's *ChemSystems* Simulator, which is discussed in more detail below.

Nexant's ChemSystems Simulator

Nexant's *ChemSystems* Simulator is the proprietary simulation model developed by Nexant and used to generate all the analysis and forecasts of *ChemSystems* Online® and other offerings including the *ChemSystems* Petroleum and Petrochemical Economics (PPE) Program. The simulation model is an experience-based database running commodity petrochemical business logic algorithms to produce multi-scenario simulations of the global industry.

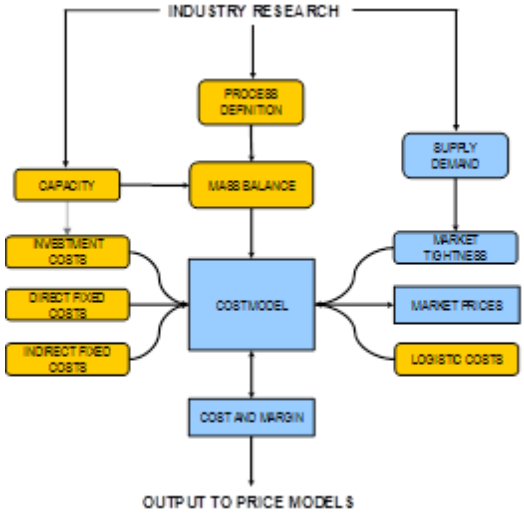
The integrated *ChemSystems* Online® Simulator simultaneously develops forecasts of regional consumption, production, imports, exports and inventory changes for all commodity petrochemicals in all countries/regions.

Figure 4.1 *ChemSystems* Simulator Simplified Logic Diagram



It is integrated from end-use markets back to petrochemical feedstocks. It considers inter-material competition, inter-regional price relationships, chain margins, product substitution, logistic costs and trade drivers. Costs and prices are integrated from crude oil, natural gas and petrochemical feedstocks through propylene to downstream derivative products, such as polypropylene. One of the functional blocks depicted in the graphic above is expanded below to illustrate the interconnectivity of these drivers and the complex relationships that are built into Simulator algorithms.

Figure 4.2 *ChemSystems* Simulator Functional Blocks
(Simplified cost model logic diagram)



Nexant's *ChemSystems* Simulator delivers step change improvements in market forecasting and business/corporate planning while reducing the resources and time required to evaluate multiple hypotheses and scenarios.

Section 5 Nexant's Experience

5.1 BACKGROUND

Nexant was established on January 1, 2000 and prior to that date, the staff of Nexant operated as a separate consulting group within a major engineering company. Nexant is now an independent company owned by a number of investors. Nexant acquired Chem Systems, Inc. on September 1, 2001, and the combined entity ("**Nexant**") now has access to even more enriched and extensive experience and resources, offering services that include:

- Master planning/feasibility studies
- Technology evaluation
- Techno-economic and commercial analyses
- Financial evaluation (cashflow modeling, etc.)
- Benchmarking
- Monitoring project implementation

Nexant is very well qualified to undertake the technical, commercial, economic and financial evaluations, from its own offices, without the need to subcontract. Owing to its extensive experience, and known for its "out-of-the-box" thinking, Nexant's *ChemSystems* Group has also received the honorable award of "**Best Large Consultancy**" by the British Consultants and Construction Bureau. This award was contended by a number of companies; however, Nexant was judged the winner for its outstanding contribution in developing a real-time, on-line chemical industry simulator. Nexant's *ChemSystems* Group is now part of Nexant's Energy & Chemical Consulting (E&CC) division.

5.2 DESCRIPTION OF SERVICES

Nexant is a specialist, not a generalist company. Areas of expertise for the E&CC Division (of which the *ChemSystems* Group is a part) are the energy and process industries, including oil refining, natural gas, petrochemicals, polymers, chemicals, pharmaceuticals and fertilizers. Our business has been built upon providing broad management consultancy services to leading companies active in these industries, and also to banks, suppliers, governments and others interested in these sectors.

Nexant's strengths lie in its combination of technoeconomic, commercial and strategic capabilities. These "competencies" are described below, followed by an outline of the practice areas into which the E&CC Division is organized.

5.2.1 Technology/Economics

From its foundation in chemical engineering and industrial chemistry, Nexant offers distinctive expertise in process technology and economic analysis. Assignments may be performed on a separate, stand-alone basis or as input to broader consulting engagements.

Services include:

- Economic and financial analyses of projects or businesses
- Valuation of assets or businesses
- Technical audit of existing facilities
- Project feasibility/planning
- Technology innovation and assessment
- Comparative/competitive technology audit and appraisal
- Process design and cost estimation
- Technology availability, screening, licensing arrangements
- Contractor pre-qualification, evaluation and selection
- Project management including resident advisory services
- Price, margin and profitability forecasting

This discipline is supported by comprehensive economics, cost and price databases.

5.2.2 Commercial

Based upon a technical and commercial understanding of the industries we serve, Nexant supports clients through a variety of market and commercial activities. As with our technoeconomic work, these commercial assignments may be performed on a stand-alone basis but are more normally an input to broader consulting engagements.

Services include:

- Feedstock and product market analysis
- Marketing and market research
- Supply/demand analysis and forecasting
- Studies of trends and future markets
- "Benchmarking" of costs and competitiveness
- Medium- and long-range planning

The commercial discipline is supported by databases of global supply, demand and capacity developments in all major petrochemicals.

5.2.2.1 Strategic Planning

Industry-specific expertise and an understanding of world market forces distinguish Nexant's work in Strategic Planning. Various innovative tools and methodologies tailored to the energy and process areas are used to challenge conventional thinking. Nexant extends its traditional project team approach to engaging clients directly in the Strategic Planning process. Interactive

client-consultant relationships promote consensus, a critical factor for successfully developing pragmatic, implementable solutions.

Services include:

- Definition of corporate and business visions
- Portfolio planning
- Entry strategy evaluation
- Diversification, acquisition, divestment studies
- Competitive analysis and business positioning
- Global competitiveness
- Trade flow and impact studies
- Strategic options, selection and implementation

5.3 ASSIGNMENTS COVERING PROPYLENE TECHNOLOGIES AND MARKETS

5.3.1 Multiclient Work

Nexant's comprehensive topically selected reports alert industry personnel to emerging trends and factors with significant potential to affect selected business sectors. Besides presenting important data on occurrences and impacts, these publications deliver penetrating technoeconomic, commercial and strategic analyses. Recent industry reports include:

- **Technology Developments in Propylene and Propylene Derivatives -** This multi-client report examines and compares the process technologies and economics of the commercially available and developing technologies for the production of propylene alone or as a co-product. The report focuses on the economics of alternate routes to propylene, how they compare to conventional routes, and how competitive they are. Conventional propylene technologies, such as, conventional steam cracking, production and recovery from refinery streams, and propane dehydrogenation, are compared to the new and developing technologies for propylene production. Newer developments in alternate technology and feedstock sources, and those technologies designed to either produce propylene exclusively or increase propylene yields from conventional sources, such as olefin metathesis, catalytic pyrolysis, natural gas based processes, methanol-to-olefins, and methanol-to-propylene are examined and analyzed.
- **New Technology Valuations: The Values of Technologies under Development** - This study evaluates the intangible assets represented by chemical and energy process technologies that are in the research and development (R&D) phase. These technologies are not yet commercialized but appear to have significant economic value. The study surveys twenty promising technologies and explains Nexant's assessment of their value. The technologies reviewed in the study include: propylene via MTP (such as Lurgi's); propylene (poly grade) via metathesis; propylene oxide (PO) via HPPO (such as BASF-DOW), and acrylonitrile (ACN) via propane ammoxidation with oxygen (recycle).

- **Technology Developments in the Polyolefins Industry** - The polyolefin industry has entered a competitive era caused mainly by the proliferation of readily available production technology, low market entry barriers, and the resulting oversupply. To retain a competitive edge, manufacturers need to keep abreast of technological developments. These developments include: metallocene/single-site catalysts; functionalized propylene; branched LLDPE; syndiotactic polypropylene; gas phase-based high alpha-olefin LLDPE (C_8+); cyclic olefin copolymers; nonpelletized polyethylene and polypropylene; in situ comonomer generation in LLDPE processes; CATALLOY and related product technology; gas phase bimodal HMW HDPE; and dual catalysts for single-reactor bimodal HMW HDPE. This study reviews and analyzes technological advances in polyolefin production, providing a perspective of the significance of these evolutionary and revolutionary developments and evaluates their likely impact on the polyolefin industry.
- **Alternative Routes To Propylene** - This *ChemSystems* Process Evaluation/Research Planning (PERP) report discusses the technology, market analysis and economics of on-purpose propylene. Some of the technologies covered include: steam cracking of ethane followed by dimerization and metathesis; biodiesel glycerine via hydrogenation to *n*-propanol followed by dehydration; raffinate-1 via isomerization and metathesis of butenes; oxidative dehydrogenation (ODH).
- **"Green" Propylene** - This *ChemSystems* PERP report discusses several routes to producing propylene from renewable feed. Several cases are considered herein for the production of green (or sustainable) propylene. Case 1: Fermentation of sugars to produce bio-ethanol is followed by dehydration to bio-ethylene. A portion of the ethylene is dimerized to produce normal butenes. The bio-butenes are then reacted with the remaining bio-ethylene via metathesis to produce green propylene. Butene-1 is isomerized to butene-2 (both cis and trans isomers) in the latter reaction. Case 2: Butanol is produced either by fermentation of sugars (Case 2a) or gasification of biomass (Case 2b) and the bio-butanol is dehydrated to produce bio-butene. The bio-butene is reacted with bio-ethylene as above. Case 3: Bio-propane produced as a byproduct of biodiesel is dehydrogenated to produce green propylene. Case 4: Vegetable oil is fed to an enhanced fluid catalytic cracker (FCC) unit to produce green propylene. Case 5: Gasification of biomass to produce a syngas is followed by synthesis of bio-methanol. Green propylene is then produced via methanol-to-olefins technology.
- **Propylene** - This *ChemSystems* PERP report discusses the chemistry, process technology, and production economics for propylene manufacture. Special emphasis is given to the on-purpose routes: metathesis, selective olefin cracking, MTO/MTP, propane dehydro and enhanced FCC. Regional supply/demand/trade forecasts are also provided.
- **Propylene Technology: The Next Generation** - This multi-client study provides an in-depth quantitative and qualitative analysis of various new and developing technologies for the production of propylene via conventional and emerging process routes and conventional and non-conventional feedstocks, including biomass. The report examines conventional propylene technologies: steam cracking, refineries, propane dehydro-

genation (PDH), olefin metathesis, and catalytic cracking. Developing technologies include: bio-propylene (NExBTL–Neste Oil) and enhanced FCC (PetroFCC- UOP). The study also discusses alternate feedstocks, including natural gas and coal, propylene economics (byproduct propylene and on-purpose propylene), regional competitiveness, and sensitivity analysis.

- **Petrochemical Market Dynamics: Propylene and Derivatives** - This report is part of the *ChemSystems* Petroleum and Petrochemicals Economics (PPE) Program which has provided accurate data, insightful analysis and dependable forecasts of the profitability, competitive position and supply/demand trends of the global petroleum and petrochemical industry. The report analyzes the market dynamics for propylene derivatives, including polypropylene, acrylonitrile, propylene oxide, acrylic acid, phenol, and cumene.

Other related special industry reports include:

- An In-Depth Analysis of the Polypropylene and Polyethylene Industry in China
- Strategic Assessment of Middle East Impact on the Asian Petrochemical Industry
- Chemicals from Acetylene: Back to the Future?
- Squeezing Profitability from the PTA/PET Value Chain: Impact of the Latest Technology Advances
- PET and Polyester Intermediates
- Chemicals and Plastics in China
- Latin American Energy, Refining and Petrochemical Industries in Transition
- The Global Polyolefin Industry: Recovery in a Period of Structural and Technological Change

5.3.2 Single Client Studies

- **Propylene, Ammonia, and Acrylonitrile Study. Confidential** - Evaluation of potential investment in a U.S. acrylonitrile manufacturer. Nexant provided an assessment of the market outlook, profitability, and operating cost benchmarking. Forecasts pricing of crude oil, propylene, ammonia and acrylonitrile.
- **North American Propylene Chain Competitiveness Analysis** - Summarizes key aspects of the North American propylene-polypropylene fabricated products value chain. It takes account of a globalized world and future investments in the world and in this region, in particular in Venezuela and Trinidad and Tobago. The study includes: propylene availability in the NAFTA region: refinery propylene availability, steam cracker, on purpose technologies, propylene supply, demand, and trade. Cost analysis: cost of production, cash costs and cost curves. End product trade and competitiveness: end product global trade impact on the NAFTA region; end product manufacturers competitiveness; end product market dynamics and net trade outlook; polypropylene

trade (Latin America, Europe, Asia Pacific, loss of propylene in imported products, U.S. propylene price setting status and impact of Venezuela and Trinidad).

- **Fermentation Propanol to Green Propylene. Confidential** - This report identifies and discusses four routes to producing propylene from renewable feedstock (corn, sugarcane and glycerine). The study included cost of production estimate for selected process technologies, including: corn ethanol dehydration to ethylene, propylene via metathesis, sugarcane ethanol, sugarcane ethanol dehydration to ethylene, ethylene (sugarcane based) dimerization to butenes, and propylene via metathesis.
- **European Propylene Supply. Confidential** – Discusses the propylene and propane markets, pricing and cost competitiveness.
- **Propylene Derivatives Options Study** – Nexant was asked to evaluate a propane dehydrogenation/derivatives complex in the Middle East. Nexant's role was to provide relevant market, technology and profitability insights into the potential products based on propylene produced from a PDH plant. Key findings and recommendations for optimum downstream derivative complex configurations were provided
- **Feasibility for Investment in Polypropylene –** For a Middle East client with an opportunity to invest in polypropylene and propane dehydrogenation technology, Nexant was retained as the Lenders' market consultant for financial approval through to close of the project. Nexant reviewed the options available for a potential new investor to develop a polypropylene business based on refinery propylene. The study covered the competitive structure based upon the potential for local feedstock sources and technology considerations.
- **Propane-Propylene Based Industries in Saudi Arabia -** To assess the feasibility of establishing an integrated industrial complex based on the production of propylene by the propane dehydrogenation process.
- **Polypropylene Markets/Margins** - For a U.S. producer, Nexant provided a near-term outlook on propylene and polypropylene that included: supply/demand globally and for ASEAN, and prices/margins including relationship between U.S. Gulf Coast and Asia.
- **Propylene and Polypropylene. Confidential –** Nexant assisted a U.S. petroleum company in evaluating investment opportunities in a joint venture to produce propylene and polypropylene at a Louisiana refinery. Nexant prepared a spreadsheet model of the plant to forecast costs, revenues and evaluate future cash flow. The study was conducted in a series of reports to include an evaluation of propylene and polypropylene at the refinery, competitive assessment, opportunities for propylene and its derivatives, and commercial analysis.
- **Petrochemical Industry Development** - Nexant performed extensive work on the development of an olefins-based petrochemical industry in the Philippines, and was retained jointly by an international oil company and a domestic Philippine company to act as consultant in the planning of a large olefins-based chemical and petrochemical project. Feedstocks were from an existing domestic petroleum refinery and products were primarily for the domestic markets, with export markets considered in developing

plants of adequate economic scale of production. The process plants involved in these studies were chlorine, caustic soda, ethylene, propylene, HDPE, LDPE, PVC, and VCM. Nexant supplied raw material supply and price assessments and analyzed the interaction of the petrochemical complex with the adjacent refinery. The study also included: product pricing and markets (both domestic and export factors), cost of production (COP) estimates that established the plant size needed to be competitive with future world-scale plants, discussions with potential joint venture partners, analyses of project financing plans, reviews of managing contractors, and establishment of project definition documents.

- **Strategic Opportunities** - Nexant suggested that this client could add value and increase profits in its refining business by upgrading streams and producing higher value products. Nexant identified suitable projects; such as recovering propylene or aromatics and manufacturing cumene or other derivatives, recovering ethylene or upgrading saturated C_4 streams, and suggested various approaches that would contribute to the success of this strategy.
- **Polypropylene Due Diligence -** A Japanese bank considering the revision of financing for an Indonesian polypropylene project engaged Nexant as advisors who understood the interaction between olefin operations, petroleum refineries, polypropylene technologies and markets and the relationship of polypropylene to other polymers. Nexant provided: a market forecast for propylene and polypropylene with an outlook for Indonesia and Southeast Asia, price forecasts for propylene and polypropylene in Asia, and a review of operations, costs, and price/margin projections of the financed plant.
- **Petrochemical Market and Technology Review – Confidential.** Nexant was retained to perform a techno-economic evaluation for selected petrochemical products, covering the supply, demand and pricing in Russia, including export pricing, together with details of the production processes and an HSE review of waste streams. The selected products included: alpha olefins, ethylene oxide/ethylene glycol, propylene oxide/propylene glycol, polypropylene, polystyrene, ethyl benzene, styrene monomer, MMPA, and PMMA.
- **Petrochemical Project Pre-Feasibility Study – Confidential.** An in-depth market analysis and technical review on the ethylene, propylene, nylon and acetic acid derivatives for a petrochemical project in Saudi Arabia.
- **Polypropylene Market Report** - For a European polypropylene producer, Nexant provided global and West European propylene and polypropylene market overviews. The study included projections of ethylene, propylene and polypropylene profitability to 2020 for Western Europe.
- **Market Study** - In support of a C_3 splitter project an international client was developing with a Venezuelan refiner, Nexant conducted a propylene and propane market study. The objective of the assignment was to identify target markets for Venezuelan exports of polymer grade propylene and propane and determine which would offer the best netback price. Tasks included development of: global supply/demand balances by region for both products for the selected time period; more detailed demand forecasts according to

end uses; global trading patterns; regional factors driving supply and demand; and price forecasts. Based on the projected balances and prices, Nexant calculated Venezuelan netback values for identified target markets which, when combined with transportation and terminalling costs, resulted in a ranking.

- **Feasibility for Investment in Polypropylene -** This report was undertaken for a Middle Eastern client with an opportunity to invest in polypropylene and propane dehydrogenation technology. Subsequently, work was undertaken as the Lenders' Market Consultant for financial approval through to close of the project. In addition the options available for a potential new investor to develop a polypropylene business based on refinery propylene were reviewed. In this case, the study covered the competitive structure based upon the potential for local feedstock sources and technology considerations.
- **Propylene and Polypropylene Investment Opportunity – Confidential.** Nexant assisted in evaluating investment opportunities in a joint venture to produce a propylene and polypropylene refinery in the United States. Nexant provided a financial model of the plant to forecast costs, revenues and evaluate future cash flow. The study provided a series of reports that included an evaluation of several propylene and polypropylene plants, opportunities for propylene and its derivatives, commercial analysis, supply/demand and trade, profitability and market share.
- **Opportunity Evaluation -** Nexant updated the findings of an earlier evaluation on the potential for the propylene recovery followed by conversion into polypropylene to include additional products, potential customer sales and strategic alliances. In addition, Nexant analyzed the potential for a new ethylene plant in the USGC adjacent to an existing refinery. The plant profile consisted of: plant size, feedstocks and products; land and investment requirements; technology and project economics; supply/demand; and potential partners.
- **Market Evaluation -** A Thai olefins producer requested an updated market and price outlook for olefins, derivatives and feedstocks. Nexant provided historical and forecast supply/demand/net trade outlooks for major petrochemicals. Naphtha through ethylene and propylene to the polyolefins and other derivatives were included. Price forecasts were prepared using the low-oil and base-oil scenarios.
- **Business Analysis -** For a company considering a plan to recover propylene from its refinery and upgrade its value by producing polypropylene as a new business venture, Nexant provided a technical and commercial evaluation that included a competitive analysis with each producer's cost structure by site, their market position, and propylene position. Industry structural issues, including transportation logistics, geographic sales distribution, operating rates and their impact on pricing, were also considered. Nexant also reviewed the client's financial model that covered commercial and economic inputs such as licensing fees, production costs, pricing, and volume.
- **Business Analysis -** As part of the in-house review of strategic options with a major U.S. petrochemical producer, Nexant was called upon to provide background information on olefins and aromatics and a financial model for the client's use. The specific information

included technology barriers that would keep the client from participating in any of the value chain for the following: ethylene, propylene, benzene and xylene and all derivatives. For selected countries throughout the world, Nexant also provided: an outlook for supply/demand, including trade of derivatives; supply demand outlook for naphtha feedstock; driving forces impacting profitability; political/governmental factors (taxes, incentives, tariffs) that affect profitability; opportunities for petrochemicals with emphasis on refinery integration and the options open to the client.

- **Olefins and Derivatives Markets -** This study was prepared for a company considering the construction of a new steam cracker that would use ethane, LPGs, and/or other feedstocks. Nexant was asked to provide data, analysis and opinions on the economics of alternative feedstocks and the future global markets for ethylene, propylene, and major derivatives. Potential target markets were also identified. As part of the analysis, Nexant evaluated several potential crude scenarios and the impact each scenario would have on feedstock (e.g., naphtha, ethane, butane, etc.) costs and subsequent olefins manufacturing costs. Pricing mechanisms and forecasts were developed for ethylene and propylene, as were global supply/demand forecasts for all major derivatives.
- **Olefins Pricing -** An analysis of the basis for pricing of deep sea ethylene and propylene with recommendations for a purchaser's future contract policy. The study established bases for pricing in all major regions and, using netback analysis, identified most likely future supply patterns.
- **Petroquimica Bahia Blanca Privatization** - Nexant provided consulting services to First Boston, the exclusive financial advisor and coordinator of the planned privatization of several petrochemical complexes. The project consisted of: comprehensive analysis of the economics of PBB and the derivative plants - Polisur for LDPE and LLDPE, Petropol for HDPE, and Monomeros Venilios for VCM. Review including: regional and global competitive and economic position of PBB and derivative plants; capital cost for debottlenecking expansions plus feedstocks and operating costs in comparison to global competitors; forecasts of the values and demand in Argentina for ethylene, LDPE, LLDPE, HDPE, VCM, ethane, and natural gas; netback values for ethane, ethylene, and derivatives under scenarios of local market sales, import and export costs for the derivative plants to supply local market and to export; regional and global supply/demand balances and production capacities for ethylene, propylene, LDPE, LLDPE, HDPE, VCM, and PVC; development of an economic and financial computer model to forecast PBB's profit from operations; and international price forecasts for ethylene, byproducts, and derivative products.
- **Petrochemical Product Screening** - Market study of a vast variety of petrochemicals that could potentially be produced at PDVSA's Amuay and Cardon refineries in Paraguay. Products included were ethylene, HDPE, propylene, polypropylene, polystyrene, benzene, cumene, and many others.

Section 6 Contact Details and Subscription Information

6.1 CONTACT DETAILS

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6.2 AUTHORIZATION FORM, TERMS AND CONDITIONS

Subscription Terms and Conditions

1. The undersigned (hereafter "Client") hereby subscribes to purchase from Nexant, Inc. ("Nexant"), Nexant's study, ***"Evolving Propylene Sources – Solution to Supply Shortages?"*** (the "Subscribed Report"), in accordance with the following terms and conditions.

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   (b) One (1) bound paper copy of each Subscribed Report on publication.

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11. This Agreement and the relationship between the parties shall be governed by and interpreted in accordance with the laws of the state of New York, United States of America.

12. Upon authorization, Client will be billed by and shall pay to Nexant a total of US$22,000.00 (twenty-two thousand U.S. dollars). Client shall be invoiced the full Subscription Fee upon signature of this Agreement. Amounts are due upon receipt of invoice and payable within thirty (30) days. If payment is not made within 30 days from the date of invoice, Client will be subject to late payment charges. Such charges will be calculated at a monthly rate of 1.5 percent of the invoice amount, compounded for each period or part period of 30 days that the invoice remains unpaid. Fees quoted do not include any applicable sales tax, or use or value added tax, all of which are for the account of Client.

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