

Prospectus

Biobutanol: The Next Big Biofuel A Techno-Economic and Market Evaluation



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The world's energy system is facing a diverse and broad set of challenges. One concern is the perceived inability to economically provide conventional petroleum to meet growing demand. Short-term global political conditions and other anxieties have raised crude oil prices to sustained highs. Concerns over climate change related to carbon emissions have reached a new level of certainty and a heightened urgency is affecting governmental and company policies and strategies. Combined with other drivers, these factors are putting increased focus on sustainable fuels made from renewable organic materials. The concept is well established, and the relevance of biofuels has increased dramatically in recent years. Many are looking to bioethanol and biodiesel as solutions to the multiple concerns. Political and media attention have also focused on biofuels, including the U.S. President's reference to switchgrass-based ethanol in a recent State of the Union address. Many other countries, including Brazil, the European Union, China, Thailand, and Japan, have embraced the use of biofuels as an attempt to lessen dependence on imported petroleum.

However, the supplies of biofuels in their current forms of ethanol and fatty acid methyl ester (FAME) biodiesel are already having significant impacts on the food and feed commodity markets – for grains, sugar, natural oils and fats, and processing byproducts. While ethanol and biodiesel have many beneficial properties in substituting for petroleum gasoline and diesel, they both have shortcomings. In the case of ethanol they include high vapor pressure, affinity for water and lower energy content than gasoline, presenting significant logistical complexity to its blending, transport and use. Ethanol is blended at the terminal instead of the refinery as it cannot be transported via pipeline in the United States. Further, the use of high blend ratios of ethanol with gasoline requires modified engines (Flex Fuel Vehicles) and, due to its lower energy content, reduces the vehicles' gas mileage. In the case of biodiesel, properties such as cloud point and viscosity are closely related to the fatty acid profiles of the feed oils and fats, and the fuel will often support microbial growth in storage.

The major technical and commercial drawbacks of the existing biofuels have prompted the continuing development of second generation biofuels which currently include: cellulosic ethanol, biobutanol and mixed alcohols. Among this group, biobutanol overcomes so many of ethanol's shortcomings that it appears poised for significant growth. Further, it can be synergistic with existing and future ethanol production technology. Butanol is a higher molecular weight alcohol than ethanol, which gives it lower vapor pressure, lower water solubility and higher energy density. The practical implications are that biobutanol can be blended at any point in the supply chain without causing problems with systems or materials, and will spread less in groundwater if spilled. Further, it will need less adjustment in gasoline blendstocks to accommodate it, and will allow drivers to travel farther on a full tank compared to ethanol blends. It can potentially be blended at higher ratios with gasoline or used as a neat fuel in all gasoline engines. Further, it can be more eco-friendly since some biobutanol routes claim to capture more biomass carbon as fuel than does fermentation ethanol (where about half the substrate carbon goes to CO_2).



Butanol Has Many Advantages

- Low solubility in water reduces tendency for spills to spread in groundwater
- Transportable in petroleum pipelines -unlike ethanol
- Blendable at refineries -unlike ethanol
- Energy density approaching gasoline's
- Low vapor pressure
- Usable in gasoline at any blend ratio
- Manufacture adaptable to existing ethanol technologies
- Also has potential for use in diesel fuel

Bioethanol has been widely tested and commercialized as a vehicle fuel. A very large investment has already been made in bioethanol R&D for producing it more efficiently from starch and sugar substrates by fermentation, from lignocellulosic biomass by hydrolysis/fermentation, and by gasification and catalytic processes. There has also been massive investment, which is ongoing, in bioethanol fermentation facilities based on grains, sugars, and other carbohydrate substrates in North and South America, Europe, and Asia. This includes agricultural feedstock systems, processing, and product and byproduct logistics. It is important to know that these investments could be adapted for some types of biobutanol production and use.

Similar to all fuels, biobutanol has a number of characteristics that will need to be addressed, including a greater toxicity than ethanol, and a perceived malodor when hydrolyzed (like spoiled milk, it is reported). Bioethanol has been demonstrated as a gasoline oxygenate and octane additive in North America, Europe, and elsewhere. It has been used as a primary vehicle fuel in Brazil and the United States. Biobutanol, on the other hand, is still largely a speculative option in the world fuels market, but in the short term it has excellent markets as a chemical and solvent, and there are good prospects for its adoption as a motor fuel, globally.

Nexant and Chemical Strategies have collaborated on this study to provide a strategic evaluation of the above and other issues.

This study's objective has been to assess the technical, commercial and economic prospects for biobutanol to significantly supplement ethanol as a gasoline blendstock over the next 10-15 years. The study considered critical elements of biobutanol manufacture and use. The critical questions addressed in this report are:

- What are the advantages and disadvantages of butanol relative to ethanol, and how important would these be in the marketplace?
- How would butanol fit into current public policy in various key jurisdictions?
- What technologies are being developed to produce large volumes of biobutanol for fuel markets?
- What are the comparative economics of biobutanol manufacture relative to bioethanol and conventional gasoline?
- What are the synergies with the existing ethanol industry? Does biobutanol represent an opportunity or a threat?
- How could an investor profit from butanol production and marketing?
- Considering the above issues, what is the outlook for biobutanol as a vehicle fuel?

To answer these questions, Nexant analyzed the current process technology platforms for bioethanol and biobutanol as well as those emerging and proposed for the future for biobutanol.

This study addresses the competitiveness of current and emerging biobutanol production routes, with respect to a wide range of technical and economic assumptions, including: different feedstocks, feedstock prices, scale factors, and policy incentives (taxes, subsidies, and other). Resulting production costs were compared to conventional fuel pricing at different crude oil price levels. Figure 2.1 presents a schematic of the relationships of current, emerging, and potential biobutanol technologies to available relevant feedstocks.

Nexant and Chemical Strategies also addressed issues of commercial viability for biobutanol, such as its chemical markets in the short term, and technical compatibility with the gasoline distribution and refueling infrastructure and on-board vehicles in the long term.



Figure 2.1Current, Emerging, and Potential Biobutanol Technologies
Relationship to feedstock availability and price

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3.1 PROCESS TECHNOLOGY COVERAGE

The types of biobutanol routes that were considered in the study include:

- **Fermentation of sugar substrates** (directly available or made from starches or cellulosics) to biobutanol to blend with gasoline at various levels, including:
 - Improvements to a new strain, the classic ABE (Acetone, Butanol, Ethanol) route including using Clostridium beijerinckii, focused on recent improvements by Blaschek/Tetravitae and DuPont-BP commercialization plans
 - ButylFuel/EEI's "Dual Immobilized Reactors with Continuous Recovery" DIRCMTM) process, using two separate Clostridium strains
 - **Other developments** in the United States, France, the UK, China, Japan, and elsewhere
- Potential technology for **dehydrating bioethanol to butanol** by the Guerbet reaction using Japanese Sangi's hydroxyapatite (HAP) or other catalyst systems
- **Gasification of cellulosic biomass** to make syngas, to produce biobutanol catalytically
- **Other** A number with significant potential for commercialization are covered.

These process technologies were evaluated from technical, economic and commercial perspectives. A review and assessment of representative process routes for each major technology was performed. In addition, the stage of process development was characterized.

Cost of production estimates were developed for the above biobutanol technologies in selected global locations. Sensitivities were performed for feedstock and capital costs. Technical issues were identified as appropriate, and estimates made of the costs and associated benefits of potential improvements along the value chains.

3.2 IN-USE ISSUES

The study addressed concerns over biobutanol's acceptability as a motor fuel. It also defined butanol's toxicity and biodegradability relative to gasoline, ethanol, methanol, and MTBE, and at what level butanol is detectable by taste in drinking water (related to spills and leaks entering groundwater). Potential users in the petroleum and automotive industries, as well as regulators, were surveyed regarding their views of this emerging biofuel.

3.3 BIOTECHNOLOGY COVERAGE

The report analyzed issues relevant to biobutanol production with respect to crop science and biotechnology as well as enzymatic or process microbiology. It assessed the leading crops, microorganisms and routes to biobutanol, as well as profile leading players. Challenges and requirements for future developments in these fields were reviewed.

3.4 FEEDSTOCK COVERAGE

The primary feedstocks considered in the study were:

- Corn
- Sugarcane
- Waste biomass
- Deliberately grown biomass, and particularly, switchgrass
- Other coarse grains, wood, waste cellulose, and agricultural wastes

3.5 GEOGRAPHIC COVERAGE

The study provided global coverage, with focus provided for the following markets:

- North America, primarily the United States
- Europe
- Brazil
- Asia, primarily China and Japan

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The evaluations of conventional technology was 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 was built up from reviews of patents, public domain information, and discussions with 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 tools and methodologies developed over the course of 40 years of process analysis in the fuels and chemicals industries.

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

Market projections were developed with the aid of Nexant's supply/demand modeling systems.



Nexant uses multidisciplinary project teams drawn from the ranks of our international staff of engineers, chemists, economists and financial professionals 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.

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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.

Nexant's clients include most of the world's leading oil and chemical companies, financial institutions, and many national and regional governments. Nexant 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)
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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 energy and chemical companies. Many of the processes to be analyzed in this multiclient have been assessed in the PERP program.

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

Over the past five 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 40-plus years of industry knowledge and experience of our consultants and enhanced it to a proven new level of forecasting expertise.

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

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- Production
- Consumption
- Supply/demand and trade
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- 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 though better investment decisions and improved competitive position.

6.1 SPECIFIC SINGLE-CLIENT EXPERIENCE RELEVANT TO BIOFUELS PRODUCTION AND USE

Nexant is exceptionally 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 40 year history.

RELEVANT NEXANT PERP PROGRAM MULTICLIENT SUBSCRIPTION REPORTS

Relevant recent reports from this program include:

Ethanol – Analysis of fuel ethanol production by dry corn milling fermentation.

Biodiesel – Including production technologies (commercial and developmental) and economics, feedstock issues, regulatory and market drivers, supply and demand.

Biogasoline – Including production technologies (commercial and developmental) and economics, feedstock issues, regulatory and market drivers, supply and demand, and relation to gasification for thermochemical routes.

Glycerine – Comparison of the natural oil and synthetic-based production routes – considering production technologies, economics, feedstocks, and global markets.

Methanol – Nexant has done a number of PERP as well as other multi-client and single client reports on methanol and its derivatives.

Plants as Plants – This a study of the emerging biotechnology, processing technologies and economics of producing and recovering polyhydroxyalkanoates (PHAs) - natural polyesters – by alternative routes of fermentation and in crops, including analyses of agricultural production economics, PHA extraction costs, byproduct biomass fuel utilization, and potential PHA markets.

Biotransformation Routes to Specialty Chemicals – Includes consideration of conversions of natural oils, fatty acids, fatty acid esters, fatty alcohols and fatty amines, and fermentation technologies and commercial overviews of many bio-based product markets.

Refinery of the Future as Shaped by Environmental Regulations – Reviews issues of supply and quality of crude oil feeds to refineries, trends in quality and volume requirements for refined products, and environmental drivers for both refinery operations as well as fuel specifications.

Biodesulfurization of Petroleum Fractions – Compares various versions of conventional refinery hydrodesulfurization with developments in fermentation based biodesulfurization.

INDIVIDUAL CLIENT STUDIES

A partial list of relevant projects includes:

Biofuels Multiclient Study - Liquid Biofuels: Substituting for Petroleum - Nexant's recently published study examines current, emerging, and potential future technologies to produce biogasoline and biodiesel, considering key elements of the value chain, including agricultural, logistics, and processing, and emphasizing techno-economic modeling. It details development trends around the world and analyzes key policy drivers, including rural development, energy independence, and reduced carbon footprint. It also considers a full range of technical, feedstock, and alternative biofuel product options. The report is comprehensive (covering the entire biogasoline and biodiesel value chains, globally), analytical, and up-to-date. The report has a broad base of subscribers from among the leading global and multinational stakeholders (based on five continents) in the biofuels value chain, including the two largest agricultural companies in the world, the largest national and multinational petroleum/energy companies, U.S. and European chemical sector giants, leaders in biotech, key technology developers and engineering firms, financial institutions, government agencies, etc.

Global Biofuels Strategy - For a leading U.S.-based multinational firm grounded in the agricultural sectors, Nexant performed a comprehensive analysis comparing technological, supply chain, and geographic options for involvement in the biofuels sector.

Technology, Company, Finance, and Project Due Diligence in Biofuels – Nexant has performed a number of recent due diligence assignments for financial institutions assessing the

feasibility and value of technologies, companies, businesses, or proposed projects focused on bioethanol or biodiesel.

Chemicals from Corn – This is a broad-based study for the National Corn Growers Association (NCGA), funded by the U.S. DOE, to identify and screen chemicals that could be feasibly produced from corn. The study considers a wide range of potential sugars, and fermentation-derived acids, alcohols, and other building blocks, but emphasizes fuel ethanol derivatives, including basic petrochemicals, solvents, intermediates and specialties, and application of the Reactive Distillation technology sponsored by the NCGA. The basic economics of ethanol production and potential improvements, economies of scale, logistics, and other production and value chain issues, are addressed in the study.

Biodiesel Glycerine Byproduct - Market Dynamics – For a major U.S.-based multi-national agricultural and food company with a growing stake in biofuels, Nexant analyzed the market demand/price elasticity (with a growing glut of biodiesel glycerine byproduct), existing uses of glycerine, potential substitutions for other polyols such as propylene glycol and sorbitol, and potential future applications, including reaction derivatives of glycerine in various applications and fuel uses. Nexant considered the near term and emerging and long-term market outlets for USP and other refined grades of glycerine, as well as for crude biodiesel glycerine byproduct, which is of a more problematic quality than soap and oleochemical byproduct. The study required developing views of biodiesel growth, and pricing scenarios under various assumptions. This subject was also addressed in two recent papers presented at international conferences.

Biobased Fuel Cells – At the BIO World Congress on Industrial Biotechnology and BioProcessing, Orlando, FL, April 20-22, 2005, Nexant presented a paper on biofuels use in fuel cells based on a study of Stationary Fuel Cells for Nexant's PERP program, and also chaired a panel on Bio-based Fuel Cells, which included discussions of enzyme-based fuel cell membrane and electrode technologies to utilize hydrogen or biofuels.

Ethanol vs. MTBE – Litigation Support – Nexant advised the U.S. Department of State in an action defending California against methanol interests for claims of losses in the phase-out of MTBE and use of ethanol as a substitute gasoline oxygenate. This work included a detailed analysis of the ethanol production and distribution infrastructure in the United States and addressing practical, environmental, safety and issues of using ethanol in gasoline.

Ethanol Market and Cost Competitiveness Evaluation - Nexant was retained by an ethanol producer and its financial advisor to provide an independent market study and evaluation of project cost competitiveness to help raise funds to convert an existing sugar- and corn-based ethanol plant in Louisiana to process organic waste (biomass) as a feedstock.

Biomass Ethanol Process Evaluation - Nexant performed a detailed technical and economic analysis of a commercial scale plant for the production of fuel grade ethanol from wood biomass via fermentation, a process developed by a national energy laboratory. Among the goals of the program was the incorporation of the latest R&D developments into the design. The results from this study were compared against earlier designs.

Biomass Ethanol Development Technical Support - Under a multi-year program, Nexant provided technical support for the SERI program to develop viable alcohol fuels production technology based on cellulosic feedstocks. Activities included: investigation of prototype cellulose to ethanol via hydrolysis plant designs for capacities of 50 MM to 250 MM gallons per year; detailed design and capital cost estimate for an anhydrous ethanol plant based on enzymatic hydrolysis of hardwood chips; techno-economic evaluation of proposed processes including biomethanation of biomass pyrolysis gases and liquid fuels from cellulosic biomass.

Ethanol Project Management - A Midwestern U.S. ethanol producer of corn-based gasohol retained Nexant to assist in the implementation of its 40 million gallon per year project. This included a review of the process technology and hardware provided by technology licensors and vendors. Nexant's study assisted the client to obtain Federal loans and secure bank financing.

"Forest Refinery" Industry Evaluation - A U.S. national laboratory retained Nexant to assess the technical and economic feasibility of a forest refinery designed to manufacture chemical products from trees. The analysis screened a variety of biomass conversion technologies and compared the production costs and energy consumption levels of each route to conventional routes. Processes evaluated included fermentation, lignocellulose separation, lignin conversion and gasification.

Cellulosic Ethanol Feasibility Analysis - A synfuels company retained Nexant to determine the technical and economic feasibility of using cellulosic feedstocks to produce commercial quantities of fuel grade ethanol. Alternatives feedstocks (corn and other grains) and byproducts were included in the evaluation.

Enzyme Process Assessment - Nexant assessed the impact on process economics and energy consumption resulting from substituting immobilized cells of Zymomonas Mobilis for conventional yeast in a commercial corn-based ethanol facility.

Fuel Ethanol Opportunity Analysis - A major oil/chemical company interested in developing fuel grade ethanol facilities in the Midwest retained Nexant to assess the competitive aspects of ethanol/gasohol. Factors evaluated included state incentive programs and change prospects, freight costs to prospective markets and the current level of penetration of unleaded gas by ethanol.

European Ethanol Markets Analysis - A study for a Japanese client reviewed the Western European ethanol business including synthetic and fermentation sources. Demand, pricing, grades, end-uses, ethanol production by location and production economics were provided. In another study for this client, Nexant compared the economics of the four plants producing synthetic ethanol with the most efficient (molasses) fermentation ethanol producer.

Ethanol Drying - For a Japanese client, Nexant reviewed the methods used in Western Europe to dry ethanol (including fermentation sources), discussed the merits of newer technologies and investigated international legislative actions to restrict the use of benzene or cyclohexane in azeotropic distillation.

Ultra Clean Fuels Study – For Conoco, under U.S. DOE sponsorship, Nexant performed a comprehensive review of the future for ultra low sulfur diesel and other petroleum distillates in transportation, considered regulatory and market drivers, production technology and economics, petroleum refining impacts, environmental/resource depletion impacts, vehicle engine and performance, consumer acceptance, distribution and refueling logistics, diesel and gasoline ICE operational issues, stationary combustors and fuel cells. The objective was to determine the feasibility of using GTL fuels – Fischer-Tropsch distillate and naphtha and methanol (comparisons to hydrogen, ethanol and biodiesel included). At issue was the use of biodiesel as a lubricity additive to counter the reduced lubricity with loss of sulfur in ULSD and GTL.

Synthesis Gas (Future Sources) - This report reviewed the technology for production of synthesis gas (H_2 , 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.

LNG Competition with Clean Diesel – For a multinational industrial gas company with a stake in technology for LNG as an alternative vehicle fuel/CNG refueling strategy, Nexant studied the current status of "clean diesel" (e.g., engine modifications along with ultra low sulfur diesel fuel enabling use of particulate traps and catalytic tailpipe controls to reduce soot and NOx emissions), and assessed the competitiveness of biodiesel in this context.

Global Finished Automotive Lubricants Market Drivers – For a leading U.S.-based multinational lubricants additives maker, Nexant studied the current and projected global market dynamics for finished automotive lubricants for the next two decades. Market segments/products included passenger car and diesel/heavy-duty crankcase, gear oil, automatic transmission, tractor, off-road and small engine lubricants. Fleet growth in various regions, ultra low sulfur diesel, and trends to "dieselization" of fleets in various regions were relevant issues examined. In this and other related work, Nexant has opined that a key vector for use of biodiesel, aside from as a fuel per se, will be as a lubricity additive to ultra low sulfur diesel. Also key will be demand for biodegradable, non-toxic biodiesel fuel in small boats in place of other marine fuels.

Synthetic-Based Drilling Fluids (SBFs) – For a multinational specialty chemicals company with a stake in oleochemicals and GTL, Nexant studied market issues and projected markets for SBFs in deepwater drilling, as driven by recent U.S. EPA regulations or these oil-based systems with respect to disposal of drilling spoils (especially in the Gulf of Mexico, but in other seas as well). The only systems allowed, by consensus in a stakeholders-involved regulatory development process, are those based on Internal Olefins (IOs) and vegetable esters (essentially, "biodiesel"). These alternatives strike a balance in meeting both toxicity and biodegradability limits.

Biodigestion of Food Wastes – Nexant performed technology audits and market studies for MOM-ECAP, and another, Kuwait-based developer of projects in New York City, New Jersey

and Kuwait to ferment food wastes to produce liquid and solid fertilizer/fungal disease suppressant products by the (aerobic) EATAD process of IBRC of Vancouver, BC. This also included analyses of competitive anaerobic-based biodigestion technologies.

M2M Feasibility for Developing Economies – For USAID, Nexant studied the feasibility of capturing various streams of fugitive methane and bringing them to market ("methane-to-market", or M2M), including anaerobic biodigestion of agricultural waste biomass.

Fatty Alcohols from Coconut Oil Project – (**Cebu**, **The Philippines**) – This was an extensive technical and market due diligence for a bank on the client's proposed new fatty acids/fatty alcohols plant, which involved visiting the client on Cebu and a number of experts and oleochemicals sites in the Philippines, meetings with the process technology vendor, Lurgi AG, in Cebu and in Frankfort, Germany to review technology, flowsheets and project budget, and performing a competitive market study (Asia and global supply/demand, prices, competition, etc.). The study included consideration of byproduct glycerine purification and disposition.

Oleochemicals Feasibility Study - For London-Sumatra's proposed new production in Indonesia, Nexant surveyed the global oleochemicals industry and markets, focusing on palm and palm kernel oils, glycerine, fatty acids, and fatty esters compared to other natural oil-based products and competition with food markets

Surveys of Global Oleochemicals Markets and Technologies – Nexant addressed natural and synthetic-based oleochemicals markets for Dow Chemical.

Chemical Strategies was formed by Mr. James Evangelow in 1989 to focus on commercial development and business planning mainly in the areas of: ethanol, solvents, lubricants, and selected other chemicals. Mr. Evangelow was previously a senior consultant with Chem Systems for a dozen years, where he developed business practice areas in these fields. He has been a consultant to the global ethanol industry for nearly 30 years. Prior to Chem Systems, he held positions as: staff consultant with Kline & Company, sales with Witco Chemical and process engineer at Chemical Construction Company (CHEMICO).

A partial list of relevant projects includes:

- Lead ethanol consultant to Morgan Stanley in their successful acquisition of Williams Bio-Energy from the Williams Companies for \$75 million. The company has since been renamed Aventine Renewable Energy and went public in 2006 (AVR NYSE). It is one the nation's premier ethanol producers and distributors, with 2006 sales approaching \$2 billion. Consultant to Texaco in the late 1970s when the company was formed as Pekin Energy.
- Lead ethanol consultant to Detroit Edison (DTE) in their attempt to acquire Commercial Alcohols, Canada's largest ethanol producer. DTE's plans included the cogeneration of electricity at Commercial Alcohols facilities for transmission to the U.S. grid. At the 11th hour, Commercial Alcohols owner decided to keep the company, which he still owns.
- Consultant to Sergenti Investment Partners on their successful acquisition of SODES, France's sole synthetic ethanol producer.
- Planning consultant to SADAF, the joint venture of Shell Oil and Saudi Basic Industries (SABIC), on their ethanol production facility in Jubail, Saudi Arabia.
- Consultant to the president of High Plains in the diversification of their fuel ethanol business to serve the industrial, beverage and export markets. The company has since been acquired by Abengoa Bioenergy.
- Conducted acquisition analysis of Lyondell's industrial ethanol business for a client seeking to enter the U.S. market.
- Worked with Japan's two private ethanol producers to deregulate the country's government run ethanol monopoly, which occurred in 2006.
- Identified the opportunity to develop New Zealand's gas fields for methanol production. The plants were built and currently operated largely for export.
- Developed and managed several global and regional commercial and economic analysis of the ethanol business. These studies detailed present and projected future synthetic and fermentation ethanol supply, demand, and production costs from indigenous feedstocks for every significant country of the world. From this information, as well as transportation costs and tariff data, future world trading patterns were assessed.

- Consultant to Japan's ethanol industry for over 25 years, providing commercial information that has guided market development inside the country.
- Authored "The World Ethanol Business" and "The Outlook for Ethanol in the U.S., Europe, Brazil and Japan, 1997-2010", two major multiclient studies.
- Worked on the feasibility studies of many of the modern U.S. fuel ethanol plants built during the birth of this industry in the late 1970s and early 1980s.
- Assisted several fuel ethanol producers in developing strategies to diversify both their product and market position.
- Worked on the chemical process design of: methanol, ammonia, urea, nitric acid and ammonium nitrate plants.
- Developed consulting practices in downstream refinery products, solvents, ethanol, lubricants, lubricant base oils and several specialty and fine chemicals.
- Developed and managed a major, detailed investigation of the hydrocarbon solvents business in the United States. The study was undertaken jointly for several of the largest solvent suppliers.
- Worked with developing countries on the utilization of indigenous resources for chemicals and energy production.
- Collaborated on several strategic planning studies for major chemical companies.
- Performed various market entry studies.
- Aided foreign producers in finding suitable domestic joint venture partners for technology transfer or product marketing.
- Conducted several studies which evaluated potential market opportunities for new chemical products. Prepared market/price sensitivities for competing products.
- Performed business/market/techno-economic analyses of petrochemicals, plastics, inorganics, specialty and fine chemicals, and allied products. Business areas/products analyzed included: paints and coatings, adhesives, printing inks, electronic chemicals, lubricants, paper processing chemicals, textile sizing agents, solvents, octane enhancers, photographic chemicals, and polymers, among many others.

Section 8

Please visit <u>www.chemsystems.com</u> to authorize engagement of the study or return the following authorization form to one of the Nexant offices.

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Mr. Phil Hunt Nexant Limited Griffin House, 1st Floor 161 Hammersmith Road London, W6 8BS United Kingdom Tel: 44-20-7950-1530 Fax: 44-20-7950-1550 e-mail: phunt@nexant.com

- The undersigned (hereafter "Client") hereby subscribes to purchase from Nexant, Inc. ("Nexant"), Nexant's study, *Biobutanol: The Next Big Biofuel* in accordance with the following terms and conditions. Nexant will provide to Client the following information and services:
 - (a) Two (2) bound copies of the report
 - (b) Access to electronic downloads of the report via a password-protected area from www.chemsystems.com
- 2. While the information supplied by Nexant to Client will represent an 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 such 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 the 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. The price of this study is US\$12,000 (twelve thousand U.S. dollars).
- 7. Client shall have the option of being invoiced the total amount upon authorization or in two equal installments, one upon authorization and the second six months later. Amounts are due upon receipt of invoice and payable within thirty (30) days. Late payments shall accrue interest at the rate of 1.5 percent 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.
- 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\$200.
- 9. The obligations of paragraphs 3 and 4 shall terminate five (5) years from receipt of reports.
- 10. 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.
- 11. This Agreement will be governed by the laws of the State of New York.

AUTHORIZATION FORM

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CLIENT:	NEXANT, INC.
Name:	Name:
Signature:	Signature:
Title:	Title:
Date:	Date:
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