NexantThinking™

Special Reports

C_5 Chemicals: Unlocking Hidden Opportunities in Steam Crackers?

Brochure
January 2017

Nexant

NexantThinking™

Special Reports

C_5 Chemicals: Unlocking Hidden Opportunities in Steam Crackers?

Brochure
January 2017

www.nexantthinking.com

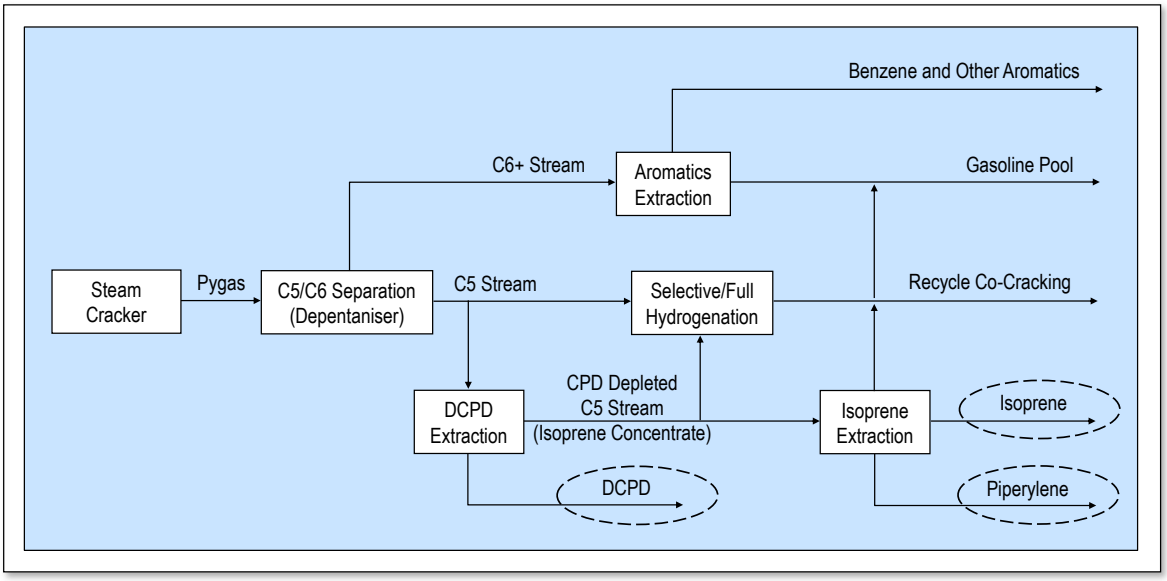
Contents

Section 1 Introduction and Report Objectives

1.1 BACKGROUND

The mixed C_5 stream from the steam cracker is a rich source of diolefins, which are used as feedstocks for a wide variety of derivatives, including hydrocarbon resins, elastomers of various kinds, and even fine chemicals. This stream, contained within pyrolysis gasoline (pygas), is comprised of paraffins, olefins, and diolefins. The normal fate for these C_5 hydrocarbons within most steam cracker complexes is in the gasoline pool or in recycle co-cracking. However, some steam crackers dependentanize the co-product pygas, opening up several options to add chemical value to the C_5 stream. The major C_5 components which are currently extracted or synthesized for chemical uses include isoprene, dicyclopentadiene (DCPD), and piperylene. The main options for chemical uses of the C_5 stream from a steam cracker are shown in the following figure.

Figure 1.1 Chemical Uses of C_5 Streams from Steam Crackers
(Extraction from pygas)



Source: Nexant

1.2 INDUSTRY OVERVIEW

A first impression of the C_5 chemicals industry could be one of relatively healthy profit margins, set against a background of reliable supply sources from established steam crackers, coupled with firm demand fundamentals for C_5 components in growing end-use markets. Such a view could also lead to the conclusion that C_5 chemicals offer a strong investment opportunity. However, there has been limited recent investment activity based on the relatively small number of producers and consumers worldwide, as well as the relatively limited recent investment activity due to various reasons (e.g., low oil price, low natural rubber price and poor economic environment). The C_5 chemicals sector evidently presents not only various potential business opportunities, but also a host of investment hurdles and strategic considerations.

The C_5 chemicals industries in North America, Western Europe, and Japan have undergone restructuring and consolidation over the past decade, and face relatively modest growth in generally maturing domestic end-use markets. A number of new C_5 extraction units have been added in some parts of Asia in recent years to support regional demand, while the limited investment activity in mature markets is opening up

potential C_5 investment opportunities for steam cracker operators in other areas of the world. Key issues facing the C_5 chemicals industry today are tied to not only the availability and production of C_5 streams from steam crackers, but also the evolving requirements for sustaining a profitable C_5 chemicals business for both existing producers and new entrants.

For example, the global chemical industry, to different extents, has been adversely affected by the falling oil prices since 2014. Many producers have curbed investments amidst uncertainties in the oil prices and in the global economic environment. The C_5 industry has since experienced falling demand in some regions. While it is widely believed that the oil price will rebound in the future, the C_5 producers may face reduced supply of available C_5 chemicals from steam crackers in the medium to long term due to continued lightening of cracker feedstocks.

As such, the C_5 chemicals industry involves a complex business that requires key investment considerations and questions to be addressed, such as:

- Market factors:
  - What are the implications for crude C_5 supply, based on projected feedstock preferences and investment patterns in the ethylene sector?
  - What are the key features and development trends in end-use markets, and how will these impact the outlook for C_5 chemicals and derivatives demand?
- Strategic considerations:
  - Are there opportunities in the merchant market, or will investments heavily rely on forward integration?
  - Can sufficient feedstock volumes be secured, and what are the appropriate options for site configuration?
  - Is the demand and price of the C_5 chemicals attractive enough to make installing of extraction units economical?
  - What are the main entry barriers for entering each of the individual C_5 chemicals business?

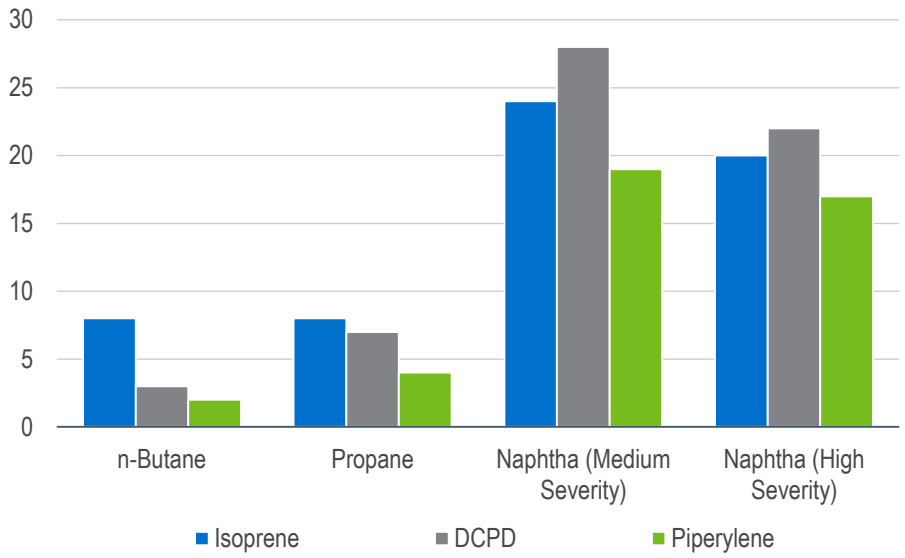
1.3 MARKET DRIVERS

1.3.1 Supply-Side Factors

A significant portion of the players in the C_5 chemicals industry are steam cracker operators, while other players procure C_5 streams or even isoprene concentrate to extract C_5 chemicals. Although isoprene is primarily produced via extraction from C_5 co-product streams of steam crackers, routes for on-purpose isoprene production are also in commercial use. Furthermore, DCPD can be produced in different purities, and multiple production configurations are available for optimizing around targeted DCPD purities, while piperylene can also be recovered in different concentrates, depending on the extraction process employed.

The content and composition of C_5 hydrocarbons in the steam cracker pygas stream also depends on the type of feedstock and operating severity (temperature and residence time) of the cracker. For example, the isoprene content in the C_5 stream is higher when lighter feedstocks are cracked. However, cracking lighter feedstocks also reduces the overall pygas yield, thereby decreasing the effective yield of isoprene from the cracker. As such, this causes some operational challenges for producers of C_5 components that are linked to steam crackers with considerable feedstock flexibility. The following figure summarizes the way in which yields of C_5 chemicals may vary depending on cracking severity as well as the type of feedstock cracked.

Figure 1.2 Representative C_5 Chemical Yields by Steam Cracking Feedstock and Severity
(Thousand tons of C_5 chemical per one million tons of ethylene)



Source: Nexant

In the global ethylene sector, a large portion of future investments will be based on lighter feedstocks, impacting the potential availability of C_5 hydrocarbons for extraction. North America continues to shift towards lighter feedstocks where the majority of steam cracker projects are ethane or ethane/propane based underpinned by the shale gas development, despite the difficult oil environment. This leads to a strong migration towards using a lighter feedstock slate, thereby somewhat reducing the availability of C_5 streams. In the Middle East, ethylene production is still predominantly based on lighter feedstocks, although the region has also been gradually trending towards using a heavier feedstock slate, with a higher proportion of crackers now using a combination of ethane and other natural gas liquids (NGLs).

Meanwhile, in Asia, certain new ethylene capacity additions are still expected to be based on naphtha feedstock, driven by continued investments in integrated refinery and petrochemical projects. In China, various coal-to-olefins (CTO) projects are also projected to start up over the coming years. However, unlike steam crackers, these projects do not have significant impact on the availability of C_5 hydrocarbons.

The investment landscape for the C_5 chemicals industry on the supply side is being shaped by several factors, including feedstock availability, operational factors, as well as issues related to scale and configuration and facility for extraction. Producers in the C_5 industry are relatively concentrated compared to some other chemical products, and new supply options for C_5 streams in mature markets like North America and Japan are increasingly limited. As such, the C_5 chemicals sector may present opportunities for attracting new entrants, such as steam cracker operators in other parts of the world.

With all considerations in mind, some of the key supply-side questions addressed include:

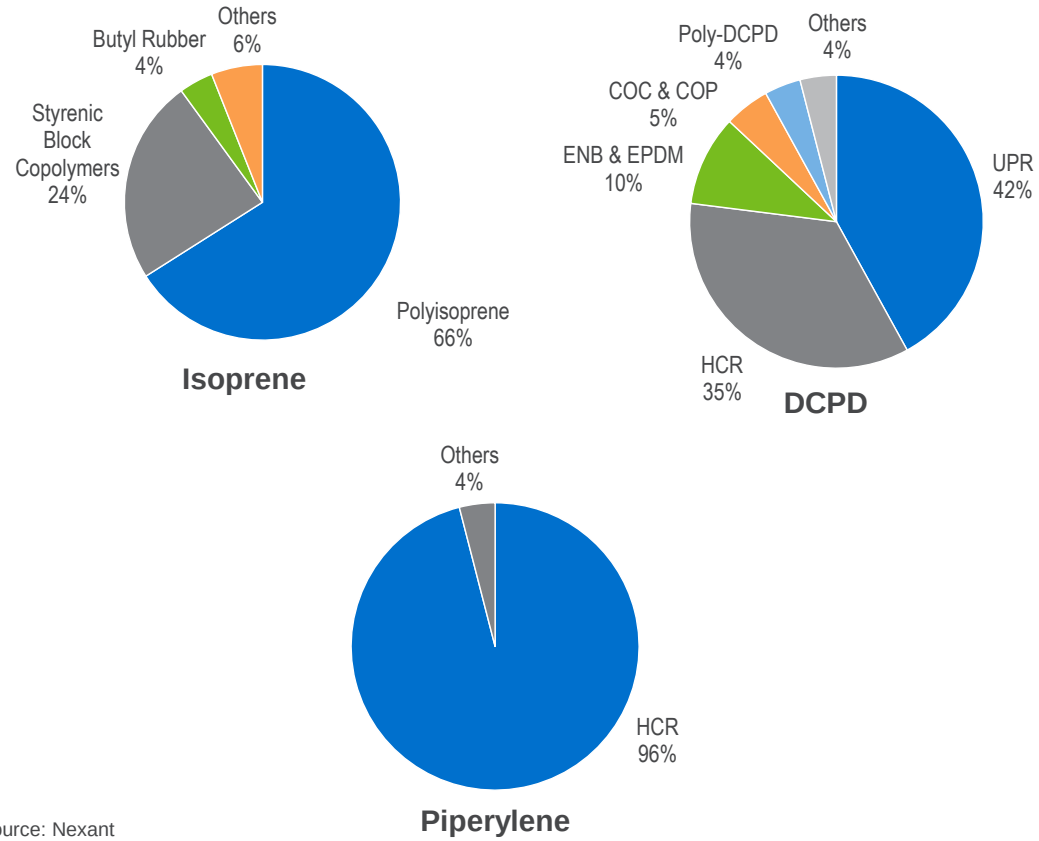
- Will a world-scale naphtha cracker provide sufficient feedstock to viably support a competitive C_5 chemicals complex?
- Can the viability of a potential C_5 extraction unit be justified based on purchased or imported pygas or even mixed C_5 streams?
- Will steam crackers providing the unsaturated C_5 streams have the flexibility to crack different types of feedstocks and operate at different cracking severities?
- What are the key criteria for extraction of C_5 chemicals?

- How will the C_5 complex be configured and optimized to extract multiple C_5 components?
- How will the continuing lightening of the feedstocks to crackers impact the availability of C_5 hydrocarbons for extraction?
- Should producers be looking into on-purpose production processes (especially for isoprene) for reliable supply of feedstock?

1.3.2 Demand-Side Factors

For illustrative purposes, the current global markets and applications for isoprene, DCPD, and piperylene are summarized in Figure 1.3. The key end-use sectors impacting overall C_5 chemicals demand include the tire and automotive industries, as well as the adhesives and construction sector, amongst others. Some of the markets for the major derivatives of C_5 chemicals, such as polyisoprene, styrene block copolymers, or even certain hydrocarbon resins, may generally be associated with high entry barriers. Forward integration in such derivatives is significant in some cases, while businesses heavily based on merchant sales are also prevalent in other cases.

Figure 1.3 Global Isoprene, DCPD, and Piperylene Demand by Application, 2013



Source: Nexant

The diverse end-use applications mean market considerations and dynamics for each of the C_5 chemicals are different. For example, isoprene derivatives (e.g., polyisoprene) are linked to the price and supply dynamics of natural rubber, other synthetic rubber and elastomers, while DCPD derivatives are much less affected by these movements. Nevertheless, due to the chemical properties of the C_5 products, DCPD is extracted first, followed by piperylene and isoprene (as illustrated by Figure 1.1). Hence, the attractiveness of installing an isoprene extraction unit cannot be determined by isoprene supply/demand analysis alone as it entails the cost of installing the DCPD and piperylene extraction units.

Some of the important questions addressed regarding the demand-side factors of the C_5 chemicals sector include:

- Are the technologies for producing C_5 chemicals and derivatives available for licensing, and are there any other major entry barriers for forward integration?
- What are the opportunities available in the merchant market for C_5 chemicals and derivatives?
- Which regions are expected to be the major importers, and will any developing surpluses in nearby markets present risks to a new C_5 complex?
- Which market and applications are projected to have the highest growth potential?
- What are the major threats for market growth for each of the C_5 chemicals?

1.4 STUDY OBJECTIVES

In this report, **C_5 Chemicals: Unlocking Hidden Opportunities in Steam Crackers?** Nexant addresses the questions that are of concern to current producers and potential market entrants to the C_5 chemical business. The objective of this study is to examine the current and developing situation in the global C_5 chemicals industry. This report aims to provide a comprehensive business analysis, including commercial, technical, economic, and strategic considerations, specifically offering insights on the following key areas of the C_5 chemicals sector:

- Supply-side market factors, such as:
  - Underlying C_5 availability and supply potential amidst evolving developments in the ethylene industry
  - Likelihood of isolating unsaturated C_5 streams from byproduct streams of steam crackers and developing a viable C_5 chemicals complex
  - Relative competitiveness of alternative production routes, such as on-purpose isoprene production
- Demand-side market fundamentals, comprising:
  - Prospects of emerging markets
  - Trends in mature markets
- Trade considerations and their implications on trade flows and patterns, with attention to projected supply and demand imbalances
- Production economics and drivers of production costs, product pricing, and profitability
- Industry attractiveness and business strategies, including:
  - Industry structure, competitive intensity, and market attractiveness, with consideration to different participants along the value chain
  - Sustainable business models based on integration, optimization, or partnership along the value chain
- C_5 investment considerations and the associated opportunities and challenges for different types of players in the chemicals sector

This report provides detailed insights and analyses into the industry dynamics that are shaping the C_5 chemicals business. This study is designed to be of benefit to both existing players and new entrants within the entire C_5 chemicals value chain. For the steam cracker operators, especially those with liquid feed slates, the report aims to evaluate the opportunities that could potentially increase their competitiveness within the industry. For new entrants, the report aims to provide guidance on business and strategic considerations for entering the industry from both the supply and demand sides.

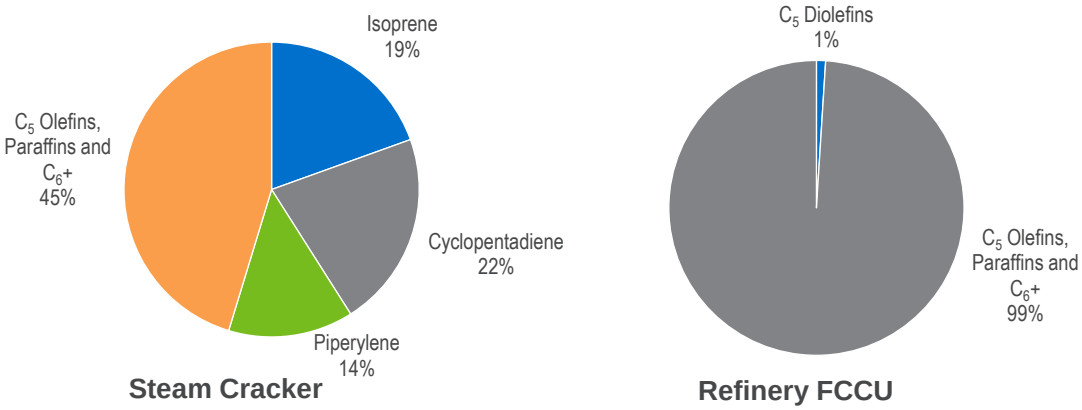
2.1 REPORT COVERAGE

There are three main sources of C_5 feed streams:

- Unsaturated pyrolysis gasoline from steam crackers
- Product stream from the Fluid Catalytic Cracking Unit (FCCU) in refineries
- Natural Gas Liquids (NGLs), (i.e., condensates)

The C_5 content and composition vary widely, depending on source. C_5 streams from steam crackers pygas streams contain a rich portion of C_5 diolefins (i.e., isoprene, CPD/DCPD, and piperylene), while refinery-based C_5 streams mainly comprise C_5 olefins (i.e., methyl-butenes and pentenes) and paraffins (mostly isopentane), with a very small amount of C_5 diolefins. In the case of NGL streams, C_5 paraffins (i.e., pentanes) are the predominant C_5 component. The composition of typical C_5 streams from steam cracker and refinery sources is presented in Figure 2.1.

Figure 2.1 Composition of Untreated C_5 Streams by Source



Source: Nexant

This study mainly focuses on steam cracker sources of C_5 streams, which are the major sources of supply for C_5 diolefins. Refinery-based C_5 streams contain a small amount of diolefin, and are used in the gasoline pool and as feedstock for tertiary amyl methyl ether (TAME) synthesis for reformulated and unleaded gasoline. This report covers C_5 streams sourced from NGL streams, insofar as identifying commercial on-purpose isoprene production via isopentane dehydrogenation and assessing the economics of this production route.

This study provides geographic coverage on global and regional bases. The regions are divided into:

- North America
- South America
- Europe
- Asia Pacific
- Middle East and Africa

Detailed coverage has been provided for the three primary C_5 chemicals of commercial importance, specifically:

- Isoprene (also called 2-methyl-1,3-butadiene) – focus on high purity
- DCPD (low purity, high purity and ultra-pure)
- Piperylene (also called 1,3-pentadiene)

The presented data in this report covers historical analysis and forecasts from 2003 to 2030.

2.2 REPORT SCOPE

The main report sections have been structured around the following key issues:

- **Demand Analysis:**
  - Overview of global C_5 chemicals consumption, discussing derivatives and end-use demand drivers, to review the overall C_5 chemicals market as well as its major products (i.e., isoprene, DCPD, and piperylene)
  - Detailed analysis of global and regional demand for isoprene, DCPD, and piperylene, supported by understanding of market trends of key derivatives and end-use applications
- **Supply Assessment:**
  - Review of the commercial routes and feedstocks for producing C_5 chemicals, evaluating market supply factors, such as the different C_5 yields for different feedstocks used in extraction processes
  - Detailed analysis of the ethylene industry, including supply and demand outlooks as well as current and future feedstock trends, allowing for an investigation of the supply of mixed C_5 streams
  - Estimates for production levels of pygas and isolated unsaturated C_5 streams, conveying the supply-side prospects and limitations of C_5 chemicals
  - Assessment on the supply of isoprene, DCPD, and piperylene, with considerations for new plant additions and capacity rationalization
- **Supply/Demand and Trade Review:**
  - Compilation of net trade patterns and overview of C_5 market characteristics as well as trade considerations and trends related to transporting the feedstocks (i.e. pygas, isolated unsaturated C_5 streams, and isoprene concentrate), and the major C_5 chemical products (i.e. isoprene, DCPD, and piperylene)
  - Summary of supply, demand, and net trade data for isoprene, DCPD, and piperylene, supplemented by further analyses of current and expected trade flows that balance the global market
- **Production Economics Evaluation:**
  - Estimates of representative production costs for isoprene, DCPD, piperylene, and their major derivatives, including both capital costs and operating costs for commercial production processes, which comprise extraction processes using steam cracker C_5 streams, as well as alternative routes, such as the isobutylene carbonylation and isopentane dehydrogenation processes

- Discussion on cost-based drivers and market-related factors regarding pricing, analyzing the implied range of profitability for C_5 chemicals, based on relevant and defined assumptions and forecasts for the valuation of feedstocks and pricing of products

- **Industry and Business Analysis:**

  - Overall summary on the strategic issues of the C_5 chemicals industry and business
  - Review of the C_5 chemicals value chain, examining the structure of the market, in terms of captive and merchant activities as well as relationships between different participants along the value chain
  - Discussion on the competitive intensity, market attractiveness, and other factors that characterize the structure of the isoprene, DCPD, and piperylene industries, addressing the different business models employed by industry players, in terms of integration levels and strategies
  - Summary of site optimization within developed C_5 clusters in certain mature markets and the prospects for potential C_5 sites in selected emerging markets
  - Concluding discussion on the key opportunities and challenges associated with investment considerations from the perspective of new prospective entrants as well as current established players

Appendix **Page**

Section 4 Methodology

4.1 OVERVIEW

Nexant has considerable experience in undertaking this type of study. The general approach included:

- Utilizing in-house databases, updated analyses, and the latest forecasts from Nexant's multi-client research programs that include:
  - The Petroleum and Petrochemical Economics (PPE) program covering supply, demand, and trade, as well as pricing and profitability, of numerous products in the global petroleum and petrochemical industries
  - Nexant's proprietary simulation model, which is an experience-based database running commodity petrochemical business logic algorithms to produce multi-scenario simulations of the global petrochemical industry
  - The Process Evaluation/Research Planning (PERP) program offering process evaluations of existing, emerging, and embryonic technologies of interest to the energy and chemicals industries
- Conducting direct market research and fieldwork with a range of relevant participants within the energy and chemicals industries, including:
  - Consumers, producers, and other relevant bodies (e.g. traders and distributors), where possible
  - Technology licensors and engineering, procurement, and construction (EPC) contractors, as appropriate
- Utilizing extensive experience and non-confidential information derived from a number of previous assignments
- Reviewing selected public domain sources to compare the latest statistics and views on market developments

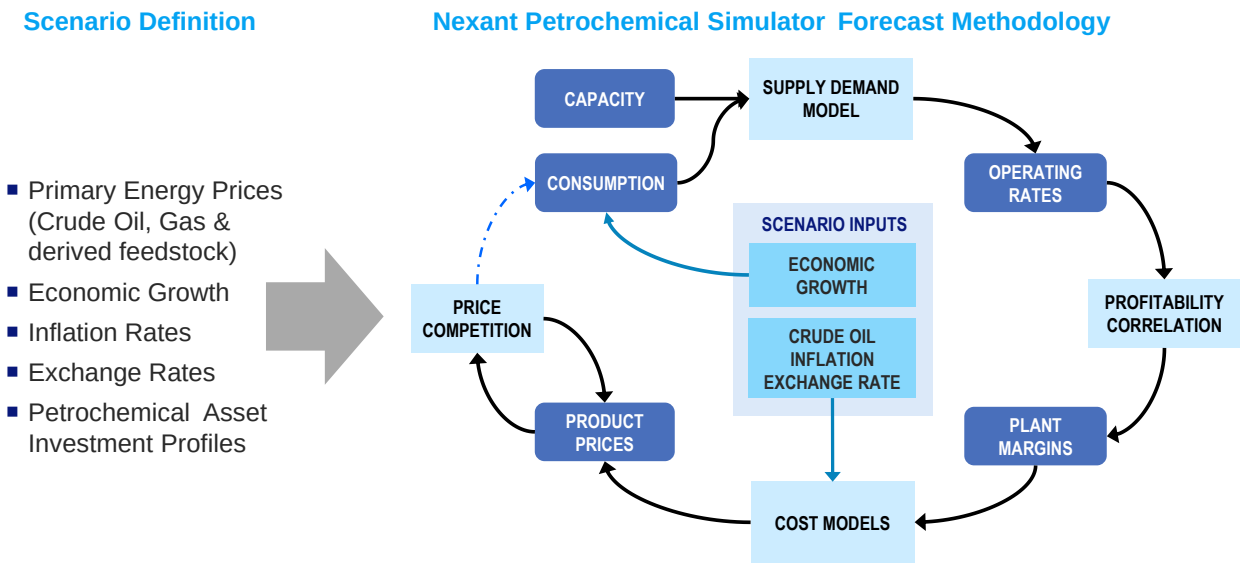
Nexant has a strong track record in evaluating petrochemical markets. This study draws upon Nexant's extensive industry experience, business and technical expertise, and deep understanding of markets, technologies, and economics within the chemicals sector.

4.2 MARKET ANALYSIS

Nexant's market forecasts are supported by a proprietary simulation model of the global petrochemical industry. This advanced simulator is a fully integrated model of global business dynamics, including material flows and cash flows, using sophisticated software. Nexant's expertise and experience in the global industry have been used to develop algorithms to simulate petrochemical business dynamics. The resulting simulator has been a major advance in market forecasting technology.

Figure 4.1 illustrates the simulator forecast methodology, which relates market demand drivers to petrochemical consumption. From a database of petrochemical processes and plant capacity the regional consumption is compared to the ability to produce. Global trade algorithms complete a full supply, demand and trade model of the industry. Basic commodity theory dictates that market tightness, measured by average operating rates, is the primary driver of profitability. Production costs are built up from a detailed database of archetype plant techno-economic models, heavily influenced by the assumptions of crude oil prices. Petrochemical product prices are determined by adding projected production costs to the margin outlook. Inter-regional competition and inter-material competition add further constraints and complexity to shape the pricing dynamics.

Figure 4.1 Nexant Petrochemical Simulator Forecast Methodology



4.3 PRODUCTION ECONOMICS EVALUATION

Nexant has well-established methodologies for production economics evaluations, which include the development of:

- Capital and production costs
- Price forecasts

As part of developing estimates for capital and production costs of petrochemicals, Nexant monitors industry technology developments on a regular basis, with inputs derived from a number of sources, including technology licensor data, discussions with producers and technology owners, project reviews, patent research, and plant performance monitoring activities, where non-confidential data are available. Investment costs are estimated using a top-down approach based on in-house data and previous project experience, rather than a bottom-up calculation based on equipment specifications and contractor unit rates. Production costs are developed at different levels, including raw material costs, by-product credits, utility costs, direct fixed costs, and allocated fixed costs.

As indicated in Figure 4.2, the variable cost of production includes the costs of raw materials – feedstocks plus catalysts and chemicals – and utilities at cash cost or purchased cost, with a credit for co-products. The direct fixed costs include:

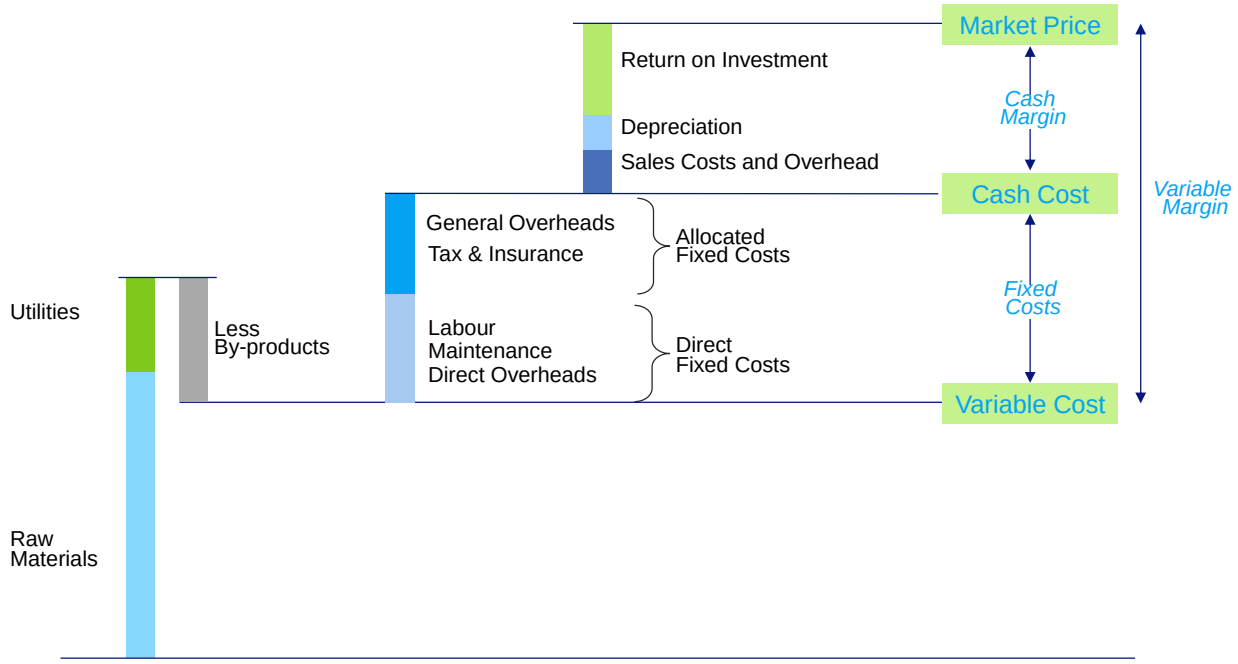
- Salaries of operating staff plus associated costs, such as holiday cover, social insurance, fringe benefits, etc.
- Maintenance costs including materials and labor, with periodic maintenance costs such as two or three year shutdowns averaged over the period; maintenance costs are usually calculated as a percentage of process plant capital cost

The allocated fixed costs are site charges, which are necessary for production but which are not directly associated with the operation of the specified process plant. They include packing and warehousing, storage and workshops, site laboratories, safety and environment, security, site management, and on-site amenities for the workers. Insurance of the fixed assets is also included under allocated fixed costs.

To calculate the total delivered cash cost involved in delivering a product to a particular target market, Nexant takes into account the freight and handling costs as well as any tariffs, in addition to the derived total cash cost of production.

As defined by Nexant for its analyses of production costs and its price forecasting, the cash cost does **not** include corporate overheads such as general marketing, company administration, and R&D. Nor does it include working capital.

Figure 4.2 Components of Cost of Delivery to Market



In addition to the derived total cash cost of production, the Return on Capital analyses for the production of major petrochemicals in key locations for the different crude oil price scenarios will be based on the following:

- Nexant's price projections for each product in the selected market
- Estimated investment costs for new, world scale facilities in each location

The methodology used to develop the investment cost estimates is briefly summarized below.

A process plant can be viewed as consisting of two types of facilities. The first is the manufacturing area containing all process equipment needed to convert the raw materials into the product. The capital costs of these facilities are commonly referred to as the inside battery limits (ISBL). The second group of facilities contains the outside battery limits (OSBL) or offsites. These include general utilities (e.g., instrument and utility air, nitrogen, fire water, etc.), administrative buildings, steam generation facilities, cooling water system, electrical distribution systems, waste disposal facilities, etc.

For all the cases considered, investment costs assume "instantaneous" construction or implementation in the designated year. This is a simplification because initiation, design, and construction can take several years to complete. In order to undertake the instantaneous analysis, phased investment costs and associated financial charges are consolidated into a single overall project cost.

In addition to the plant capital, the owner usually has other costs associated with the project such as project management, startup, etc. Working capital is calculated to reflect raw material, byproduct, and supplies inventories; accounts receivable; cash requirements etc., with credit for accounts payable.

For petrochemical price forecasting, Nexant's methodology is largely based on an assumption for the underlying price of crude oil, which drives production costs, and on an understanding of the long-term relationship between supply and demand conditions and profit margins. This methodology primarily considers long-term fundamental industry developments in global supply, demand, and regional cost competitiveness, and also assumes that market conditions have come to equilibrium with no short-term disturbances.

5.1 OVERVIEW

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

Nexant is an international consultancy and is dedicated to assisting businesses within the global energy, chemical, plastics, and process industries by providing incisive, objective, results-oriented management consulting. Over five decades of significant activity translates into an effective base of knowledge and resources for addressing the complex dynamics of specialized marketplaces. By assisting companies in developing and reviewing their business strategies, in planning and implementing new projects and products, diversification and divestiture endeavors and other management initiatives, Nexant helps clients increase the value of their businesses. Additionally, we advise financial firms, vendors, utilities, government agencies and others interested in issues and trends affecting industry segments and individual companies.

Nexant was formed as an independent global consulting company in 2000, and combines a number of companies that had a long history of providing consultancy services to the chemical and refining-related industries. Nexant's experience covers all aspects of project development relating to major refinery, petrochemical, and polymer investments, ranging from grassroots plants to revamps of existing process units. Nexant's key offices serving the petrochemical and downstream oil sectors are located in New York, London, Bangkok, and Bahrain, and locations for other offices are shown in Figure 5.1.

Figure 5.1 Nexant Office Locations

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 developing areas including the Middle East, Africa, and East and Southeast Asia.

Major annual subscription programs are:

- Process Evaluation/Research Planning (PERP)
- Petroleum & Petrochemical Economics (PPE) – United States, Western Europe, Middle East and Asia
- PolyOlefins Planning Service (POPS)

5.2 PROCESS EVALUATION/RESEARCH PLANNING (PERP)

The PERP program provides valuable insights and information to research planning and marketing personnel. It examines existing, developing and embryonic technologies, aiming to provide early identification of commercially significant technical developments. Ten or more reports per year are on petrochemicals; additional reports cover polymers, fine and performance chemicals, and other topics.

The PERP program covers technology, commercial trends, and economics applicable to the chemical industry. The program has more than 40 subscribers, including most of the major international chemical companies. Many of the processes to be analyzed in this multi-client study have been assessed in the PERP program.

5.3 PETROLEUM & PETROCHEMICAL ECONOMICS (PPE)

The PPE program provides historic and forecast analysis of the profitability, competitive position, and supply/demand trends of the global petroleum and petrochemical industry. The program includes capacity listings and analysis, global supply, demand and trade balances, profitability, competitiveness, and price analysis and projections for all the major petrochemical value chains. The PPE program is supported by an internet-based planning and forecasting tool that provides online access to the database behind the reports of the PPE program.

5.4 POLYOLEFINS PLANNING SERVICE (POPS)

The POPS program provides reports on the global polyethylene and polypropylene industry. It is recognized globally as the benchmark source for detailed information and analysis on current commercial, technical, and economic developments in the polyolefins industry. Coverage includes: capacity listing and analysis, detailed consumption, supply/demand, trade, operating rates, price forecasts, technological developments, new products, inter-material substitution, and regional competitiveness.

Section 6 Contact Details

6.1 CONTACT INFORMATION

AMERICAS
Nexant, Inc.
44 South Broadway, 4th Floor
White Plains, NY 10601-4425
U.S.A.

Attn: Marcos Nogueira Cesar
Vice President, E&CA, NexantThinking
Tel: + 1-914-609-0324
Email: mcesar@nexant.com

EUROPE
Nexant Limited
1 King's Arms Yard, 1st Floor
London EC2R 7AF
United Kingdom

Attn: Anna Ibbotson
Global Director, Petrochemical Markets & Profitability, NexantThinking
Tel: +44 20 7950 1528
Email: aibbotson@nexant.com

ASIA
Nexant (Asia) Ltd
22nd Floor, Rasa Tower 1
555 Phahonyothin Road
Kwaeng Chatuchak, Khet Chatuchak
Bangkok 10900
Thailand

Attn: Tiankanok Sirichayaporn
Managing Consultant, E&CA, NexantThinking
Tel: +66 2 793 5050
Email: tiankanoks@nexant.com

or

Attn: Hsien-Hsi Kao (Kenny)
Consultant, E&CA, NexantThinking
Tel: +65 9093 8903
Email: kkao@nexant.com

Nexant, Inc.

San Francisco
New York
Houston
Washington D.C.
London
Frankfurt
Bahrain
Singapore
Bangkok
Shanghai
Kuala Lumpur

www.nexant.com

www.nexantthinking.com

Nexant