IHS CHEMICAL

Process Economics Program (PEP): Steam Cracking of Crude Oil

PEP Report 29J Prospectus

Contents

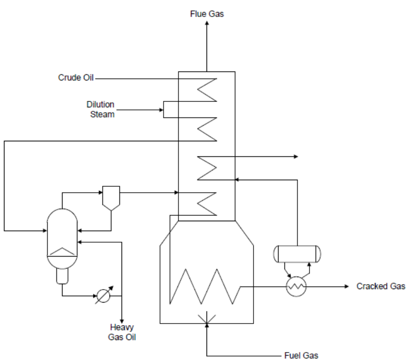
Introduction

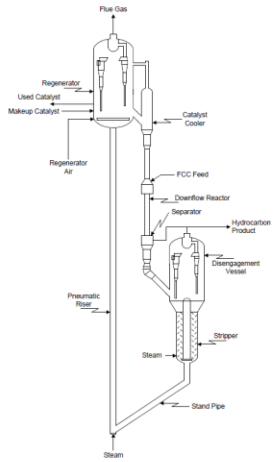
Can olefins from crude oil outcompete conventional steam cracking of naphtha? How do these processes work? What are the economic drivers?

This report covers the technology and costs of manufacturing ethylene from crude oil via steam cracking. Ethylene is the world's most important petrochemical, and steam cracking is by far the dominant method of production. However, the use of crude oil as feedstock is a novel and recent development.

Two processes are presented. Section 5 gives the ExxonMobil process. This process feeds crude oil directly to modified cracking furnaces. The cracked gas from these furnaces is further processed in a traditional steam cracking front-end depropanizer facility. Section 6 gives the Saudi Aramco process. In this process crude oil is fed directly to a hydrocracker. The hydrocracker products include naphtha, distillate, and vacuum gas oil cuts. The naphtha and distillate are co-cracked in traditional steam cracking furnaces. The vacuum gas oil is sent to a newly developed, proprietary, high-severity fluid catalytic cracking (FCC) unit. We present preliminary engineering designs for both the ExxonMobil and Aramco processes.

In addition to these two engineering designs, we present in Section 4 a review of the applicable steam cracking and hydrocracking technologies. We also discuss therein details of the novel ExxonMobil flash pot system as well as the new Aramco high-severity FCC technology.





Abstract

In January 2014 ExxonMobil officially opened in Singapore a novel steam cracker that produces olefins directly from crude oil. The Saudi Arabian Oil Company (Aramco) has discussed plans to build a crude-to-olefins complex. SABIC is another company that has looked into direct crude-to-olefins. In this report we examine some of the technologies required to support the direct production of olefins from crude oil. We present process design studies for the ExxonMobil and Aramco processes.

We look at capital and production costs for a facility in Singapore using the ExxonMobil process and compare that process in detail with traditional naphtha cracking. In particular, we lay out side by side crude oil vs. naphtha comparisons of yield sets, major equipment sizes, and process economics. Our analysis indicates that the ExxonMobil process achieves a $100-$200/ton cost advantage vis-à-vis naphtha cracking with only a modest increase in capex.

We also present capital and production cost estimates for a facility in Saudi Arabia using the integrated Aramco crude-to-olefins process. The Aramco route benefits from a significant by-product value uplift and an advantageous feedstock price spread. These result in a cash cost advantage to the Aramco process of over $200/ton compared to conventional naphtha cracking. Capex is significantly higher, however. These two factors largely cancel one another out. We conclude that the Aramco process shows equivalent to slightly advantageous economics compared to naphtha cracking.

Key Questions Addressed in the Report

- How does the ExxonMobil process work?
- What is the feedstock that ExxonMobil is using?
- What are the olefins yields from their process?
- Can olefins from crude oil really outcompete naphtha steam cracking?
- What is the Aramco process layout?
- Will Aramco implement their technology?
- What drives olefins from crude oil vs naphtha cracking process economics?

Deliverables

The narrative report will be delivered in PDF format. We will provide process flow diagrams and major equipment lists for the ExxonMobil and Aramco processes. Class 3 capex and opex estimates will be given for the ExxonMobil process on a Singapore basis and for the Aramco process on a Saudi basis. We will supply for both processes side-by-side comparisons of crude oil cracking yield sets vs. those for naphtha cracking. A side-by-side comparison of major equipment size differences between the ExxonMobil process and a naphtha cracker will be furnished. IHS experts will be available to answer questions about the report content.

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Meet the Authors

Michael Arné – Sr. Principal Analyst

Michael Arné has 36 years of industry experience in chemical engineering consulting, chemical manufacturing, and related positions. Has authored numerous PEP reports on topics bearing on process design and capital and operating cost estimation for polyolefins, and petrochemicals and is the ongoing technical lead and co-author of the "Greenhouse Gases Handbook".

Michael's areas of expertise include Chemical Engineering Design, Capital Cost Estimation, and Technoeconomic Analysis and his Domain Knowledge includes Olefins from Liquids, Carbon Accounting, Chemicals and Fuels from Bio-Sources.

Mike holds a M.S., Engineering Management from Stanford University, and a B.S., Chemical Engineering, from the University of California at Berkeley.

Gajendra Kumar - Principal Analyst

Gajendra Kumar works with IHS's PEP program and is responsible for Refinery & C1 process economics studies. He has 12 Years Industrial Experience in Refinery & Petrochemicals in Plant Operations, Process Engineering, Start-up and process simulation studies.

Prior to IHS, he worked with Reliance Industries, Honeywell, Kellogg Brown & Root, CB&I. Gajendra's areas of experience include Process Economics Studies, Process Design, Process Simulation & optimization, Engineering Studies for validation of process design and controls scheme, Multi-Client Activities, Experience in various industrial processes like GTL, Ammonia, LNG, NGL, Refinery and petrochemical. Gajendra holds a Bachelors in Chemical Engineering from IIT-Roorkee.

IHS Chemical Process Economics Program (PEP)

PEP provides in-depth, independent technical and economic evaluations of both commercial and emerging technologies for the chemical, biochemical, and refining industries.

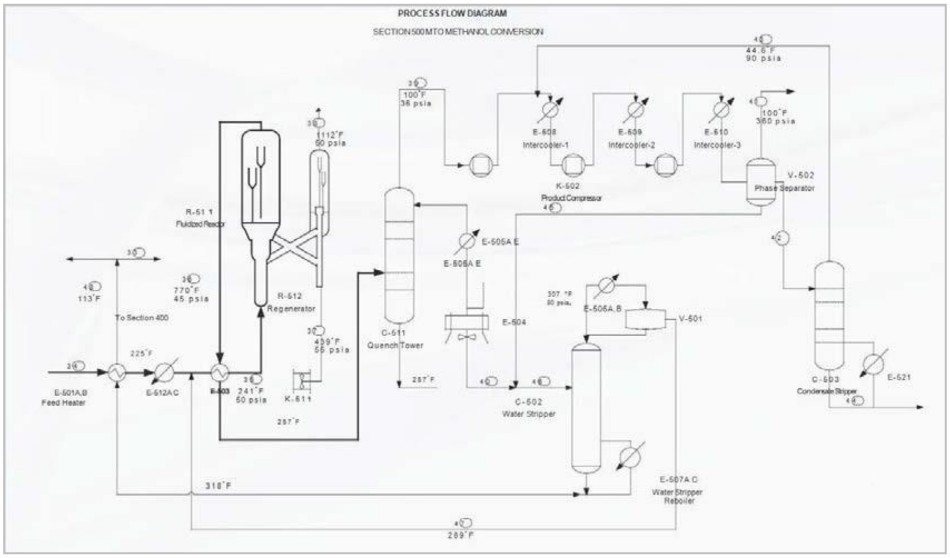
PEP analyzes the impact of changes in processes, feedstocks, energyprices, and government regulations on chemical and fuel production economics for our clients. And with the celebration of the 50th anniversary of PEP, we enter a new era, offering new functionality and key report contents through interactive Excel data files that allow our clients to generate process economics tailored to their specific project needs.

Benefits

New technologies can either off an opportunity or pose a threat. Prompt and thorough analyses of new developments are crucial to making the proper decision—whether you are exploiting a proprietary technology or responding rapidly to a competitor's move. PEP reduces the time and costs associated with collecting and interpreting the voluminous information needed to assess new technologies. Clients make use of PEP's independent analyses—which draw on our experts' industry experience in process design, cost estimation, and R&D planning—to make informed decisions. Complementing that expertise are the program's extensive databases and ongoing contacts with chemical companies worldwide.

PEP is a partnership

PEP is designed to be a problem-solving partnership, combining independent analysis with client needs. PEP experts stay up-to-date on issues affecting clients through on-going contacts with industry representatives, conference participation, and site visits. The insights gained from these activities are reflected each year in the topics suggested for research. Clients then vote on PEP's suggestions to ensure the selected topics reflect their areas of interest.



Typical vapor phase process sections

Inquiry privileges

PEP customers receive access to IHS Chemical experts to discuss information in the studies.

PEP Reports and Reviews

Our subscription-based service delivers PEP Reports and PEP Reviews to our clients each year. Each Report covers three or more processes, while each Review covers one process or a specific topic. Available in print and online, PEP Reports and PEP Reviews are universally acknowledged as the industry standard for techno-economic evaluations of chemical process technologies.

PEP Reports emphasize commercially significant products and processes for which technology is rapidly changing. PEP experts develop and evaluate process designs using patent literature and licensor information, and they estimate capital and operating costs of world-scale production plants. Every PEP process economics evaluation is based on an in-depth process analysis and starts with a clear design basis and a PFD (process flow diagram).

PEP Reviews provide timely analysis of “hot issues” affecting the industry—from process technology to industry restructuring. Included with the 2014 Reports and Reviews is an iPEP Navigator Excel-based interactive data module, which allows a user to quickly select a process and a region, and convert process economics between English and metric units.

PEP Consolidated Reports

Each PEP Consolidated Report provides a single and comprehensive report on a specific chemical that includes all competing processes, with the same detailed process design and economics as PEP Reports. Consolidated Reports also contain an iPEP Navigator module that allows a user to quickly select a process and a region, and convert process economics between English and metric units.To ensure the information in the Consolidated Reports remains relevant, we will update the process economics and industry review section of each report once a year. PEP Consolidated Reports serve technical managers and process engineers who are interested in understanding all competing processes in detail and keeping track of market conditions and production economics annually.

PEP Process Summaries

PEP Process Summaries offer a concise comparison of competing processes by capturing key differences in design features and process parameters. Process Summaries include an iPEP Spectra interactive data module prepared in an Excel pivot table where quarterly production economics of competing processes are easily compared over a period of 10 or more years. The iPEP Spectra data module will enable our customers to compare production economics of competing processes in various plant locations using a wide selection of economics metrics. The process summaries are meant to serve business and project managers who are interested in understanding competing processes’ key differences at a high level but still need to closely track profitability.

PEP Yearbook

The PEP Yearbook is the world’s largest online process economics database. Updated quarterly starting in 2014, it provides current production economic data for more than 1,400 processes used to manufacture over 600 chemical, polymer, refining, and biotech products. The database estimates raw material and utility requirements and demonstrates capital and production costs for three plant capacity levels, while an online application tool enables users to customize plant capacity for quick scaling analysis.

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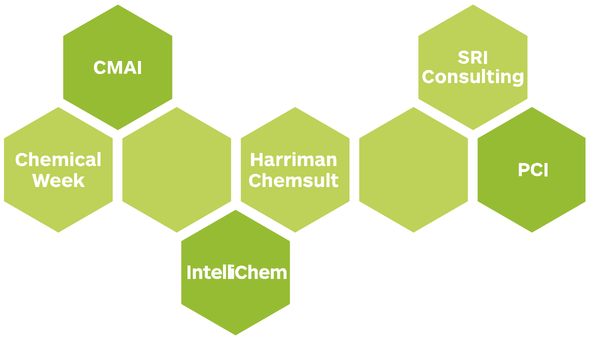
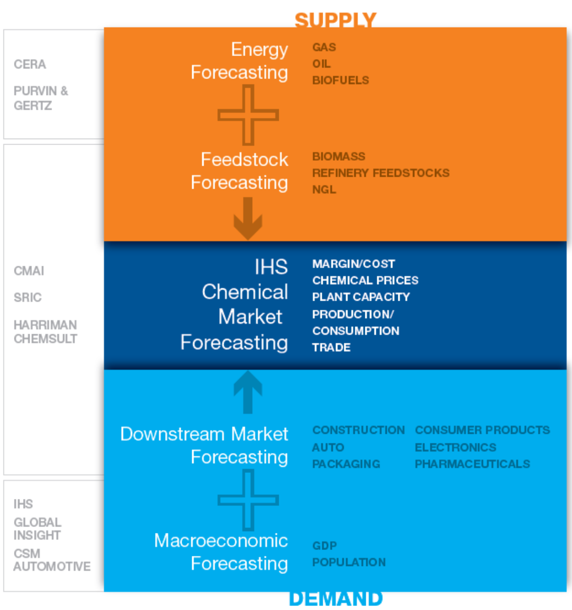
IHS Chemical now combines the former CMAI and SRI Consulting groups together with Chemical Week Magazine, Harriman Chemsult, IntelliChem and PCI Acrylonitrile into one integrated business unit comprising its multiclient and single client services. IHS Chemical's experts, analysts and researchers who are well respected throughout the industry for their deep-rooted analysis and forecasts, extends the value that IHS can now offer by connecting clients with the vast resource of insight and expertise that exists across IHS including energy, supply chain and economics.



Comprehensive Coverage

IHS Chemical provides the most comprehensive chemical market content and industry expertise in the world. The company has more than 200 dedicated chemical experts working together to create a consistent and integrated view across more than 300 industrial chemical markets and 2,000 chemical processes for 95 industries. Ensure that your decisions are based on broad, comprehensive information, forecasts, intelligence, and analysis.

IHS has assembled a team of chemical experts that offers an unprecedented coverage level for core chemical markets and technologies. Backing them is a larger IHS community of experts covering related markets, from energy and the macro economy to the world's largest chemical-using industries, such as automotive, construction and others. IHS Chemical's intellectual capital is built on an operating model that utilizes over 1,800 consultants, researchers and economists to advance cross-disciplinary collaboration and analysis.



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IHS is the leading source of information, insight and analytics in critical areas that shape today's business landscape. Businesses and governments in more than 165 countries around the globe rely on the comprehensive content, expert independent analysis and flexible delivery methods of IHS to make high-impact decisions and develop strategies with speed and confidence.

IHS has been in business since 1959 and became a publicly traded company on the New York Stock Exchange in 2005. Headquartered in Englewood, Colorado, USA, IHS is committed to sustainable, profitable growth and employs more than 8,000 people in 31 countries speaking 50 languages around the world.

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IHS offers must-have business information, advanced research and analytics, and deep expertise in core industry sectors, such as energy and natural resources, chemicals, electronics, and transportation. We focus on business-critical workflows that support our customers' needs, including:

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- Energy Technical: Exploration-Production, Geoscience, Engineering, Commercial Development
- Product Design: Engineering Design, Research and Development
- Supply Chain: Procurement, Logistics, Operations, Manufacturing

This interconnected information, expertise, and analytics across industries and workflows allows IHS to provide best-in-class solutions that power growth and value for our customers.

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