NexantThinking™

Special Reports

China's Refining Industry – The Transforming Giant

Brochure
August 2016

Nexant

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1.1 OVERVIEW

The Chinese economy has developed at an almost exponential rate in the past 50 years. Due to its sheer magnitude, China's economic growth has transformed the world during the 20th and 21st centuries. In 1970, China contributed to less than 2 percent of the world's GDP, increasing to approximately 15 percent in 2015. Currently, the Chinese economy is one of the biggest in the world, worth over US$10 trillion, and second only to the United States.

Figure 1.1 China GDP Global Contribution

Percent of Global GDP

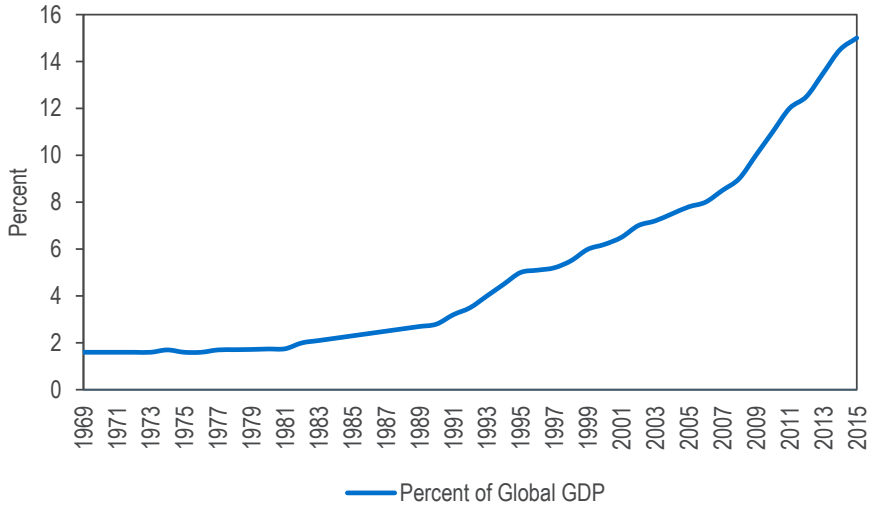
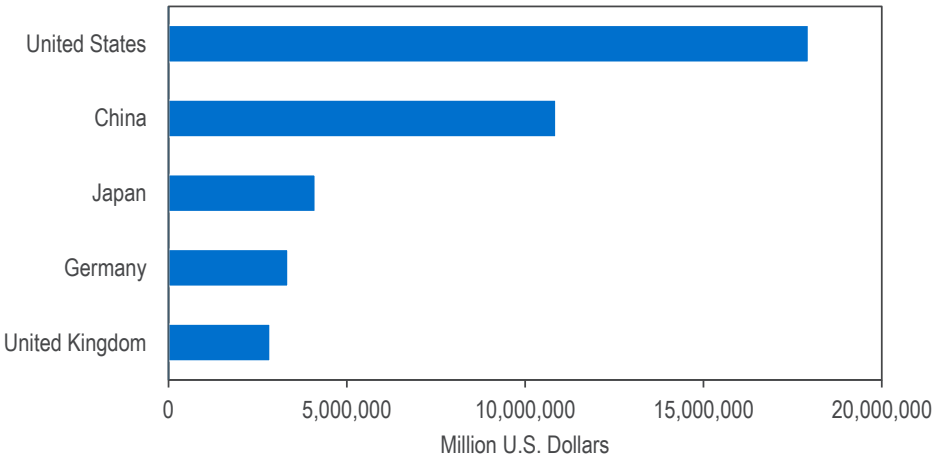


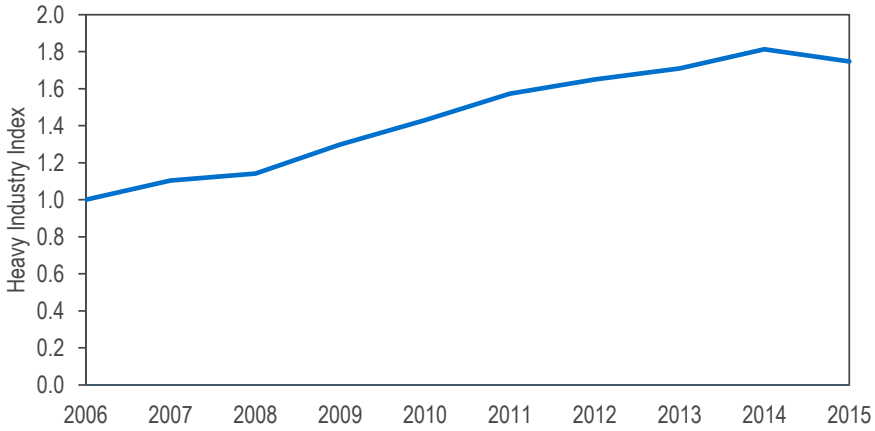
Figure 1.2 World Leading Economies



China's growth in GDP has been due to massive national industrialization and development resulting in incredible manufacturing and exporting strengths. China has surpassed Germany as the world's largest exporter, in revenue terms. As economies grow, they also undergo internal transformation. Although heavy industry is a primary growth sector, other sectors such as agriculture and services can also have a significant contribution. Nexant's heavy industry index for China, which is built up of major industrial

indicators, shows a slowing down in 2015 and indicates a growth in the proportion of the GDP being derived from service based industries. This can be seen in Figure 1.3.

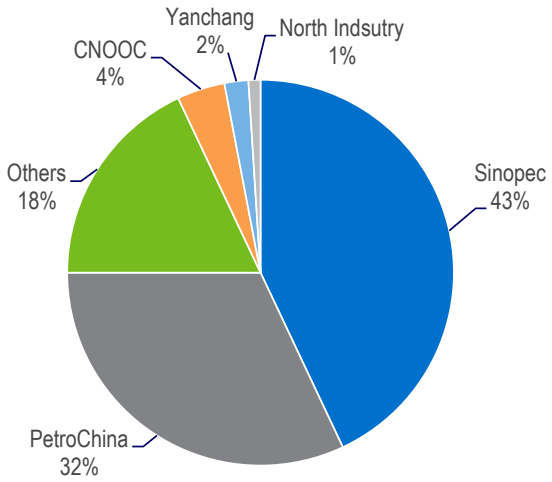
Figure 1.3 Heavy Industry Index
(2006 = 1)



Due to the scale of the Chinese economy, this small impact can have wide ranging consequences both within China and internationally. One effect is the impact on domestic fuel consumption. China's passenger vehicle fleet is strongly reliant on gasoline for its fuel supply, whereas the commercial vehicle fleet is dependent almost entirely upon diesel. As a knock-on effect of the decreasing heavy industry, the domestic demand for diesel has decreased.

The supply side of China's fuels balance is a domestic refining capacity of approximately 420 million tons per year, dominated by the national companies of PetroChina and Sinopec, who own approximately 75 percent of the total capacity.

Figure 1.4 Refining Capacity Ownership China
(420 million tons per year)



Of the remaining 25 percent, a significant proportion is owned by smaller independent refiners, sometimes referred to as 'teapot' refineries, due to their comparatively lower distillation capacity. Historically, these refiners have experienced problems trying to remain competitive; one of the main challenges has been

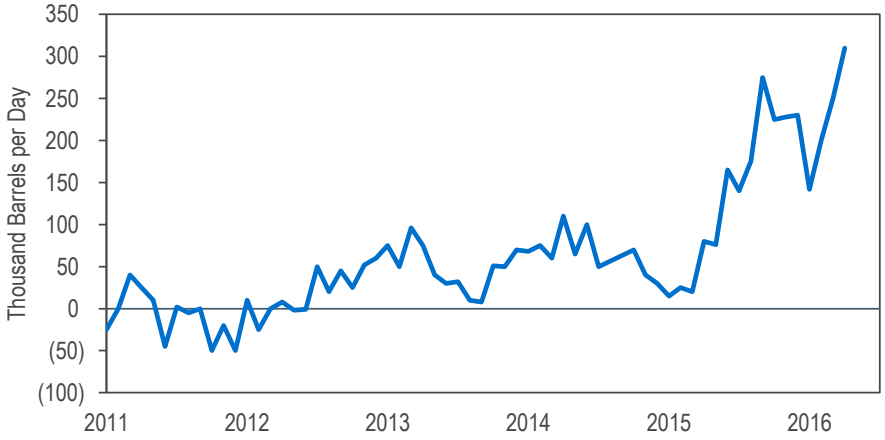
access to feedstock. Licenses for crude oil imports in China are state controlled and until recently have only been granted to major refineries and select teapot refineries. This has meant that most 'teapot' refineries have been forced to run blends of fuel oil as a feedstock, subsequently limiting operating margins.

In 2015, the Chinese state oil authority increased the crude oil import quota for independent refineries to 50 Million tons per annum. The quota has been welcomed by these refiners with an appreciable increase in demand for imported crude oil. Operating rates of teapots have correspondingly increased to the highest levels seen by this sector.

Although the Chinese economy is still growing at a rate of approximately 6 percent per annum, the demand for fuels is changing. The changing economic fundamentals from lower growth in heavy industry are contrasted by an increase in the contribution from services based sectors. This alters the market dynamics, with demand for gasoline and jet growing faster than demand for diesel.

The competitive ambition of the 'teapot' refiners with greater access to feedstock results in an increase of diesel supply to the market at a time when demand is decreasing. This additional supply has found an alternative to the domestic market. China's former balanced net trade position for diesel has now developed into a significant export position. As shown in Figure 1.5, China exported approximately 300,000 BPSD of diesel within the space of just one year.

Figure 1.5 Chinese Monthly Diesel Exports

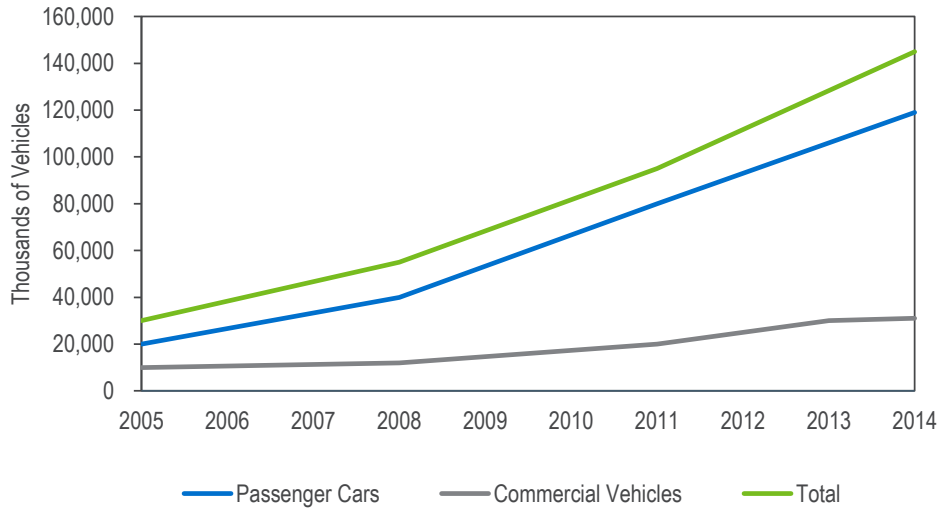


The changes mentioned above raise some interesting points for analysis:

- Will China's exports of diesel continue to increase? Is it possible to predict how the Chinese refining industry will develop?
- Where is the diesel being exported? How sustainable is this distillate production?
- Just how competitive are the teapot refineries? Will higher crude oil prices remove any competitive edge that they have?
- Are there any themes to the refining configurations of the teapot refineries? Are they particularly distillate selective?
- How do the teapot refineries compare with other refineries? How does ownership influence competitiveness?
- How much of an impact does petrochemical integration have in China? To what extent are refineries integrated with petrochemicals?
- How do refining margins for Chinese refiners compare with regional benchmarks and leaders?

Although domestic demand for diesel may be reducing, transportation and vehicle ownership in China is certainly not. Mirroring the increase in GDP, growth in car ownership has been dramatic. In 2005, the number of passenger vehicles and commercial vehicles were comparable. Both indicated a low overall level of motorization or vehicle ownership per capita. In the last 10 years, the number of commercial vehicles has increased only gradually, whilst passenger vehicles have grown dramatically to almost 5 times the number of commercial vehicles. The Chinese car market is currently the largest in the world; it became the largest in 2009, and has remained the largest ever since. In 2015, automakers sold 21.1 million passenger cars. The year on year growth from 2014 of 1.1 million was almost as big as the entire Australian car market.

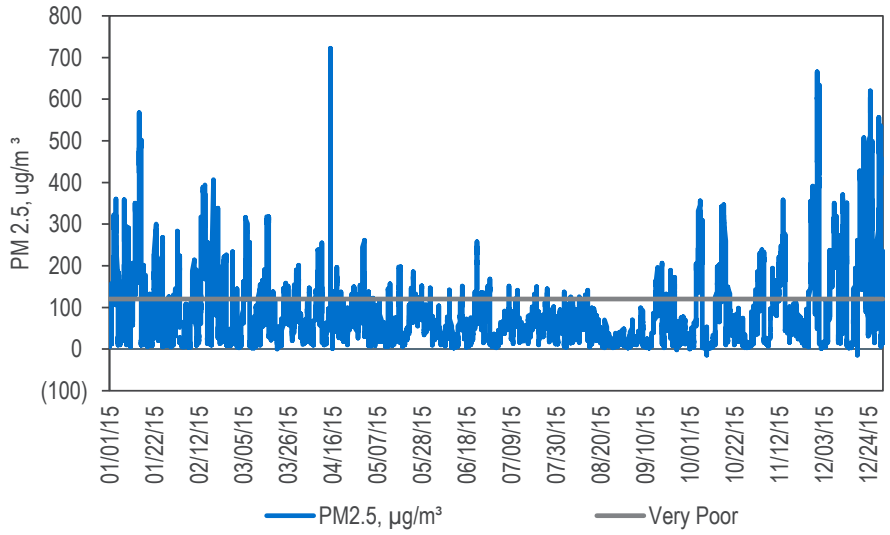
Figure 1.6 Motor Vehicles in China



The increase in GDP per capita has allowed many Chinese to purchase vehicles. Although this trend has been a very positive result for vehicle growth and motorization, it has contributed negatively and significantly to pollution levels, due to the very populous nature of large cities in China. As a result, air quality has decreased to dangerous levels.

Monitoring the PM 2.5 particulate has become a key metric to assess and alert reporting of air quality in cities. In Beijing, one of the most populous cities in the world, vehicle use is high and subsequently emissions and particulate levels are very high. This is detailed in Figure 1.7. Frequently, the air quality in Beijing rises to dangerous levels, forcing authorities to curtail vehicle use.

Figure 1.7 Beijing Particulate Pollution
(PM 2.5, 2015)



Chinese authorities have taken actions to reduce the sometimes crippling levels of pollution by introducing a number of measures. New car licenses are limited in China; obtaining a new license apparently requires selection which is based on a queuing system. Vehicle use can also be controlled. On days where air quality drops low, cars with even number plates and odd number plates are only allowed to be driven on alternate days. Incentives have also been given to domestically produced electric vehicles (EVs), which have seen rapid growth and acceptance. As these electric vehicles do not have any direct emissions, they are not subject to the same queuing system for new vehicle ownership.

China's economy will continue to grow. Vehicle use will increase towards higher levels of motorization. The path forward is however unclear, with some interesting questions being raised:

- How will car ownership develop in the next 10 years in China? What are the expected limitations?
- How much will public transportation be expected to develop?
- What is the subsequent impact on diesel and gasoline demand?
- What types of legislation is there surrounding EV's in China?
- What is the current status of EV's in China? How is this expected to evolve?
- What type of activity is seen with autonomous vehicles (AVs)? How easily could this take off? Could China adapt and develop its own AVs?
- Is there a maximum to the number of combustion engine vehicles in certain cities with respect to air quality?
- Could fuel quality be increased to make air cleaner?

Section 2 Report Scope

2.1 OBJECTIVE

The study will provide a specific and objective analysis of the key elements of change expected in the refining and fuels arena in China. It will aim to assess the pressure facing both refining and fuels as well as what the shape of the future may be. The analysis will provide subscribers with insightful analysis to the changing nature of the refining industry in China and its regional and global impact.

2.2 SCOPE

This report will analyze:

- What are the specifics of the Chinese refining industry
  - National initiatives
  - Impacts of policy
- What does Chinese refined product demand look like on a regional and global scale?
- What are the key drivers for demand growth?
- How does the GDP slowdown affect refined products?
- What is the current status of the sector (i.e., current refining sector and planned firm projects)
- What policies exist to support future growth? Where will new projects emerge and what policies will support them? How have these affected the 'teapot' refiners?
- What factors govern current demand patterns
  - National power requirements
  - Country demographics
    - Energy demand per capita
  - Fuel specifications
  - Vehicle fleet analysis
- What factors will influence investment models
  - State versus 'teapot'
    - Crude availability and type
    - Current and future trade flows
    - Impact of domestic demand
  - Investment strategy per country
  - Capacity versus Complexity – Where is the optimum?
  - What is the current and future extent of petrochemical integration
    - Why?
- Where are the most competitive Chinese refineries?
  - How much of a role does geography play?
  - How do they compare in terms of size and complexity?
  - How do refining margins in China compare? How competitive are Chinese refiners?

- What does the future hold for Chinese refineries?
  - What are the future target markets? How much of a role will 'teapots' play
  - Future specification changes
  - What is the impact upon other refining centers such as India and the Middle East?

2.3 STUDY COMPLETION DATE

The study has a targeted completion date of end Q4 2016.

3.1 EXECUTIVE SUMMARY

3.2 CRUDE OIL DYNAMICS

The report will contain an analysis of crude oil supply demand and net trade for China with consideration of the following:

- Commercial characteristics and how they have developed
- Indigenous crude production
- Increases in demand
- Imports and origins

3.3 DEMAND

The report will analyze refined product demand within China and the specific features giving rise to the demand drivers. This will be done by consideration of demand for refined products for:

- Transportation Fuels
- Other Fuel
- Petrochemical Feedstock

3.3.1 Transportation Fuel Demand

This section of the report will:

- Assess the impact of pollution/congestion on legislation and alternative transportation.
- Analyze the current vehicle fleet size and composition in terms of passenger and commercial vehicles
- Examine the impact of electric vehicles (EV's) and their current status
  - Factors contributing to growth, local technology, incentives
  - Barriers to further implementation, challenges
- Assess potential impacts on domestic demand.
- Forecast future trend, vehicle growth expectations/projections.
- Examine use of other fuel sources, (e.g., CNG)
- Detail autonomous vehicle (AV) current status and legislation.
  - Consider the main factors influencing the likelihood of further development

3.3.2 Fuel Demand

This section of the report will analyze other fuel requirements for refined products. The following categories will be considered:

- Fuel for power generation:
  - Current sources for fuel used for power generation
  - Future power requirements and likely fuel sources
  - Impacts on demand for refined products

- Cooking/Heating:
  - Major fuel sources for cooking (LPG, Kerosene, Other)
  - Factors affecting change
  - Impacts of development on demand

3.3.3 Petrochemical Feedstock Demand

This section of the report will examine the domestic demand of petrochemical feedstocks. China relies heavily on liquid based feedstocks. This section will include the following elements:

- Analysis of projects
  - Domestically sourced feedstocks versus imported feedstocks.
  - Examination of domestic petrochemical feedstock (Ethane, Propane, Butane, Naphtha).
- Future feedstock requirements
- Issues relating to feedstock supply

3.3.4 Demand of Refined Products

This section will summarize the overall demand for refined products built up from the main end use categories. A domestic demand forecast will be provided for:

- LPG
- Naphtha
- Gasoline
- Kerosene
- Diesel
- Fuel Oil
- Petroleum Coke

Historical data will be supplied for 2010 to 2015 with forecast for 2015 to 2030

3.4 SUPPLY

3.4.1 Analysis of Chinese Refining Capacity

This section will examine and analyze the pertinent factors relating to domestic supply of refined products in China by consideration of the following:

- An examination of the total capacity and profiling of each refining asset including:
  - Geographic Location
  - Capacity
  - Configuration
  - Strategic objectives
  - Ownership (NOC, 'Teapots')
- Future supply
  - An examination of the issues surrounding addition of new refining capacity, pace of additions, private versus state, project execution
  - Number of new refineries which will be required for domestic demand

- Analysis of crude intake and types of crude being use, import crude requirements, access to feedstock
- Analysis of refinery configurations and factors influencing configuration selection
- Refinery ownership – analysis of the extent of private versus state ownership. Influence of business philosophy, export versus domestic product use, and link to competitiveness.

3.4.2 Supply

This section will summarize supply by providing historical data will be supplied for 2010 – 2015 with forecast for 2015 to 2030 for the following products:

- LPG
- Naphtha
- Gasoline
- Kerosene
- Diesel
- Fuel Oil
- Petroleum Coke

3.5 NET TRADE

This section will analyze the effect of supply and demand on the import and export requirements and the subsequent net trade position of China for each of the following refined products:

- LPG
- Naphtha
- Gasoline
- Kerosene
- Diesel
- Historical data will be supplied for 2005 to 2015 with forecast from 2015 to 2030
- Analysis and discussion of the key consolidated findings from section 3.2 and 3.3 and their impact on the net trade position

3.6 COMPETITIVENESS

This section will compare and contrast each refining asset within China with respect to its competitiveness. This will include the following:

- Analysis of size and complexity of each refinery and comparison in a matrix
- Comparison with other Asian and global leaders, (e.g., Middle East)
- Comparative profitability analysis – consideration of the net refining margin of each asset
- Analysis of competitive advantages
- Analysis of issues relating to cost structure compared to other global leading refining centers

3.7 PETROCHEMICAL INTEGRATION

China depends on refined products such as LPG and naphtha for use as feedstocks in petrochemicals. This section will analyze the following:

- The extent of refinery/petrochemical integration within China with respect to the production of
  - Ethylene
  - Propylene
  - Aromatics (*para*-xylene and benzene)
- The impact on profitability
- Compare regional benchmarks for integration. Analysis of the factors contributing to current level of integration
- Project future of petrochemical integration based on demand for petrochemicals and domestic and import feedstock challenges

3.8 FUTURE OUTLOOK

This section of the report will analyze and summarize the future impact of the changing Chinese economy on the following:

- Changes in demand patterns
- Changes in supply and refining capacity
- Net trade changes and their regional and global impact
- The role of technology and changing fuel use in China
- The impact of air quality control on the use of fuels in China

4.1.1 Product Supply and Demand

Nexant employs an integrated methodology for supply and demand forecasting which gives a world-wide view of projections for refined product demand based on oil's share of the overall market. The overall methodology is summarized in Figure 4.1.

Figure 4.1 Forecasting Approach and Methodology

Demand

Projections of future demand for refined products are developed in relation to a number of general and specific factors. The key demand drivers for each product are summarized in Table 4.1.

Table 4.1 Key Drivers for Refined Product Growth

LPG	Rate of penetration of electricity and natural gas into domestic market
	Population growth
	Substitution for gasoline and diesel automotive fuels
	Industrial use linked to GDP growth
Naphtha	Petrochemical expansions and new projects
	Growth in existing applications
	New power generation schemes
Gasoline	Vehicle population and consumption per vehicle
Jet	Growth in air transport and turbine efficiency improvements
Diesel	Vehicle population and use
	Rail transport growth
	Agricultural growth
Fuel Oil	Power generation projects
	Industrial growth linked to GDP

Supply

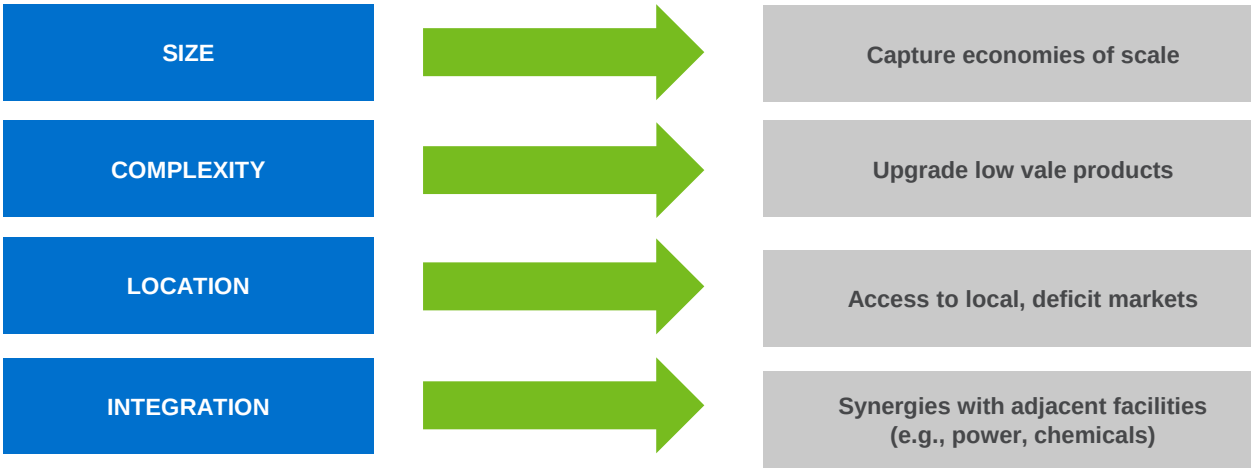
Existing refining capacity (and utilization), together with announced addition, provides the basis for Nexant's forecast of refined product supply. Capacity additions, through 2017, are to be based on announced firm projects. For the period from 2018 onwards, supply projections assume a combination of investment plans currently being discussed and developed, together with speculative additions in regions where capacity is likely to become tight, and where refinery development is likely to be both politically acceptable and commercially attractive. Nexant maintains a comprehensive listing of announced projects, and applies judgment with regards to each project, and develops a "risk-adjusted" outlook for new capacity additions.

4.2 COMPETITIVENESS

4.2.1 Introduction

Nexant utilizes a robust approach to evaluating the relative competitive position of global refinery assets, utilizing four key criteria that it establishes to facilitate a comparison of very different assets, on a common basis. These are summarized in Figure 4.2.

Figure 4.2 Refinery Competitiveness
(Key Evaluation Criteria)



4.2.2 Complexity

There are various measures utilized to assess the complexity of a refinery, the simplest of which is to group refineries based on their degree of upgrading, for example:

- **Simple** or Hydroskimming (no upgrading)
- **Thermal** (including a thermal cracker or a visbreaker)
- **Complex** (including a process to upgrade vacuum gas oil – *FCC or Hydrocracking*)
- **Residue Upgrading** (including residue destruction via *residue processing or coking*)

An often cited measure of complexity is the Nelson Complexity Index. However, under this index the primary driver of complexity is a reference capital cost of the individual processing units utilized. In some ways, this is overly simplistic because the relative upgrading capability of individual processing units is not directly linked to its investment cost. Directionally this index provides an indicator of complexity.

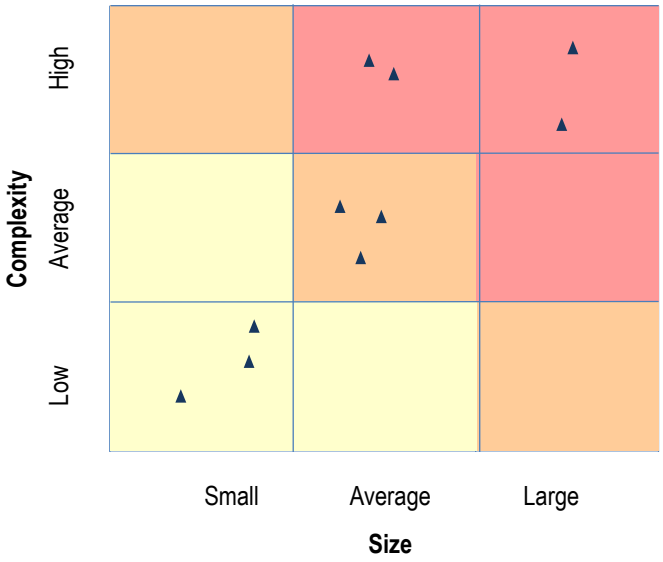
Nexant uses a Complexity Index based on an FCC-equivalence. Nexant also keeps an extensive database of Nelson Complexity for all refineries on a global basis.

The FCC Equivalence Complexity Index assigns an upgrading index to each process unit that takes a residue (fuel oil) feed and assesses its capability to convert the residue to more valuable lighter products. The scoring reflects two primary factors:

- The heaviness of the residue feed
- The degree of conversion to lighter products

4.2.3 Size and Complexity

Nexant utilizes a standard 3x3 matrix to compare size and complexity of different refineries.



4.2.4 Location and Integration

4.2.4.1 Location

The influence of location is of high importance and can have a greater influence on pricing and margin performance than either of Size or Complexity. The important consideration is the impact of location on pricing; this normally falls between two extreme cases:

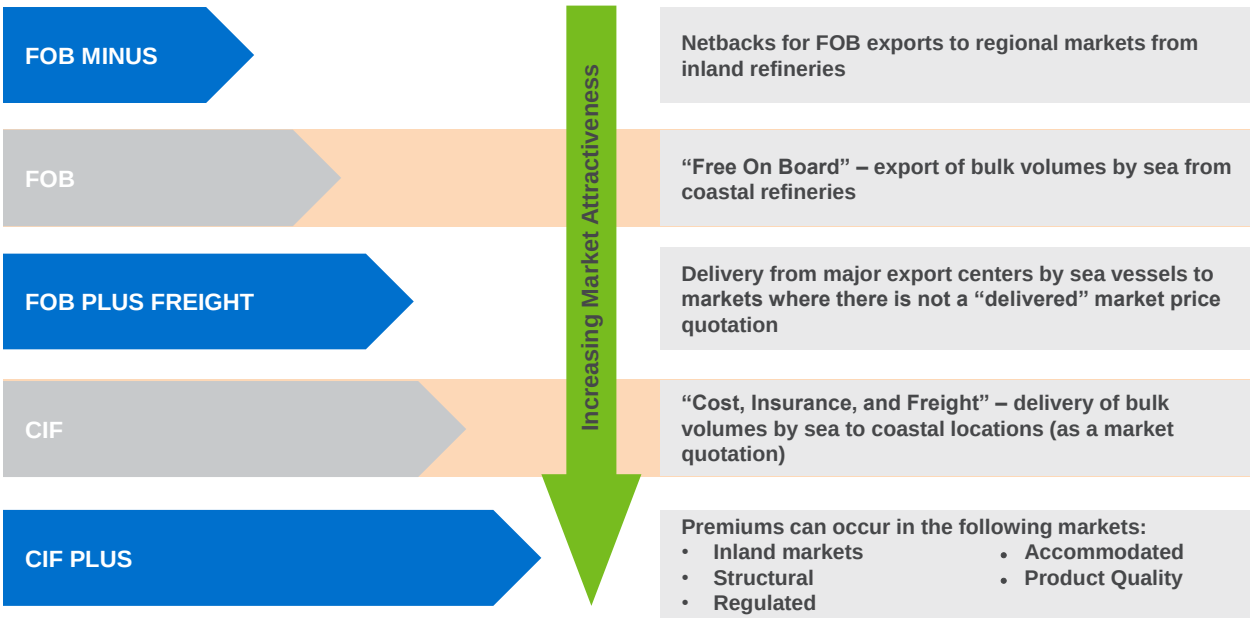
- Export parity pricing, where product is moving out of a region, which is less economically attractive.
- Import parity pricing, reflective a deficit region; this is desirable, especially where it is supported by an additional inland premium.

Another important implication of location is cost. This will govern two very important factors,

- the capital costs (which will be heavily location dependent)
- the operating costs (largely the price of fuel and labor)

The location driven price drivers are summarized in Figure 4.3, as they relate to product sales.

Figure 4.3 Location Impact on Pricing



A similar comparison is made for feedstocks, showing the positioning between export parity (favorable for a local consumer) and import parity (less favorable).

The evaluation criteria for Integration include the impact of co-location of refining with power generation or petrochemicals.

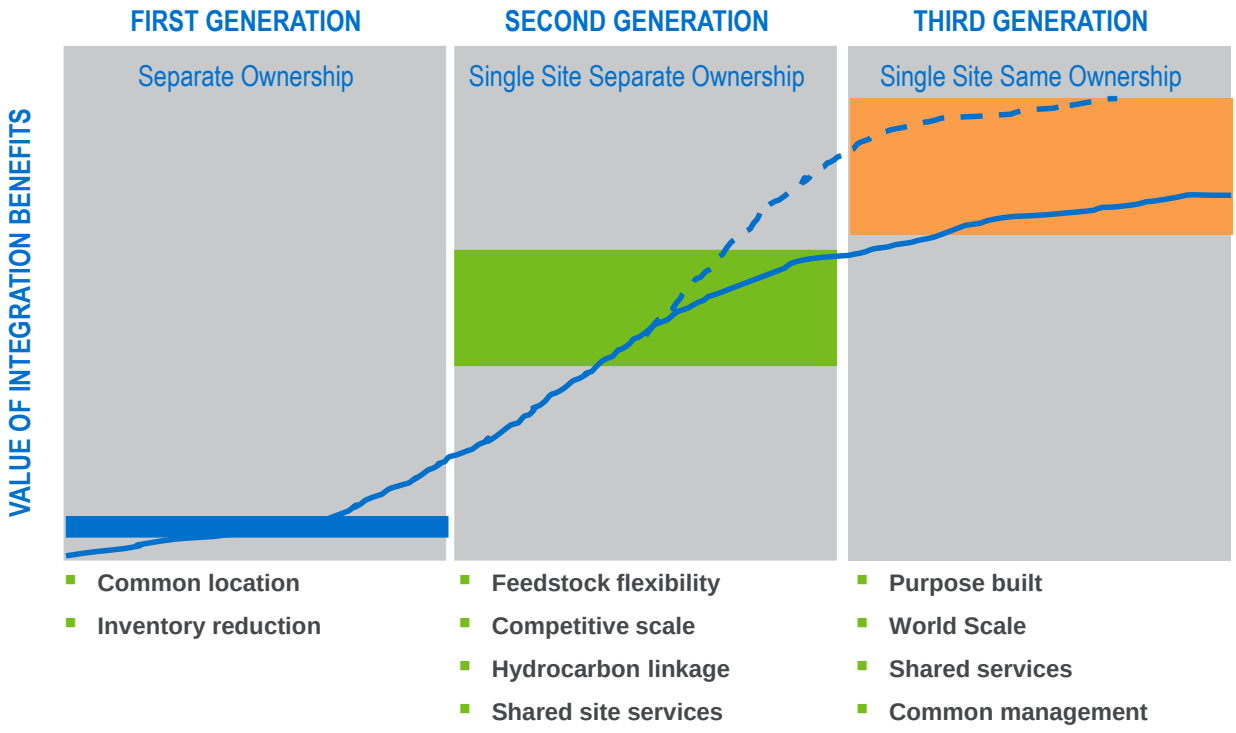
4.2.4.2 Integration

Petrochemical integration can be very specific. Many factors contribute the nature and extent of the integration. These include some of the following:

- Purpose built asset versus added integration
- Ownership type
- Type of integration, ethylene, propylene, aromatics etc.
- Commercial arrangements

These are summarized in Figure 4.4.

Figure 4.4 Degrees of Refinery Petrochemical Integration



5.1 NEXANT ENERGY AND CHEMICALS ADVISORY

For over 40 years, Nexant's consulting professionals have helped clients by providing strategic advisory, technical and operations consulting services, and most importantly, privileged insights. The company has completed thousands of client assignments in more than 100 countries. Our clientele ranges from major oil and chemical companies, governments, and financial institutions to regulator and development agencies and law firms.

We are unique in our comprehensive focus on the entire energy, oil, gas and chemical sector. Staffed by over 150 seasoned industry experts, we understand the challenges facing senior management in the industries we serve. Our global consulting team brings together our collective technical, commercial and financial skills, who work closely and confidentially with our clients to address real world issues and identify opportunities that add value to their businesses. Our staff includes engineers, chemists, bio chemists, MBA's and seasoned business leaders from the sectors we serve.

Nexant provides a range of targeted consulting services from the initial assessment of corporate and business unit strategies to the development of actionable strategies, to advisory support in project finance and due diligence for mergers and acquisitions – all backed by deep knowledge of downstream oil & gas, petrochemicals, plastics, specialty chemicals and Clean Tech markets and products.

Significantly, Nexant has proprietary technology and commercial analysis, NexantThinking™ market data, which includes market dynamics and pricing forecasts, capacity developments and production cost economics.

Our purpose is to deliver subject matter expertise that gives a clearer perspective and to provide visionary thinking which allows our customers to be insightful and ahead of the competition

This can only be achieved through an unrivalled combination of:

- **Industry Knowledge** - our consultants all have extensive industry experience, and are engaged fulltime on identifying and addressing the challenges facing the Alternative Fuels, Petroleum/Gas and Chemical industry.
- **In-house Data** - we have an unrivalled database on the industry its technology and market dynamics, and employ teams of researchers to continually update this resource. Our NexantThinking™ products which can be accessed by subscribers, contains the core of this knowledge base covering the commodity chemicals and polymers plus a range of intermediates and specialties.
- **Proven and Tested Methodologies** - we have developed a range of methodologies to cover different types of assignments, such as feasibility studies, project finance support, privatizations, due diligence studies for acquisitions and financings, market and technology reviews. All of these have been tailored and continuously improved to suit the needs of the industry.
- **Technical Competence** - we continuously track the technical improvements in the industry and frequently review new process improvements for clients. Our NexantThinking™ Process Evaluation/Research Planning (PERP) product encapsulates some of this work and is available to subscribers. A core strength is our capability to provide independent support to the key issue of process technology selection.
- **Global Presence** - our permanent offices in London, Frankfurt, Bahrain, New York, Houston, Singapore, Bangkok, Kuala Lumpur and Shanghai will provide comprehensive coverage. In addition, we have long-term relationships with representatives or registered branch offices in most

major locations, including Beijing, Seoul and Tokyo. Nexant professionals have extensive experience in emerging markets such as the former Soviet Union and China, and our team of industry experts can work fluently in over ten languages.

- **Strategic Consulting** - we have been on the leading edge of many of the strategic initiatives in the industry, including major investments, acquisitions, consolidations, restructuring, and privatizations.
- **Thought Leadership** – We pride ourselves on identifying key issues at their formative stages and exploring options for the industry to capture any associated potential benefits.
- **Coverage** - across all relevant sectors. Our team can provide clients with a complete and holistic view of the sector and its place in the overall economy covering the entire hydrocarbon value chain.

We are recognized for our quality and industry thought leadership:

- Nexant is often quoted in the alternative fuels, petroleum/gas and chemical press on its views on markets and developments and team members are regularly called on to give expert papers at major conferences.
- Our team of experienced vice presidents is responsible for the quality of our work in their individual areas of expertise. They are expected to provide inputs to and supervise every assignment we undertake.

5.2 REFINING STUDIES

Nexant has undertaken an extensive range of projects for refinery and integrated refinery petrochemical complexes. The form of single client engagements undertaken includes technology evaluations, feasibility studies, technical and commercial due diligence, market studies, etc. Some relevant examples are detailed below:

Project	Scope	Nexant's Role				
		Market Study	Technical Review	Design Development	Environmental Assessment	Economic Evaluation
Grassroots Refinery, Nigeria	Pre-Feasibility study for major grassroots refinery	✓	✓			✓
Dalian Shide Group, China	Feasibility study for major grassroots refinery & petrochemical complex	✓	✓	✓		✓
Confidential, Syria	Feasibility Study for a Grass Roots Refinery	✓	✓	✓	✓	✓
Confidential, Sri Lanka	Feasibility Study for a Grass Roots Refinery	✓	✓			✓
ENAP, Chile	Refinery Master Plan Feasibility Study	✓	✓		✓	✓
BAPCO Refinery, Bahrain	Feasibility study for major upgrade project	✓	✓		✓	✓
Sohar Refinery, Oman	Feasibility study for major grassroots refinery	✓	✓	✓	✓	✓
Omsk Refinery, Russia	Feasibility study for major upgrade project	✓	✓	✓	✓	✓
Reliance Refinery, India	Feasibility study for major grassroots refinery	✓	✓		✓	✓
Hyundai Oilbank, S Korea	Feasibility study for major upgrade project	✓	✓			✓
Caribbean Refinery (Confidential)	Refinery upgrading feasibility study	✓	✓		✓	✓
Norsi Refinery, Russia	Feasibility study for major upgrade project	✓	✓	✓	✓	✓
TUPRAS Refinery, Turkey	Feasibility study for major upgrade project	✓	✓	✓	✓	✓
IRPC, Thailand	Feasibility study for major upgrading project	✓	✓			✓
Bluestar, China	Feasibility study for major upgrade project	✓	✓			✓
Tamoil Refinery, Switzerland	Feasibility study for major upgrade project	✓	✓	✓		✓
Confidential	Alkylate Market Study	✓				
Confidential	MTBE Market Study	✓				
Confidential	Residue Upgrading Project, FSU	✓	✓		✓	

Section 6 Contact Details and Subscription Information

6.1 CONTACT INFORMATION

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