Sanjeev Kapur is an independent consultant in the field of olefins based petrochemical businesses. He brings the value of strategic thinking, specific industry insights, knowledge and depth of experience for olefins based petrochemical businesses to develop, build and operate best-in-class facilities. Sanjeev has 35 years of industry experience and had been associated with Fluor, Shaw Stone & Webster (now part of Technip), ABB Lummus Global (now CB&I Lummus), and The Kinetics Technology International (now part of Technip). He has extensive experience working in the licensing and engineering / construction industry. Most of this work has been in ethylene/propylene-based petrochemical projects and integration of these with refineries, aromatic production, natural gas processing, polymers, derivatives and specialty chemical units. Sanjeev provides independent expert advice and impartial analysis to deliver value to the businesses to realize their full potential.

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Agenda

- Understanding the value chain
- Industry fundamentals
- Trends
- Success factors & challenges
Understanding the value chain

Approximately 12% of crude oil and natural gas ends up in petrochemicals, the *multiplier effect* makes it an important avenue for value creation.
Energy to Base Chemicals

- Coal
- Natural Gas
- Crude Oil

Energy and Feedstock

- Methane
- Ethane
- Propane
- Butane
- Condensates
- Off-gases
- LPG
- Naphtha
- Gasoil
- Reformate

Syn gas

Methanol Unit

- Methanol
- Ethylene
- Propylene

Olefins Plant

- C4’s (Butadiene, Butylene)
- Pygas (Benzene, Toluene, Xylene)
- Benzene, Toluene, Xylene

Aromatics Unit

- Methanol
- Ethylene
- Propylene

Base Chemicals
Ethylene Value Chain

- Polyethylene
  - HDPE
  - LDPE
  - LLDPE

- Ethylene Dichloride / Vinyl Chloride Monomer

- Ethylbenzene / Styrene

- Ethylene Oxide / Ethylene Glycol

- Alpha Olefins / Fatty Alcohols

- Pipes, Extruded Films, Sheet, Blow-molded, Injection-molded etc.

- PVC

- Polystyrene Copolymers

- Polyester PET Anti-Freeze

- Surfactants Synthetic Lubes

End Markets
- Automotive/transportation
- Consumer Products
- Packaging
- Building/Construction
- Textiles
- Medical
- Pharmaceuticals
- Electrical/Electronics
- Personal Care
- Industrial
- Agricultural
Global Ethylene Demand - 2014

- Total Demand: ~136 MM MTA
- Capacity Utilization: 88%
- Expected AAGR (2030): ~3.3%
Propylene Value Chain

- Polypropylene
- Acrylonitrile
- Cumene Phenol
- Propylene Oxide
- Oxo-Alcohols Acrylic Acid
- Acrylic Fibers
- Pipes, Films, filament, molding, tubing etc.
- BPA, MMA, Poly Carbonate, Resins
- Polyols Polyurethanes
- Solvents, Esters, Paints, Adhesives

End Markets
- Automotive/transportation
- Consumer Products
- Packaging
- Clothing/Textile
- Nylon
- Carpet
- Furniture
- Insulation
- Appliances
- Paints
- Adhesives
- Plasticizers
Global Propylene Demand - 2014

Total Demand: ~88 MM MTA
Capacity Utilization: 84%
Expected AAGR (2030): 4.5%
Typical Cost of Production - Chemicals

Cash Costs

Fixed

Utilities

Feed
EIA Outlook – Crude and NG Prices

Figure ES1. North Sea Brent crude oil spot prices in four cases, 2005-40 (2013 dollars per barrel)

Source: www.eia.gov

Figure ES2. Average Henry Hub spot prices for natural gas in four cases, 2005-40 (2013 dollars per million Btu)
Shale Driven Growth – Petrochemical Industry

**Natural Gas**

- **Ethane**
  - Polyethylene
  - EO/EG
- **Propylene**
  - Polypropylene
  - PO

**Propane**

- **Ethylene**

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Shale related investments in US chemical industry

Driven by Base Chemicals: Ethylene, Propylene (PDH), Methanol

NEW MANUFACTURING PROJECTS ARE GROWING OUR ECONOMY & CREATING JOBS

- $153 billion in new capital investment
- 465 thousand direct & indirect jobs by 2023
- $322 billion in new economic output
- $23 billion in new tax revenue by 2023

COST OF PRODUCTION

ME Ethane Crackers: $50 – 200/MT

NA Ethane Crackers: $100 – 350/MT

World Naphtha Crackers: $900-1300/MT

World Naphtha Crackers: $400-800/MT

Source: based on publically available data/costs
World Ethylene Capacity

Capacity expected to grow at ~3.3% AAGR for next 15 years. An additional 100 million MTA ethylene may be needed by 2030.

Source: based on publically available data
Based on announced additions, US will add more than 50% capacity over 5 years

Source: GHS, Apex PetroConsultants, industry news sources
World Propylene Demand

Source: based on publically available data
PDH (Propane Dehydrogenation) Capacity Additions

Based on announced capacity additions in North America and Asia

Source: GHS, Apex PetroConsultants

Based on announced capacity additions in North America and Asia.
Petrochemical Industry – Top Trends

• Shale driven growth
• Alternate feedstock - Coal to a large extent, potentially bio/renewables
• Middle East feed diversification, breadth of product coverage
• Demand growth – led by China, India, Brazil, Turkey, Mexico etc.; growing middle class and urbanization; growth of construction sectors/ automobile and packaging industry
• Energy market dynamics – crude oil prices relative to natural gas and coal
• Technology & Innovation - On-purpose technologies for C3s, C4s and aromatics; material advances (lightweight, nanomaterials, functional textiles etc.)
• Environmental - Greenhouse gas emissions regulations, water management, recycling/waste treatment
Petrochemical Business Success Factors

- Access to feed, markets, and resources
- World scale, integrated, and competitive
- Global coverage
- Technology, product range coverage
World Scale Ethylene Plant Capacity Trend
Ethylene Cracker Complexes – Mega Projects

Planning is vital

• Mature technology, access to cheap feed-stock cost and the market is critical
• Robust business case development - master planning is crucial
• Integration is the key - hydrocarbon management, energy integration, synergies
• Successful delivery of mega capital projects
  • Capital efficiency, project costs, timely start-up and quick ramp-up to full capacity
• Economics of large scale projects are based on long-term outlook (20 to 30 years is typical) – feed security is important
• Regulatory uncertainty – permitting, taxation, trade barriers, environmental regulations
• Technical and skilled resources
• Access to financing, financing structure
Propane Dehydrogenation (PDH) Plants

• Technology is not as mature and as widely used as ethylene crackers
• Propylene is transitioning from by-product/co-product production to more on-purpose & will be subjected to cyclical nature of the industry
• On-purpose propylene capacity will more than double in next 5 years
• PDH plants, and other on-purpose technologies for propylene, will become swing producers and price setters
• Propane-propylene spread is the major driver of economics (propane price is subjected to seasonal variations)
• Propylene margins diverge on regional basis
  • North America: positive PDH economics due to excess propane supplies
  • Overcapacity in Asian plants
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