Refining & Petrochemicals Integration

Business Drivers & Enabling Technologies

• Refining & petrochemicals markets
• Investment strategies
• Enabling technologies
• Concluding remarks
**Refining Situation**

- Refining utilisation significantly higher in 2004 - 06
- Margins currently above re-investment “threshold”

*Refining investments potentially attractive*
Refining Investment Imperative

- ~ 1.5 Mb / d incremental refined fuels annually
  - ~ 45% in M. East + China
  - Clean transport fuel growth
- Refining investments essential
  - Capacity
  - Conversion
  - Upgrading

Global Demand Growth

Source: IEA, July, 2006

$30 – 40 billion per year

Substantial investments essential
Investment Remuneration

• Escalating fabrication and construction costs affecting investment returns

New 200 kb/d Cracking refinery

$4bn investment

10% Internal Rate of Return

~ $6+/bbl average margin for 20+ years required

Investment Risk Remains Challenging
Risk Mitigation

• Feedstock and product flexibility
  - “Opportunity” feedstocks
  - Optimal upgrading & conversion
  - Maximize value addition
  - Prosper from cyclical markets

• Operational efficiency
  - Economies of scale
  - Energy
  - Control & optimization

Leading-Edge Technology
Advantages Of Integration

- Integrated refinery and petrochemical operations minimize costs and optimize product distribution
- Optimized integration of hydrocarbon processes, energy, hydrogen, and water
- Feedstock flexibility to capitalize on available low cost crude oils and intermediates
- Supply chain optimization provides faster delivery of products
Petrochemicals Can Add Significant Value
Aromatics Markets

Demand Increase over 1999 - MM MT

- Other BZ
- BZ to Cyclohexane
- BZ to Phenolics
- BZ to Styrenics
- p-Xylene

Sources: CMAI & UOP

Annual Growth
- 6.8%
- 3.6%

Strong Aromatics & Derivatives Growth
p-Xylene Capacity & Demand
(Committed Projects Only)

- Refineries are main source of xylenes supply
- Future p-X demand growth expected to average 1.8M MTA/Yr

3 To 4 World Scale p-X Complexes Annually

Sources: PCI & UOP
Propylene Market

MT Propylene / MT Ethylene

Supply from steam crackers

Demand increasing faster than supply from conventional sources

Growing Demand For “On-Purpose” Propylene

Source: CMAI 2005
BTX & Olefins: Integration Potential

• Strong growth potential
• Attractive value addition
• Assured feedstock supply
  - Potential for low cost & “distressed” refinery intermediates
• High value return streams to refinery, e.g., hydrogen, high octane gasoline

Potential To Raise Returns & Mitigate Risk
Integration Strategies

Crude Oil → Naphtha

Reformate → BTX

Kerosene → Detergents

FCC Intermediates
- LPG
- Cracked Naphtha
- Light Cycle Oil

Residues → Chemicals

Light Olefins → Hydrogen

Power

Technology Provides Link
Integration Strategies

Crude Oil

Refinery

Naphtha
Reformate
Kerosene
FCC Intermediates
  • LPG
  • Cracked Naphtha
  • Light Cycle Oil
Residues

Light Olefins

BTX

Detergents
Chemicals
Hydrogen
Power

Technology Provides Link
Refinery – Light Olefins Integration

Olefin Cracking: Developed by Total Petrochemicals & UOP
Doubles Propylene Production & Reduces C₄/C₅ Olefins

AGO / VGO → FCC

FCC → Gasoline → Propylene Recovery → C₃= 

AGO / VGO → Fuel oil

LPG → Olefin Cracking

Olefin Cracking: C₃= → Lt. Olefin Recovery: C₂= → C₃=

AGO / VGO → Gasoline → FCC

AGO / VGO → Fuel oil
Olefin Cracking Enhances Gas To Olefins

- 20% increase in light olefin yields
- Nearly 80% reduction in C_4+ by-products
- 2:1 propylene/ethylene production ratio
PetroFCC™ Process: BTX + Olefins

Traditional FCC

PetroFCC Process

Light Olefins

The "Petrochemicals Refinery" Enabler
Aromatics Processing

- Proven performance track record
- State of the art technology – continuous innovation
- Cost effective designs; high on-stream efficiency

90% of p-X capacity since 1970 uses Parex process
BTX Innovation: LCO-X™ Process

- FCC light cycle oil (LCO)
  - Distillate range intermediate product
  - High sulfur, high density, highly aromatic
  - Difficult to blend to clean transport fuel

- High content of multi-ring aromatics
  - Unlock benzene and xylenes

- LCO-X process for converting LCO to BTX recently announced

Low value as fuel blendstock

Low cost, high value BTX feedstock

$0.75/Bbl crude increase in operating margin
A Future Scenario

- **Crude Oil** → **Refining**
  - **Resid** → **Separation** → **Gasification** → **Refining** → **Syn Gas Production** → **Hydrogen** → **Electricity**
  - **Natural Gas** → **Reforming** → **Syn Gas Production**

- **Transportation Fuels**:
  - **Gas Conversion**:
    - **Chemicals**:
      - **Power**:
        - **Electricity** → **O₂, N₂, CO₂, S, sulfuric acid** → **Naphtha** → **Diesel** → **Jet fuel** → **Wax**
      - **Hydrogen** → **Carbon monoxide** → **Fertilizer** → **SNG** → **Olefins** → **Methanol/Ethanol** → **Acetic acid**

Innovation, Research, Development

- UOP Awarded National Medal of Technology in 2005
  “…over 85 years of sustained technical leadership and innovation for the worldwide petroleum refining and petrochemical industries……benefited quality of life throughout the world.”

Ref: National Medal of Technology Award to UOP, 2005

- Broaden the knowledge base
- Leverage academic and industrial experts
- Keys to success:
  - Collaboration / alliances
  - Commercialize

Technology Imperative – A Key Enabler
Summary

• Strong growth of refining and petrochemicals markets, healthy margins
  - Investment in additional capacity essential

• Integrating petrochemicals with refining can mitigate investment risk

• Continuing technology innovation key enabler for successful integration
Thank You