



# Strategies for Propylene and Derivatives Value Creation In Market

7<sup>th</sup> MENA Olefins and Polyolefins

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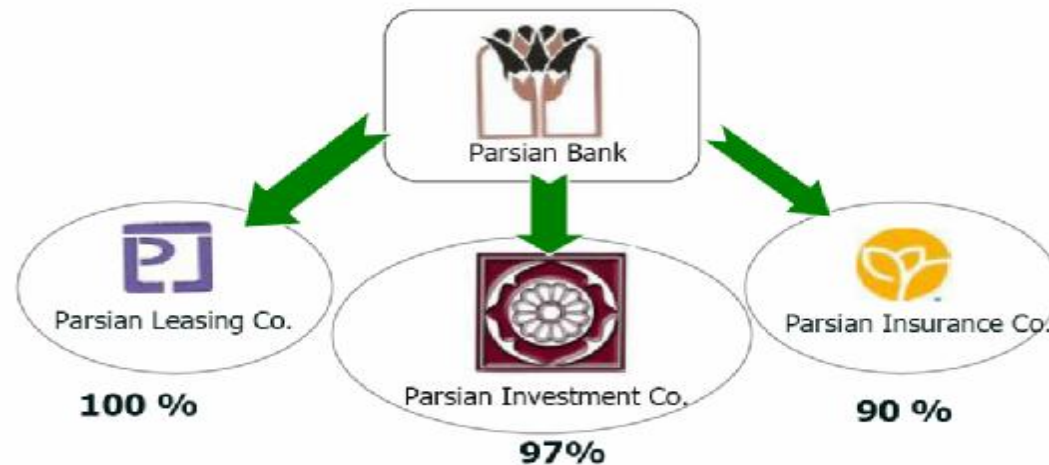
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# BRIFE



- § **Mehr Petro Kimia Co. : one of the biggest holding & investment company in energy, oil, gas and petrochemical industries in Iran.**
- § The company is 100% subsidiary of Parsian investment Co. which itself is a subsidiary of Parsian Bank –the biggest private bank in Iran



# Parsian Investment subsidiaries



## Parsian Investment Co.

100% of each subsidiaries



Mehr Petrokimia

Oil, Gas,  
Petrochemicals  
Industry



Opal Kani Pars

Metal &  
Non-metal  
Minerals



Parsian Construction Co.

Civil &  
Building  
Industry



Parsian Lotus Hotels

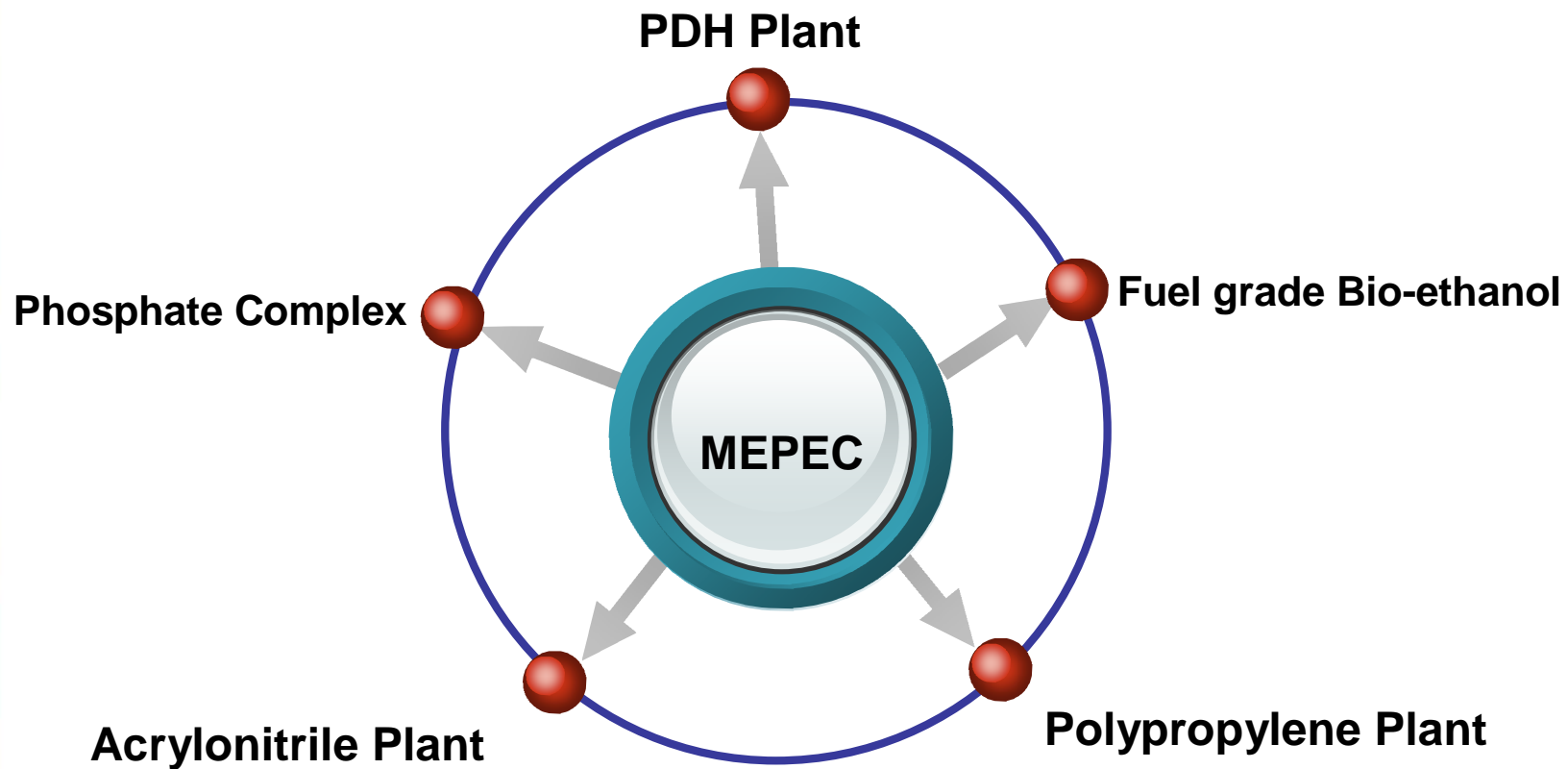
Tourism  
& Hotels



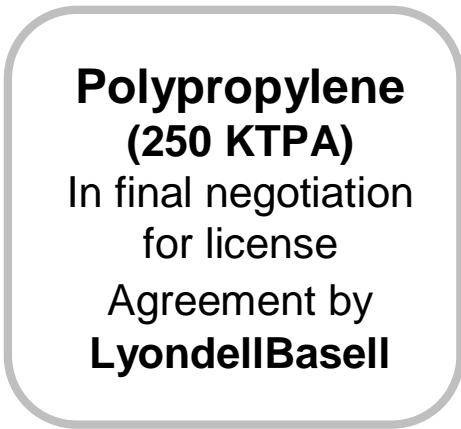
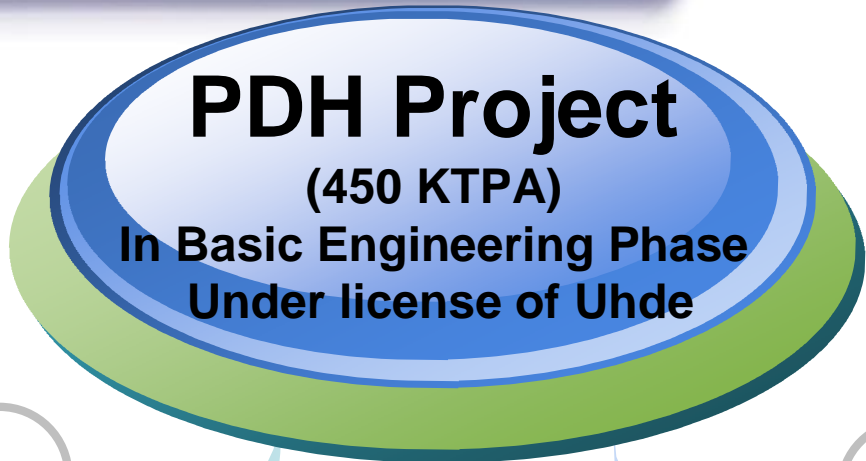
Raah Abrisham

Transportation  
Industry

# MEPEC Projects



# MEPEC Propylene downstream chain



# 1) Propylene



§ **Propylene is produced in three grades:**

§ polymer (64%)

§ Chemical (26%)

§ refinery (10%)

**97% of polymer-grade propylene is consumed in polypropylene production**

# Propylene Grades & applications



1

## **POLYMER GRADE** (purity: min 99.5%)

Polypropylene 97%  
EPDM Rubber 3 %

2

## **CHEMICALGRADE** (purity: 92-96%)

Acrylonitrile	32%
Propylene Oxide	28%
2-Ethyl Hexanol	12%
Acrylic Acid	15%
Others	13%

3

## **REFINERY GRADE** (purity <92%)

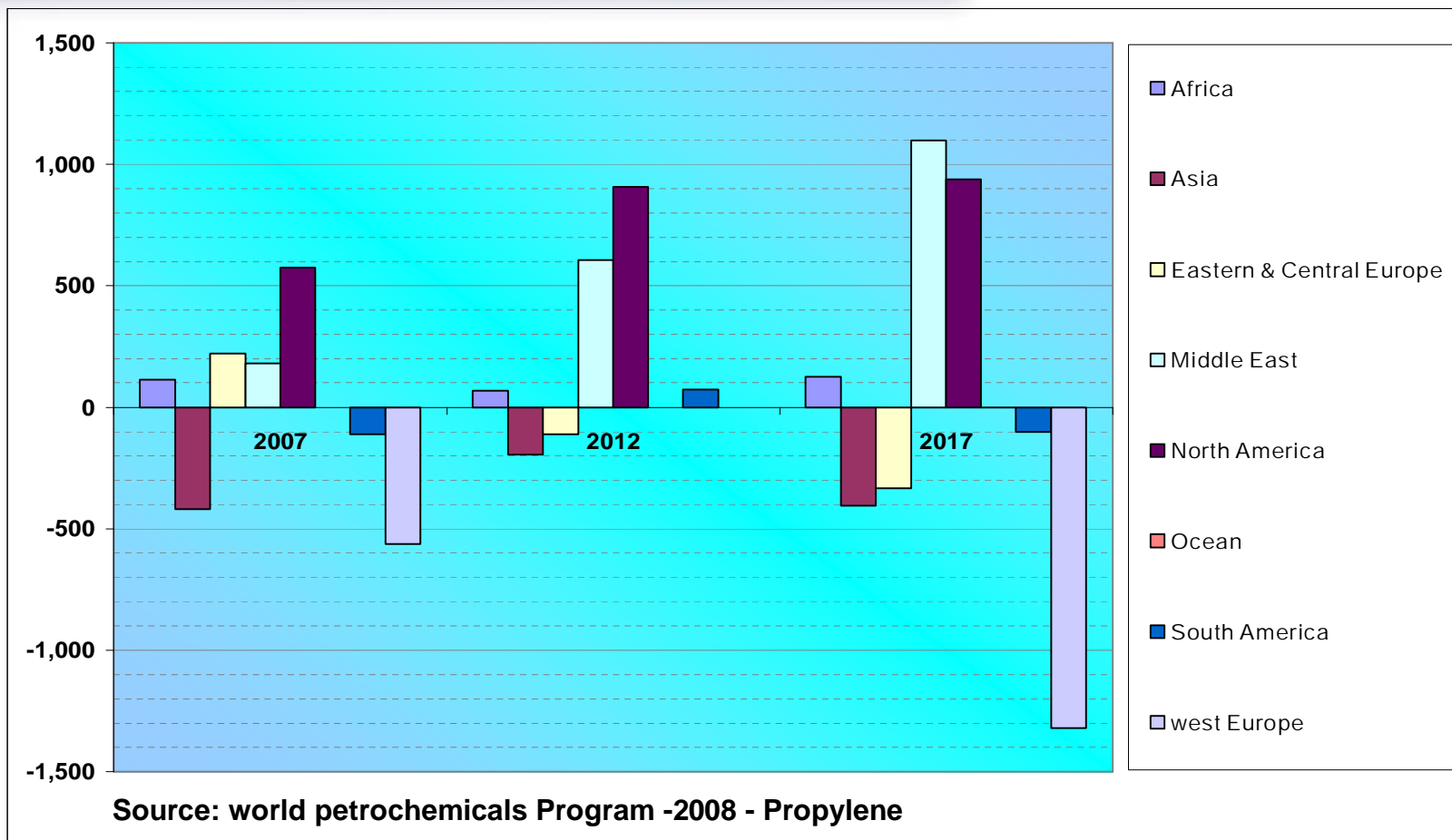
Cumene	60%
Isopropyle alcohol	21%
Others	19%

## 1-1) Market Review



- § Global demand for propylene is forecast to grow strongly 3.8%.
- § Propylene demand is mainly driven by PP (predicted annual growth 4.7% between 2007-2012).
- § World propylene capacity in 2007 was 84 million tones which will exceeds 110 and 123 million tones in 2012 and 2017.
- § Asia will be the biggest producer and consumer of propylene during next decades with 45% of global propylene supply & demand share.
- § West Europe and Asia would be the biggest net importers against Middle East as the net exporter region.

# Propylene Net Trade



## 1-2) Technical Analysis



- § Propylene production as the coproduct of ethylene in ethylene crackers is still the main propylene source with 58% of total world propylene supply. Share of refineries is 36% and the remained 6% is by on-purpose routes mainly PDH.
- § During 2012-2017 Growth of propylene production by PDH technology is estimated 14.3% in Middle East thanks to low cost propane gas supply.
- § In this region, especially Iran and Saudi Arabia, propylene production by PDH process would result high added value and short investment payback period due to high margin between propane and propylene price.
- § PDH as the only-propylene production process, is recommended for propylene derivatives investors.

## 1-3) Cost & Investment

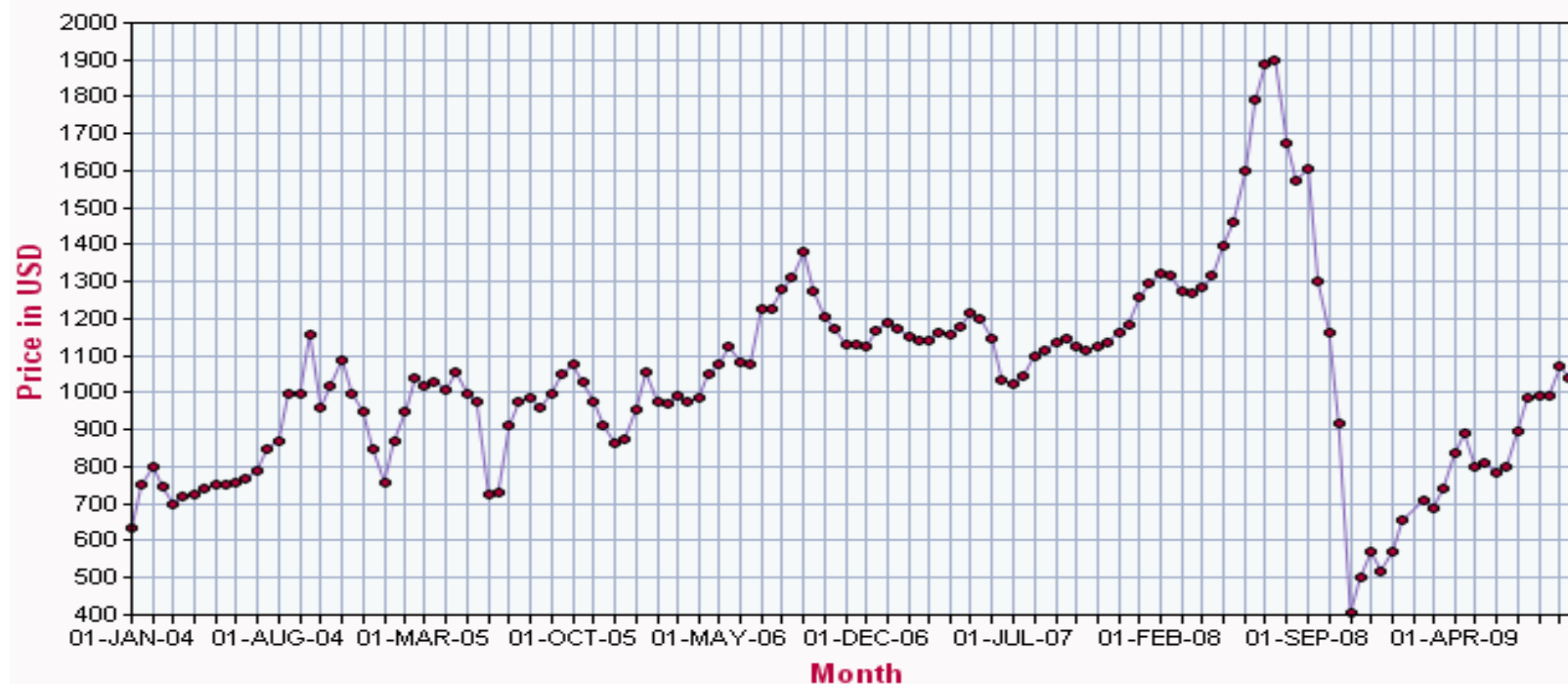


- § for the PDH plant with capacity of **450 KTPA** including offsite & utility plant is **635 million US\$**.
- § The total production cost was around **725 US\$/ton** against the unit price of **1036 US\$/ton** in 2008.

## 1-4) Price Trend



### Propylene Price Trend (CFR SE Asia)

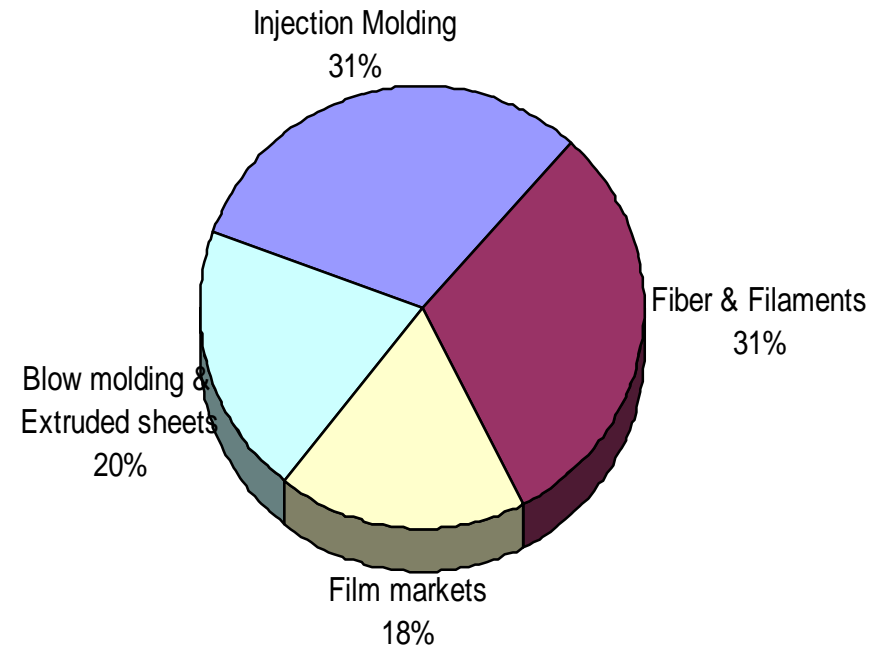


Source: [www.plastemart.com](http://www.plastemart.com)

## 2) Polypropylene



- § The largest chemical use for propylene (62%)
- § mostly produced from polymer-grade propylene
- § Most often used as homo-polymer, but recently in co-polymers and ter-polymers.



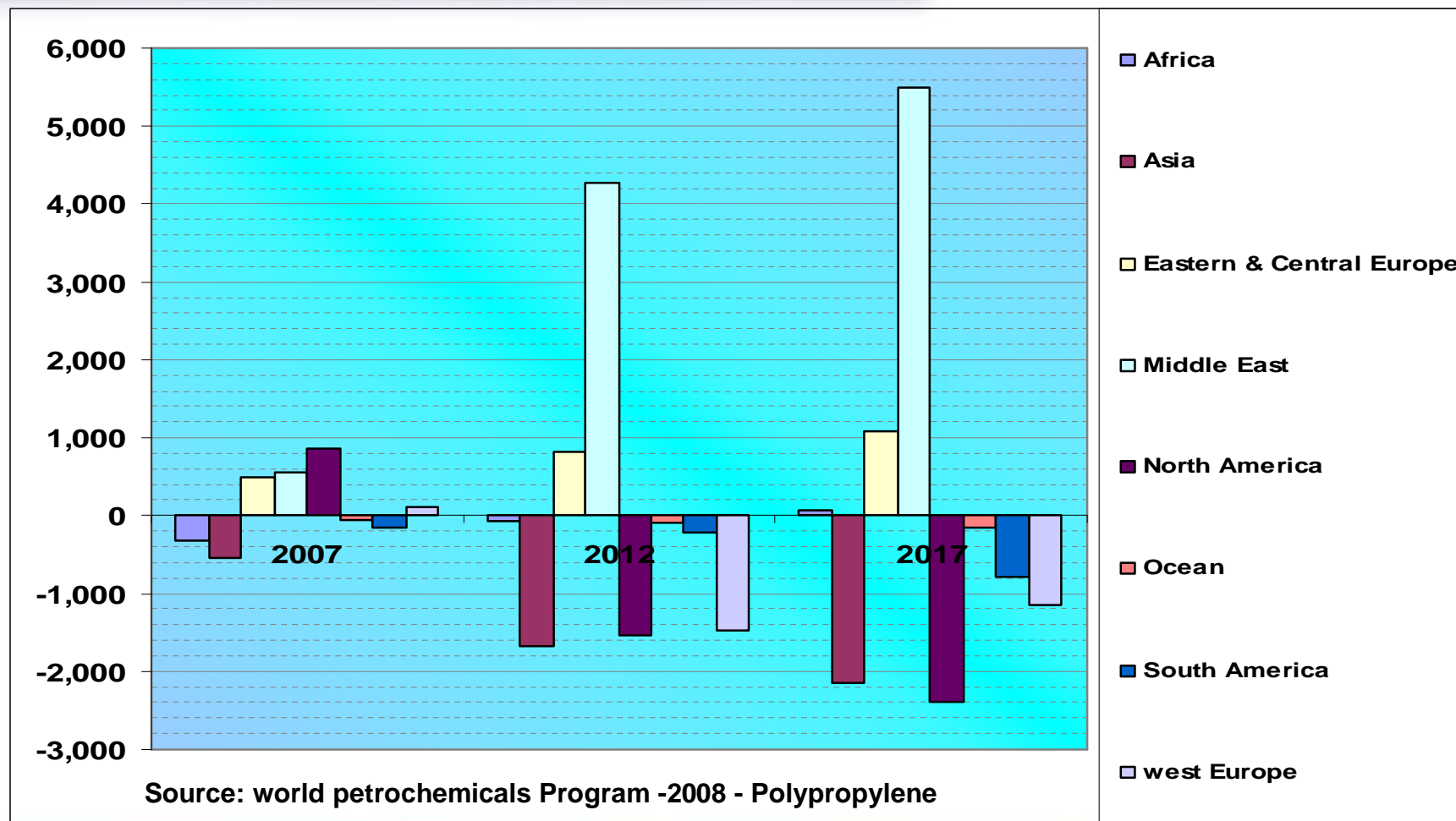
Source: world petrochemicals Program -2008 - Polypropylene

## 2-1) Market Review



- § During 2007-2012 the highest annual growth rate as 24.8% in polypropylene capacity would happen in Middle East.
- § With predicted Production growth rate of 23.2% and low 6.2% demand rate during 2007-2012, Middle East would be the **biggest PP net exporter in the globe.**
- § West Europe and North America change their position from **net exporter to net importer.**
- § During 2007-2012, 49% and 40% of total world polypropylene supply increase would occur in Asia and Middle East respectively against 55% and 13% of total world polypropylene demand increase in Asia and West Europe.
- § Iran currently imports 160,000 to 200,000 tons annually polypropylene as a result of fast demand growth.

# Polypropylene Net Trade



## 2-2) Technical Analysis



### § Sources of world polypropylene production:

- § Bulk Polymerization            55%
- § Slurry Polymerization        25%
- § Gas Phase Polymerization 20%

§ slurry process: simple polymer recovery but higher operating pressure so higher investment and operating cost.

§ bulk polymerization process (solution phase): although the product separation is more difficult than slurry process, but some specific specialty grades could be produced.

§ New gas phase technologies focusing on versatility and improved special products.

## 2-3) Cost & Investment

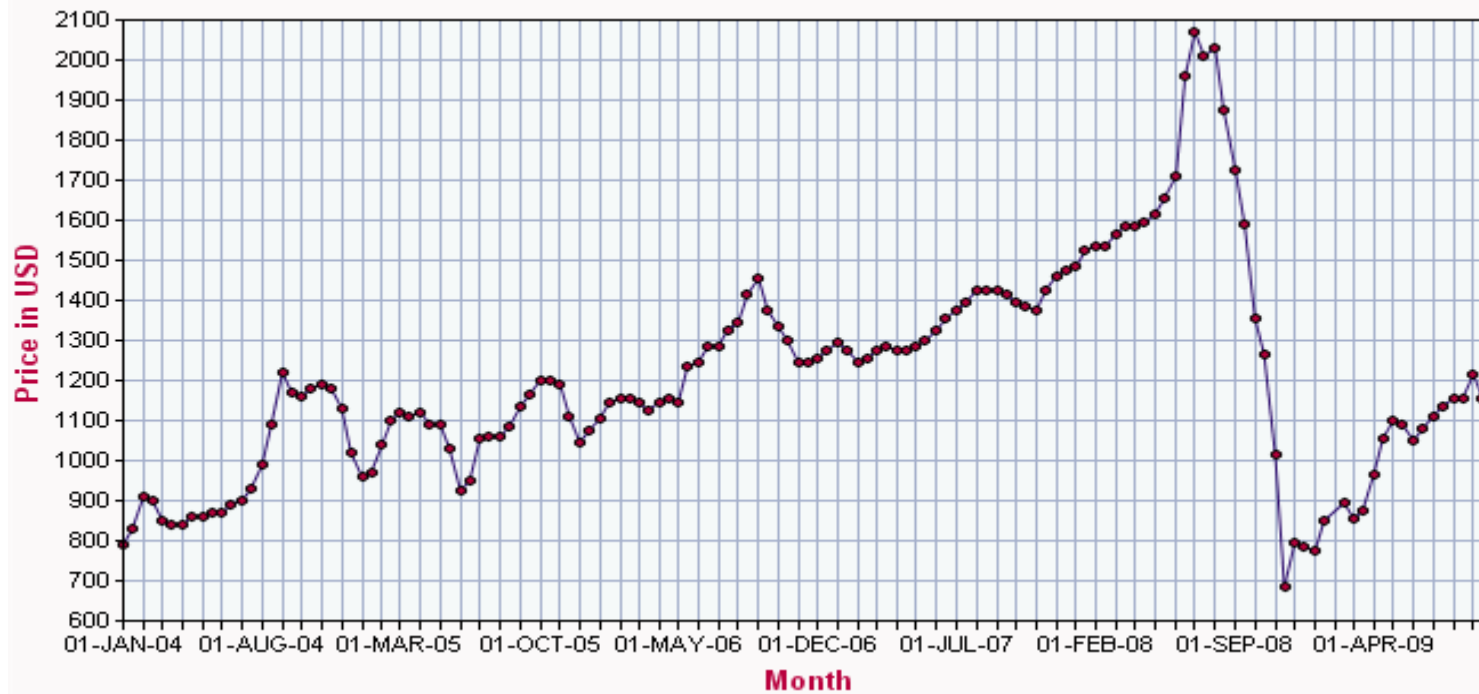


- § for the Polypropylene plant with capacity of **250 KTPA** is **240 million US\$**.
- § The production cost is around **1090 US\$/ton** based on captive propylene supply with the cost of 932 US\$/ton in 2008.
- § Average unit price of Polypropylene based on CFR India was **1450 US\$/ton** in 2008.

## 2-4) Price Trend



# Polypropylene Price Trend (India)



Source: [www.plastemart.com](http://www.plastemart.com)

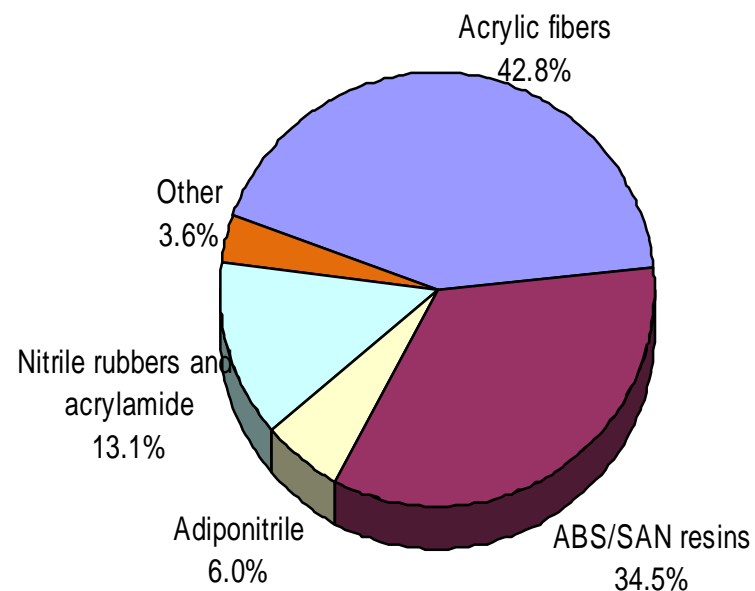
### 3) Acrylonitrile



§ Acrylonitrile (ACN) is used as chemical intermediate.

§ Major outlets:

- § Acrylic textile fibers
- § ABS/SAN resins production
- § Adiponitrile (a nylon 66 intermediate)
- § Nitrile rubbers and acrylamid



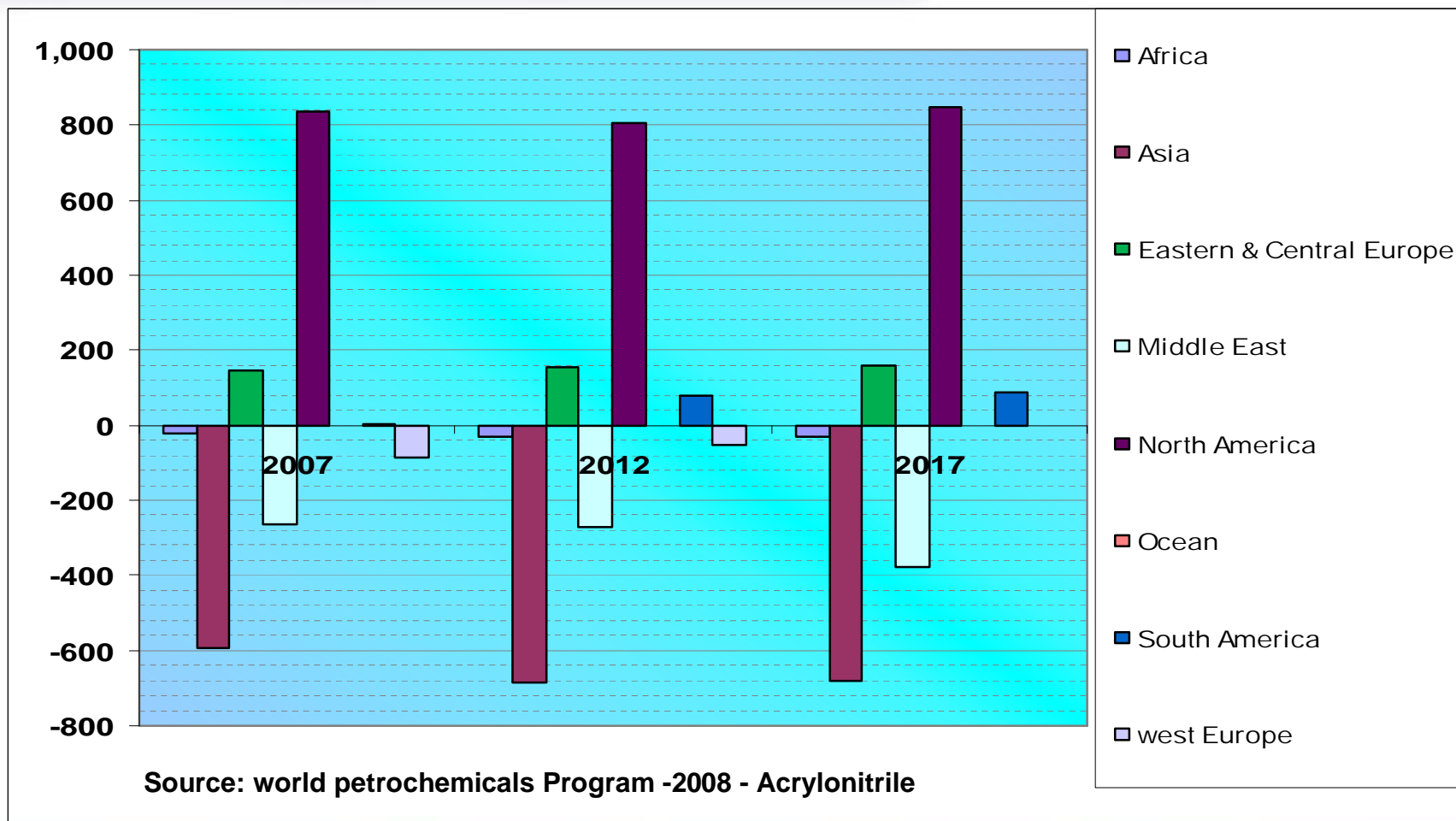
Source: world petrochemicals Program -2008 - Acrylonitrile

## 3-1) Market Review



- § The ACN market has consolidated by shutting or idling of old or non-profitable facilities (over 560 KT capacity) in Europe and North America.
- § Oversupply in their local markets and loss of export markets in Asia mainly due to start up of the new 260 KTPA capacity in China in 2005, was the main reason of consolidation
- § Rising feedstock costs mainly propylene were the main reasons for the production stagnation and low 0.6% annual growth during 2004-2007.
- § Of total 880 KT increase in ACN production during 2007-2012, 49% and 17% will occur in China and Thailand respectively.
- § ACN supply market is predicted to be tight and only cost-effective plants (low cost available feed) would remain in the ACN business market.
- § Iran currently imports more than 100,000 tons annually.

# Acrylonitrile Net Trade



## 3-2) Technical Analysis



- § Propylene ammoxidation is currently the only commercial technology used to make ACN.
- § Propylene, Ammonia and air are reacted in a fluidized bed catalytic reactor at low pressure of 2 atm and temperature of 430 °C.
- § Consumption of ammonia and propylene in the process is respectively 0.443 and 1.0936 ton per ton of ACN so **highly dependent to propylene price**.
- § **Hydrogen cyanide (HCN)** is the valuable by-product of the process.
- § New propane-based technology is under development by Asahi Kasei which has recently started a 150 KTPA at Japan.

### 3-3) Cost & Investment

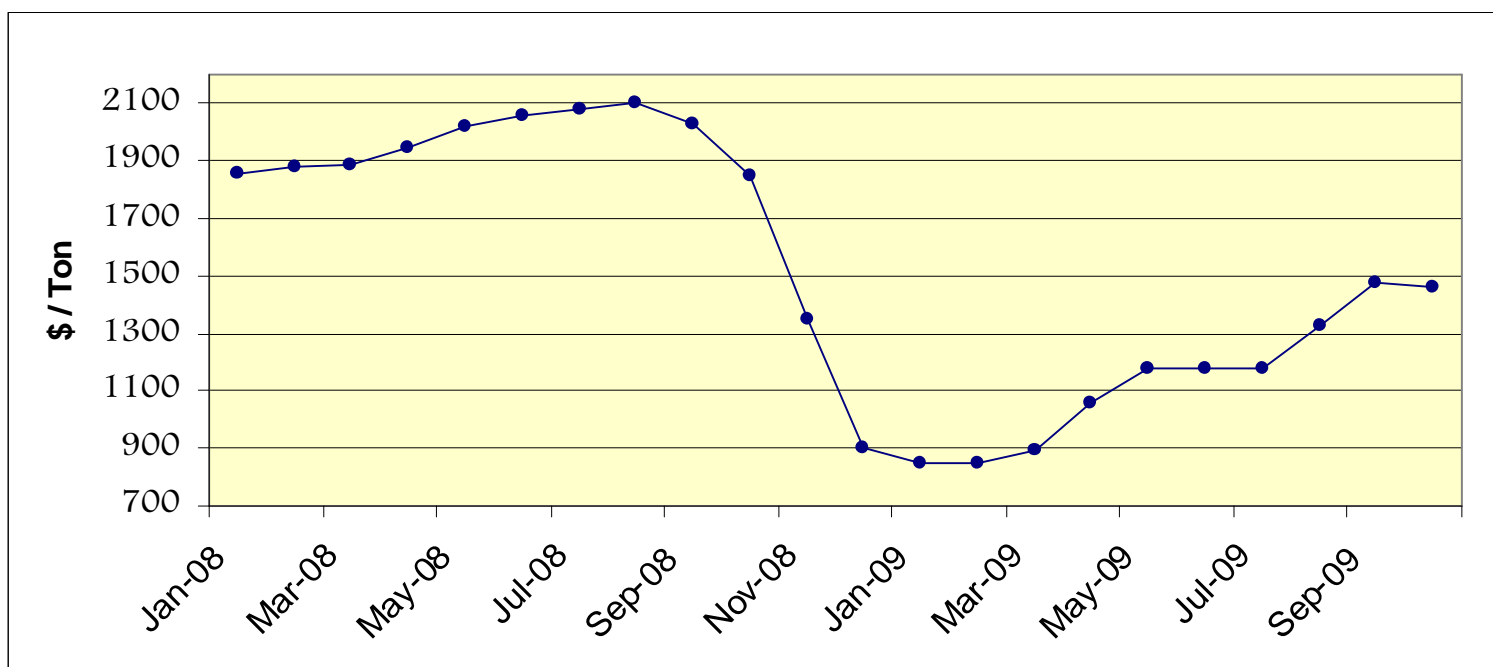


- § for the Acrylonitrile plant with capacity of **90 KTPA** including offsite & utility plant is **230 million US\$**.
- § The production cost is around **1334 US\$/ton** based on captive propylene supply with the cost of 932 US\$/ton in 2008.
- § Average unit price of Acrylonitrile based on CFR NE Asia was **1830 US\$/ton** in 2008.

## 3-4) Price Trend



### Acrylonitrile Price Trend (CFR N.E. Asia)



Source: ICIS LOR

## 4) Cumene



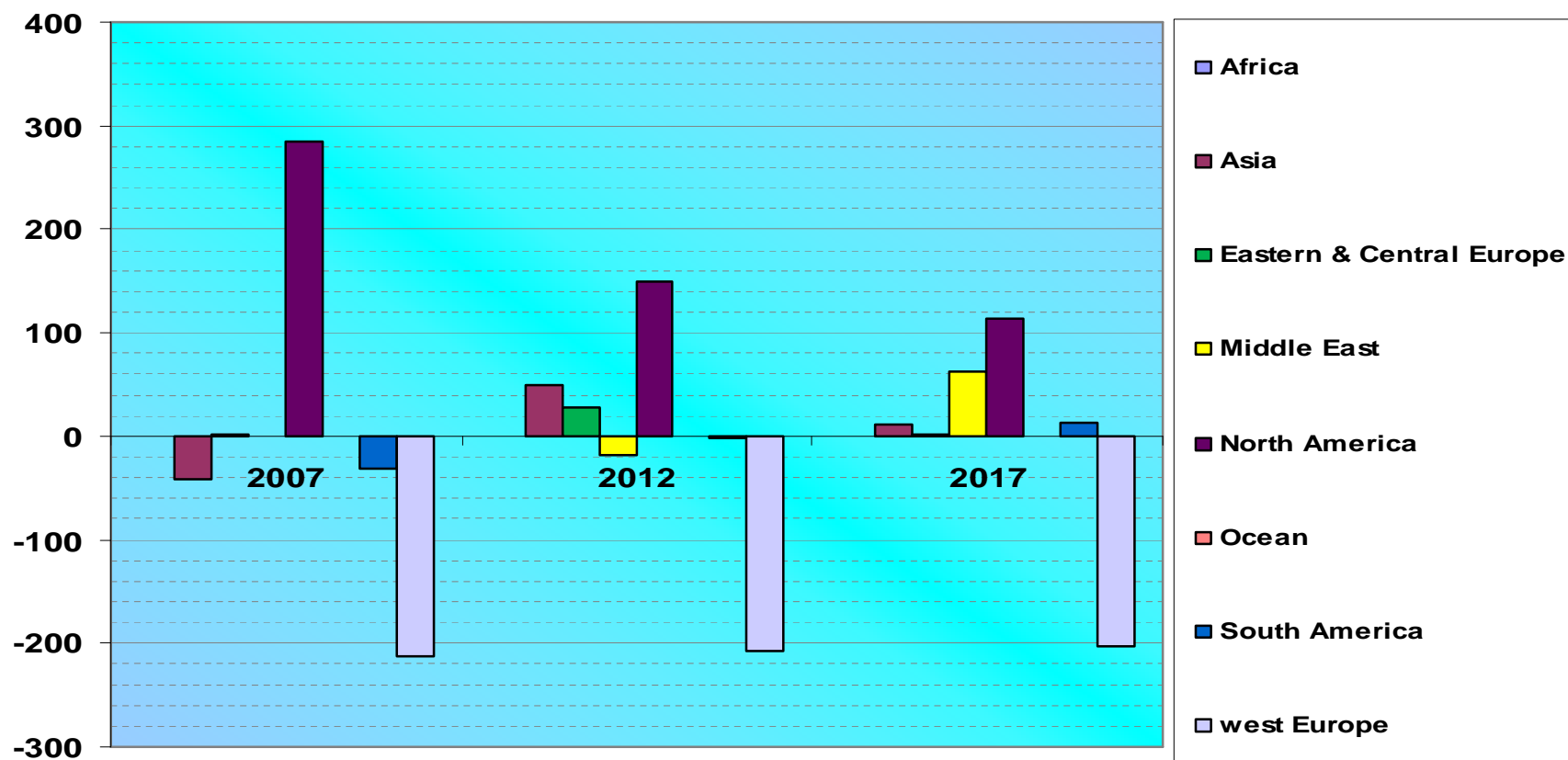
- § Cumene -a colourless liquid- used mainly as intermediate in phenol/aceton production.
- § **Over 99% of total consumption in phenol/acetone plants and minor accounts in production of  $\alpha$ -methylstyrene.**
- § **Over 95% and 92% of total phenol and acetone production in 2007 was originated from cumene as raw material.**
- § **Highly increased demand for bisphenol A and phenolic resins in Asia are the phenol/acetone demand driving force.**

## 4-1) Market Review



- § World cumene capacity in 2007 was 11.6 million metric tons and it is predicted with annual growth rate of 4.8% would reach to 14.6 million metric tons in 2012.
- § The fastest annual growth rate for cumene supply and demand will be in Asia as 9.9 % and 9.5% respectively.
- § 54% and 17% of world cumene capacity increase during 2004-2007 would occur in **China and Middle East** respectively.
- § Increased demand for **bisphenol A and phenolic resins** will result in strong demand for phenol in **China and Middle East**.
- § During 2007-2012 almost 51% and 19% of world cumene consumption will be in **China and Middle East** respectively.

# Cumene Net Trade



Source: world petrochemicals Program -2008 - Cumene

## 4-2) Technical Analysis



- § All commercial production of cumene is via alkylation of benzene with propylene under elevated temperature and pressure .
- § The main commercial routes are based on three catalyst systems:
  - § Solid phosphoric acid (SPA) on an alumina support
  - § aluminum chloride
  - § New developed zeolite-based
- § Zeolite-base catalysts which was introduced since 1994 has advantages:
  - § More purity
  - § More overall yield
  - § Regenerable
  - § Usable for many cycles so eliminating the need for waste disposal associated with SPA catalysts.

## 4-3) Cost & Investment

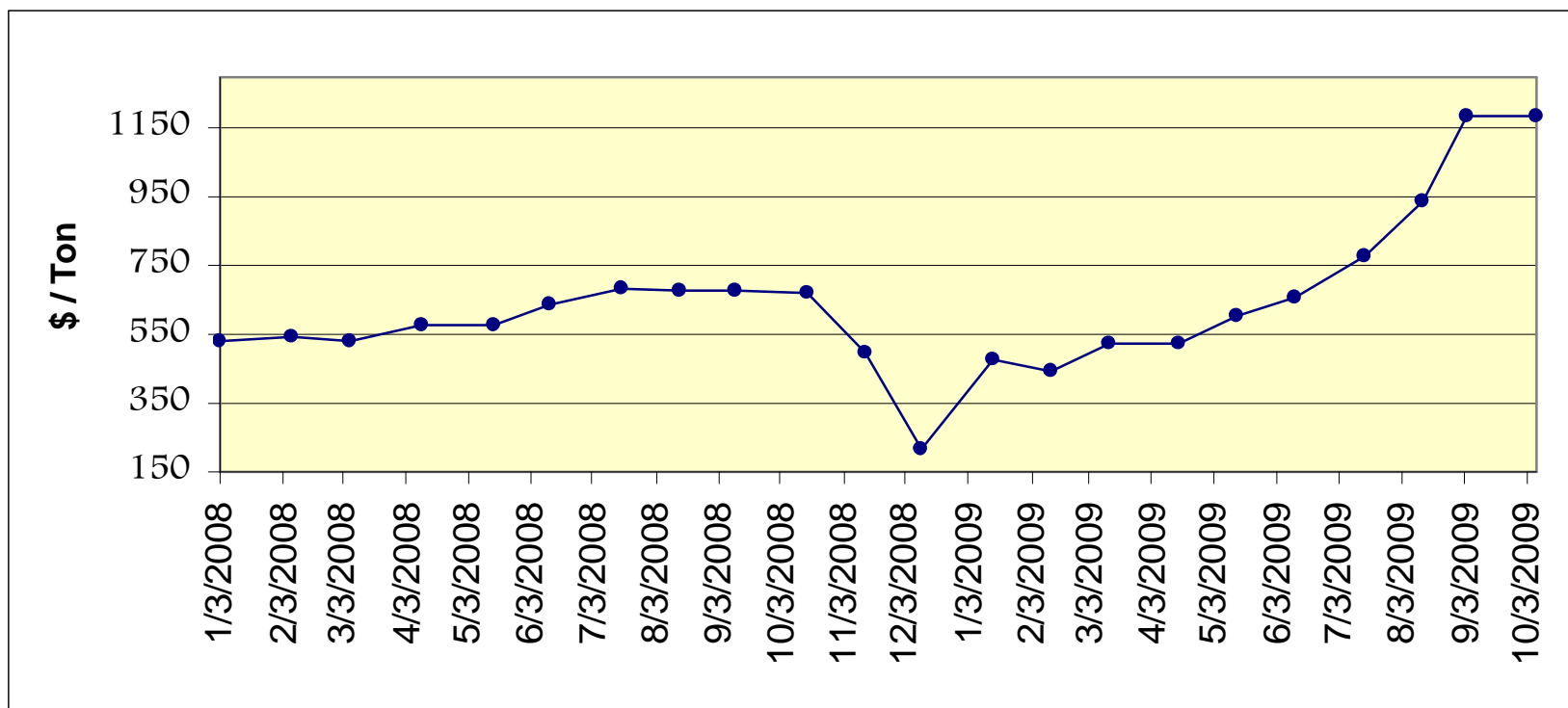


- § for the Cumene plant with capacity of **136 KTPA** including offsite & utility plant is **36 million US\$**.
- § The production cost is around **1120 US\$/ton** based on captive propylene supply with the cost of 932 US\$/ton in 2008.
- § Average unit price of Cumene in Europe was **1200 US\$/ton** in 2008.

## 4-4) Price Trend



### Cumene Price Trend (US Gulf)

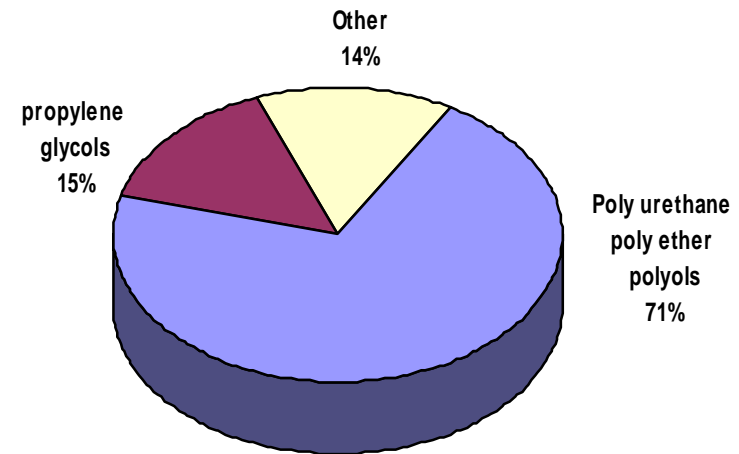


Source: ICIS LOR

## 5) Propylene Oxide



- § Propylene Oxide (PO) -a colourless liquid- mainly applied in production of polyester polyols, used to make Polyurethanes.
- § **The second largest derivative is mono propylene glycol (MPG).**
- § Other uses include propylene glycol ethers, flame retardants, synthetic lubricants, oilfield drilling chemicals, butanediol, propylene carbonate, allyl alcohol, isopropanolamines, modified starches and textile surfactants.



Source: CEH Report 2006

## 5-1) Market Review



- § Average propylene oxide world growth will be 4.6% per year until 2010.
- § The fastest annual growth rate for PO demand will be in China as the growing demand for polyols to produce urethane.
- § China will displace slow-growing (1% per year) Japan to fourth position in the world PO consumption (share just 6%) as China share would reach 16% of world PO consumption.
- § Producers believe demand has improved since the second quarter 2008, mainly from the polyols sector.
- § PO output is highly dependent to propylene supply and could be restricted by a shortage of propylene feedstock.

## 5-2) Technical Analysis



- § The traditional route of PO production is either by chlorohydrin and peroxidation respectively 51% and 46% of total world production in 2006.
- § Two types of peroxidation are used:
  - § PO-SM (styrene product co product) accounting 33%
  - § PO/TBA (MTBE co product ) accounting 18%
- § New developed Sumitomo as Hydroperoxidation based on cumene (HP-CU) that involves regeneration of a coproduct back to cumene.
- § In the PO-only process (HP-CU) developed from 2003, there is no need to by product separation so low cost investment and high PO yield of 92.5%.
- § Sumitomo Chemical Co. started the first HP-CU plant in Japan in 2003. Also the 300 KTPA and 200 KTPA respectively in Belgium and Saudi Arabia started production in 2009.

## 5-3) Cost & Investment

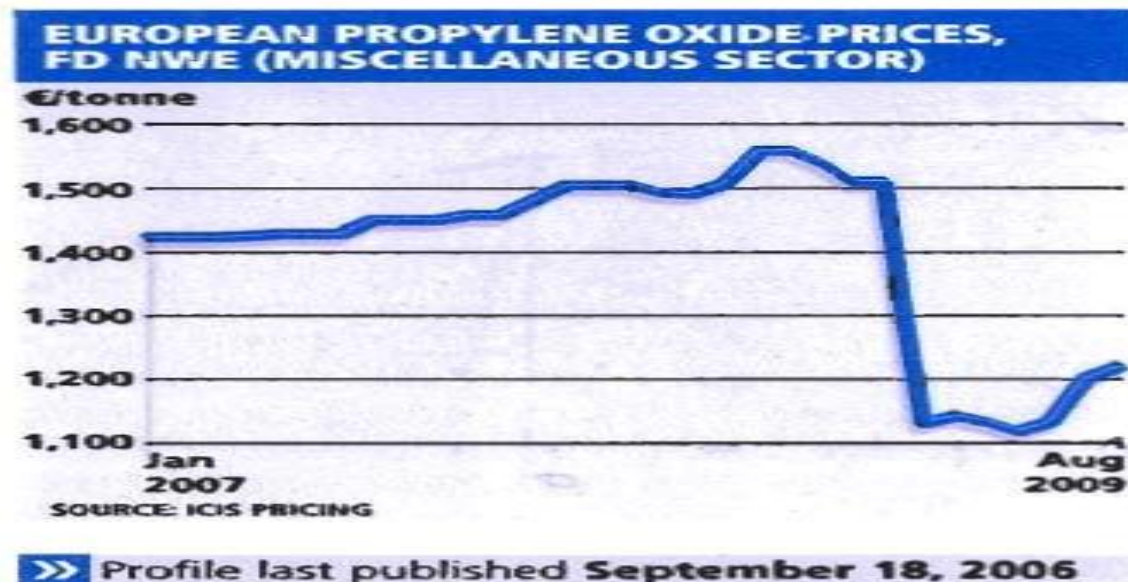


- § for the PO plant with capacity of **100 KTPA** including offsite & utility plant is **280 million US\$**.
- § The production cost is around **1120 US\$/ton** based on captive propylene supply with the cost of 932 US\$/ton in 2008.
- § Average unit price of PO based on FD (free delivered) NW Europe was **2100 US\$/ton** in 2008.

## 5-4) Price Trend



### Propylene Oxide Price Trend (FD NWE)



Source: ICIS

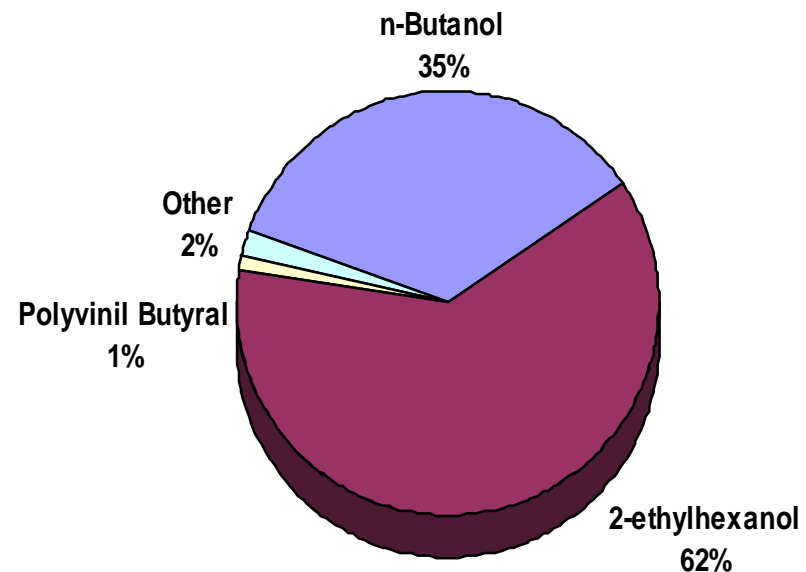
## 6) N-Butyraldehyde



§ Butyraldehyde is produced from oxo reaction of propylene in the isomeric forms of N- and Iso.

§ In 2008, in Middle East, consumption pattern for butyraldehydes for N- and Iso- butyraldehyde were 97% and 3% respectively.

§ 2-Ethyl hexanol and n-butanol are the two main driving force for N-butyraldehyde demand.



Source: CEH Report 2006

## 6-1) Market Review



- § Average n- butyraldehydes world growth will be 2.4% per year during 2007-2012.
- § Middle East consumption of n- butyraldehydes is forecast to grow **significantly** at the average annual rate of 5% during 2008-2013.
- § High consumption volumes for both n-butanol and 2,ethylhexanol (main derivatives on N-butyraldehyde) will continue.
- § In Middle East and Asia, share of n- butyraldehydes in oxo chemical demand were 93% and 79% respectively.
- § **Access to low-cost feedstock (mainly propylene) and energy** are one of the main success factors in the butyraldehydes market.

## 6-2) Technical Analysis



- § In oxo reaction of propylene to butyraldehydes, three common catalyst systems are used:
  - § Cobalt Hydrocarbonyl Catalyst (pressure: 1500 – 4000 psig)
  - § Phosphine-modified Cobalt Catalyst (pressure: 500 psig)
  - § Rhodium Catalyst (pressure: 100-300 psig)
  
- § The preference for a higher n/iso butyraldehyde ratio resulted in the development of rhodium-based system as ratio up to 25:1 is also achievable although the common ration in 8:1 to 12:1.
  
- § Low pressure Rh-based process affords **lower capital investment and lower operating costs** than high-pressure technologies.

## 6-3) Cost & Investment

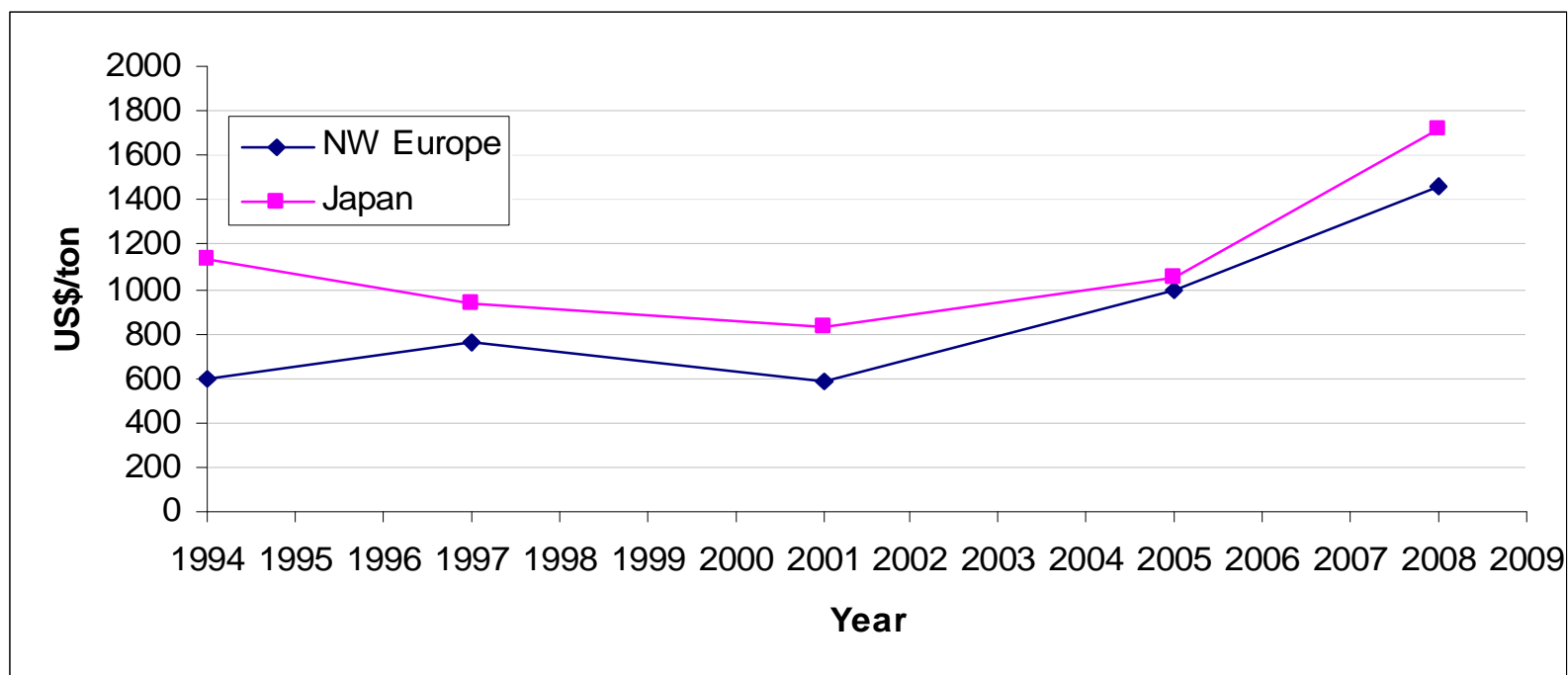


- § for the N-Butyraldehyde plant with capacity of **50 KTPA** (based on Rh catalyst) including offsite & utility plant is **45 million US\$**.
- § The production cost is around **770 US\$/ton** based on captive propylene supply with the cost of 932 US\$/ton in 2008.
- § Average unit price of European N-butyraldehyde based on NW Europe was **1400 US\$/ton** in 2008.

## 6-4) Price Trend



### N-Butyraldehyde Price Trend (NEW & Japan)



Source: CEH report 2008

## 7) Epichlorohydrin



- § Epichlorohydrin (ECH) is a liquid epoxide most frequently produced by Chlorohydrination of intermediate Allyl Chloride.
- § The principle uses for Epichlorohydrin are in the production of epoxy resins (80-85%) and synthetic resins.
- § ECH elastomers, Specialty water treatment chemicals and wet-strength resins for paper industry are other ECH applications.

## 7-1) Market Review



- § **Epichlorohydrin demand depends on its downstream products market mostly Glycerin and Epoxy resins.**
- § **China and West Europe would be the big importers of Epichlorohydrin.**
- § **It is predicted during next years the China ECH imports would reach to 350,000 tons.**
- § **Most of Western Europe epichlorohydrin imports are supplied from Eastern Europe specially Russia.**

## 7-2) Technical Analysis



- § Epichlorohydrin is manufactured from Propylene and chlorine through the intermediacy of Allyl chloride.
  
- § Epichlorohydrin production plant includes three following steps:
  - § Chlorination of propylene
  - § Chlorohydrination of Allyl chloride
  - § Hydrochlorination of the formed dichlorohydrin
  
- § HCl (solution 32%) is the process valuable byproduct.
  
- § Ratios for propylene and chlorine per ton of product are 0.61 and 2.02 and the produced byproduct HCL (32%) is 1.6 ton/ton.

## 7-3) Cost & Investment

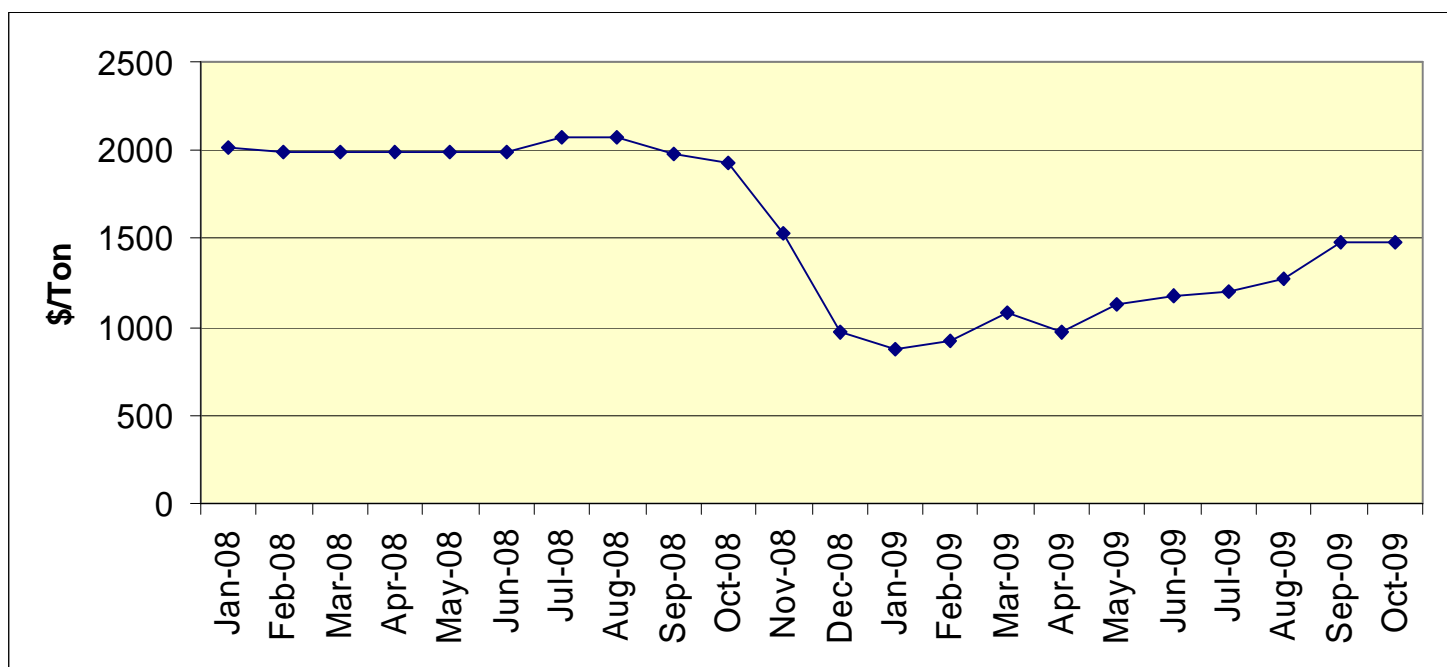


- § for the Epichlorohydrin plant with capacity of **30 KTPA** including offsite & utility plant is **85 million US\$**.
- § The production cost is around **1690 US\$/ton** based on captive propylene supply with the cost of 932 US\$/ton in 2008.
- § Average unit price of Epichlorohydrin based on CFR Chian was **1875 US\$/ton** in 2008.

## 7-4) Price Trend



### Epichlorohydrin Price Trend (CFR China)



Source: ICIS LOR

## 8) Acrolein



- § Acrolein is used in the preparation of acrylic acid, polyester resin, polyurethane, propylene glycol, acrylonitrile and glycerol.
- § Acrolein is prepared industrially by oxidation of propane and also produce from propylene oxidation.
- § Acrolein is sometimes used as a fixative in preparation of biological specimens for electron microscopy.

## 8-1) Market Review



- § Acrylic acid is one of the biggest markets for Acrolein.
- § World demand for acrylic acid is forecast to grow at 3.7% annually during 2006–2011.
- § With growing demand for acrylic acid derivatives, led by super absorbent polymers, major producers have debottlenecked and expanded plants and built new facilities, resulting in continuing growth of Acrolein.

## 8-2) Technical Analysis



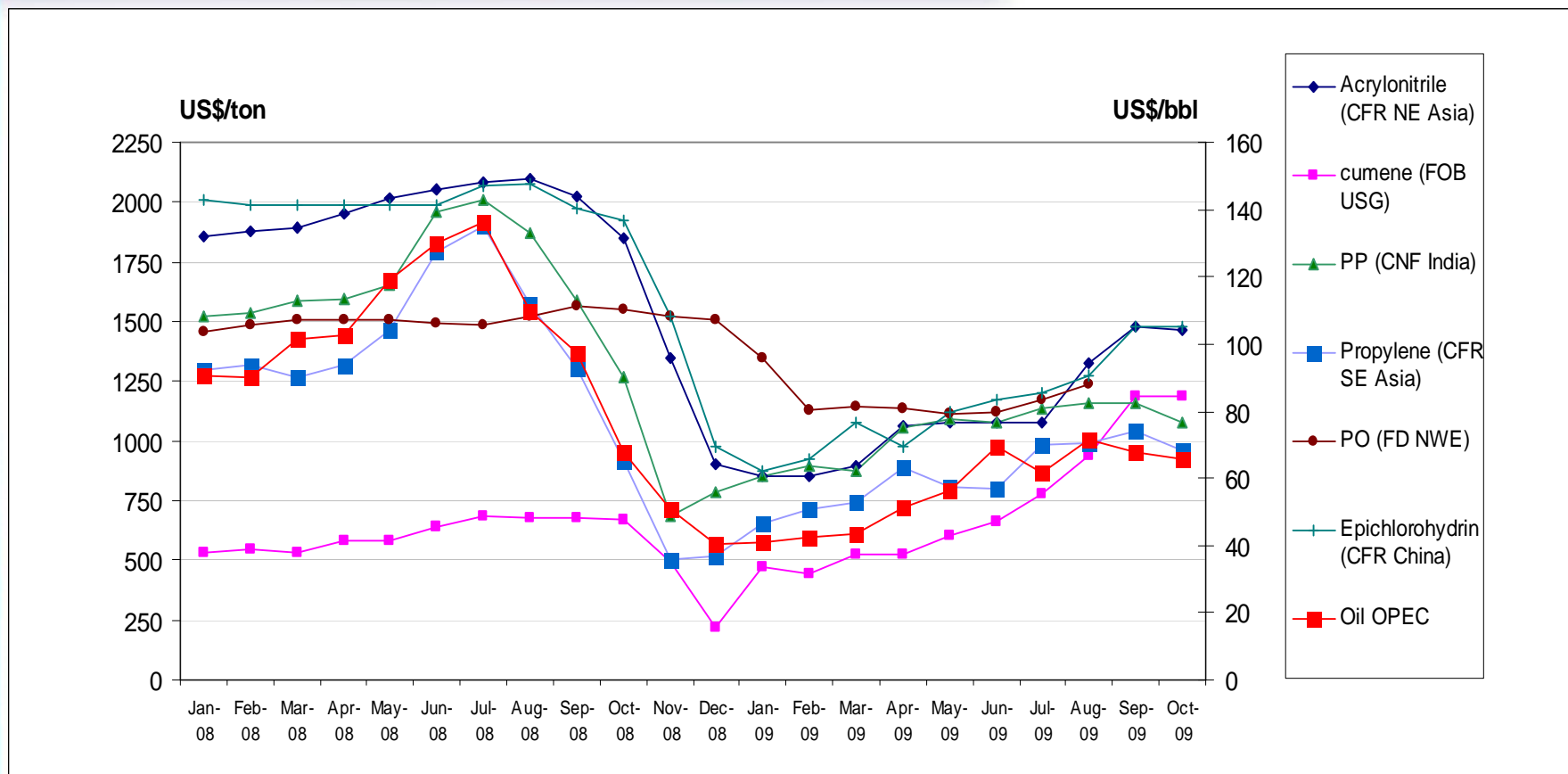
- § The principal process for Acrolein production is via oxidation of propylene with air.
- § DOW and BASF have developed processes for the production of acrolein using lower cost propane as feed. The process is based on oxydehydrogenation of propane with in situ conversion of propylene to Acrolein.
- § In this technology, oxidation is done by oxygen instead of air in conventional acrolein production from propylene.
- § Acrolein can be hydrogenated to Allyl chloride which is used in producing Epichlorohydrin and Glycerin.

## 8-3) Cost & Investment



- § for the Acrolein plant with capacity of **9 KTPA** (based on Rh catalyst) including offsite & utility plant is **46 million US\$**.
- § The production cost is around **800 US\$/ton** based on captive propylene supply with the cost of 932 US\$/ton in 2008.
- § Average unit price of European Acrolein based on NW Europe was **910 US\$/ton** in 2008.

# Propylene & Derivatives Prices vs. Oil Price



Sources: ICIS LOR, [www.plastemart.com](http://www.plastemart.com), [www.iranoilgas.com](http://www.iranoilgas.com)

## 9) Project Matrix Evaluation



### Feedstock

- Low cost
- Availability
- Added-value

### Technology

- Advanced
- Low Investment
- Valuable byproduct

### Market

- Local
- Regional

### Infrastructural Facilities

- § access to shipping ports in south of Iran
- §available utilities
- §cheap human resource

# Propylene Matrix



## Feedstock

- Low cost propane in Iran (ME) thanks to south pars gas field.
- 38% Added-value

## Technology

- PDH technology
- It's on-purpose and low cost investment
- No by-product separation
- The best process for investment on propylene derivatives

## Market

- Local market until 2012
- Fast growing market in china and West Europe

## Infrastructural Facilities

- § access to shipping ports in south of Iran
- § available utilities
- § cheap human resource

# A) Polypropylene Matrix



## Feedstock

- § No high shipping price for propylene supply
- § No high investment for propylene separation from by-products
- § Single feed (propylene)
- § 25% Added-value

## Technology

- § Gas phase technology technology
- § Variety of products by producing bi-modal products
- § Safety
- § Compact

## Market

- § 200 KTPA Local market until 2012
- § growing demand market in Asia and West Europe
- § Middle East: the net exporter

## Infrastructural Facilities

- § access to shipping ports in south of Iran
- § available utilities
- § cheap human resource

## B) Acrylonitrile Matrix



### Feedstock

- §No high shipping price for propylene supply
- §No high investment for propylene separation from by-products
- §Ammonia (0.443 t/t) and propylene (1.09 t/t)
- §Availability of ammonia in south of Iran
- §27 % Added-value

### Technology

- §Propylene Ammoxidation technology
- §The only commercial technology
- §HCN byproduct
- §Not complicated

### Market

- §100 KTPA imports to Iran
- §growing demand market in Middle East and Asia
- §No plant in Iran

### Infrastructural Facilities

- § access to shipping ports in south of Iran
- §available utilities
- §cheap human resource

## C) Propylene Oxide Matrix



### Feedstock

- §No high shipping price for propylene supply
- §No high investment for propylene separation from by-products
- §Use of 0.78 ton propylene and 0.12 ton benzene per ton product (cumene itself is a derivative of propylene)
- §34% Added-value

### Technology

- §PO only process
- §No chemical (esp. Styrene) by product
- §Low investment in comparison with other routes specially with styrene co products

### Market

- §growing demand market in West Europe
- §No production in Iran
- §No new investment in Europe
- §Highly dependent to propylene market

### Infrastructure Facilities

- § access to shipping ports in south of Iran
- §available utilities
- §cheap human resource

## D) Butyraldehyde Matrix



### Feedstock

- §No high shipping price for propylene supply
- §No high investment for propylene separation from by-products
- §Use of 0.66 ton propylene
- §(Rich sources of natural gas for syngas production
- §45% Added-value

### Technology

- §Rh catalyst-based process
- §High N-/Iso ratio
- §Low pressure in comparison with traditional routes so low investment

### Market

- §Annual growth rate of 5% in Middle East
- §97% of butyraldehydes demand in Middle East is in N-isomer.
- §No production in Iran

### Infrastructure Facilities

- § access to shipping ports in south of Iran
- §available utilities
- §cheap human resource

## 10) Conclusion



### Polypropylene

- § Local attractive market
- § Good possibility for Export
- § 25% Added-value

### Acrylonitrile

- § Exclusive Local Growing Market
- § 27% Added-value.

### Butyraldehyde

- § No production in Iran
- § Limited Local market
- § 45% Added-value

### Propylene Oxide

- § No local market
- § Difficult for Exporting
- § 34% Added-value



Thanks For Kind Attention

