

# Recovery & Monetization of Lean Ethylene from FCC Off Gas

PRESENTED BY

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for  
LKMT WORKSHOP 2017

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- 1 FCC Off Gas - A Promising Petchem Feedstock**  
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- 2 Recovery of Ethylene from FCC Off Gas**  
.....
- 3 Ethylene Monetization - Derivatives Beyond Bulk**  
.....
- 4 Potential Derivatives for Implementation**  
.....
- 5 Conclusion & Key Take Aways**

- 1 FCC Off Gas - A Promising Petchem Feedstock**

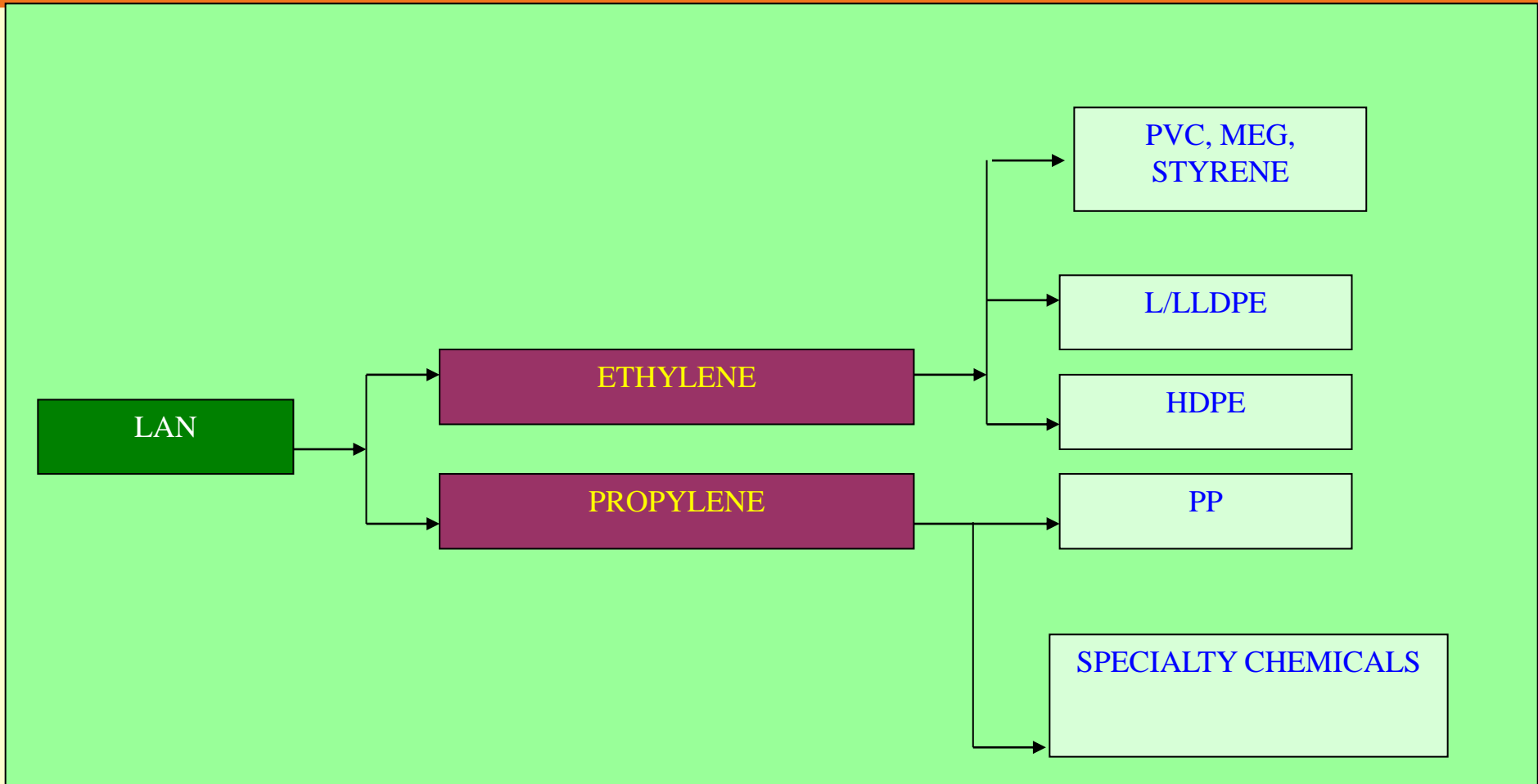
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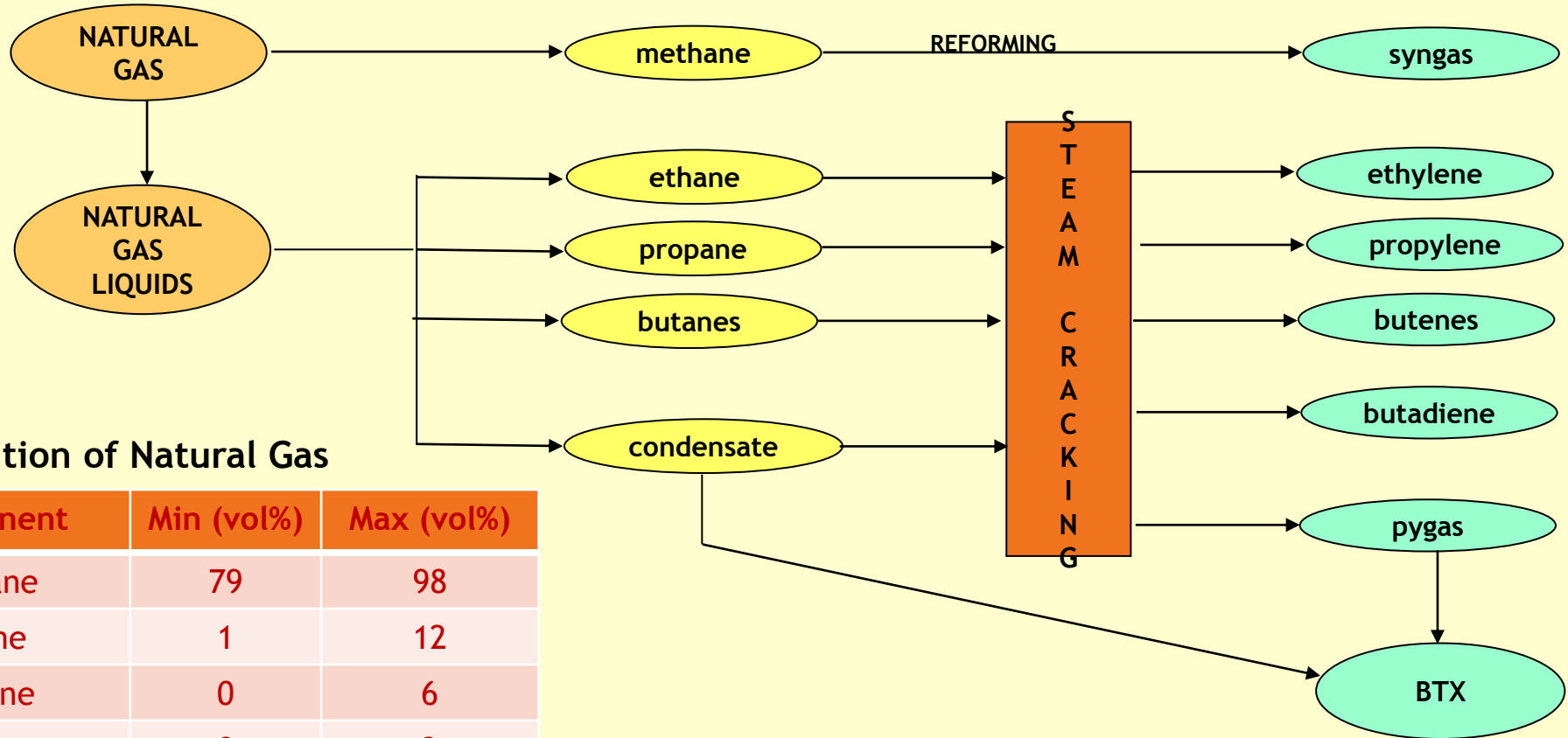
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# CONVENTIONAL PETCHEM FEEDSTOCKS USED IN INDIA - BASED ON REFINERY SOURCES



*Products from Low Aromatic Naphtha*

# CONVENTIONAL PETCHEM FEEDSTOCKS USED IN INDIA - BASED ON NON REFINERY SOURCES



Composition of Natural Gas

Component	Min (vol%)	Max (vol%)
Methane	79	98
Ethane	1	12
Propane	0	6
Butane	0	3
C5+	0	3

w/o acidic components and water

- First tranche of LNG supply to India from Middle East had high potential of C2/C3 components - potential petrochemical feedstocks

# FEEDSTOCK CHALLENGES FACED BY INDIAN PETROCHEMICAL INDUSTRY

## Indian petrochemicals industry susceptible to few hindrances:

- Lesser feedstock availability - a major impediment for growth of industry in the country
- Country not self-sufficient in availability of Naphtha and producers compelled to import the vital feedstock
  - Naphtha available in small pools - supply/transfer logistics a critical issue
  - Limited availability of Naphtha for future projects
- Present supply of LNG has reduced C2/C3 potential as the same is extracted by LNG suppliers in Middle East thus restricting petrochemical feedstock availability

## In order to tackle the situation, some players exploring alternative feedstock but same is riddled with challenges:

- Reliance Industries Limited (RIL) importing ethane from US
  - Development of complete infrastructure for sourcing ethane including dedicated cryogenic vessels, necessary berthing facilities and re-gasification terminal
- ONGC implemented C2 / C3 extraction from RLNG along with downstream polymers
  - Cost competitiveness could be a concern given the current low crude oil prices

# ALTERNATE FEEDSTOCK OPTIONS AVAILABLE DOMESTICALLY

- **Coal Gasification & downstream based on syn gas production**
- **Residue Gasification & downstream based on syn gas production**
- **Deep Catalytic Cracking (DCC) Selective cracking of feed stocks to maximize light olefins. e.g IOCL's INDMAX, UOP's Petro FCC, SWEC-DCC**
- **Ethylene/ Propylene Recovery unit based on DCC Dry gas/LPG**
- **Ethane Recovery Unit (for CDU, FCC, COKER Off gases) for feed to steam cracker**
- **Propane Dehydrogenation Unit (PDH) for on-purpose propylene production**

# ENHANCED OLEFINS AVAILABILITY FROM DCC

**Typical Yields FCC Vs DCC Based on hydrotreated VGO feed (in %)**

	FCC (gasoline)	FCC (gasoline + LPG)	DCC
C2 Minus	3.5	4.4	11.9
C3 , C4 LPG	17.6	29.0	42.2
Naphtha	54.8	42.0	26.6
LCO	10.2	13.1	6.6
CLO	9.3	6.0	6.1
Coke	4.3		6.0
Loss	0.3	5.5	0.6
	100.0	100.0	100.0
<b>Ethylene</b>	<b>0.4-0.8%</b>	<b>0.9-1.4%</b>	<b>5%</b>

**Ethylene potential increases with the severity of FCC operation**



# ENHANCED OLEFINS AVAILABILITY FROM DCC (CONTINUED...)



Typical Composition Off Gas FCC Vs DCC (in %)		
	FCC - medium severity	DCC - high severity
Nitrogen	17.5	12.0
Hydrogen	8.3	1.0
Methane	39.0	21.0
Ethane	15.0	16.0
Ethylene	15.5	40.0
C3s	1.0	3.9
C4s	0.3	0.7
Others	3.4	5.4
	100.0	100.0
<b>Total C2= Potential</b>	<b>27.2</b>	<b>52.3</b>

Ethylene potential almost doubles and increases to 52% in high severity mode of FCC operation making FCC Off gas a potential petchem feedstock

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# ETHYLENE RECOVERY PROCESS FROM FCC OFF GAS

Process/Configuration to be adopted for Ethane/Ethylene Recovery from FCC Off Gas is contingent to:

- Feed Quality - ethane rich/ethylene rich
- Product Quantity Requirement - if sufficient ethylene available from DCC, direct ethylene recovery, other wise ethane & ethylene recovery followed by ethane cracking
- Opportunity available for integration - cracker availability in the vicinity; recovered ethane can be utilized to supplement cracker feed

Technologies Available for Ethylene/Ethane Recovery:

- CBI Lummus LPR Process (recovery as high as 99% achievable)
- Technip Stone & Webster Process Technologies

# PROJECTS BASED ON ETHYLENE FROM FCC/REFINERY OFF GAS

A. RIL Refinery Off Gas based Cracker Complex

- Recovery of Ethane/Ethylene followed by cracking

B. IOCL's 330 KTA Ethylene Glycol Project at Paradip based on DCC Off gas

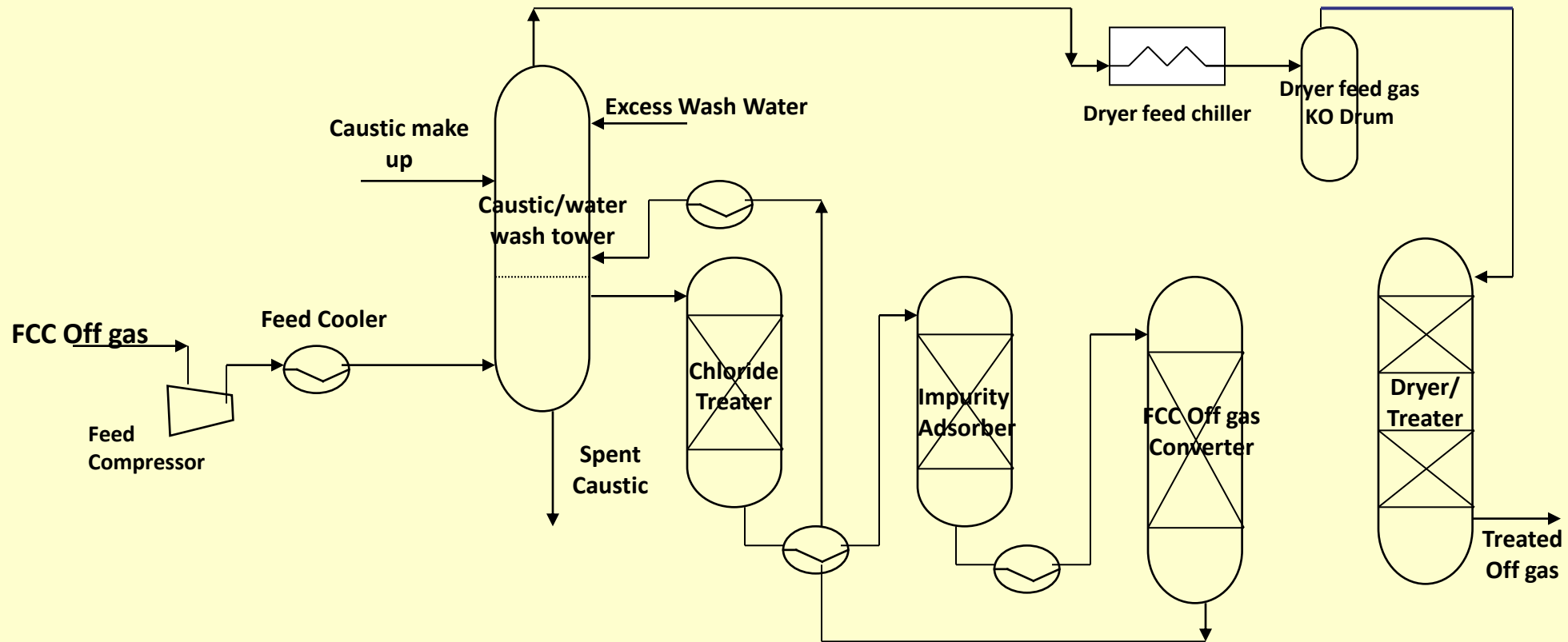
- Recovery of Ethylene followed by conversion to Ethylene Glycol

C. IOCL's Ethane/Ethylene Recovery Project from Refinery Off gases at Panipat Cracker Complex

- Recovery of Ethane/Ethylene to supplement cracker feed for PE/Glycol production

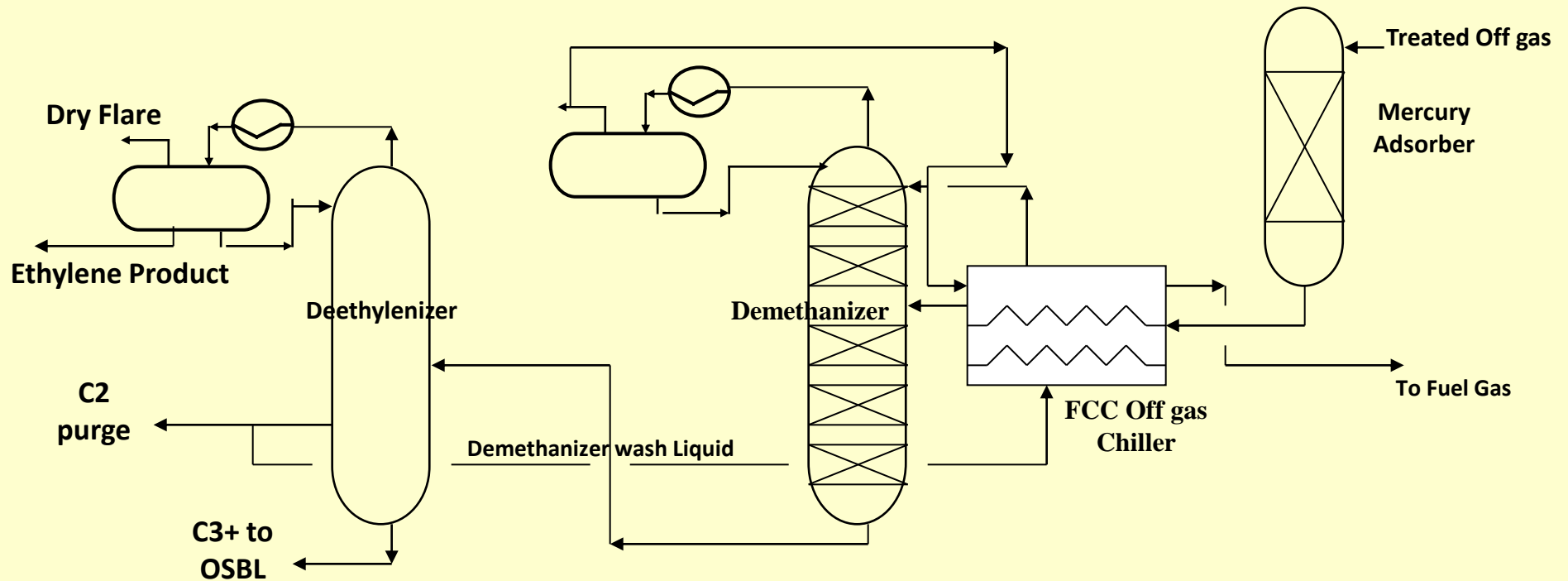
# ETHYLENE RECOVERY PROCESS FROM FCC OFF GAS

## Section - A: Impurities Removal

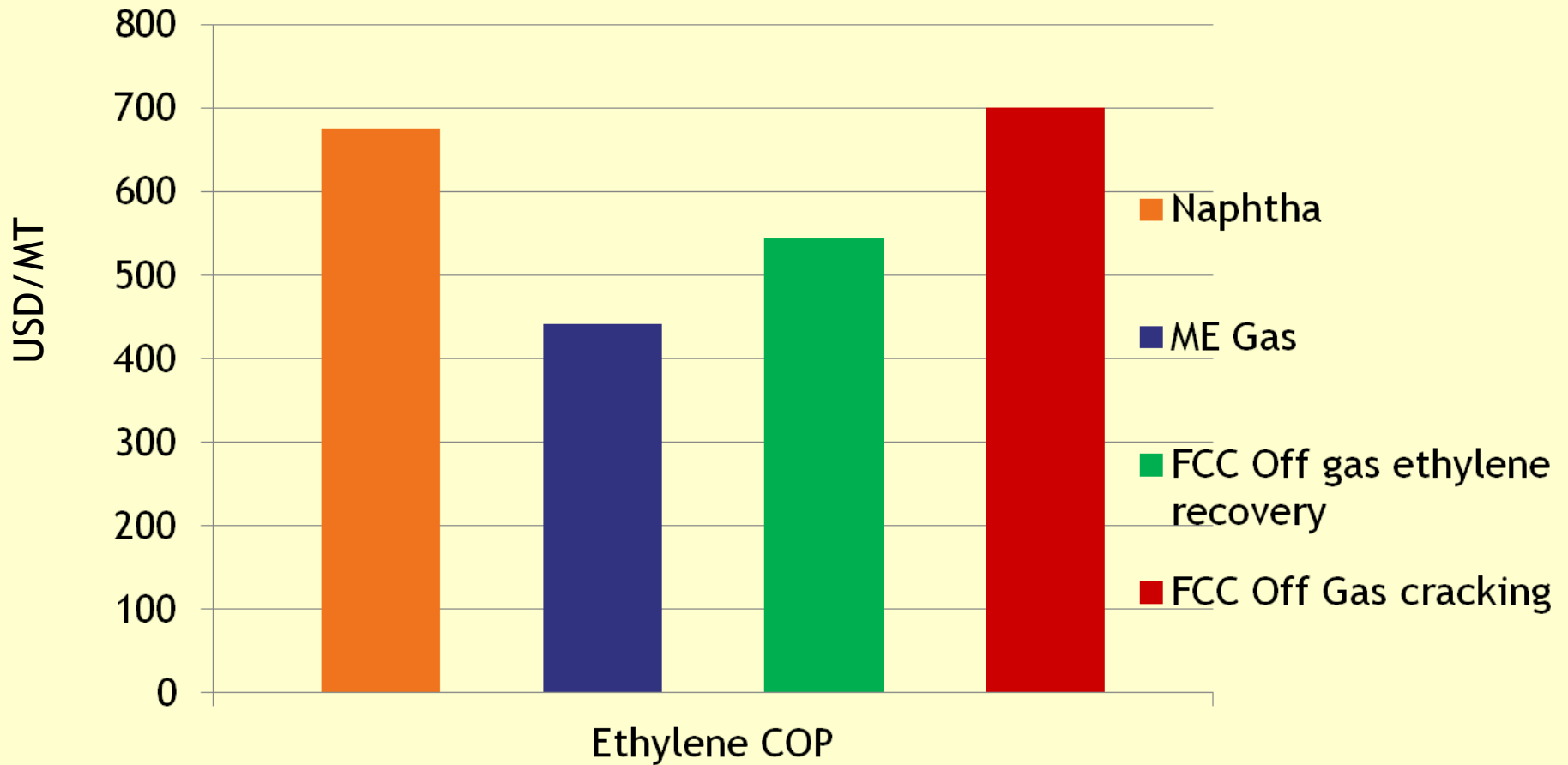


# ETHYLENE RECOVERY PROCESS FROM FCC OFF GAS (CONTD..)

## Section - B: Fractionation (similar to that of a cracker downstream)



# ETHYLENE PRODUCT COMPETITIVENESS BASED ON FEEDSTOCK



Source: In house estimate based on 2014-2016 prices

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# EMERGING GLOBAL TRENDS IN PETROCHEMICALS

- Rapid economic growth in transition countries like India and Brazil resulting in many fold increase in petrochemicals demand
- Growth in China, a major export target market for Asia Pacific & Middle East, slowing down; further the country moving towards self sufficiency
- Matured markets in Western Europe and North America
- Middle East & US advantaged by availability of low cost feed stocks -major exporters of Petrochemicals esp. polymers
- Ethylene production in US targeted for bulk polymers - polyolefins and glycol; less focus on other derivatives

# INDIAN PETROCHEMICALS MARKET

- India - one of the fastest growing economies of the world.
- Indian petrochemical industry - one of the most promising industries in the country and also an important growth driver to the economy.
- The industry, according to Ernest & Young, has been growing at a rate of 14% annually since the past few years.
- Per capita consumption in the country gradually growing manifold from the current state of a substantially lower per capita consumption in comparison with the trend of much higher consumptions in countries, such as, China, Japan and USA.
- The annual per capita consumption in the country is around 7.6 kg/capita compared to global average of 35 kg/capita
- Consumption of key polymers showing high single digit or even double digit growth.

# C2 VALUE CHAIN

## Ethylene Derivatives:

- High Density Polyethylene (HDPE)
- Linear Low Density Polyethylene (LLDPE)
- Low Density Polyethylene (LDPE)
- Vinyl Acetate Monomer (VAM)
- Ethylene Vinyl Acetate (EVA)
- Styrene
- Poly Vinyl Chloride (PVC)
- Mono Ethylene Glycol (MEG)
- Ethylene Propylene Diene Monomer (EPDM)
- Ethylene Oxide
- Butene-1

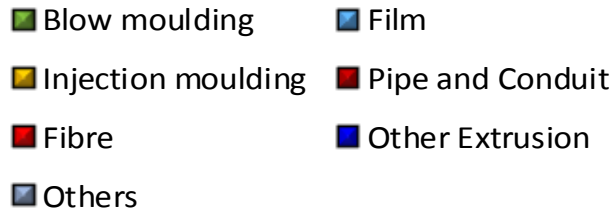
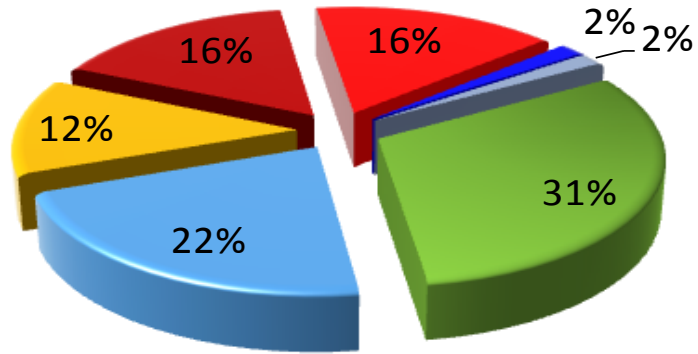
# ETHYLENE DERIVATIVES INDIA MARKET SCENARIO

All quantities are in KTA	2016			2025			Demand % CAGR	Plant Capacity
	Products	Demand	Capacity	Deficit*	Demand	Capacity	Deficit *	2015- 2025 World Scale
	HDPE	2122	1670	620	3930	3384	884	7.20 450
	LLDPE	1536	1670	33	2695	2556	395	6.60 450
	LDPE	714	205	529	1199	610	650	6.10 300
	VAM	159	0	159	262	0	262	5.80 200
	EVA	174	15	160	367	15	354	8.90 200
	Styrene	602	0	602	970	0	970	5.20 500
	PVC	3014	1482	1680	5212	1482	3878	6.50 400
	MEG	2390	1408	1123	5282	1970	3509	9.50 500
	EPDM	53	0	53	141	0	141	18 75
	EO	135	135	0	282	282	0	8.80 -
	BUTENE-1	119	120	11	182	120	74	10.20 40

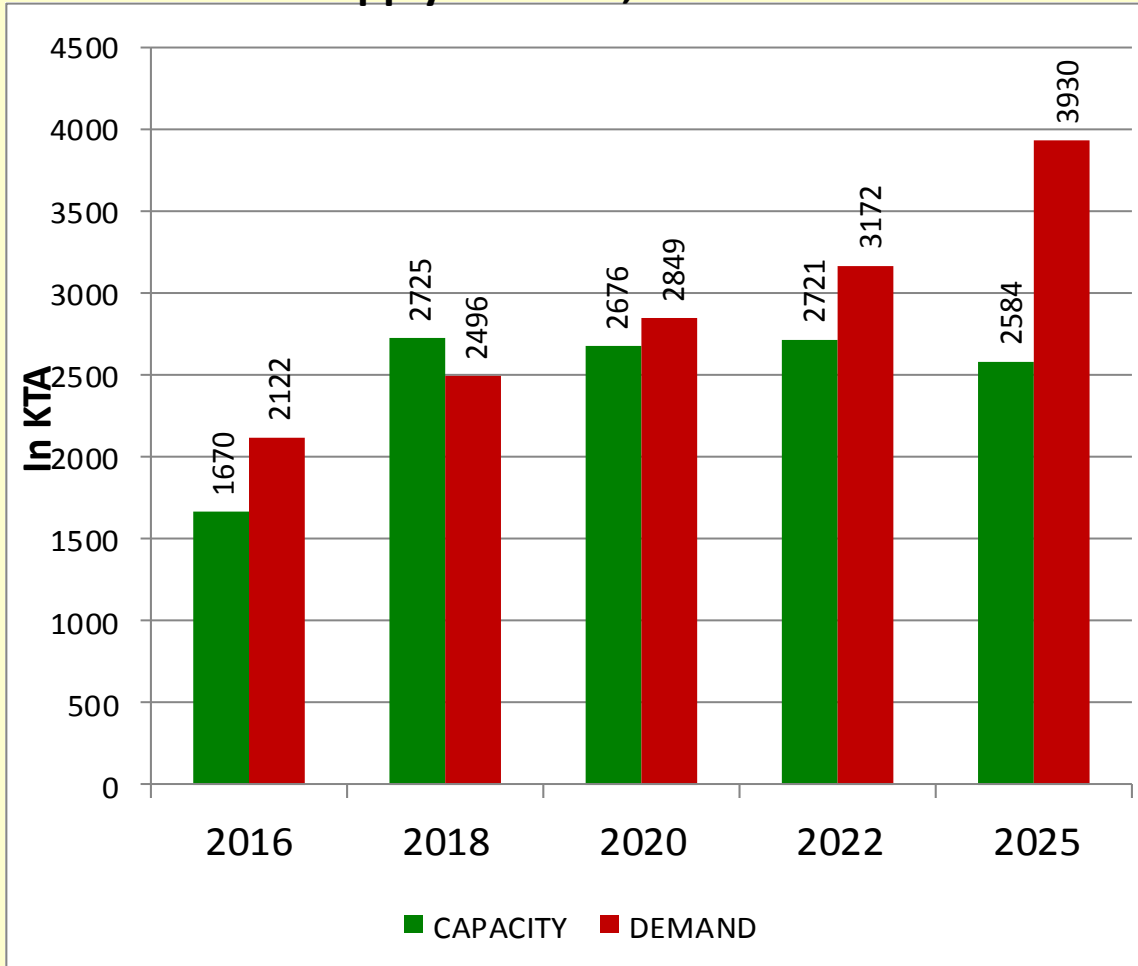
\* Source of Market Data: M/s Nexant

# HDPE INDIA SUPPLY DEMAND

### Sales by Application, 2017

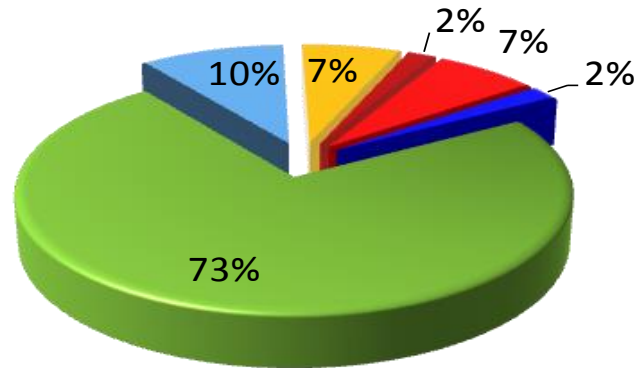


### HDPE Supply Demand, CAGR = 7.2%



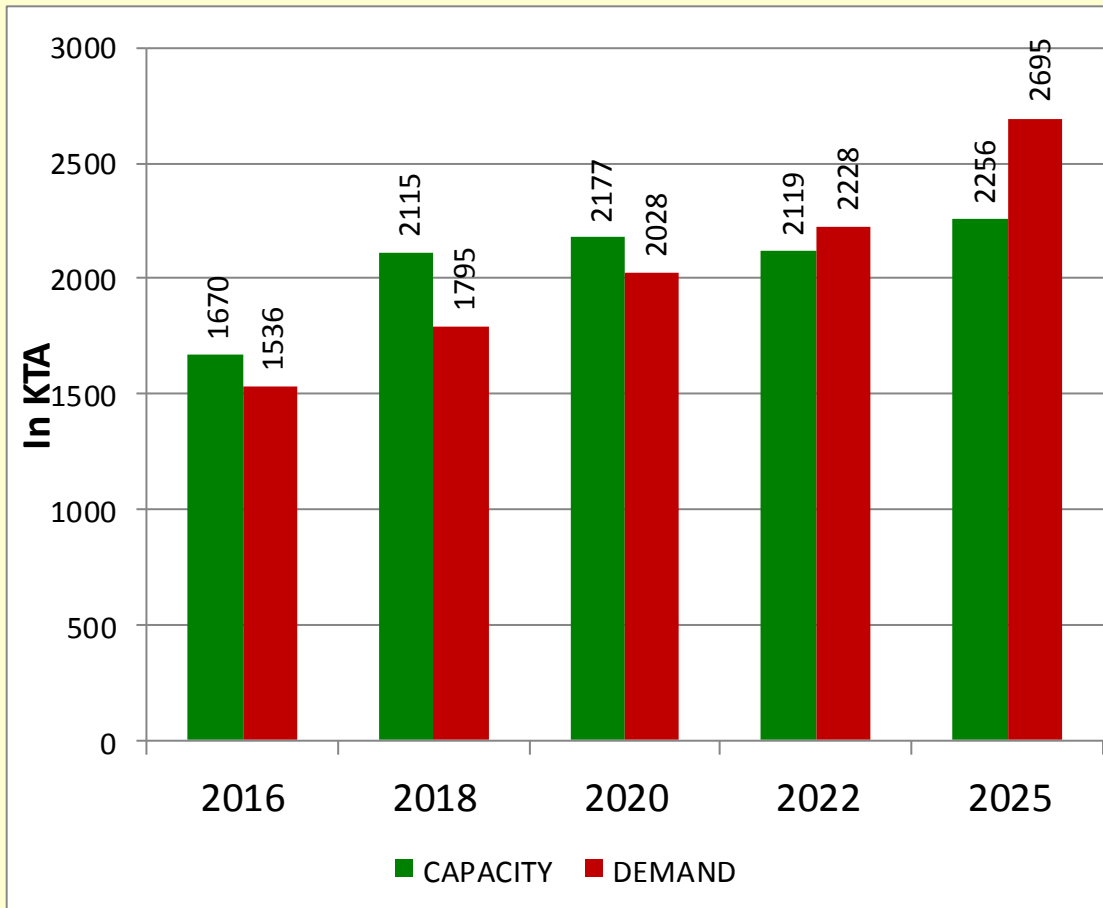
# LLDPE INDIA SUPPLY DEMAND

Sales by Application, 2017



- Film
- Injection moulding
- Rotomoulding
- Other Extrusion
- Extrusion Coating
- Others

LLDPE Supply Demand, CAGR = 6.6%

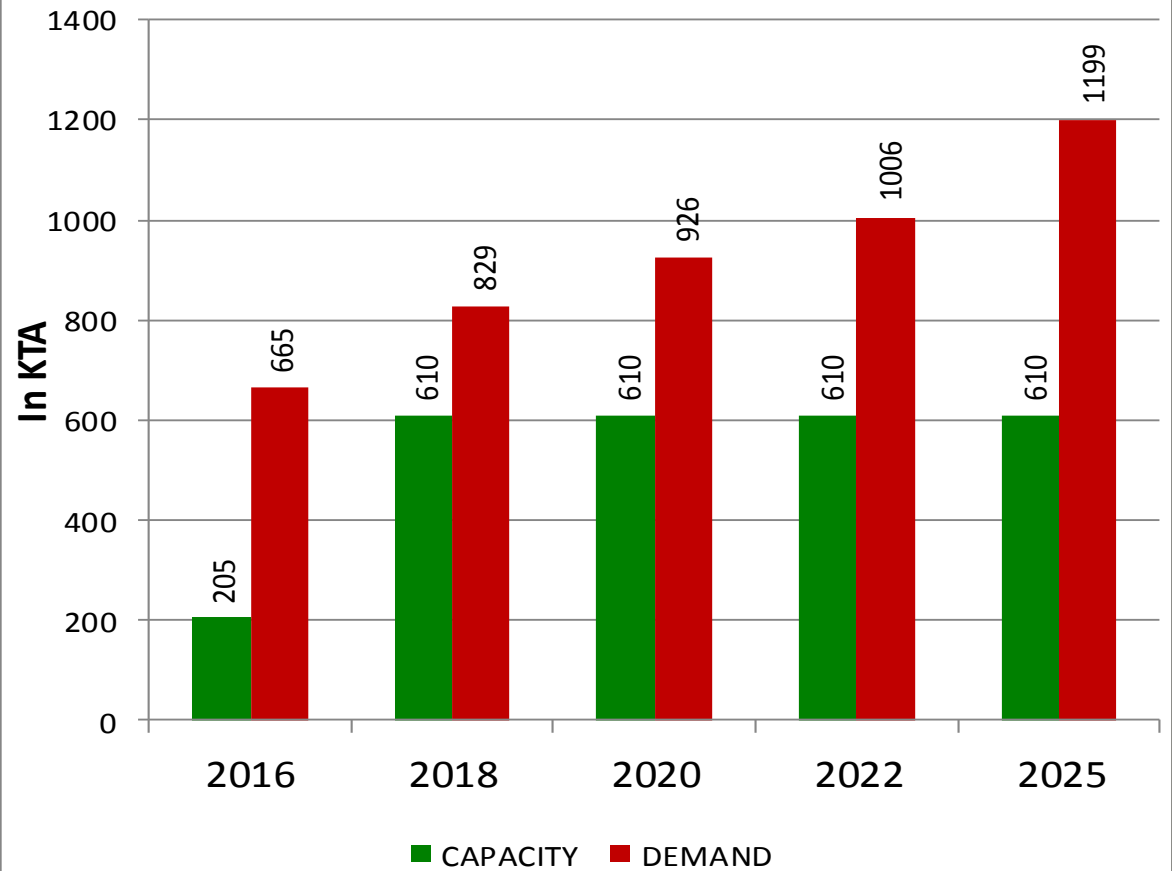
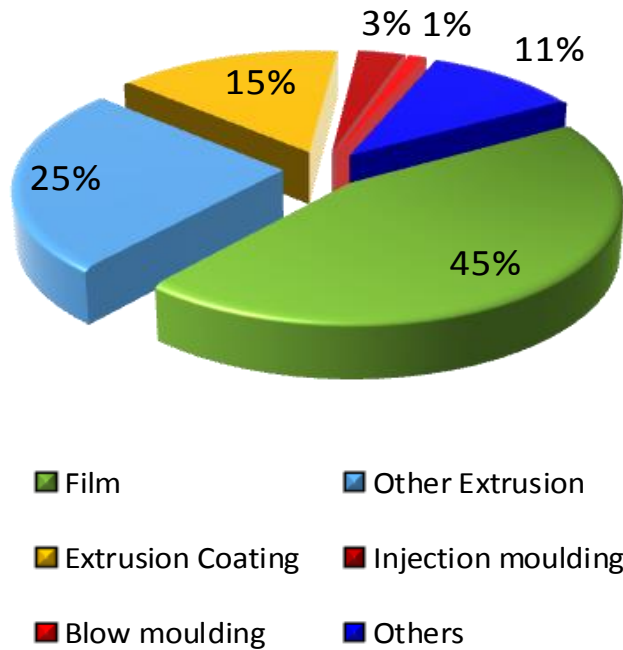


Source: Nexant

# LDPE INDIA SUPPLY DEMAND

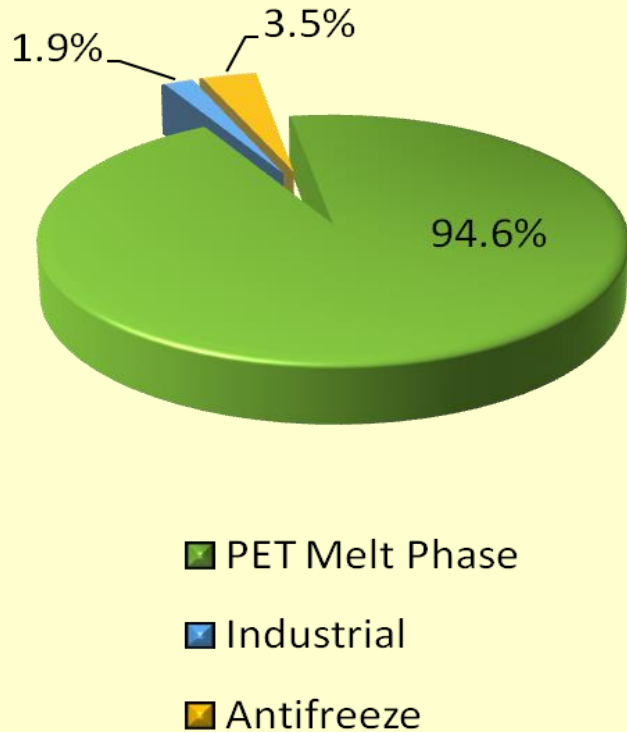
## LDPE Supply Demand, CAGR = 6.1%

Sales by Application, 2017

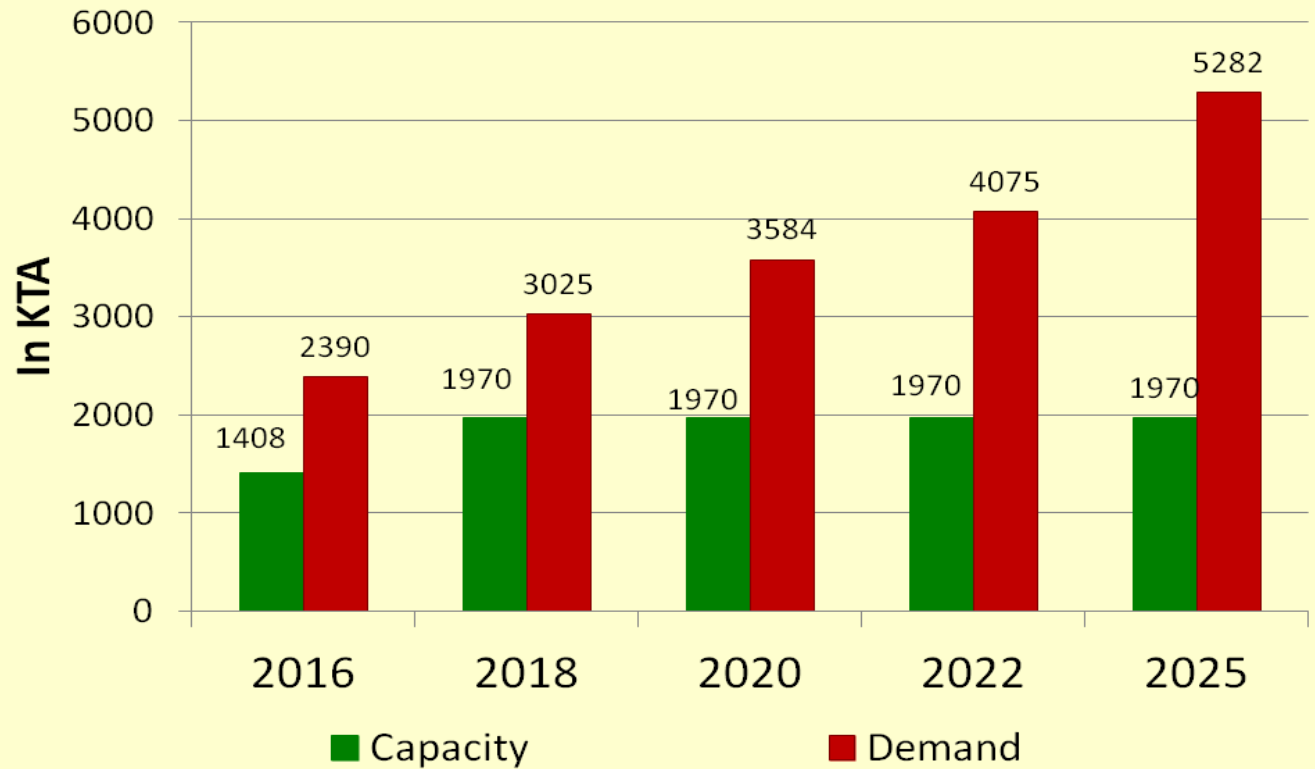


# MEG INDIA SUPPLY DEMAND

### MEG Consumption By Application

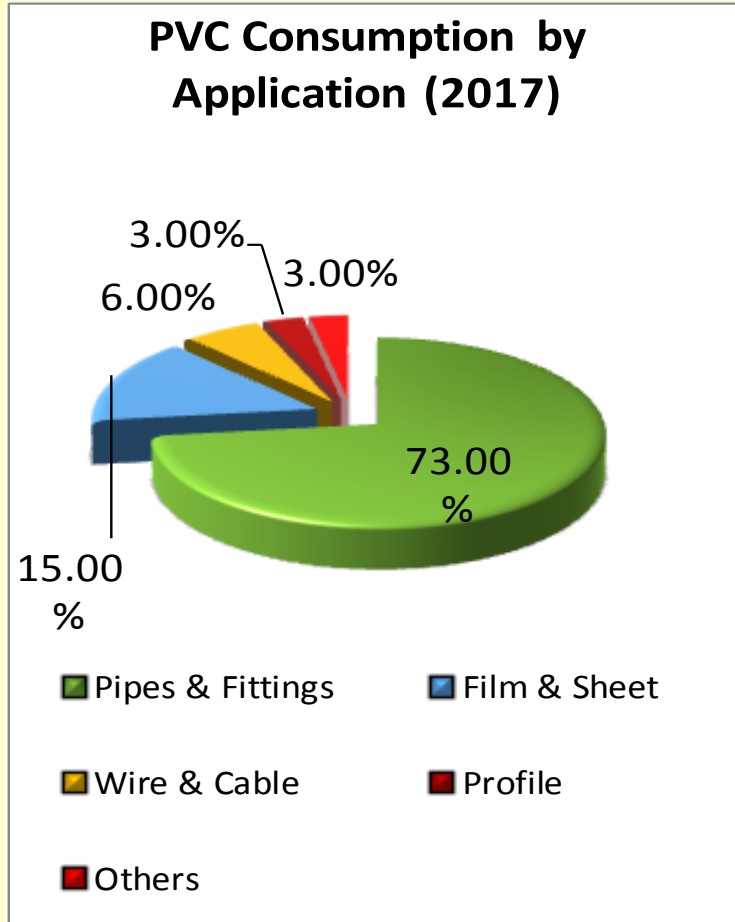


### MEG Supply Demand Scenario, CAGR= 9.5%

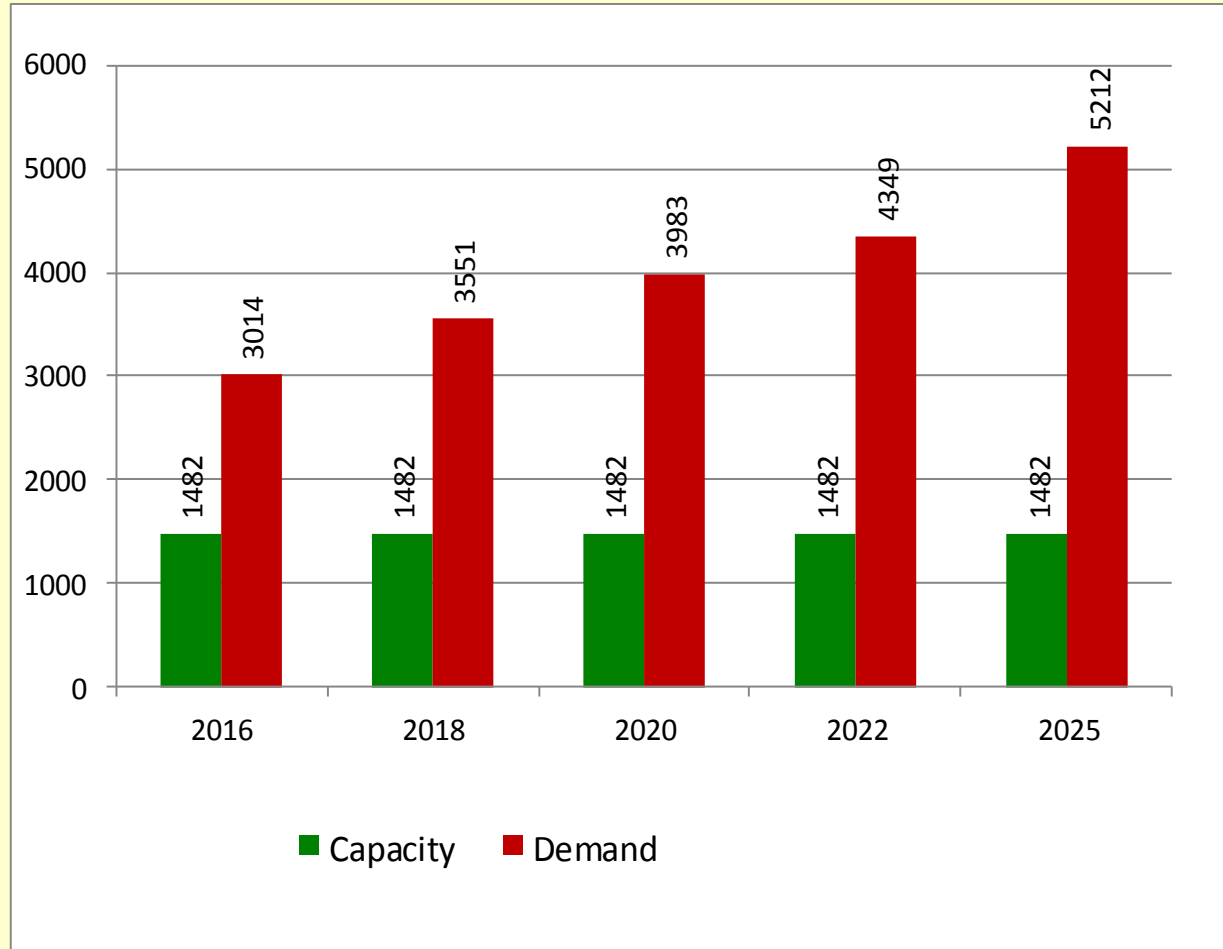




# PVC INDIAN SUPPLY DEMAND



## PVC Supply Demand Scenario (CAGR = 6.5%)

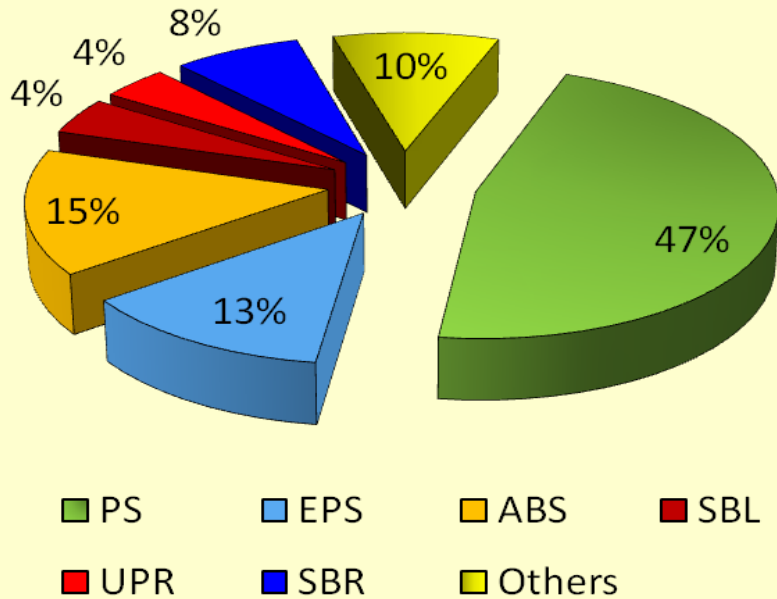


Source: Nexant

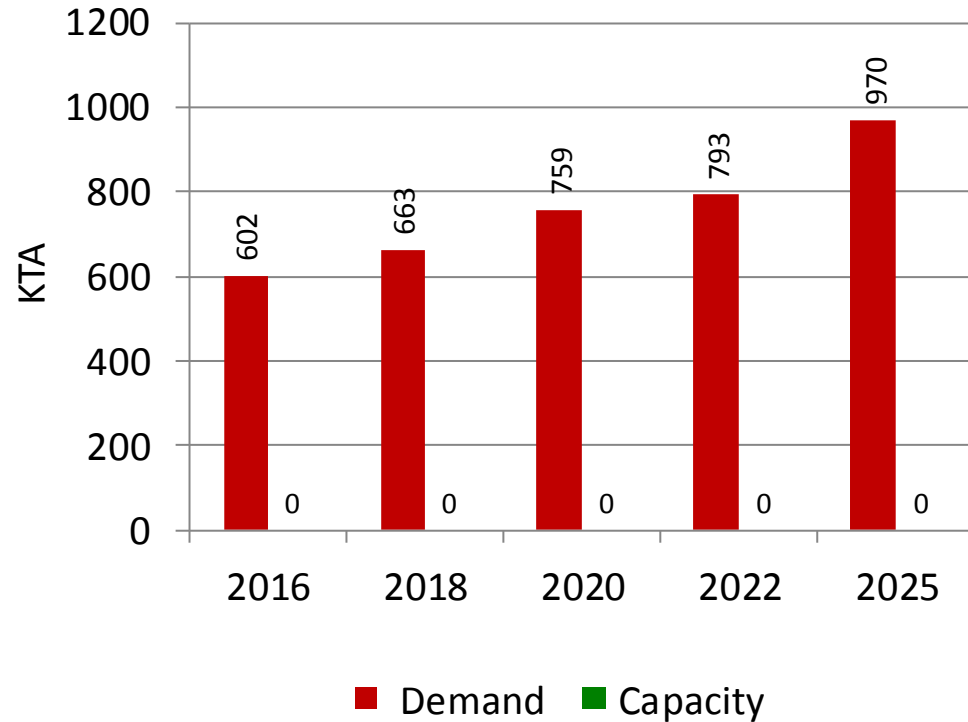
**PVC and its raw material import = 5543 KTA; stagnant production growth**

# STYRENE INDIAN SUPPLY DEMAND

Styrene Sales By Application



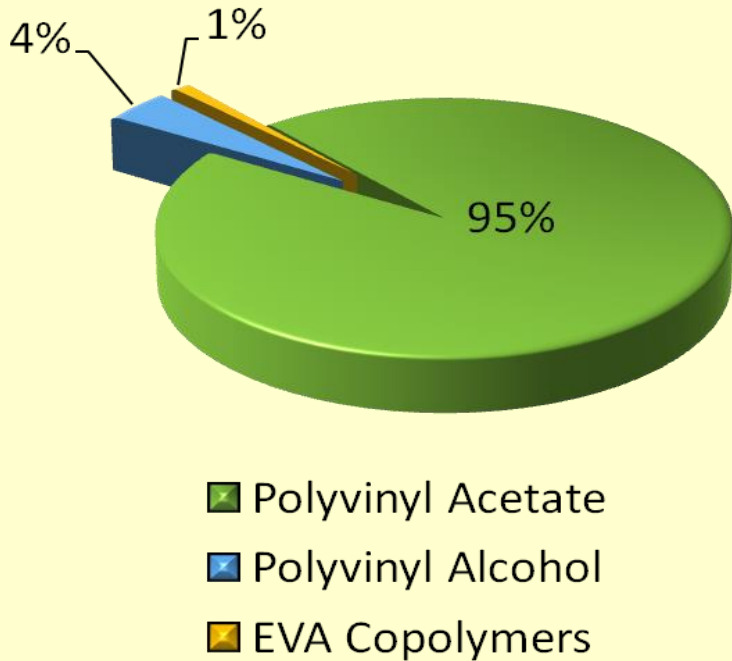
Styrene Demand, CAGR = 5.2%



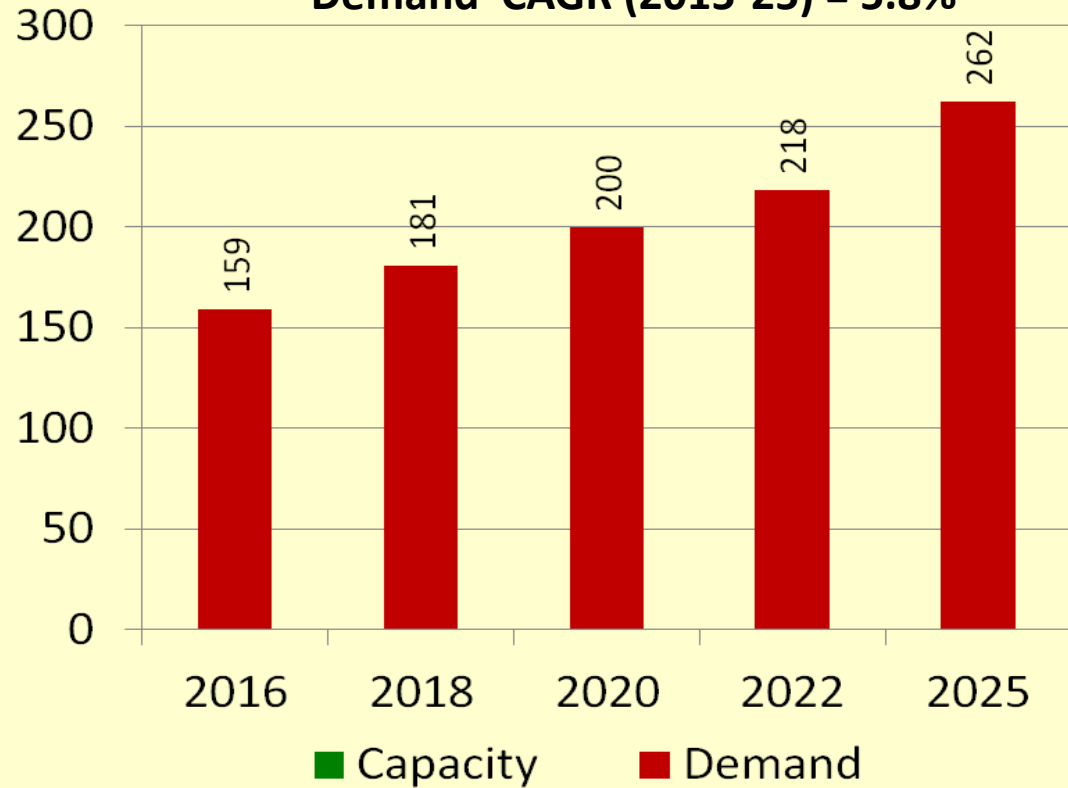
**No Styrene Capacity present in the country.**

# VAM INDIA SUPPLY DEMAND

## VAM Consumption by Application

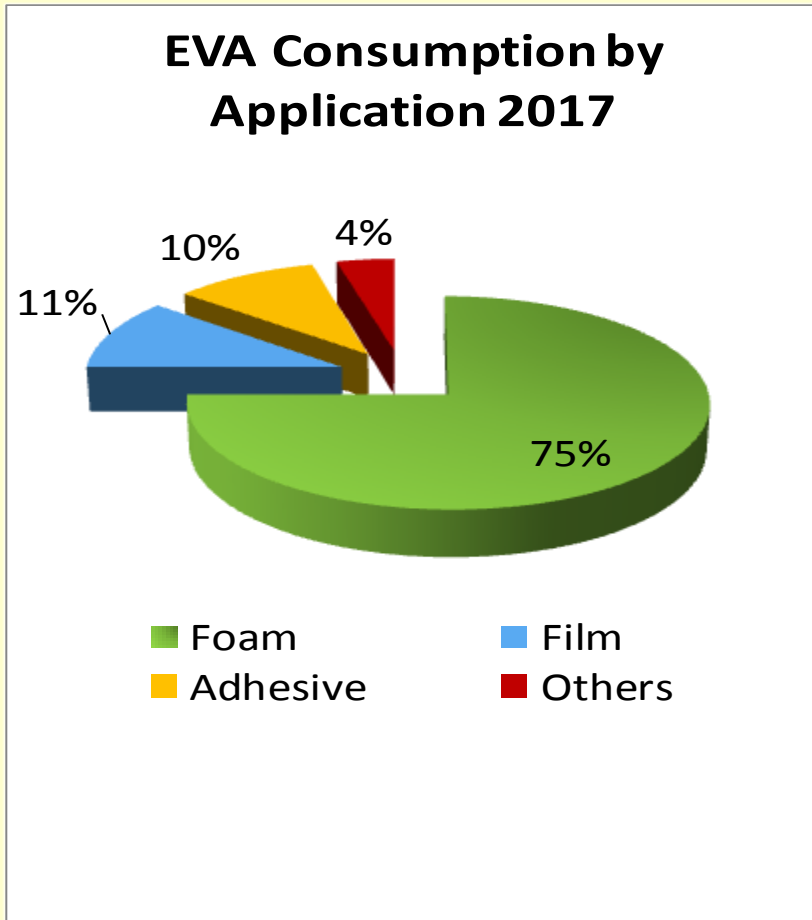


## Supply Demand Scenario Demand CAGR (2015-25) = 5.8%



**No VAM Capacity present in the country.**

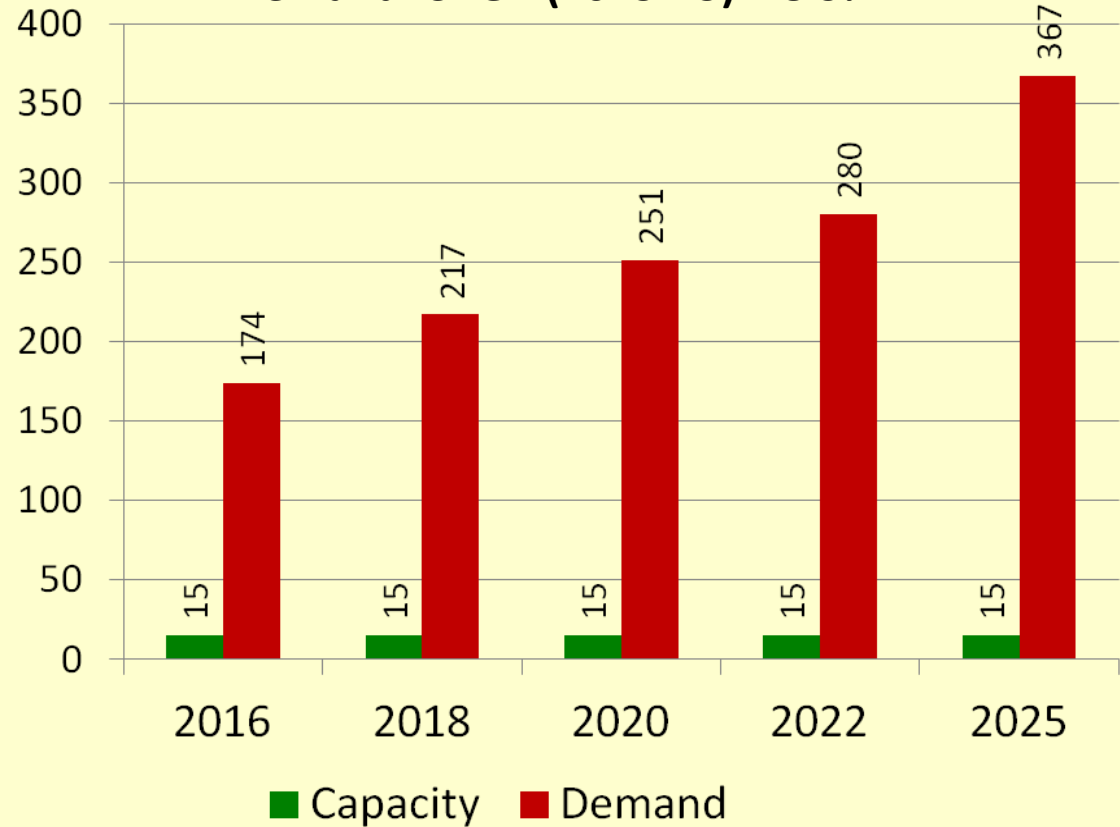
# EVA INDIA SUPPLY DEMAND



Source: Nexant

### Supply Demand Scenario

Demand CAGR (2015-25) = 8.9%



**Insignificant Capacity present in the country.**

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# PRODUCTS COMPETITIVENESS CRITERIA

## PARAMETER

## KEY OBJECTIVES

**Size**



Capture economies of scale

**Location**



Access to low cost feed stocks/ deficit markets

**Technology**



Cost advantage/ product differentiation

**Integration**



Synergies with adjacent facilities/by product off take

# POTENTIAL ETHYLENE DERIVATIVES FOR IMPLEMENTATION

- For most of the Indian Refiners ethylene potential in FCC Off gas: 200 - 300 KTA
- Ethylene availability not sufficient to implement world scale poly-olefin plants esp. HDPE & LLDPE
- MEG, PVC, Styrene and LDPE/EVA potential derivatives for implementation
- Butene-1 and EO markets balanced markets; however any new PE capacity can be accompanied by captive Butene-1 production. Long distance movement of EO is a concern, EO downstream needs to be developed in the vicinity of EO plant.
- EPDM is a growing market with no domestic production. However, world scale EPDM plant would not be able to consume entire ethylene production. Also the project is capital intensive and requires availability of propylene and Ethylidene Norbornene which is imported.

# POTENTIAL ETHYLENE DERIVATIVES FOR IMPLEMENTATION (CONTD..)

## ■ PVC Project

- Availability of low cost Chlorine an imperative
- Alternatively availability of low cost power & assured off take of caustic soda
- East coast could be a potential location with significant caustic soda requirement & import of salt from Australia
- EDC based PVC is also an option but does not fully utilize ethylene available; also EDC market dynamics changing, availability a concern.

## ■ Styrene Project

- Margins typically on the lower side as compared to other derivatives; however availability of benzene from captive/nearby aromatics complex can boost project profitability



## ■ EVA/LDPE

- High demand growth rate due to footwear segment; can be planned as a swing unit of EVA and LDPE with maximization of EVA grades

## ■ MEG

- Highest growing market amongst all ethylene derivatives; delivered cost of MEG based on FCC ethylene comparable with that of imports coming from ME



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# CONCLUSION & KEY TAKE AWAYS

- Development of Petrochemical projects in India would be primarily based on liquid feed stocks/ harnessing of alternate feed stocks.
- Choice of feedstock and technology would aim at extracting value from every single molecule to minimize cash cost of production.
- Recovery of Ethylene from FCC Off Gas involves removal of contaminants and subsequent fractionation of components similar to that of cracker.
- Configuration of ethylene recovery from FCC Off Gas is contingent to Off gas quality, ethylene quantity requirement and integration opportunities available.
- FCC based ethylene can complement ethylene derived from naphtha and act as a good substitute for imported gas based ethylene.
- FCC based ethylene ideal feed for non bulk ethylene derivatives like PVC, Styrene, MEG & EVA/LDPE.



IndianOil

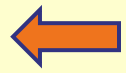
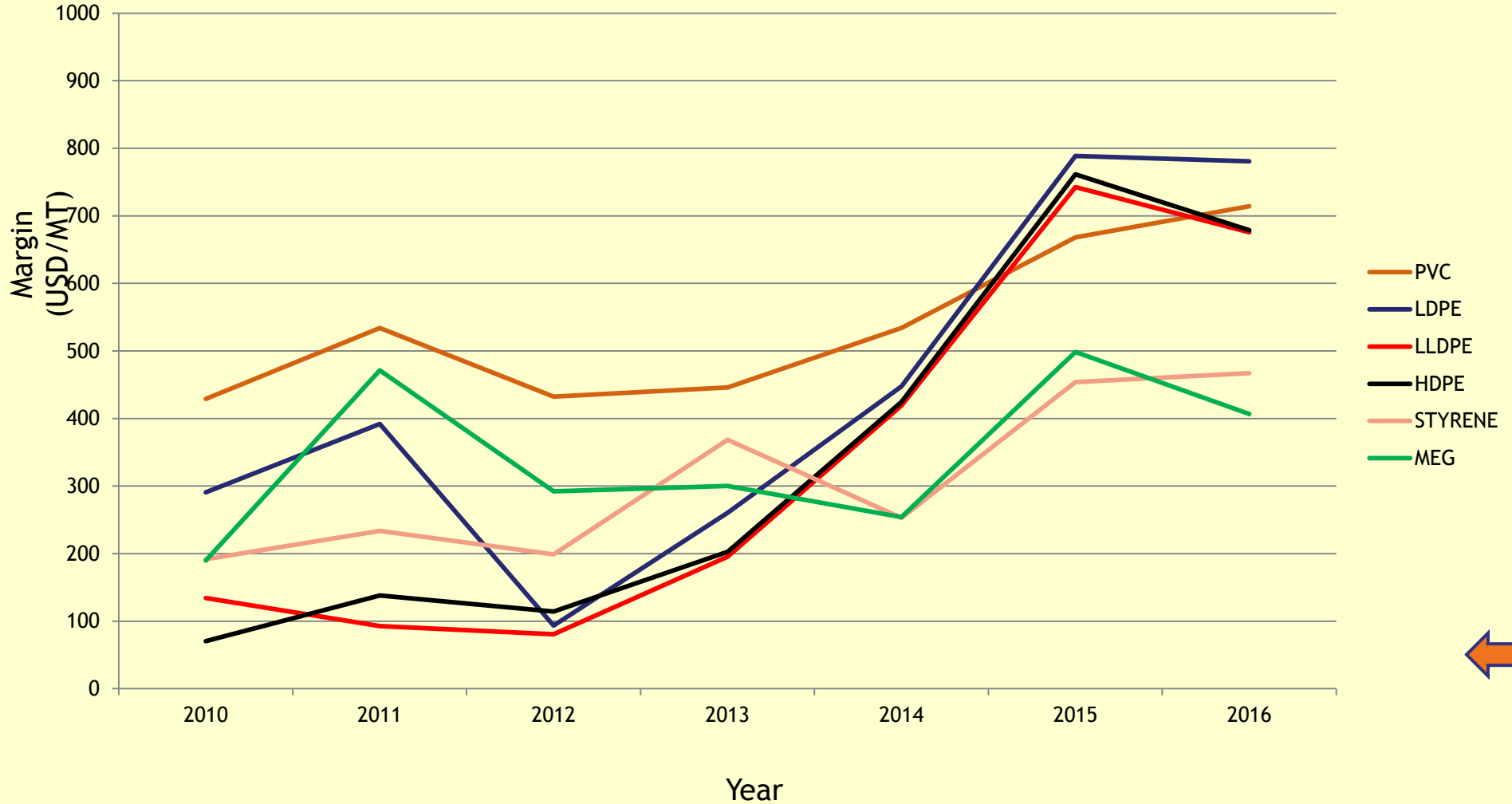
**THANK YOU**



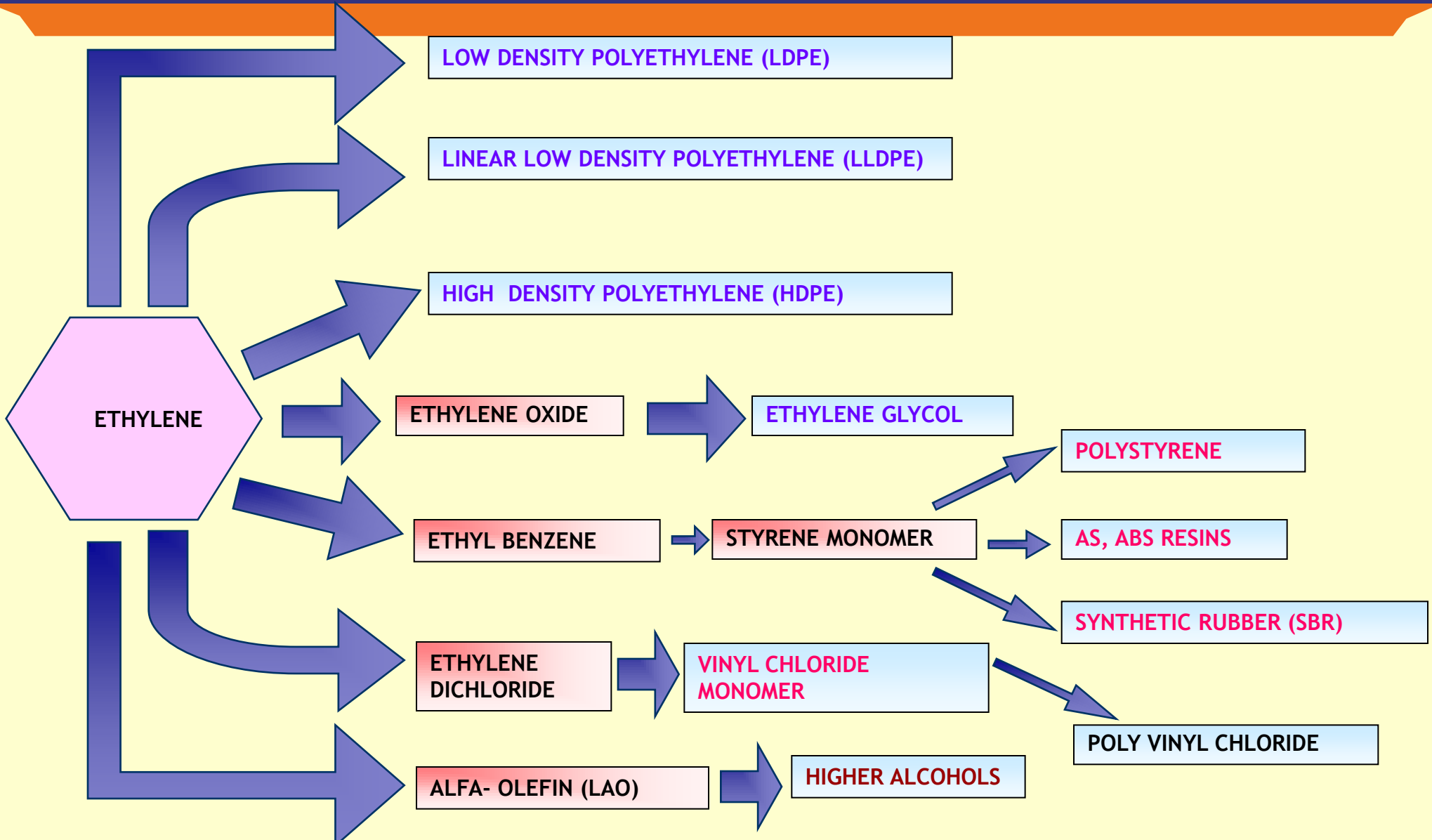
IndianOil

# BACK -UP

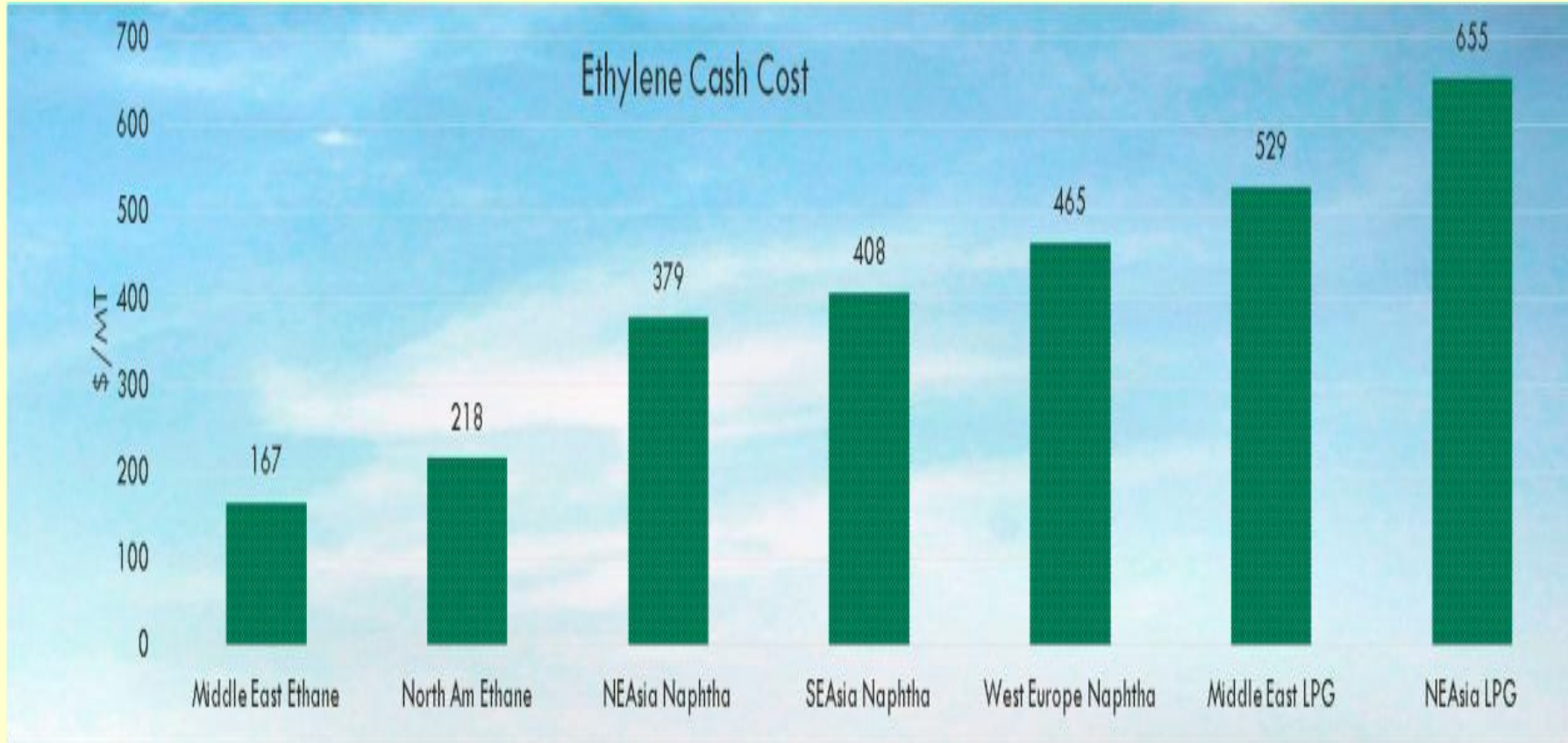
# HISTORICAL MARGINS FOR KEY ETHYLENE DERIVATIVES



# ETHYLENE BASED PETROCHEMICALS/ CHEMICALS



# Ethylene Product Competitiveness based on Feedstock



# PVC Evaluation for Current Crude Oil Prices (50\$/bbl)

	PVC from NCU Based Ethylene	PVC from Petcoke Based Ethylene
Capex (Rs. Cr.)	2810	2810
Ethylene COP 50\$/bbl (Rs/MT)	33227	60300
Chlorine (Rs/MT)	2000	2000
EBIDTA (Rs Cr)	1500	960
EBIDTA/Capex	53%	34%

Source:

- ❑ Capex estimations based on INEOS technology
- ❑ Ethylene COP for NCU based on Lummus model for IOCL PNC,
- ❑ Ethylene COP for Petcoke gasification estimated by Nexant
- ❑ Chlorine prices as per proposal from NALCO.

- Profitability of standalone PVC depends on Chlorine prices as well as source of Ethylene as stated in above table.
- For a particular source of Ethylene, PVC profitability is worse than PE/MEG as evaluated by Nexant for Petcoke gasification based Ethylene as well as evaluated in-house for Panipat Naphtha Cracker Expansion for NCU based Ethylene.