

# Ethylene - Global

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# Ethylene Market: Key Issues



- Ethylene capacity additions globally outpace demand growth in updated forecast (2016/18); but, a demand surge or supply constraint (project start up delays) could leave markets short.
- “Unconventional” sources (CTO, MTO) will add more capacity; steam crackers fed by: ethane, LPG, and naphtha, will continue to drive competitive economics.
- Naphtha crackers required to balance demand swings; weak propylene markets (increasing cash cost) will support higher ethylene prices to keep these assets in the black.
- North America ethylene integrated margins are lower (still profitable) despite new capacity coming on stream.

# Capacity, Demand, and Operating Rates

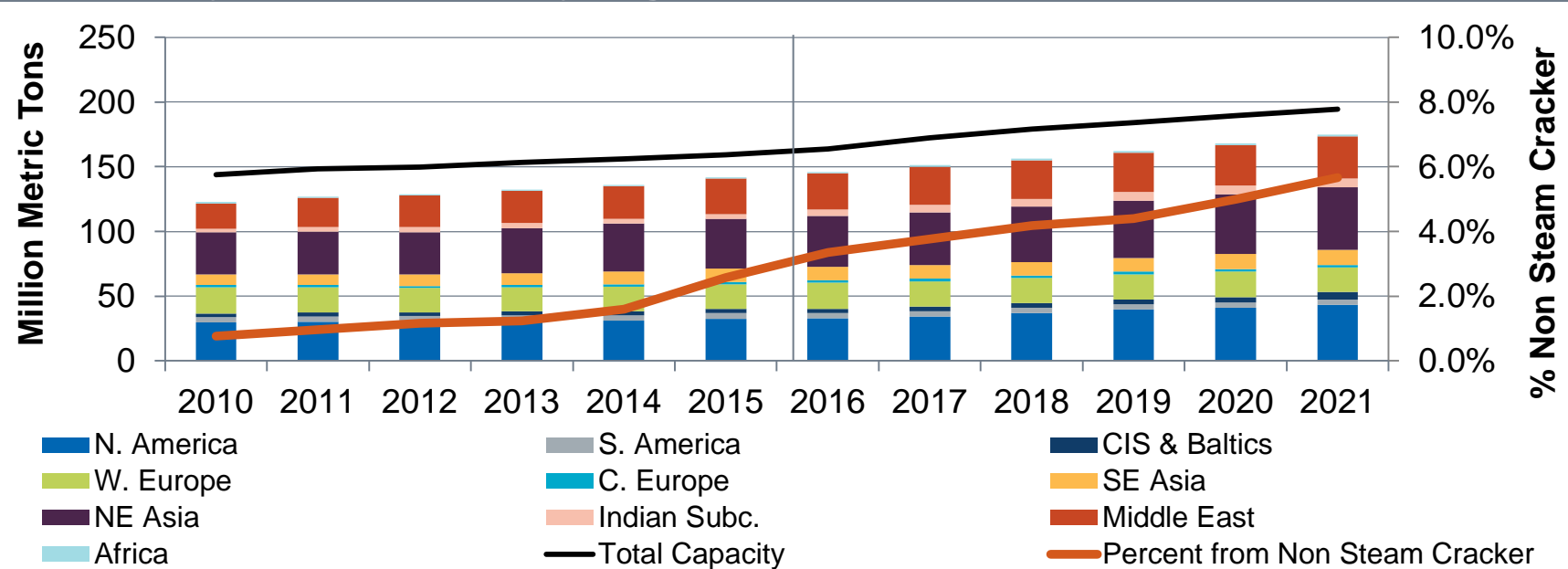
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# Global Ethylene Supply

*Four Main production regions. Non-Traditional Sources on the rise*

## World: Ethylene Production by Region



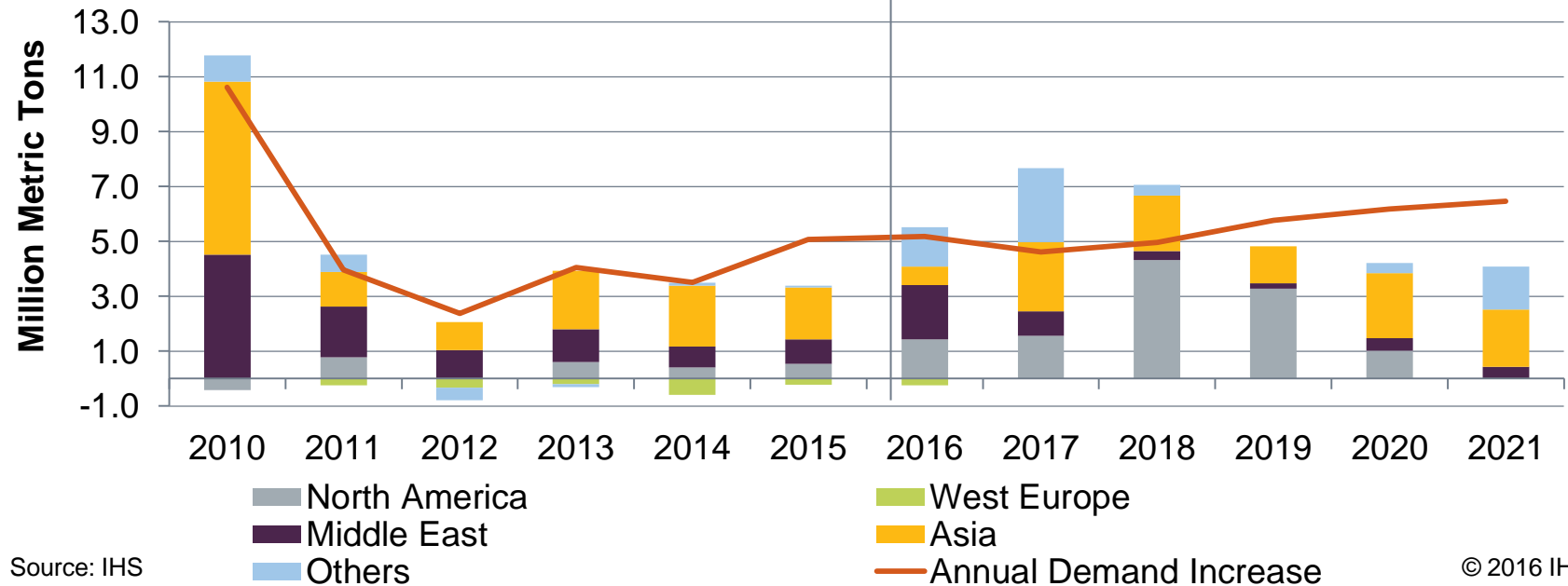
Source: IHS

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# Ethylene Capacity Additions Delayed and Reduced

*Capacity Does Not Equal Supply, inferring margins via these trends is risky.*

Global Ethylene Capacity Additions vs. Demand



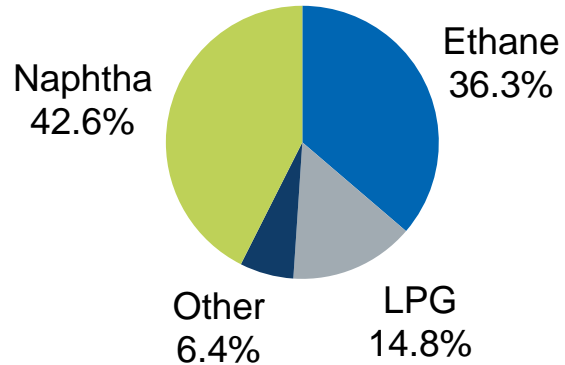
Source: IHS

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# Ethylene Supply by Feed Type

*Volumes by type Up Across the Board driven by ethane and other (CTO/MTO)*

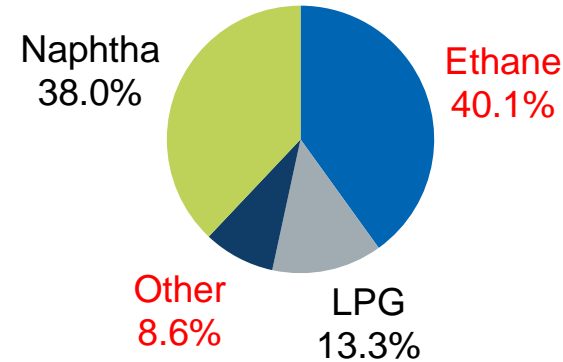
**2016**



Notes: Production = 146,093 Thousand Metric Tons  
Source: IHS

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**2021**



Notes: Production = 174,663 Thousand Metric Tons  
Source: IHS

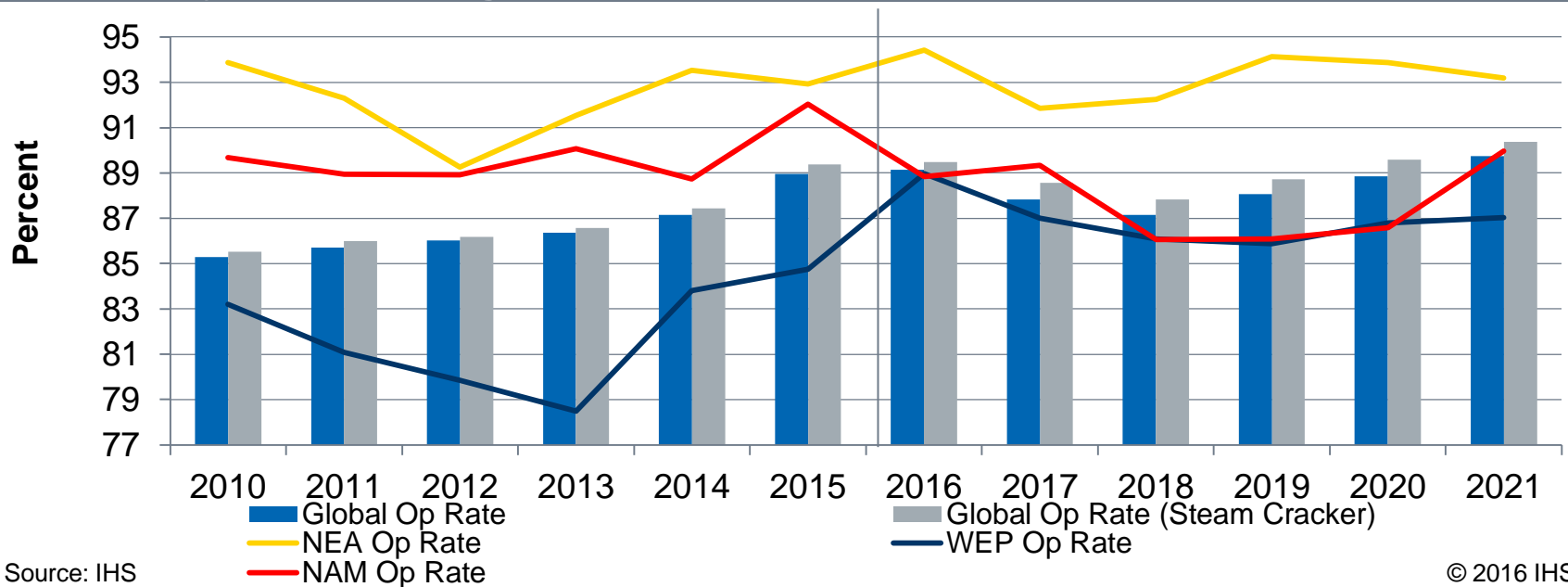
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KTA, ethylene	2016	2021	%AAGR
Naphtha	62,182	66,289	1.3%
Ethane	52,977	69,959	5.7%
LPG	21,610	23,311	1.5%
Other	9,325	15,104	10.1%

# Global Ethylene NAMEPLATE Capacity Operating Rates

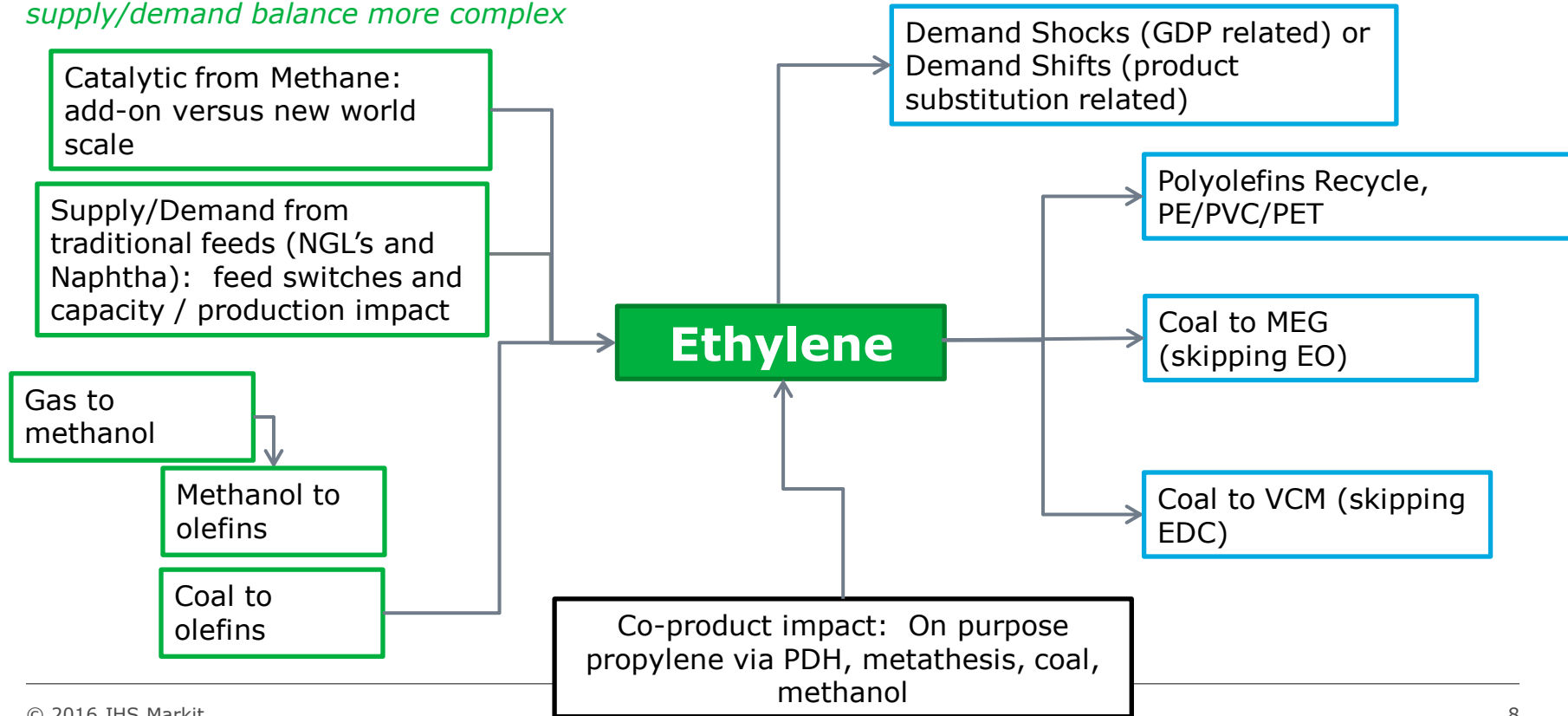
*2015 Peak Not Seen Since Early 2000's, Outlook Stronger, effective operating rates are high – are they sustainable at this level? No spare capacity as seen pre 2013 to absorb project delays.*

## Global Ethylene Operating Rates



# Increasing Complexity In The Ethylene Value Chain

*Emerging changes in ethylene supply drivers and demand drivers make modeling the ethylene supply/demand balance more complex*

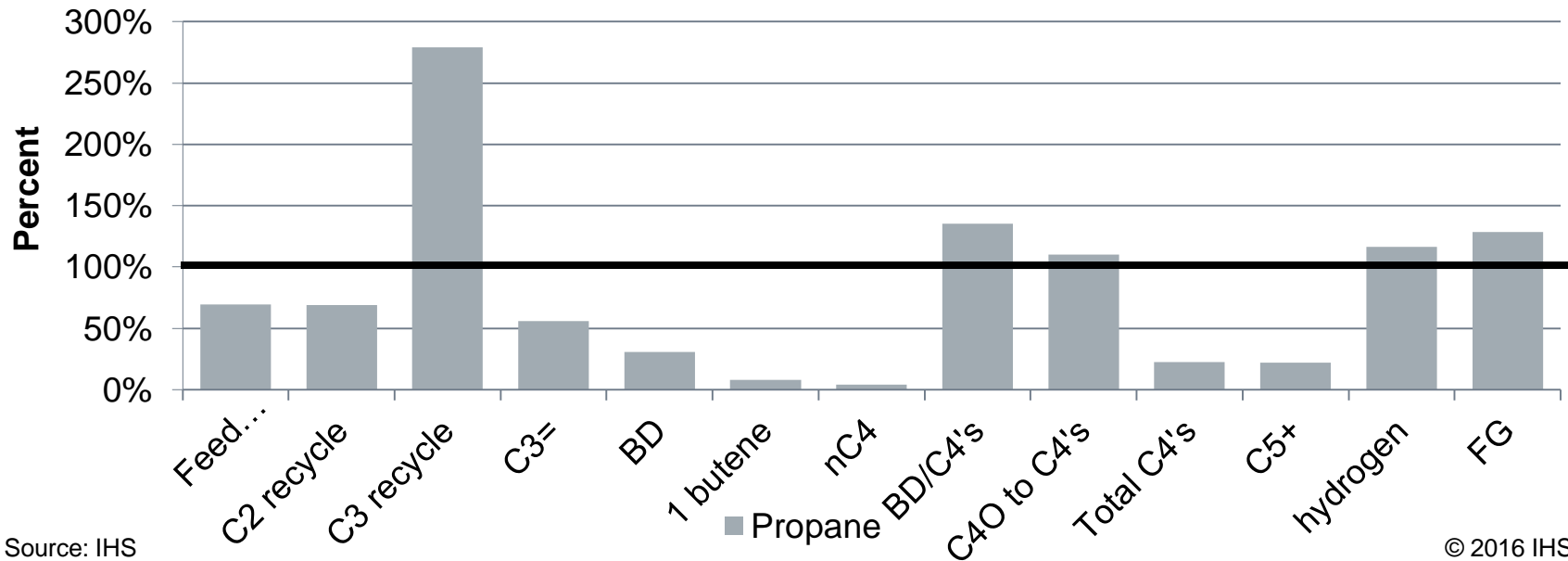




# Yields and Recycles

*So why can't I just switch from Heavy Naphtha to lighter feeds?*

Yields and Recycles(Compared to Full Range Naphtha Feed @ 100%)

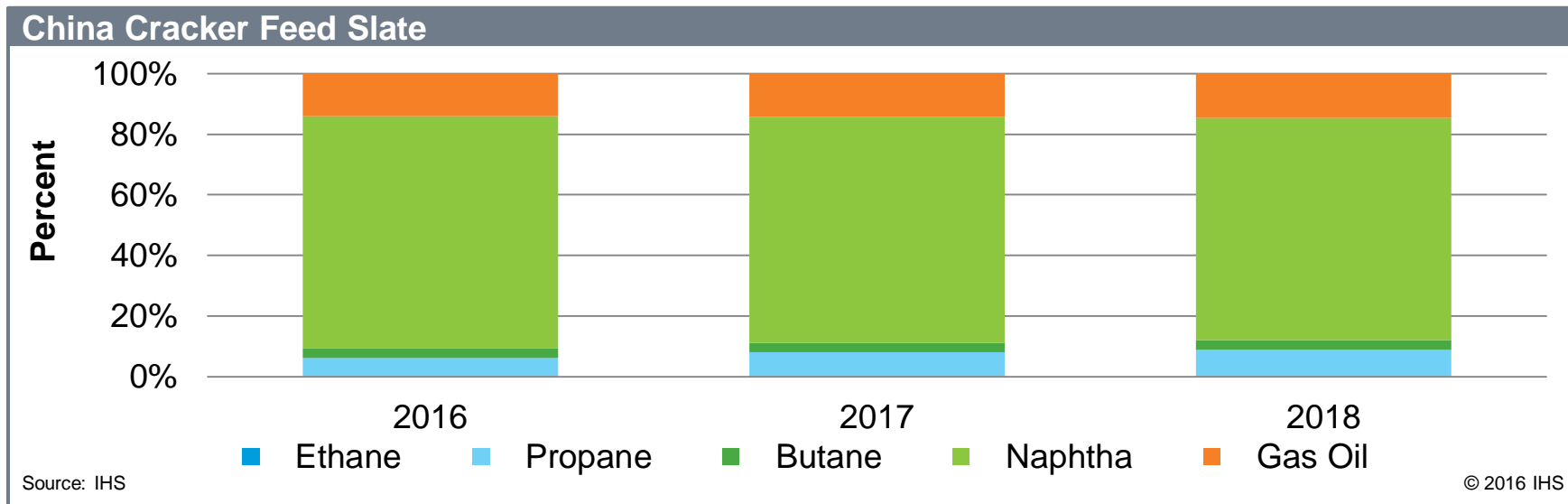


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# China Cracker Feed Slate

*19 MMTA of total ethylene production from crackers ~90% naphtha plus*

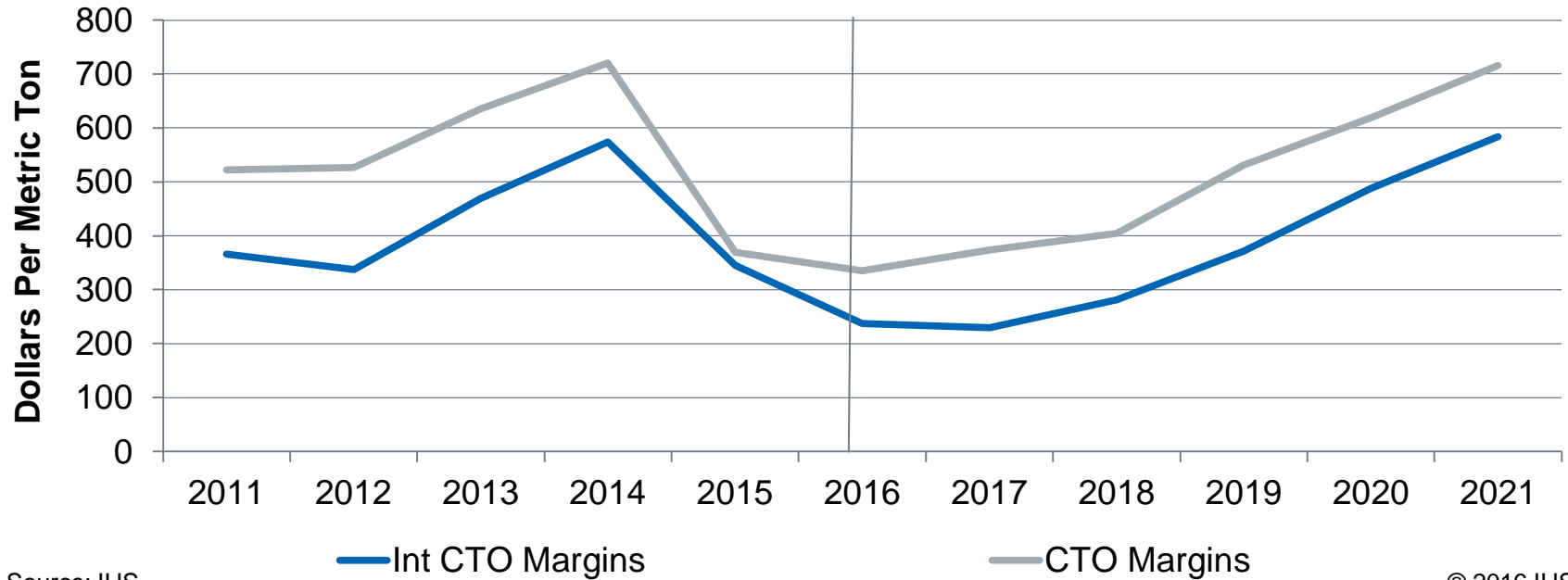


- 15% swap to propane like WEP, with a C3 recovery limit
- Could be a loss of up to 1.5 MMTA of ethylene production capability
- Or about 1% of global nameplate capacity reduction.

# Coal to Olefins / Poly-olefins Outlook on Margins

*Positive margins for all of the coal to olefins units*

## Integrated & Non-Integrated Margins



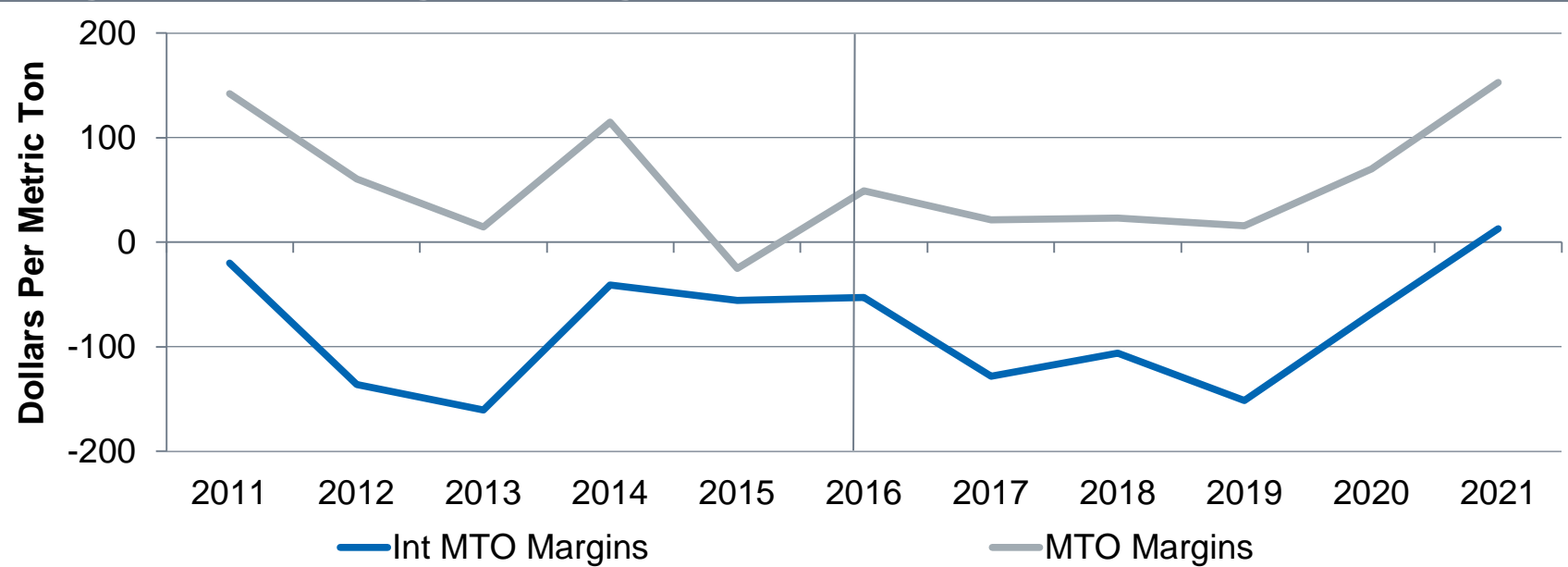
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# Merchant Methanol to olefins and derivatives outlook on Margins

*Will these assets run with negative margins? Product slate for ethylene less PE driven more MEG/vinyls driven. Propylene slate better aligned with global average*

## Integrated & Non-Integrated Margins



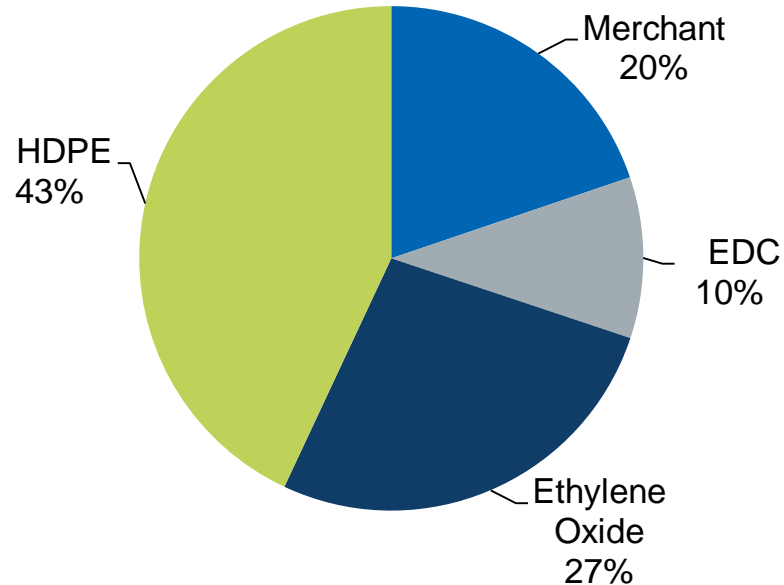
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# MTO/CTO Ethylene Derivatives

*CTO is PE based, MTO more non-PE builds (merchant linked to EO/EB/PE)*

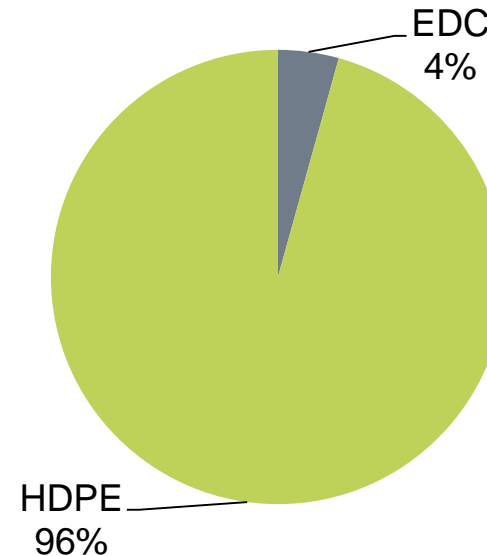
## MTO-Ethylene Derivative



Source: IHS

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## CTO- Ethylene Derivatives



Source: IHS

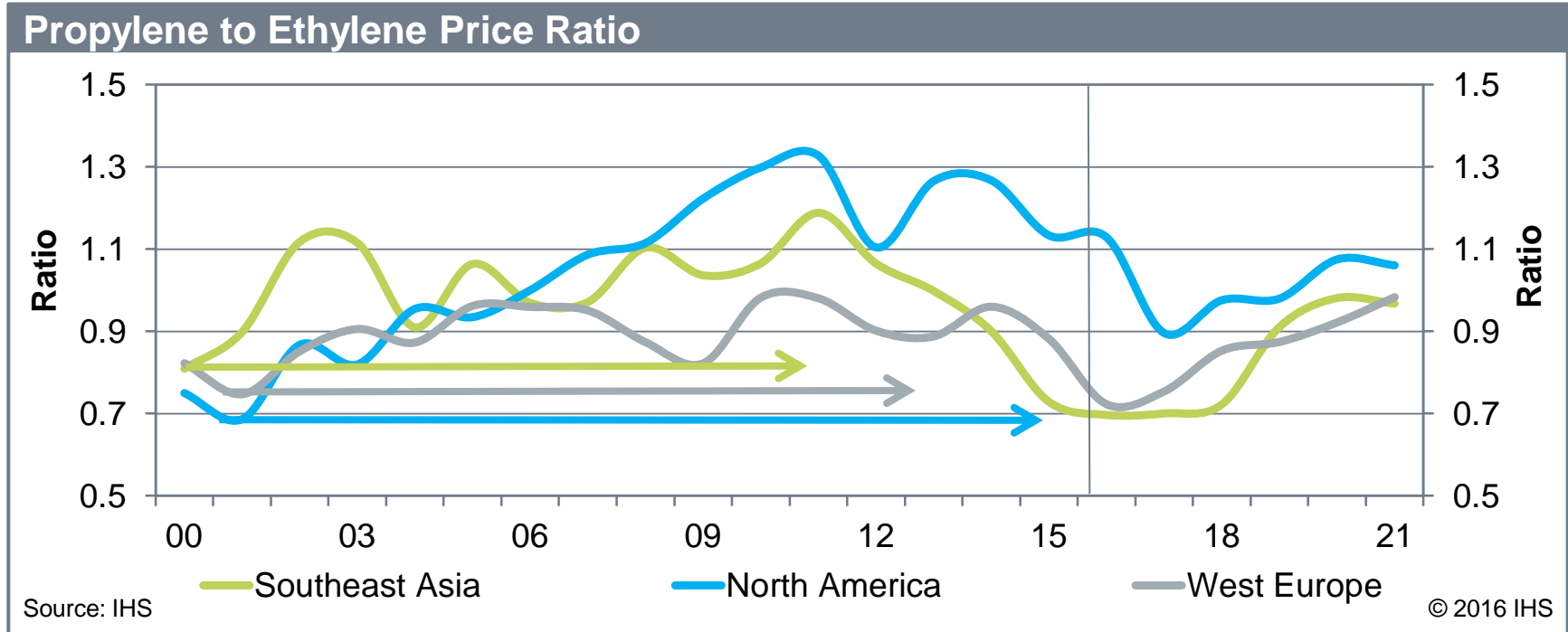
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# Back to Ethylene

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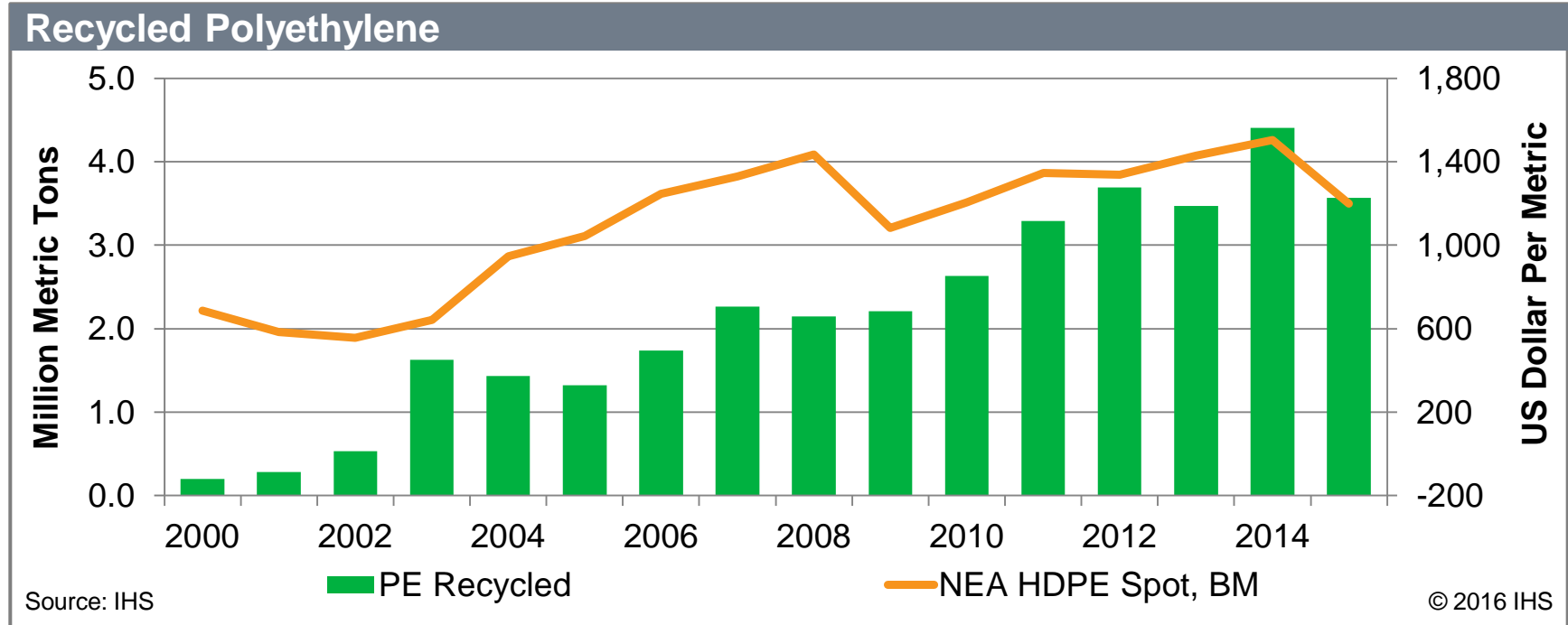
# Propylene Market View

*Propylene to Ethylene Price Ratios, big impact on cash costs – Asia and West Europe below recent history, North America may have bottomed out? But NAM an ethylene story.*



# China PE Recycled Demand

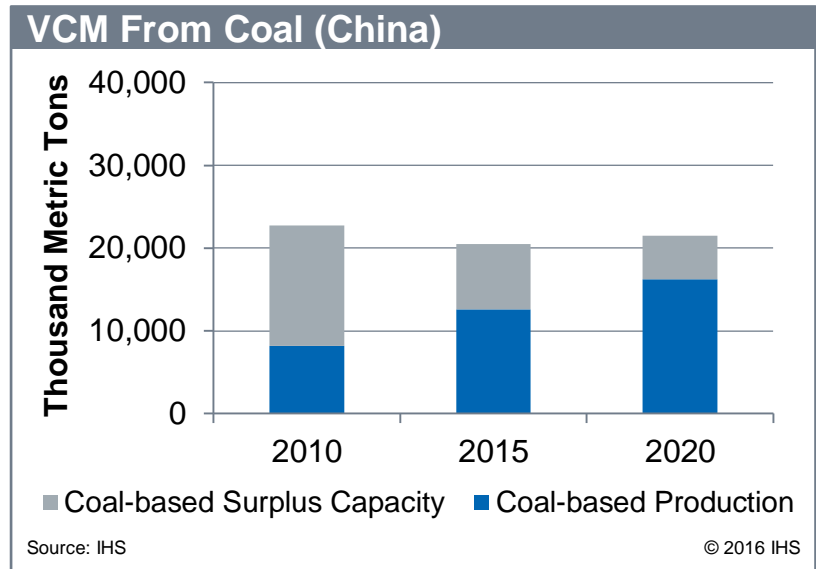
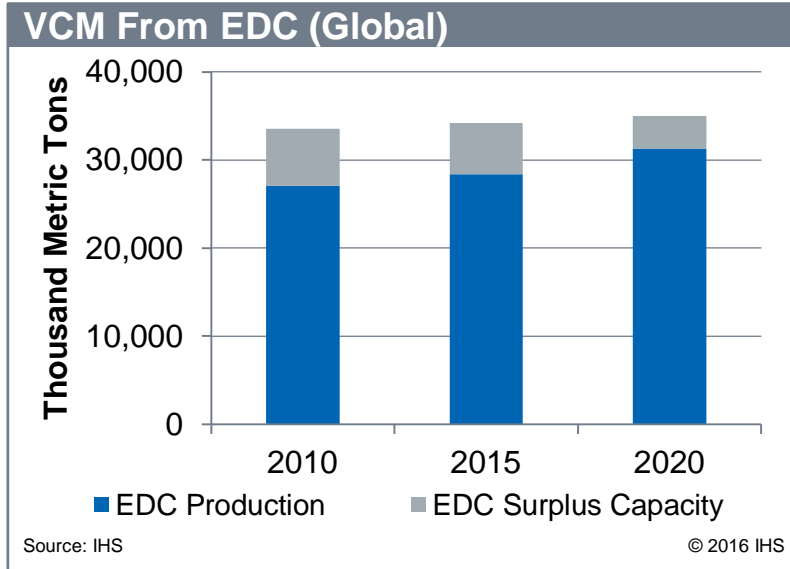
*Continual growth over last 15 years with higher virgin PE prices*





# VCM swing for EDC/Ethylene versus Acetylene/Coal

*China, can swing ethylene demand and pressure ethylene operating rates*



MMTA	2010	2015	2020	2010	2015	2020
CAPS Cont. C2=	16.8	17.1	17.5	11.4	10.3	10.7
Ethylene demand swing	+3.2	+ 2.9	+ 1.9	(7.3)	(4.0)	(2.6)

# Feedstocks Pricing

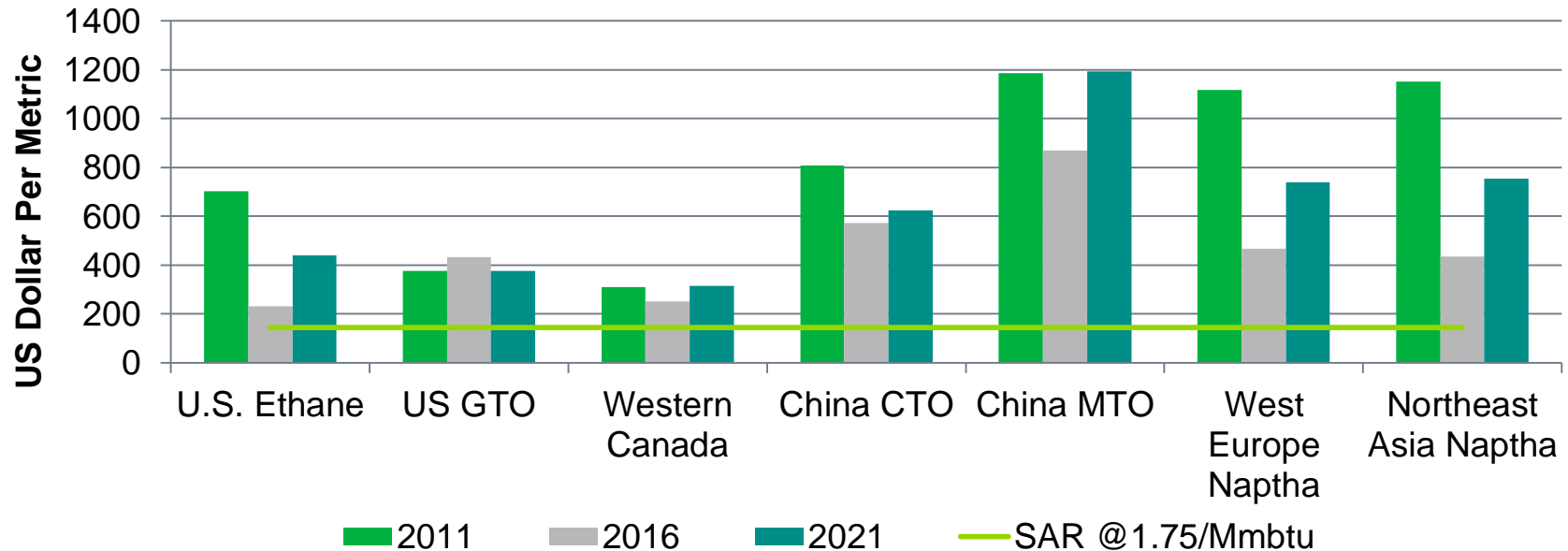
## Ethylene: Costs, Pricing, Margins

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# World Cash Costs

*US loses some cost advantage but maintains about \$400/ton*

## World Ethylene Cast Cost Comparison

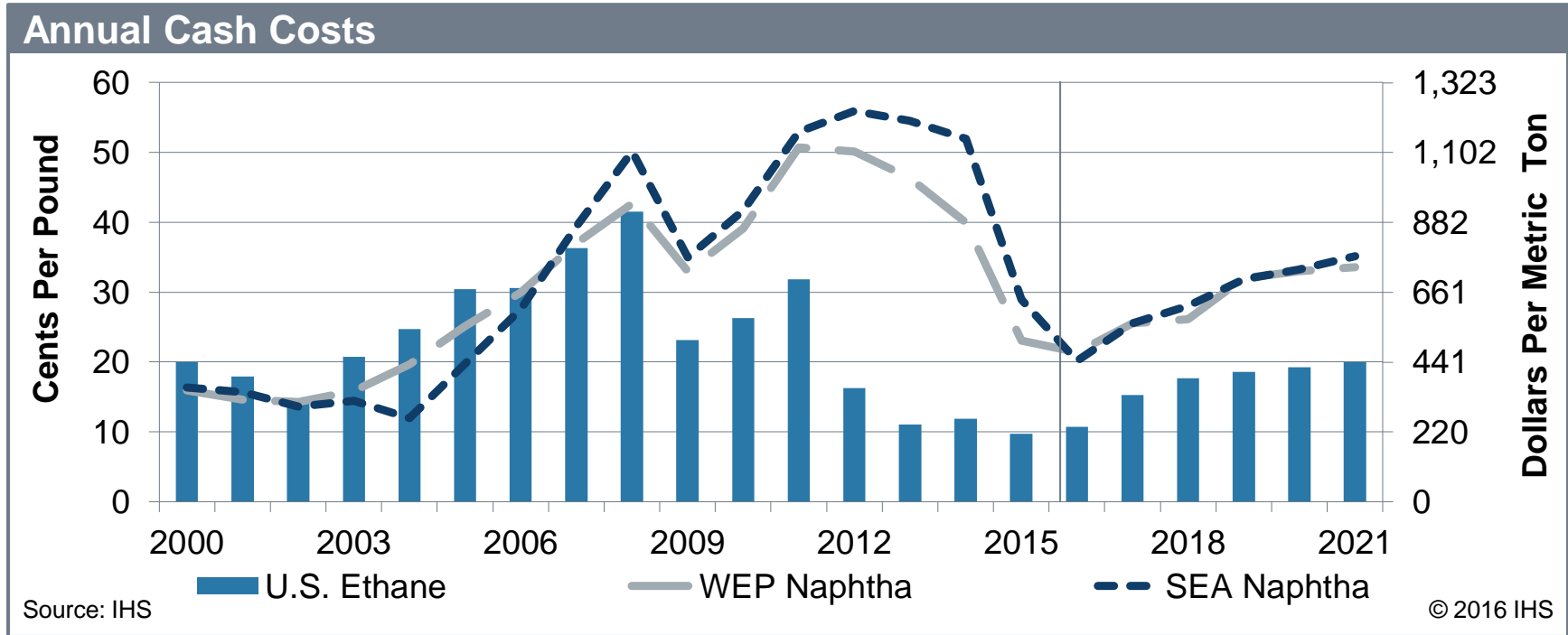


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# Regional Ethylene Cash Costs

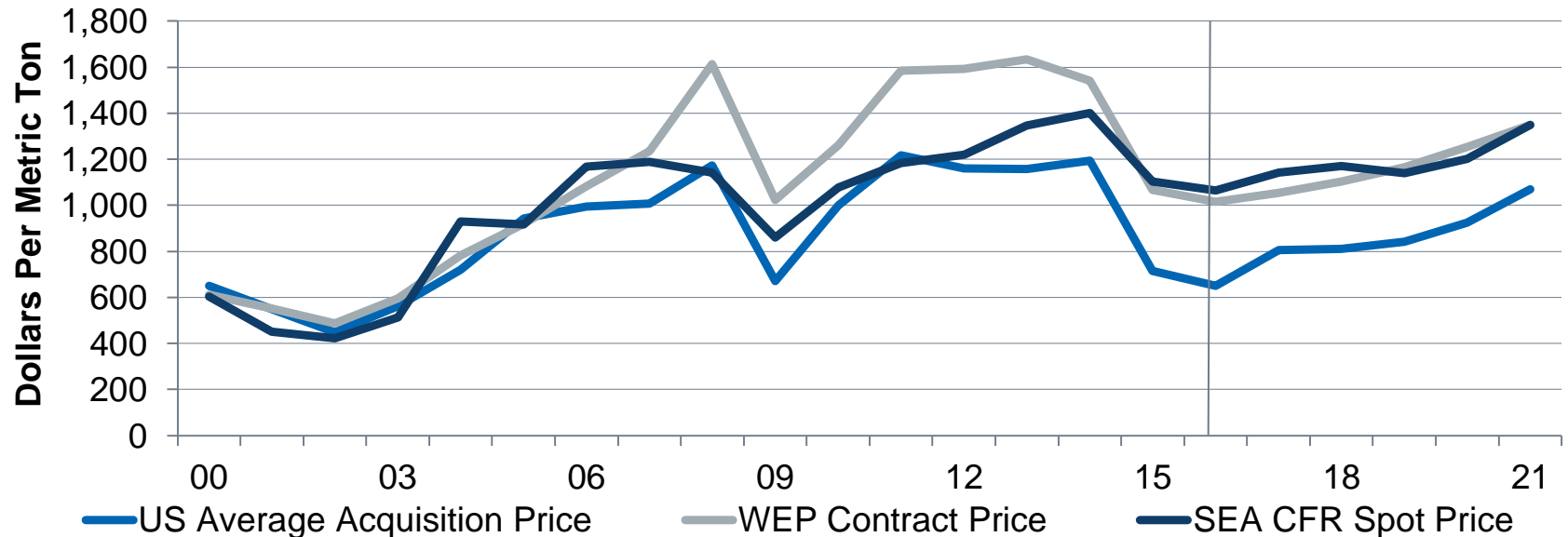
*Energy drives the longer term cost structure as does ethane demand growth*



## Regional Ethylene Prices

*Average Acquisition in US moves up with higher cash cost on ethane feed*

### Global Annual Ethylene Prices



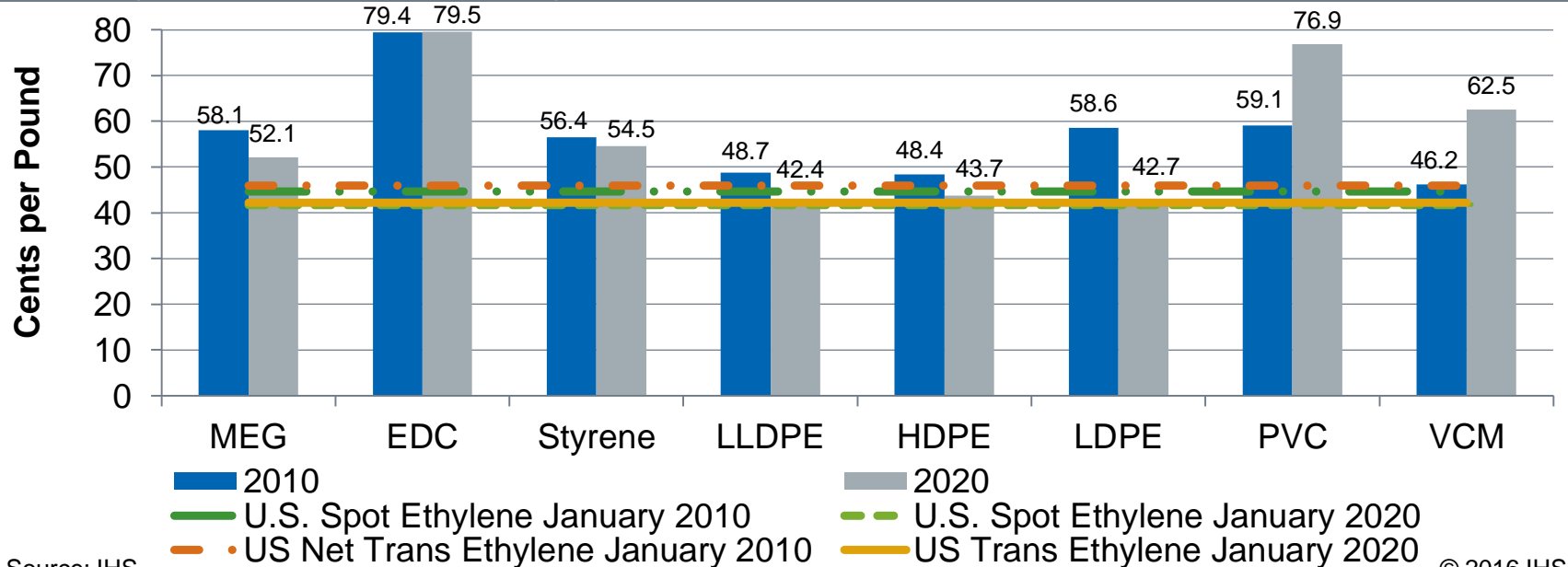
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# Ethylene Market View

*US Ethylene Spot Affordability (using spot/export derivative pricing)*  
*.....Room to be a bit more Bullish for ethylene pricing.*

## US Ethylene Spot Affordability



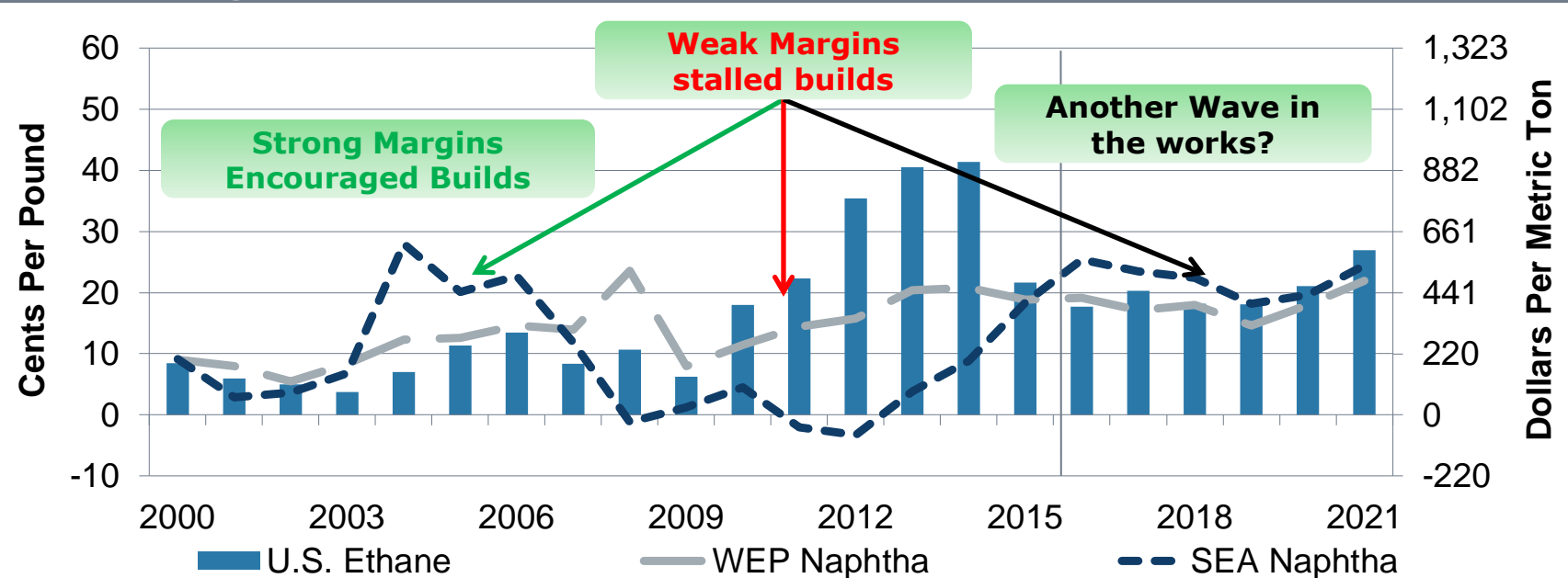
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# Regional Ethylene Cash Margins

*Asia margins driving capacity additions*

## Annual Margins



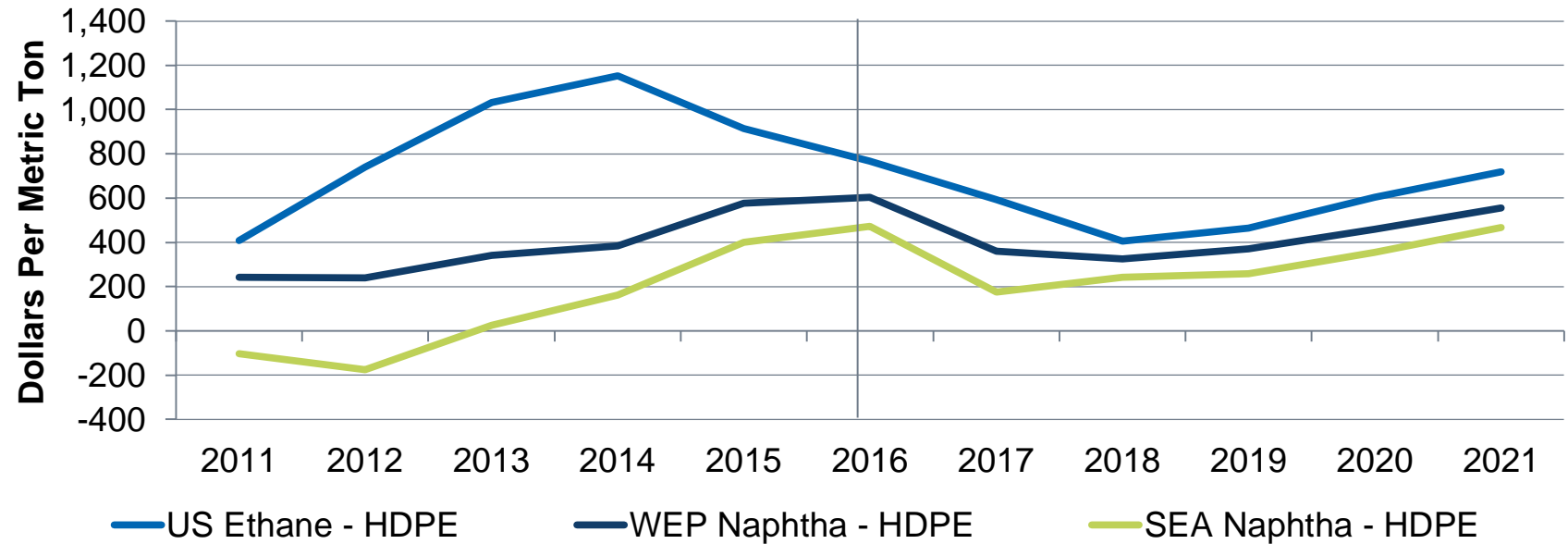
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## HDPE Integrated Margins -similar story

*Integrated Margins to PE off peaks. Asia still strong versus recent history.*

### Integrated HDPE Margins

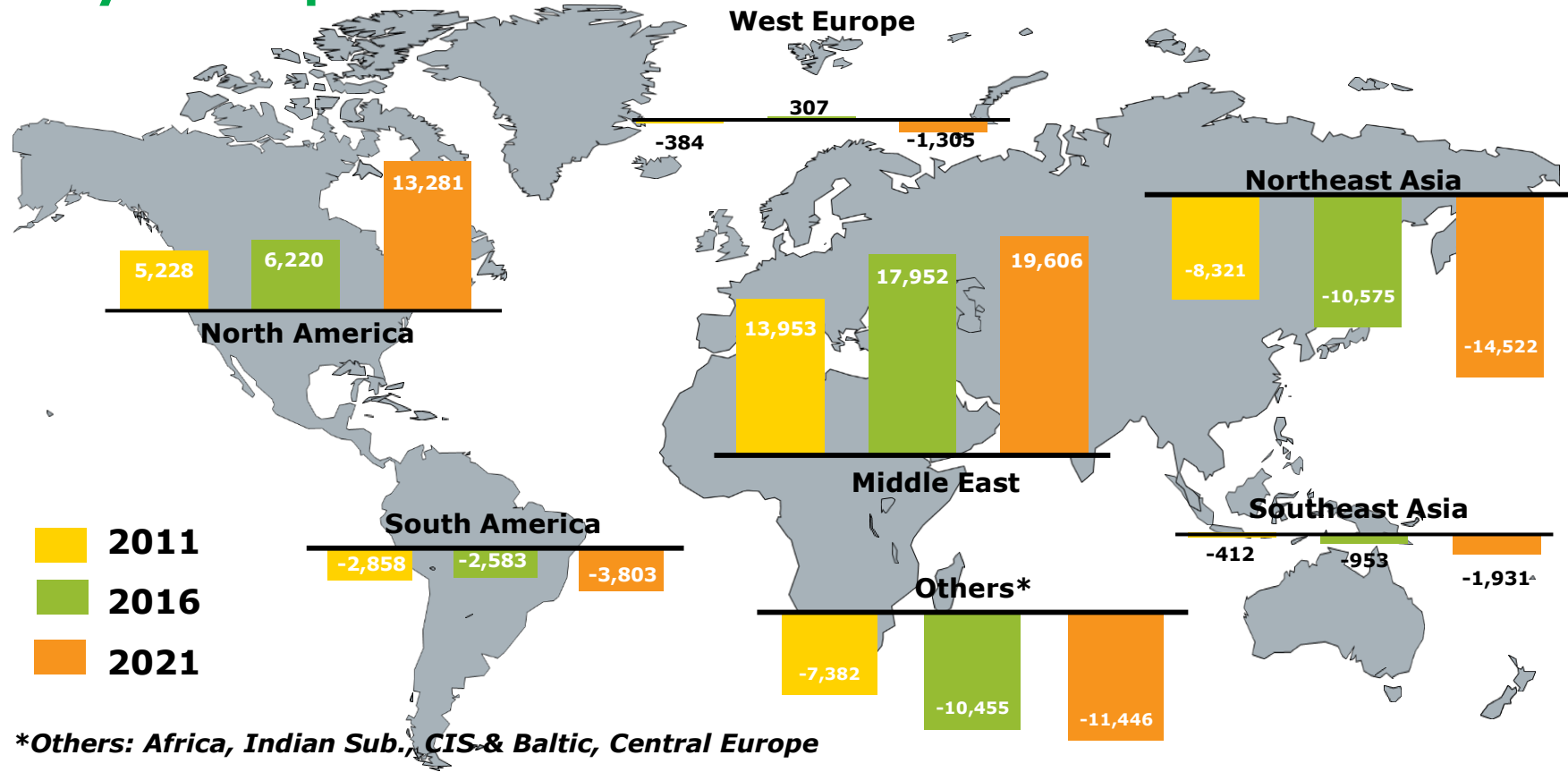


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# Ethylene Equivalent Trade Flow



# US Ethylene Capacity Wave

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# North America Ethylene Capacity Growth – (-000- Metric Tons)

*Firm through 2021/22, Shell Monaca, PA was last to FID*

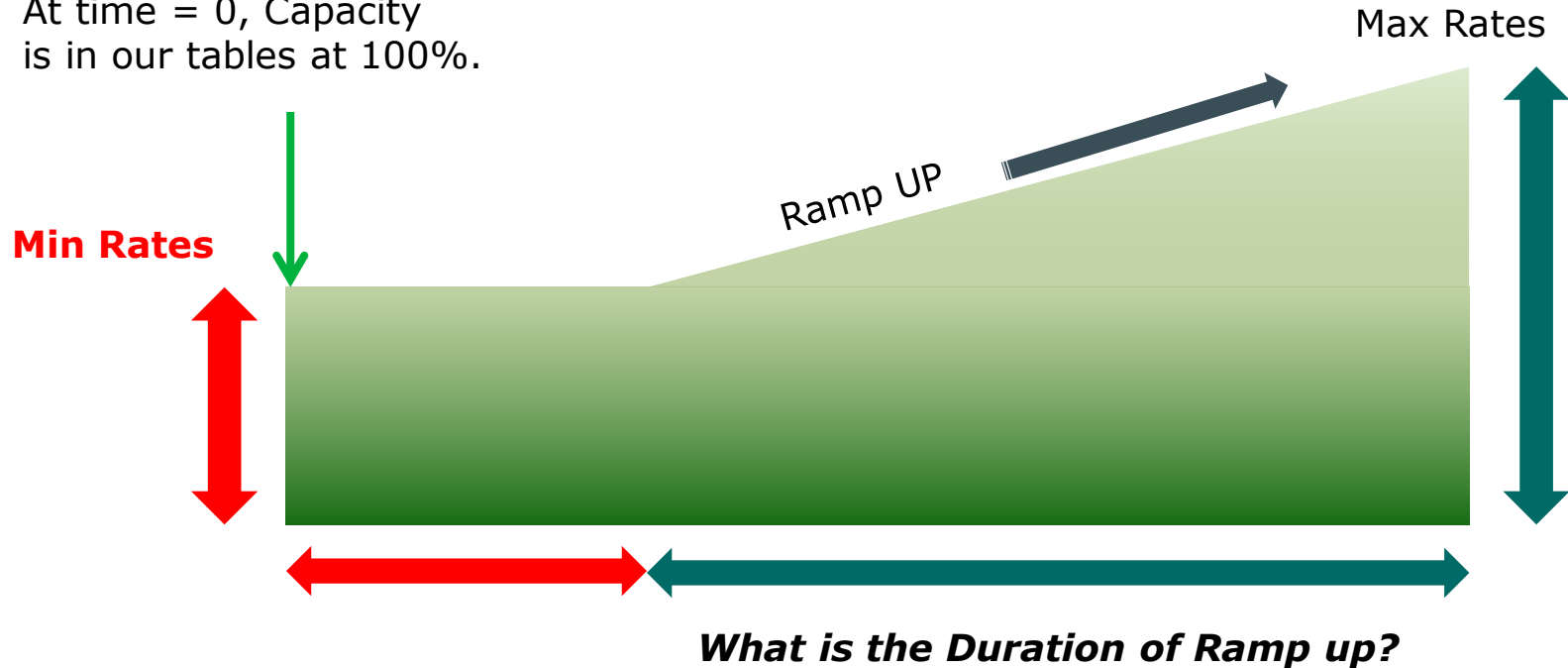


Company	Location	Total Growth
<b>ChevronPhillips</b>	<b>Cedar Bayou, TX</b>	<b>1,500</b>
<b>Dow</b>	<b>Freeport, TX</b>	<b>1,500</b>
Dow	Plaquemine, LA	250
Equistar	Various sites	401
<b>ExxonMobil</b>	<b>Baytown, TX</b>	<b>1,500</b>
Flint Hills	Port Arthur, TX	50
<b>Formosa</b>	<b>Point Comfort, TX</b>	<b>1,150</b>
Indorama	Lake Charles, LA	363
<b>Lotte/Axiall</b>	<b>Lake Charles, LA</b>	<b>1,000</b>
<b>Oxy/Mexichem</b>	<b>Ingleside, TX</b>	<b>550</b>
<b>Shell</b>	<b>Monaca, PA</b>	<b>1,500</b>
<b>Shin-Etsu</b>	<b>Plaquemine, LA</b>	<b>500</b>
<b>Sasol</b>	<b>Lake Charles, LA</b>	<b>1,550</b>
Westlake	KY and LA sites	154
Williams	Geismar, LA	129
<b>Braskem Idesa</b>	<b>Mexico</b>	<b>1,000</b>
<b>Total Additions</b>		<b>13,097</b>

## Ramp up Timing

*Lower nameplate operating rates are skewed by potential ramp up issues on new assets to come on line. Effective operating rates will be high.*

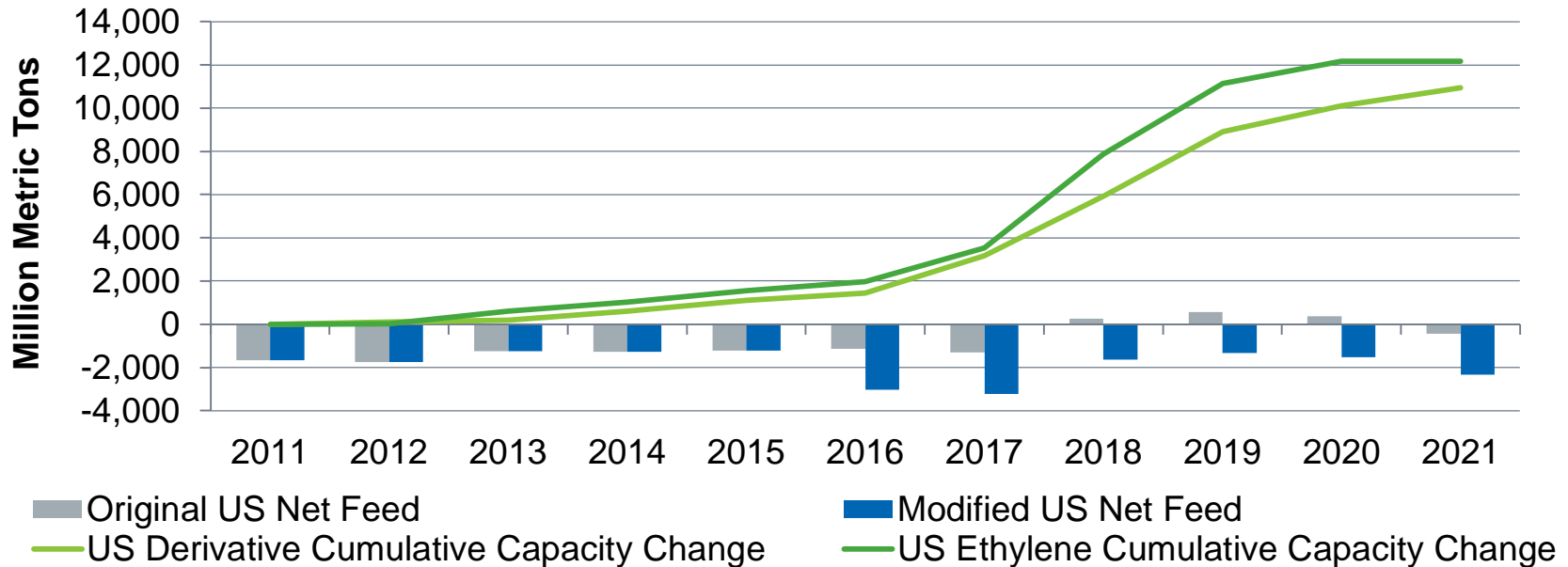
At time = 0, Capacity is in our tables at 100%.



# US – Capacity Integration

*Do we have an imbalance?*

## Change in Ethylene Capacity Vs. Capacity to Consume



**Notes: Post 2015 includes 1600kta demand creep for PE and 300kta of export monomer**

Source: IHS

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# Ethylene Market

## Key Take Aways



- **Ethylene capacity** globally we come up short on additions in 2019-21.
- **Ethylene capacity** US wave will have its challenge from the production side. Derivatives projects should be available first and ready to consume ethylene once it becomes available.
- **Stress on global Ethylene** as supply could be challenged via feed switching and MTO negative economics. Demand up with more virgin resin demand and coal chemistry challenges. Nameplate capacity operating rates remain at elevated levels.
- **Global Margins remain strong** ethylene integrated margins remain high with a question on what does it take to encourage the next Asian capacity wave?

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