ANO – Association for Development of Energy initiatives

KAZAN - 14 September 2018

TRENDS IN HYDROCARBONS PROCESSING AND PETROCHEMISTRY

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MAIN SOURCES OF DOCUMENTATION UTILIZED (ALPHABETICAL ORDER)

- Axens
- BP
- IEA
- IFP
- IHS Market
- Mitsubishi
- TOTAL
- TPA
- UOP

SUMMARY

1813: FIRST SYNTHESIS GAS PRODUCTION (LONDON)

1813: FIRST OIL WELL (ELSASS - ALSACE)

INTRODUCTION:
BASICS OF PETROCHEMISTRY

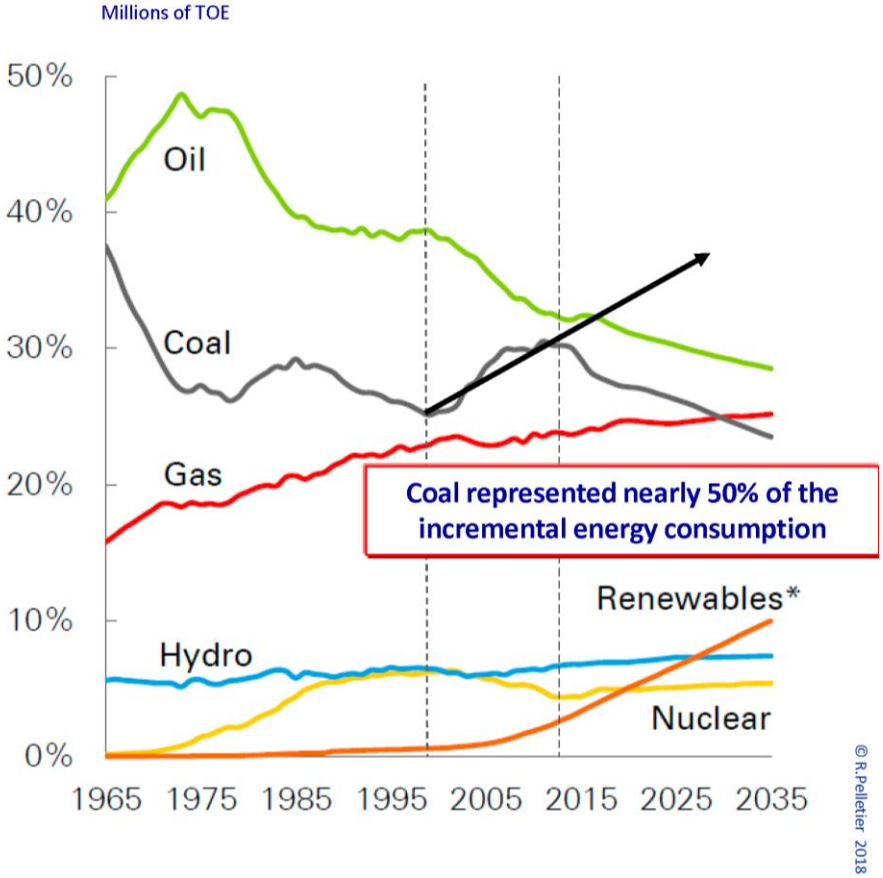
REFINING, PETROCHEMICALS AND THE ENERGY WORLD

World Primary Energy. Trends over the last 50 years

Paradoxical situation! While world realizes the danger of climate change,
fastest growing source of primary energy in last 15 years was Coal,
with the highest CO2 content,
while Nuclear energy, virtually CO2 free, has declined (Germany and Japan)!

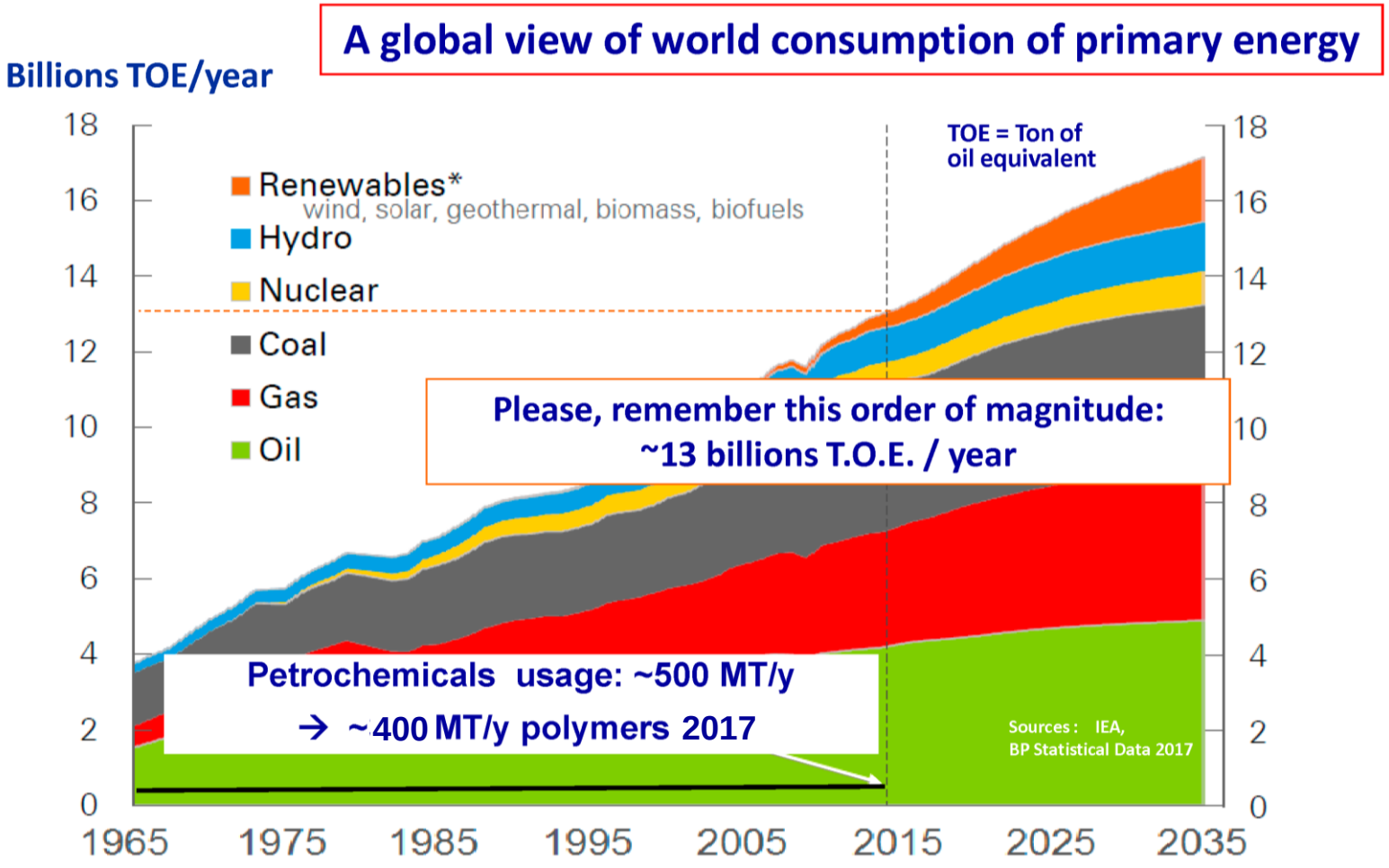
Renewables (others than hydroelectricity) now close to 2.5%

Share of fossil energies probably still more than 75% in 2030



TPA Refining Petrochemicals

REFINING BELONGS TO THE ENERGY WORLD
PETROCHEMICALS ARE A « BRIDGE » BEETWEN ENERGY & MATERIALS



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REFINING & PETROCHEMICALS DIVERGING GROWTH RATES

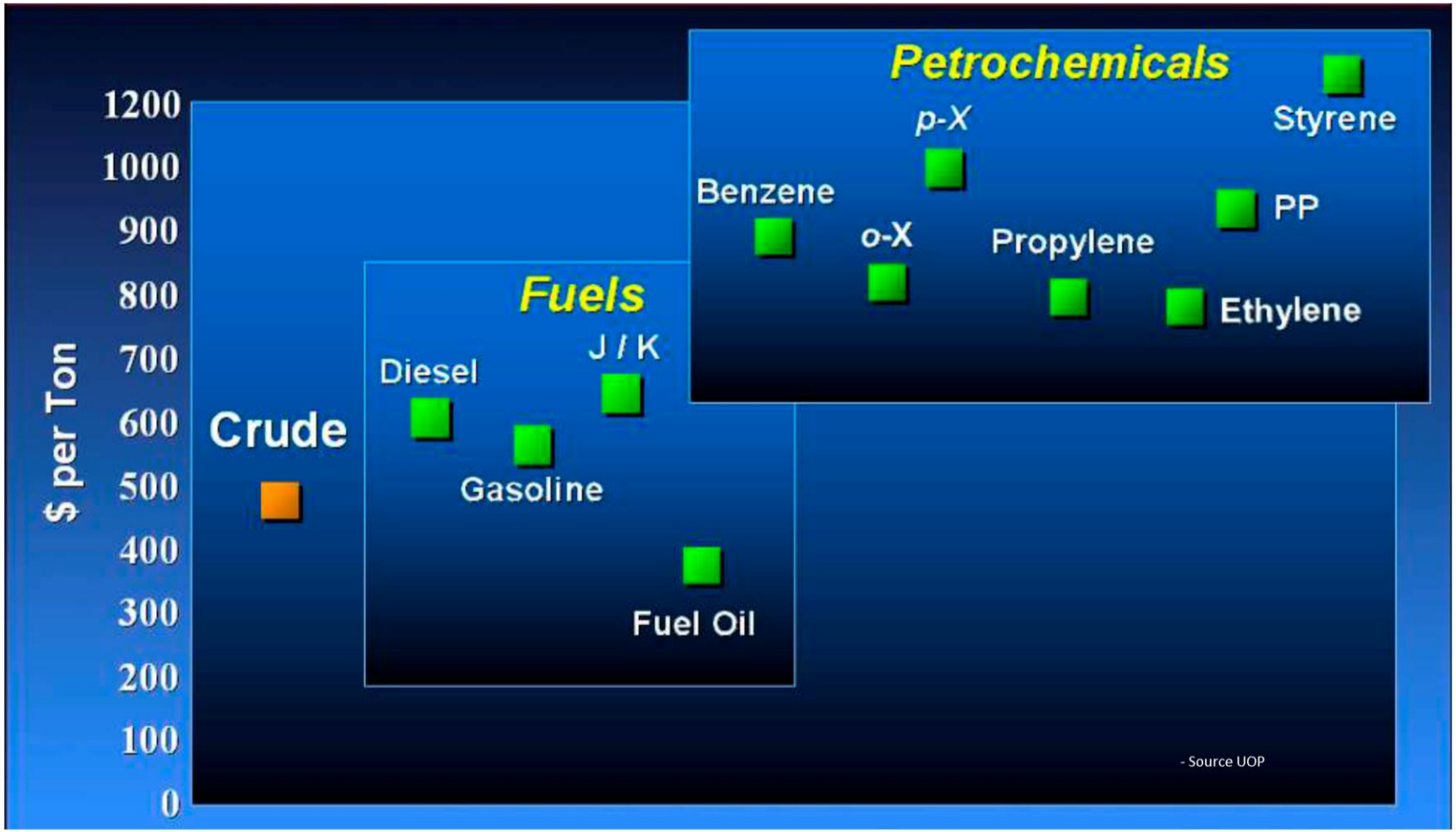
- **Global worldwide capacities for crude oil production and for refining can only be similar (If under-capacity of refineries, crude oil production must slow down - If over-capacity of refineries, "refining margin" collapses and "laggard" (= most inefficient) refineries lose money and will shut-down)**

- **Global primary energy growing at ~2.3%/y rate, crude oil production nearly flat but petrochemicals growth rate close to 6%/y**

- **All modern refineries are now associated with a petrochemical complex. Examples in Russia:**
  - **TANECO refining and petrochemical complex in three phases (250.000 t/y PET and 200.000 t/y polypr. Start up october 2010)**
  - **SIBUR complex near TOBOLSK (objective of 1,5 Mt/y of PET in 2024)**

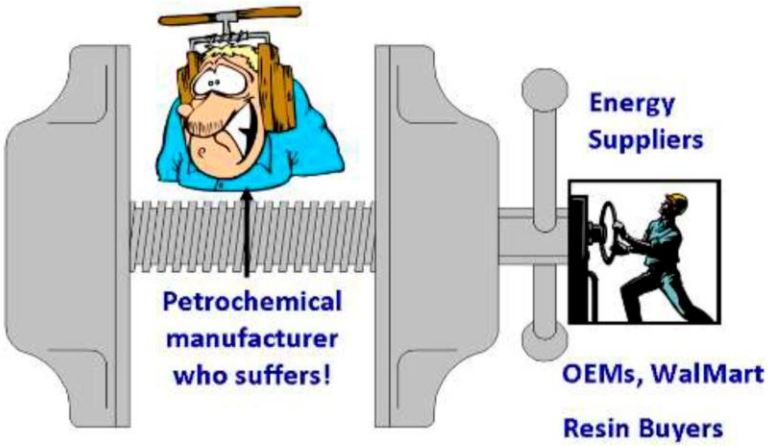
- **Synergies between refining and petrochemicals are increasing but are complicated by diverging growth rates**

PETROCHEMICAL INDUSTRY: ADDING VALUE TO CRUDE (OR TO GAS)



Source : UOP

PETROCHEMICALS: A BRIDGE WHICH CAN BECOME A SQUEEZE?



Controlled by demand/supply equilibrium and competition from other materials

PRICE of polymers

Margin

Costs

Controlled by Energy prices (feedstocks) on a marginal basis

A ZOOM ON BASE PETROCHEMICALS

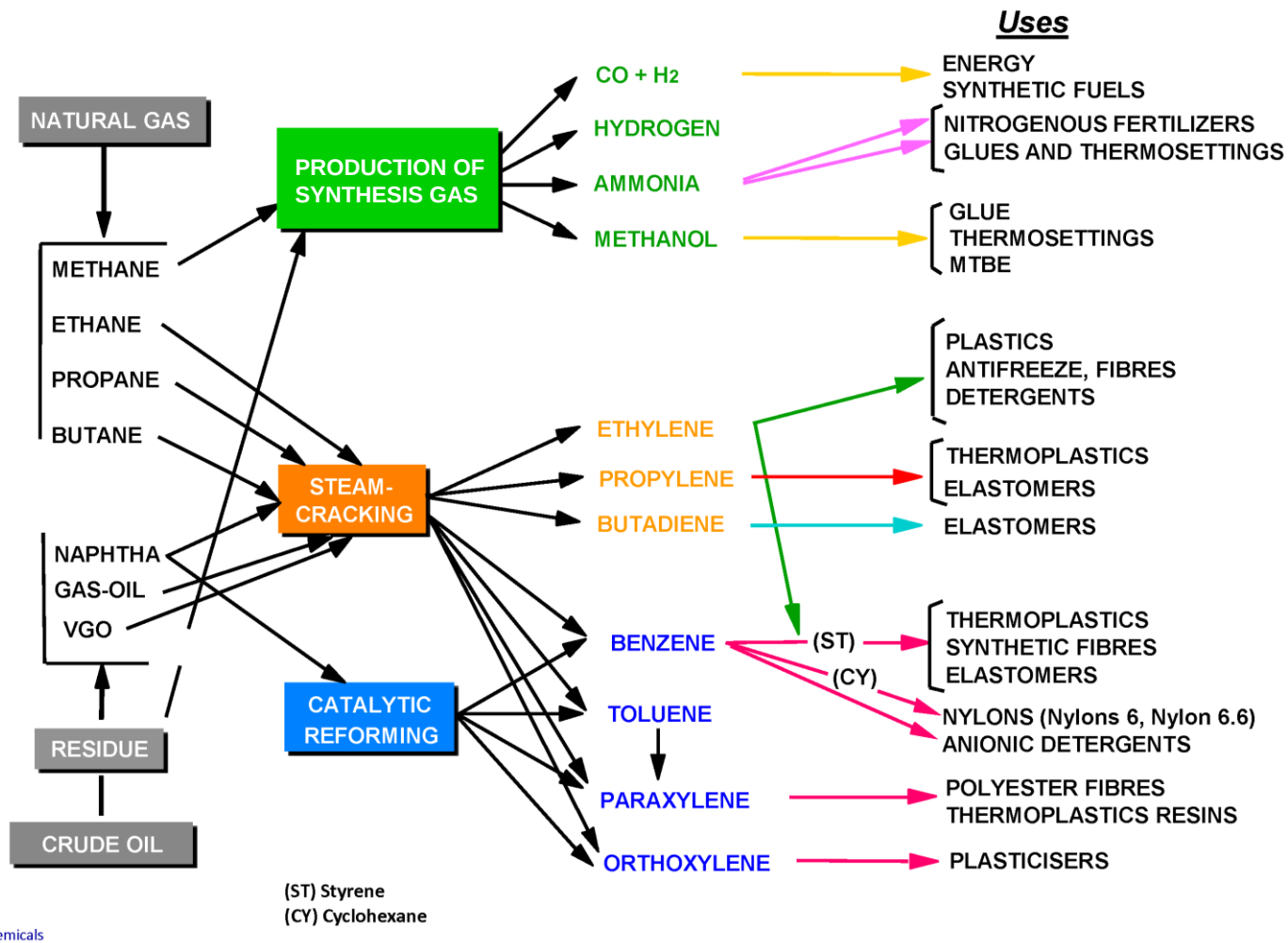
BASE PETROCHEMICALS

- **Base chemicals** designate those intermediates reactive molecules, between refining and polymers
-
- **Main products** are
  - Ethylene, propylene, C4 cut (olefins)
  - Benzene, paraxylene (aromatics)

- **Crackers** (for olefins) and **Catalytic Reformers** (for aromatics) are the main industrial tools of today

- **Syngas** (synthetic gas) will receive renewed development to make use of new feedstock (such as coal or biomass)

MAIN STAGES AND PRODUCTS OF PETROCHEMICAL INDUSTRY



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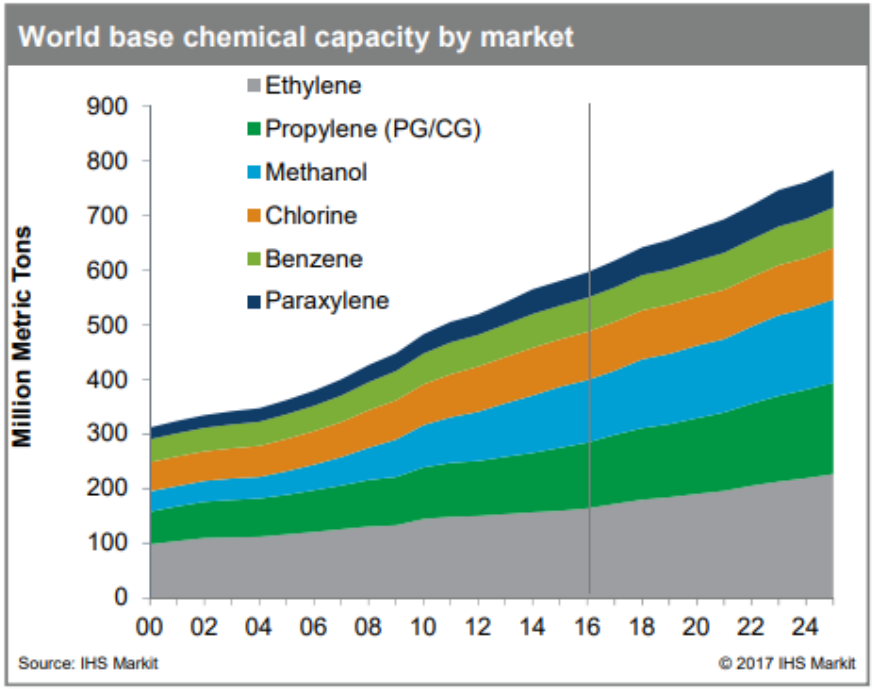
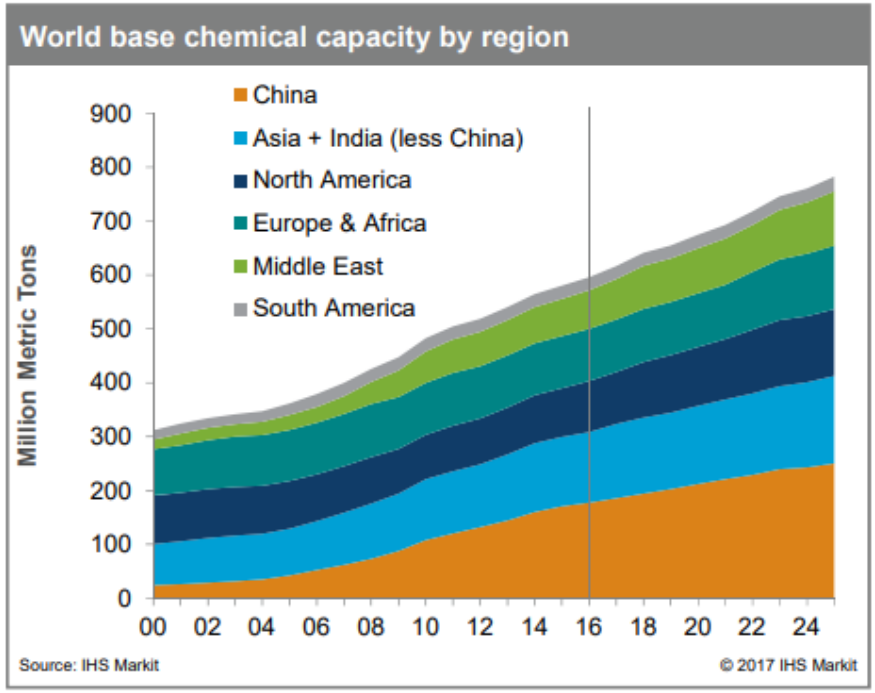
PETROCHEMICAL BASIC TRENDS:
PRODUCTS GROWTH DOMINATED BY ETHYLENE, PROPYLENE AND METHANOL: NEW CAPACITIES DOMINATED BY ASIA





SYNGAS: AN OLD (1813!) BUT AGAIN PROMISING TECHNOLOGY
STARTED AS AN ENERGY CARRIER BUT TODAY A PETROCHEMICAL BASE PRODUCT

- **Generic name given to gas mixtures that contain varying amounts of carbon monoxide (CO) and hydrogen (H2) …**
  - together with CO2, residual CH4, and steam…
  - produced from any hydrocarbon feedstock (typically methane or naphtha), coal, biomass, waste & refuse, …
  - through a conversion by steam, oxygen or air, …
  - preferably with a minimum level of inert gases.

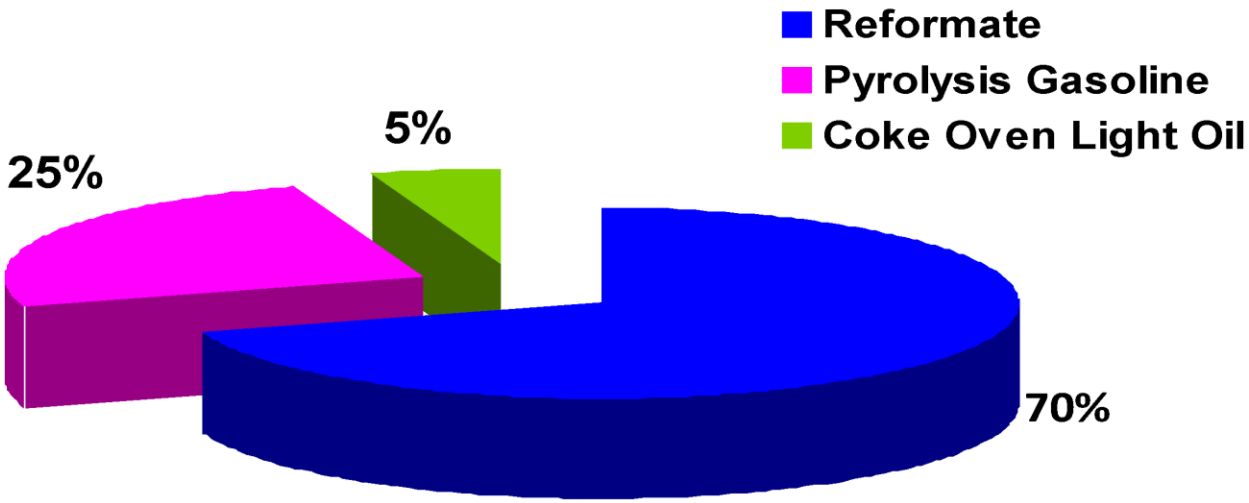
- **Used for the production of**

• H2	→ hydro-treatments in refineries, …
• H+N2	→ ammonia and urea
• methanol	→ formaldehyde, MTBE, MMA, …
• oxo-alcohols	→ plasticizers, higher acrylates, …
• Fischer-Tropsch conversion	→ liquid hydrocarbons

BASICS OF AROMATICS

- **Aromatics are at the interface between Refining and Petrochemicals.**
- **World Gasoline production: over 1 billion tons/y (around 20% of world crude oil production)**
- **World Benzene production: around 50 million tons/year (around 5% of gasoline production or 1% of crude oil production)**
- **Although very different in size, strong links between the the Refining and Petrochemical industries.**

WORLD SOURCES FOR AROMATICS



- Reformate ex **Continuous catalyst regeneration reforming (CCR)**
- Pyrolysis Gasoline ex **Steam Cracker**
- Coke Oven Light Oil ex **Coking Plants**

Catalytic Reformers in refineries are the work horses of aromatics production

Source: Axens

TPA Refining Petrochemicals

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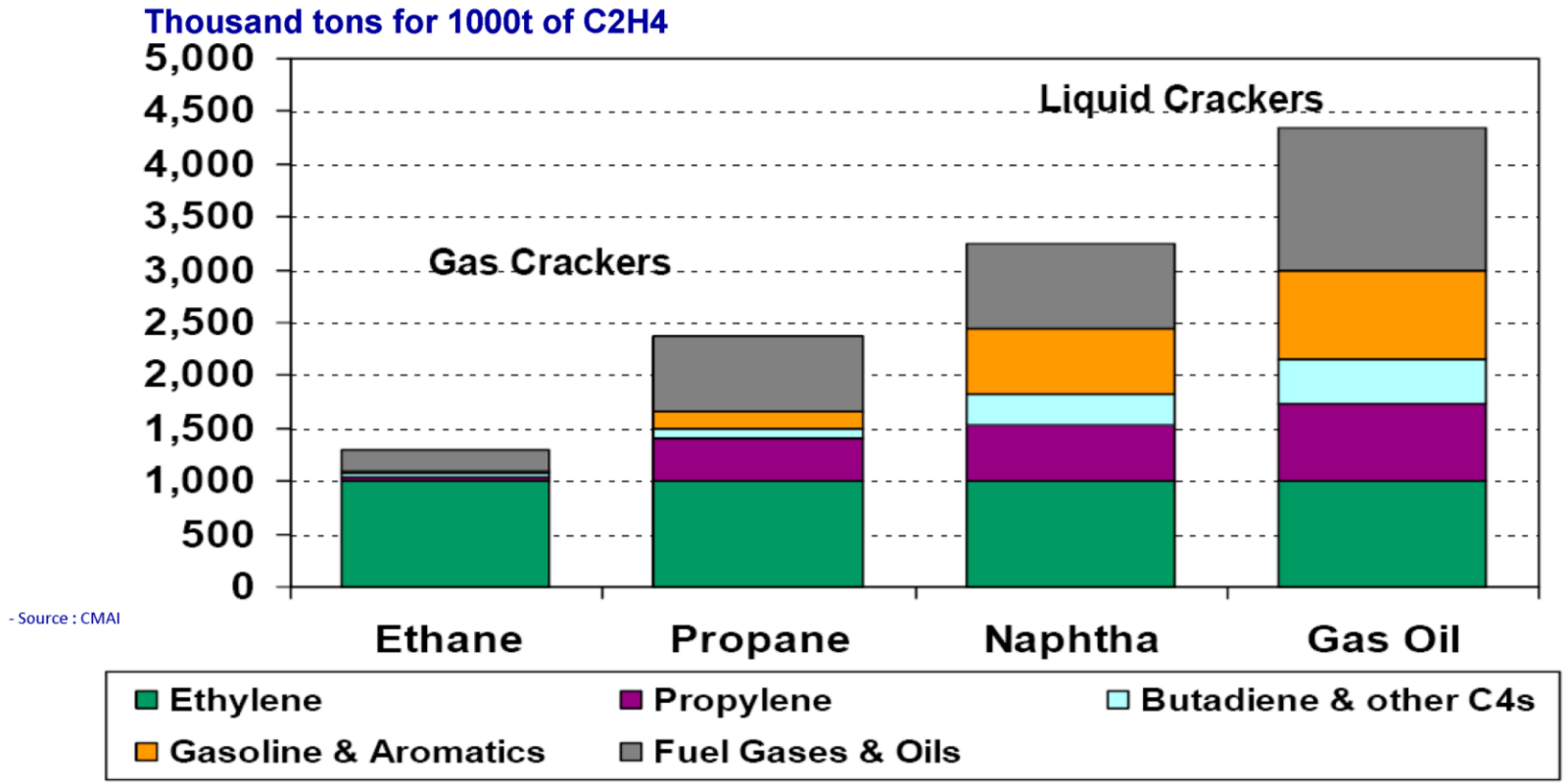
BASICS OF OLEFINS

Olefins

Ethylene
Propylene
Butadiene
…

CRACKER PRODUCT SPLIT IS STRONGLY RELATED TO FEEDSTOCK NATURE



- Source : CMAI

For same 1 MT/y ethylene outlet, a liquid feed cracker yields 3 to 4 MT/y products, which are processed into valuable petrochemicals.
Long term supply chain needs to be strategically secured.

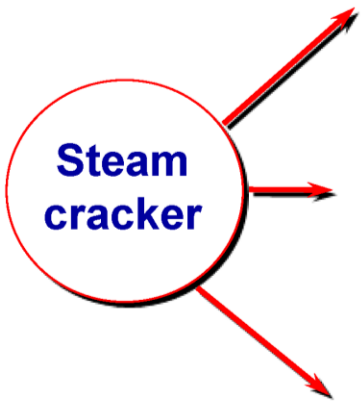
NUMERICAL ILLUSTRATION OF STEAM CRACKER YIELDS (Wt%)

Products \ Feeds	Ethane	Propane	Butane	Naphtha	Gas oil	VGO
Hydrogen	8.8	2.3	1.6	1.5	0.9	0.8
Methane	6.3	28	22	17	11	8.8
Ethylene	**78**	**42**	**40**	**33**	**26**	**21**
Propylene	**3**	**16**	**17**	**16**	**16**	**14**
Butadiene	1.9	3.0	3.5	4.5	4.5	5.3
Other C_4	0.7	1.3	6.8	4.2	4.8	6.3
Gasoline C_5-200	1.7	6.6	7.1	19	18	19
Benzene	0.9	2.5	3.0	6.7	6.0	3.7
Toluene	0.1	0.5	0.8	3.4	2.9	2.9
C_8 aromatics	-	-	0.4	1.8	2.2	1.9
Non aromatics	0.7	3.6	2.9	6.8	7.3	10
Fuel	-	0.5	1.7	4.7	18	25

Virtually no propylene out of ethane crackers

Typical yields above are obtained at very high severity, after recycling of ethane and/or propane, unconverted or produced in pyrolysis.

OLEFIN UTILIZATIONS: NEARLY EXCLUSIVELY FOR POLYMERS



	Demand 2016 (millions tons)	Usages	
Propylene	100 MT	Polypropylene	65 %
		Acrylonitrile (acrylic fibers)	9 %
		Propylene oxyde	8 %
		Oxo alcools	7 %
		Cumene/phenol (phenolic resins)	4 %
		Acrylic acid	4 %
		Others	3 %
Ethylene	150 MT	Polyethylenes, LDPE, LLDPE, HDPE	59 %
		Polyvinyl chloride	12 %
		Polystyrene	7 %
		Ethylene oxide and derivatives (polyesters)	14 %
		Alpha-olefins	3%
		Vinyl acetate	1%
		Other derivatives (ethanol, acetic acid …)	10 %
Butadiene (~45% of C4 cut)	15 MT extrapolation	Styrene-butadiene	48 %
		Polybutadiene	27 %
		Other elastomers	9 %
		ABS (styene-acrylonitrile-butadene)	10 %
		Adiponitrile – adipic acid	6 %

Sources:
Mitsubishi Chemical TechnoResearch March 2017 Argus Media.com May 2015

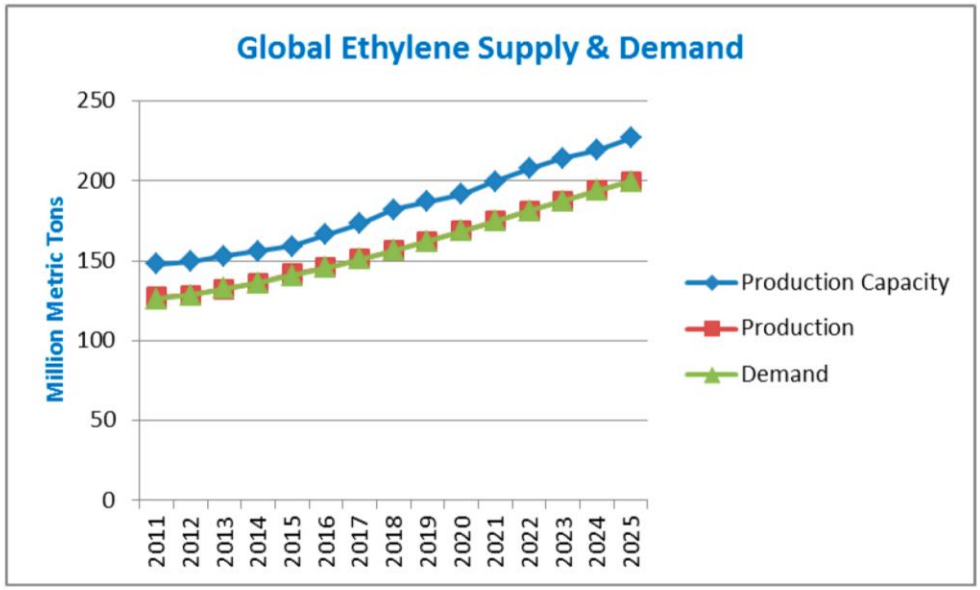
TPA Refining Petrochemicals

FEEDSTOCKS & GLOBAL OLEFINS EQUILIBRIUM

- **Ethane contained in natural gas can have a very low net back price, when sold along with natural gas (see after: the US shale revolution)**
- **Gas producers search for a higher added value favors ethane cracking**
- **Since ethylene costly to move, simultaneous development of downstream units (PE, VCM, …) is a logical solution**
- **Very fast development of highly competitive ethane crackers for the ethylene chain leads to fewer liquid crackers being built (Therefor a risk of ethylene excess and propylene deficit)**
- **However in Russia Ethylene capacity still small compared to the size of Russian economy and considering availability of feedstocks**

A FOCUS ON ETHYLENE

WE WILL FOCUS ON ETHYLENE BECAUSE IT IS THE LARGEST BASE PRODUCT FOR PETROCHEMICALS



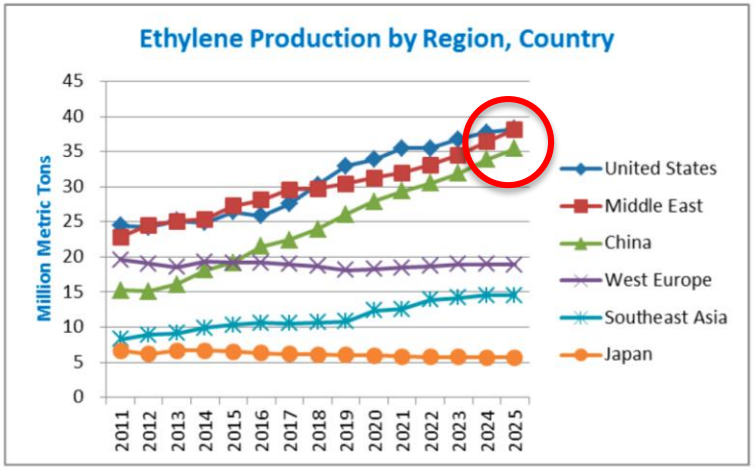
Y-2016

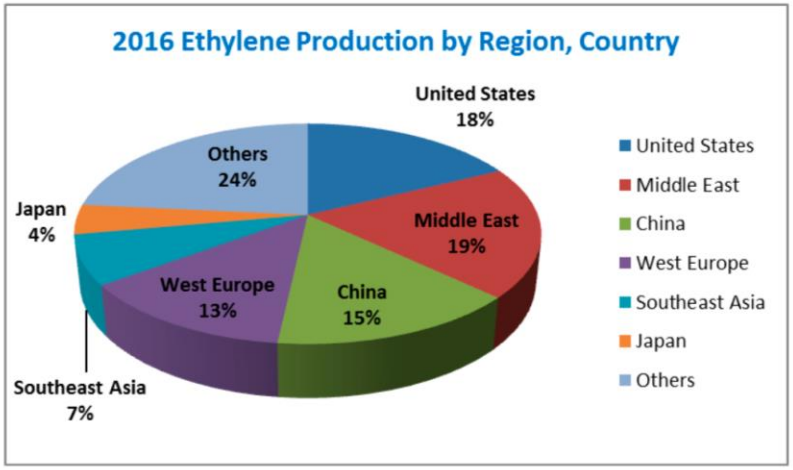
- **Production Capacity of Ethylene : 170 Million Metric Tons**
- **Global Demand of Ethylene : 150 Million Metric Tons**

Y-2025

- **Production Capacity of Ethylene : 230 Million Metric Tons**
- **Global Demand of Ethylene : 200 Million Metric Tons**
- **Demand growth rate (2016-2025) : 3.6%/year**

ETHYLENE PRODUCTION TRENDS BY REGIONS. BY 2020 – 2025 ONLY « THREE MAJOR PRODUCING AREAS: USA, MIDDLE EAST & CHINA »



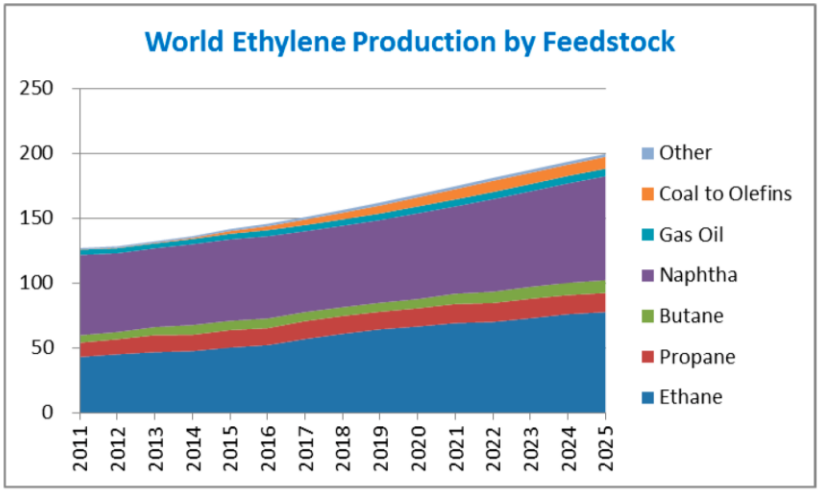


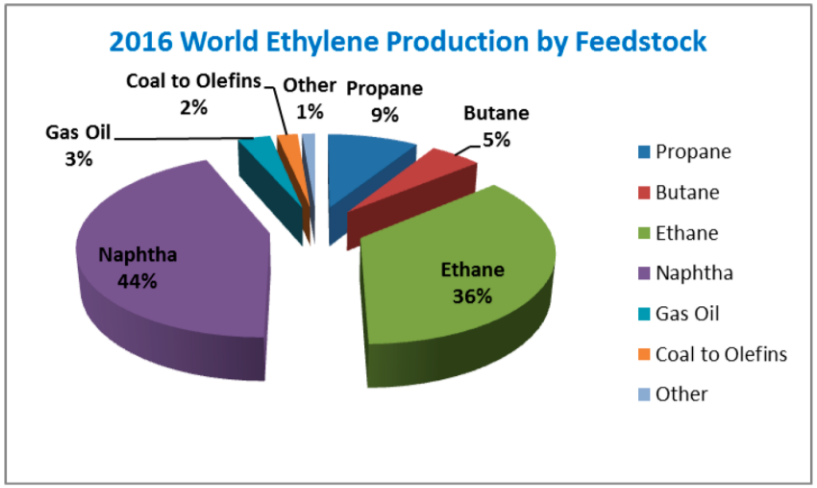
2016 Ethylene/Propylene Production by Region, Country
(Million Metric Tons)

Region/Country	USA	Middle East	China	West Europe	SEA	Japan	Others	World
Ethylene	26	28	22	19	11	6	34	146
Propylene	14	9	26	13	7	6	24	99
Total	40	37	47	33	18	12	59	245

- **United States, Middle East and China are the world's largest ethylene producing regions.**
- **United States, Middle East and China's production share of Ethylene are 18%, 19% and 15% in 2016.**
- **Ethylene production is forecast to grow at an average annual rate of 4.5% in United States, 3.4% in Middle East, 5.7% in China over the next ten years .**

WORLD ETHYLENE PRODUCTION STABLE TRENDS BY FEEDSTOCK « TWO MAJOR FEEDSTOCKS, NAPHTHA & ETHANE »





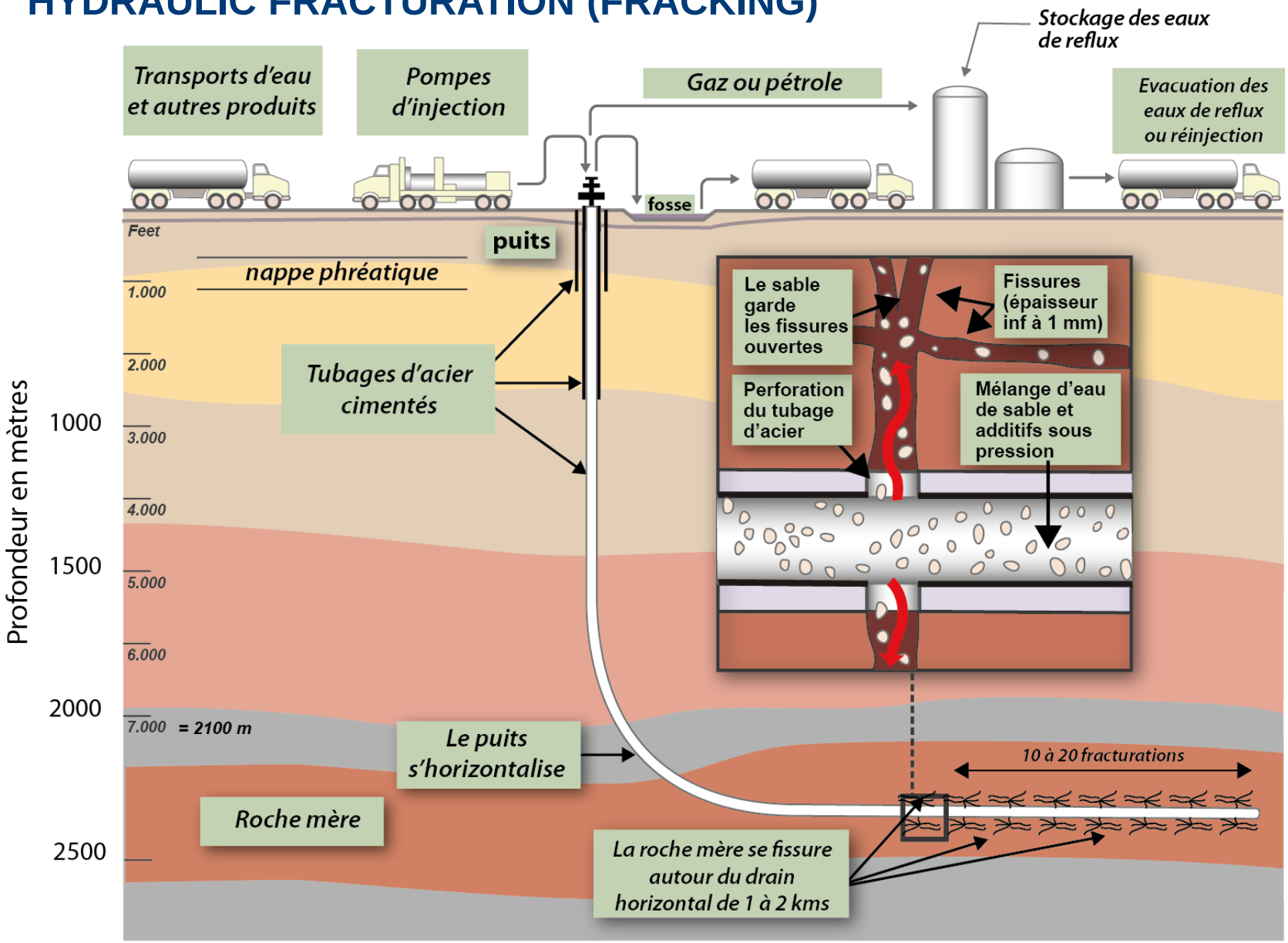
2016 Global Ethylene Production by Feedstock
(Million Metric Tons)

	Propane	Butane	Ethane	Naphtha	Gas Oil	Coal	Other	Total
Production	13	7	52	63	5	3	2	146
Share	9.0%	5.1%	35.8%	43.5%	3.3%	2.1%	1.3%	100%

- **Naphtha and ethane are major sources of Ethylene production**
- **2016 World Ethylene Production = 146 Million Metric Tons**
- **2016 Propane based Ethylene Production = 13 Million Metric Tons (9%)**
- **2016 Butane based Ethylene Production = 7 Million Metric Tons (5%)**

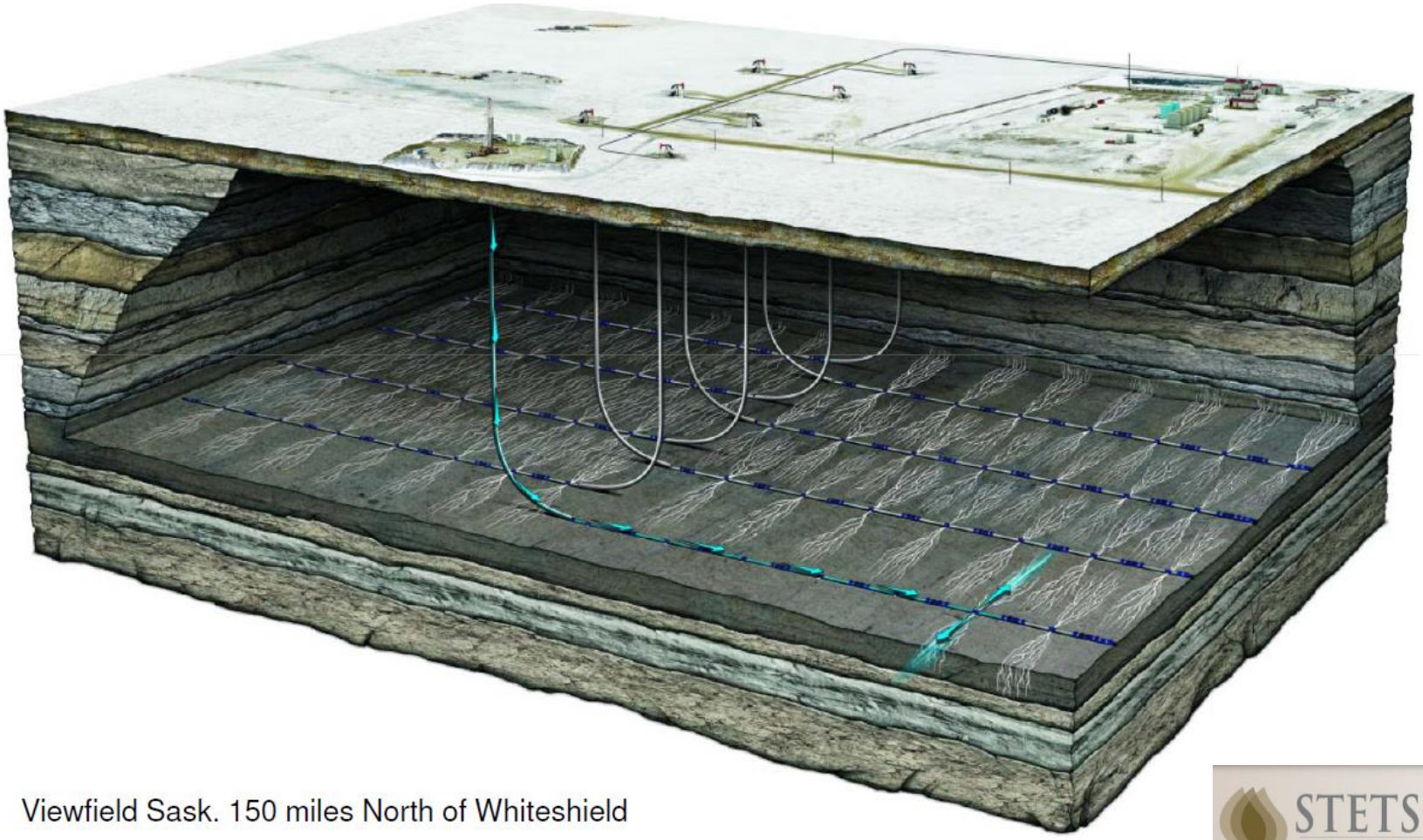
IMPACTS OF THE USA SHALE OIL AND GAS REVOLUTION

HYDRAULIC FRACTURATION (FRACKING)



source : PR Bauquis - 15 janvier 2014

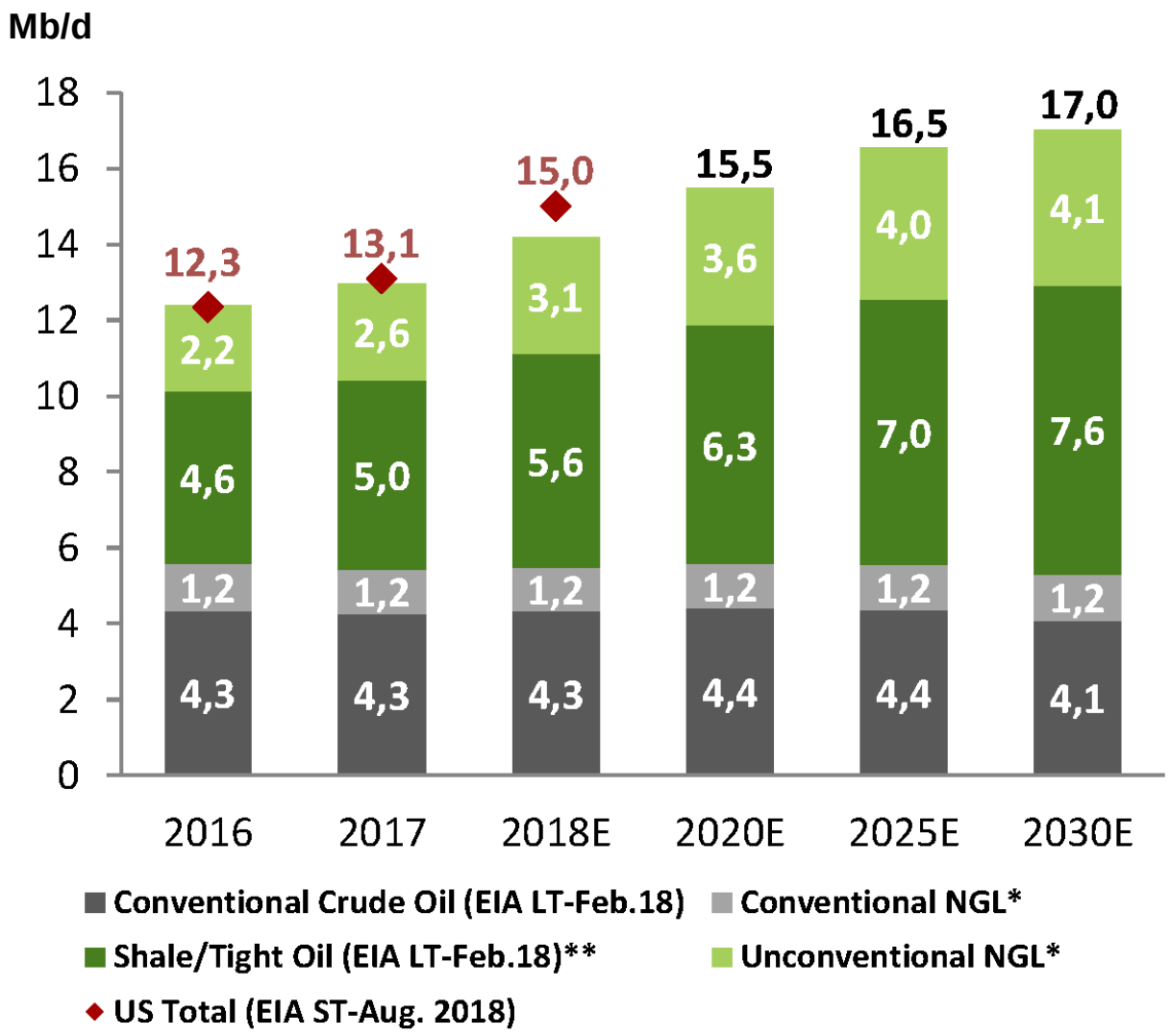
SHALE GAS OR SHALE OIL TYPICAL DEVELOPMENT (USA)



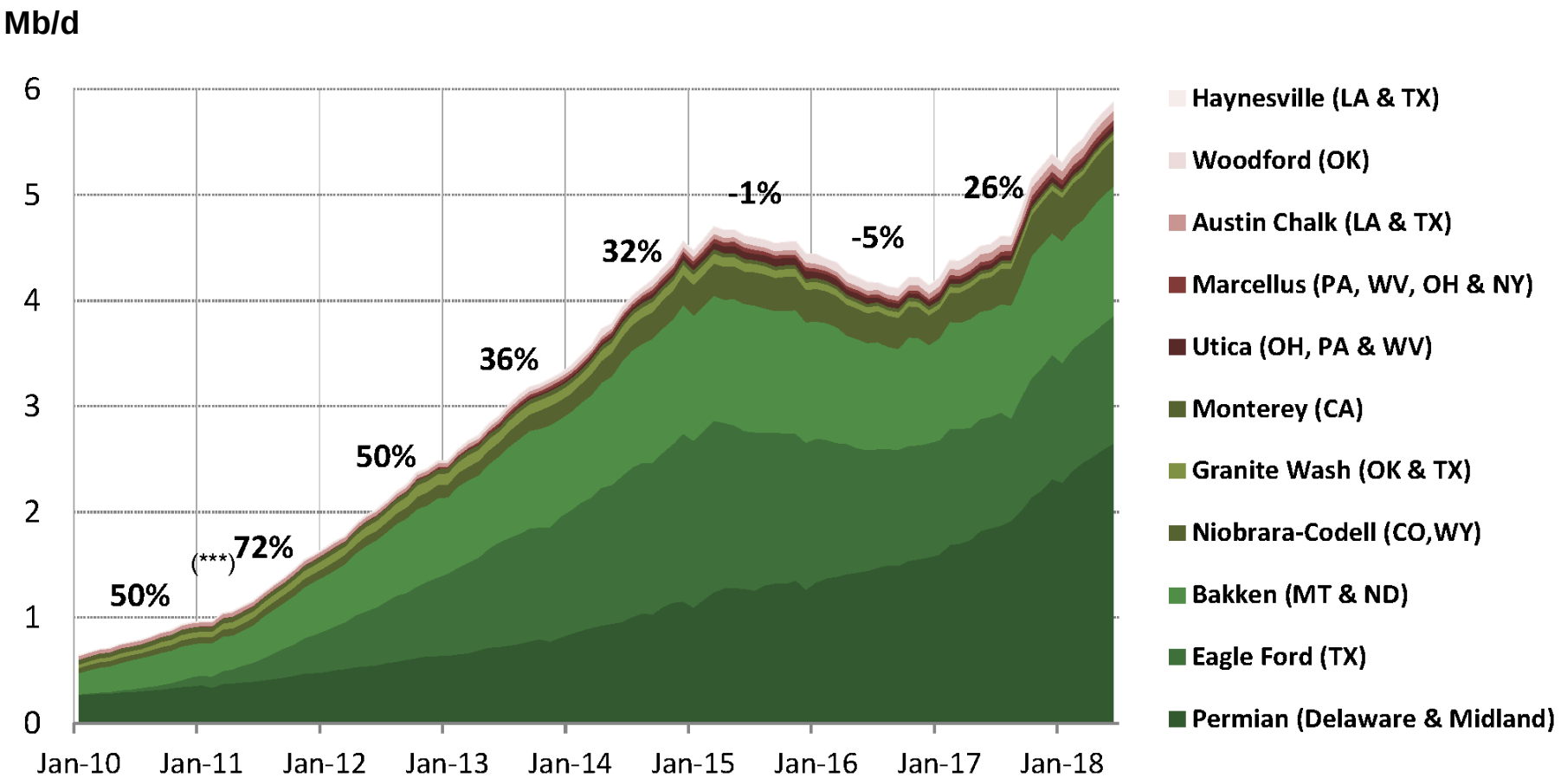
Viewfield Sask. 150 miles North of Whiteshield

STETSON OIL & GAS LTD

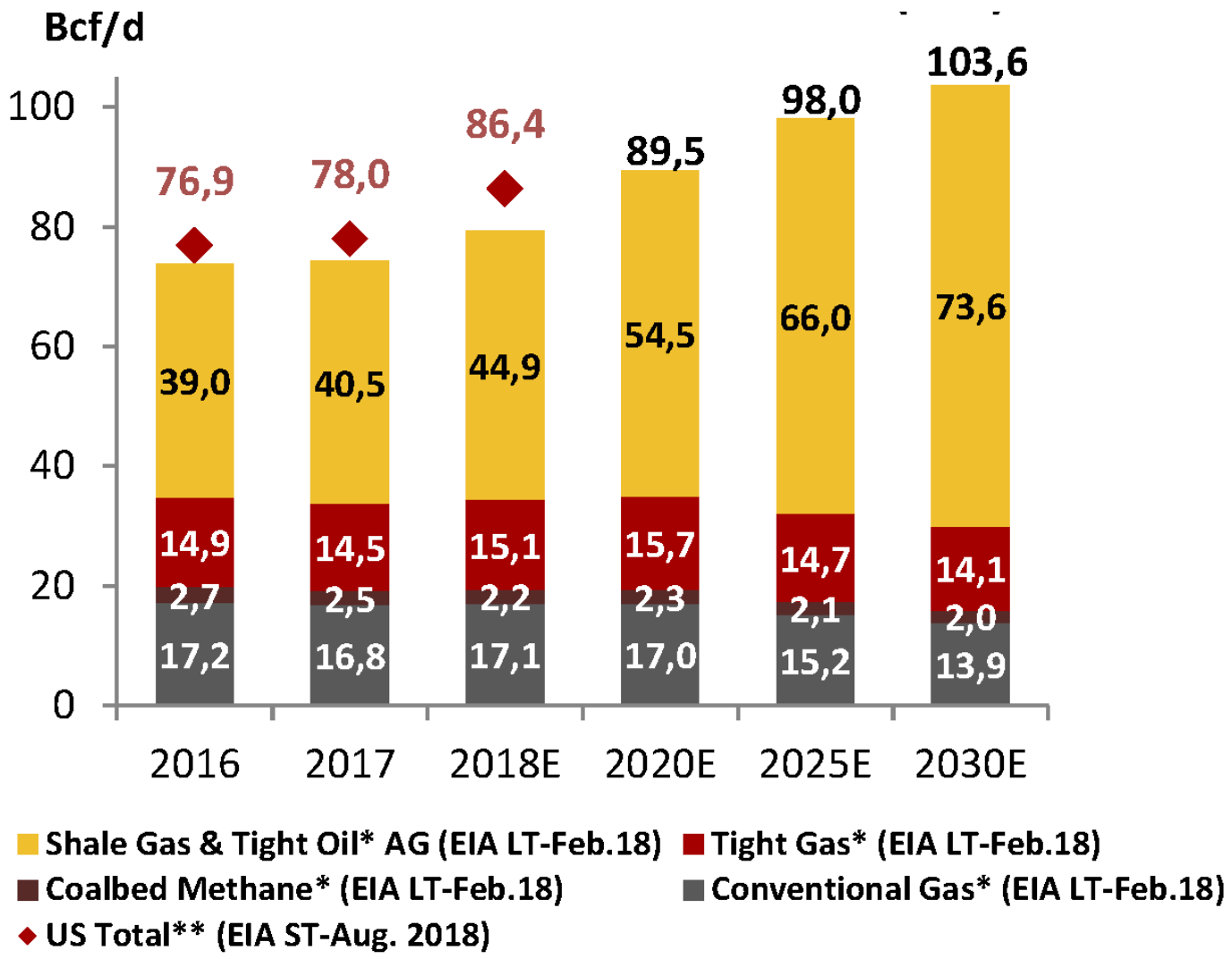
US LIQUID PRODUCTION (EIA JULY 2018)



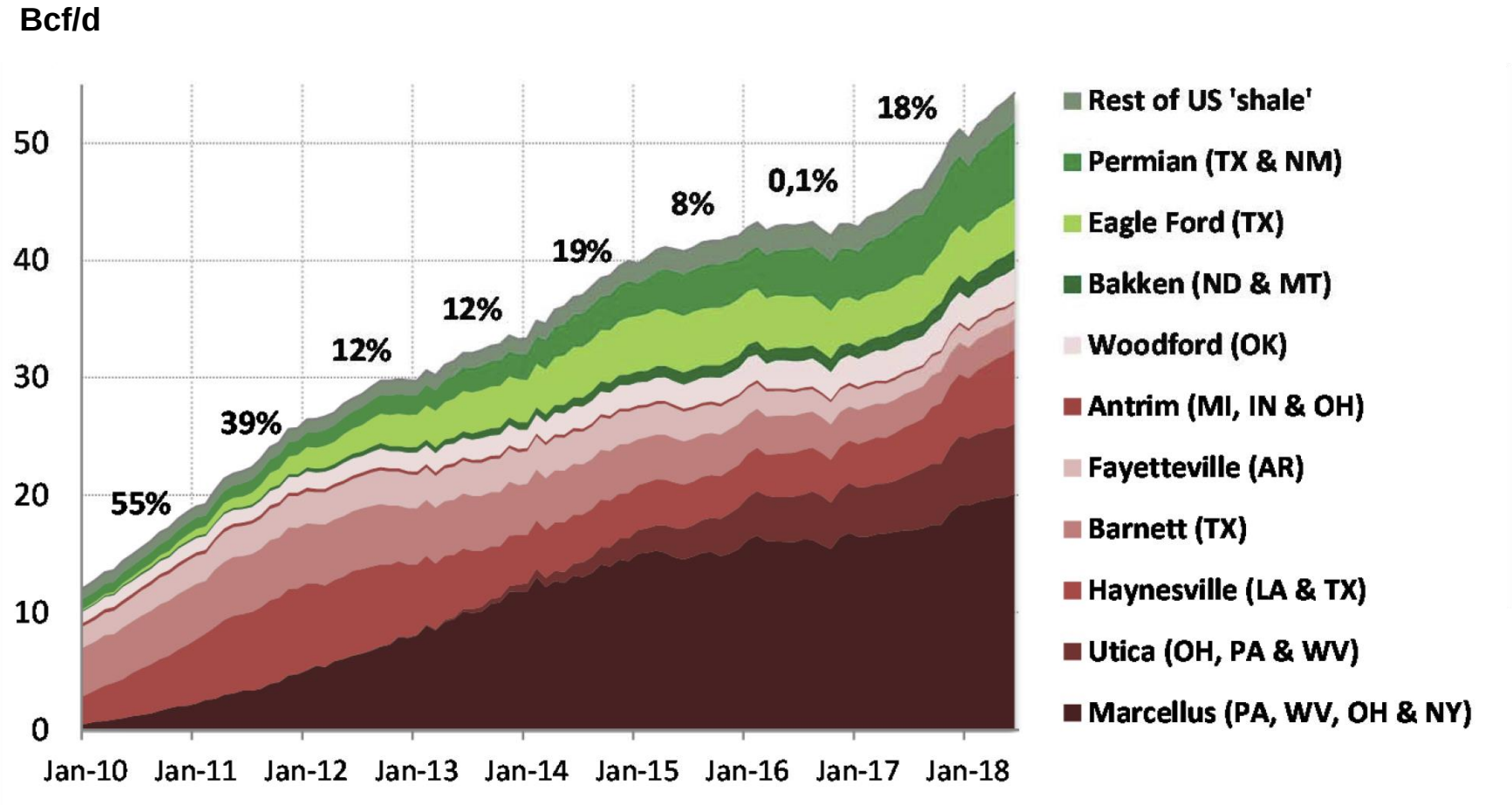
LTO (LIGHT TIGHT OIL) PRODUCTION PER MAIN PLAYS (EIA)



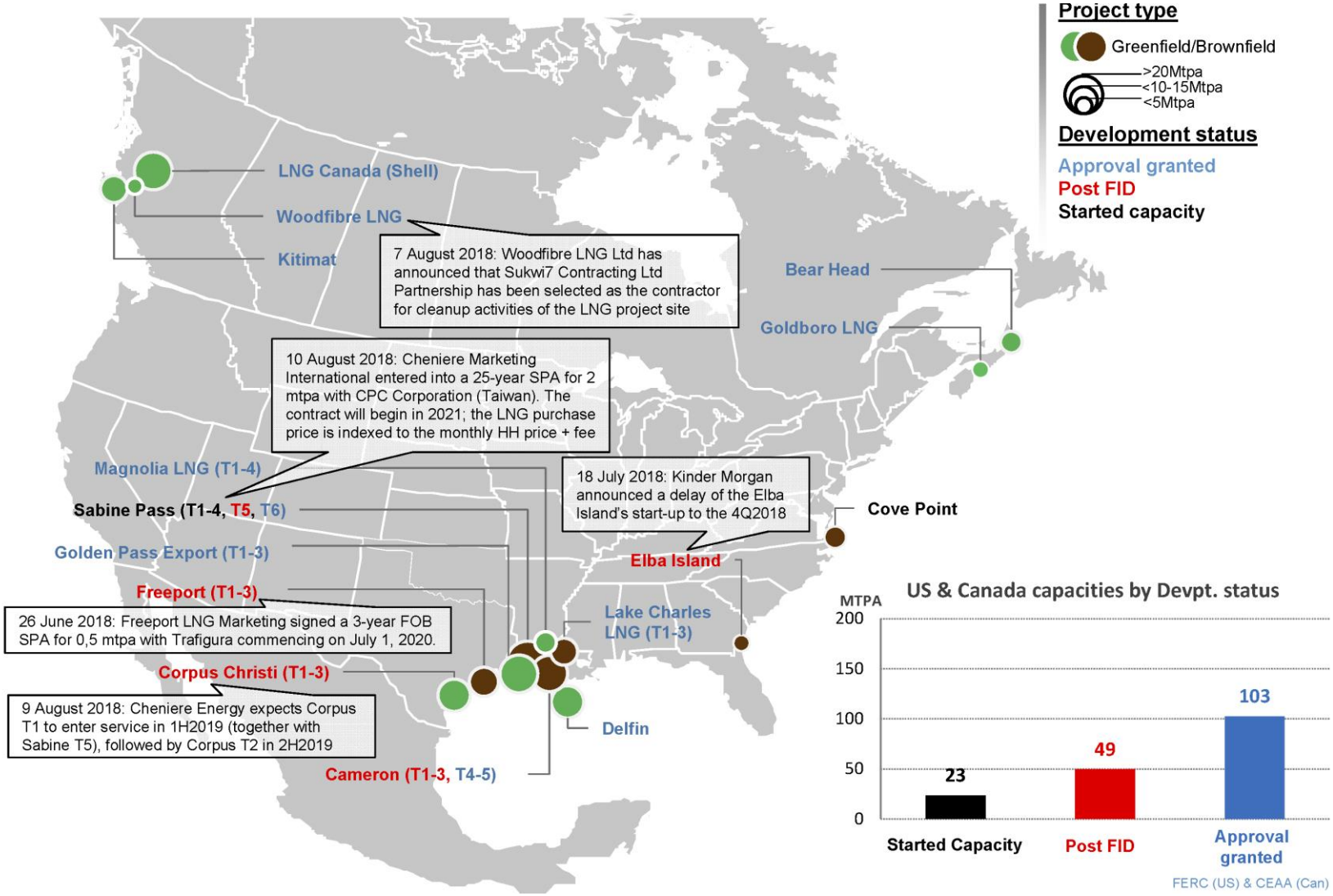
US GAS PRODUCTION FORECAST (EIA – FEB 2018)



US DRY SHALE GAS PRODUCTION PER PLAY (EIA JULY 2018)

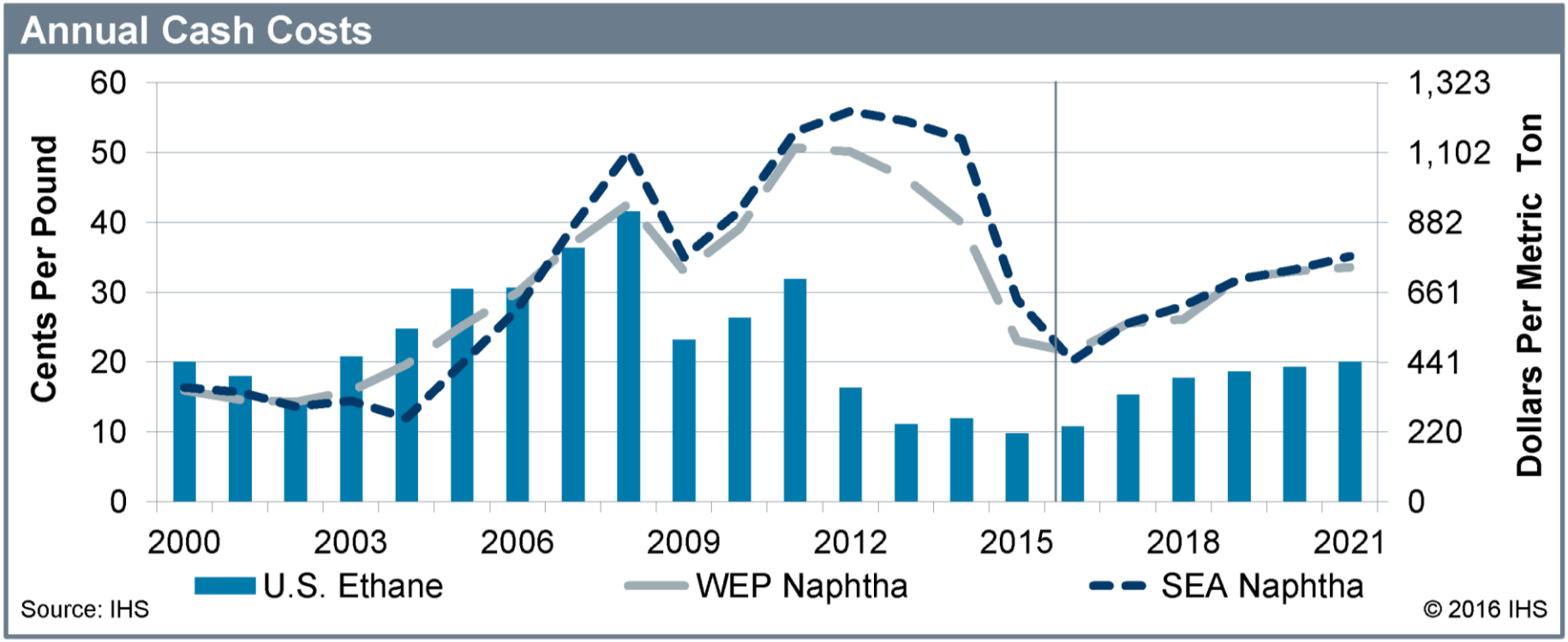


USA LNG EXPORT PROJECTS (AS OF AUGUST 2018)

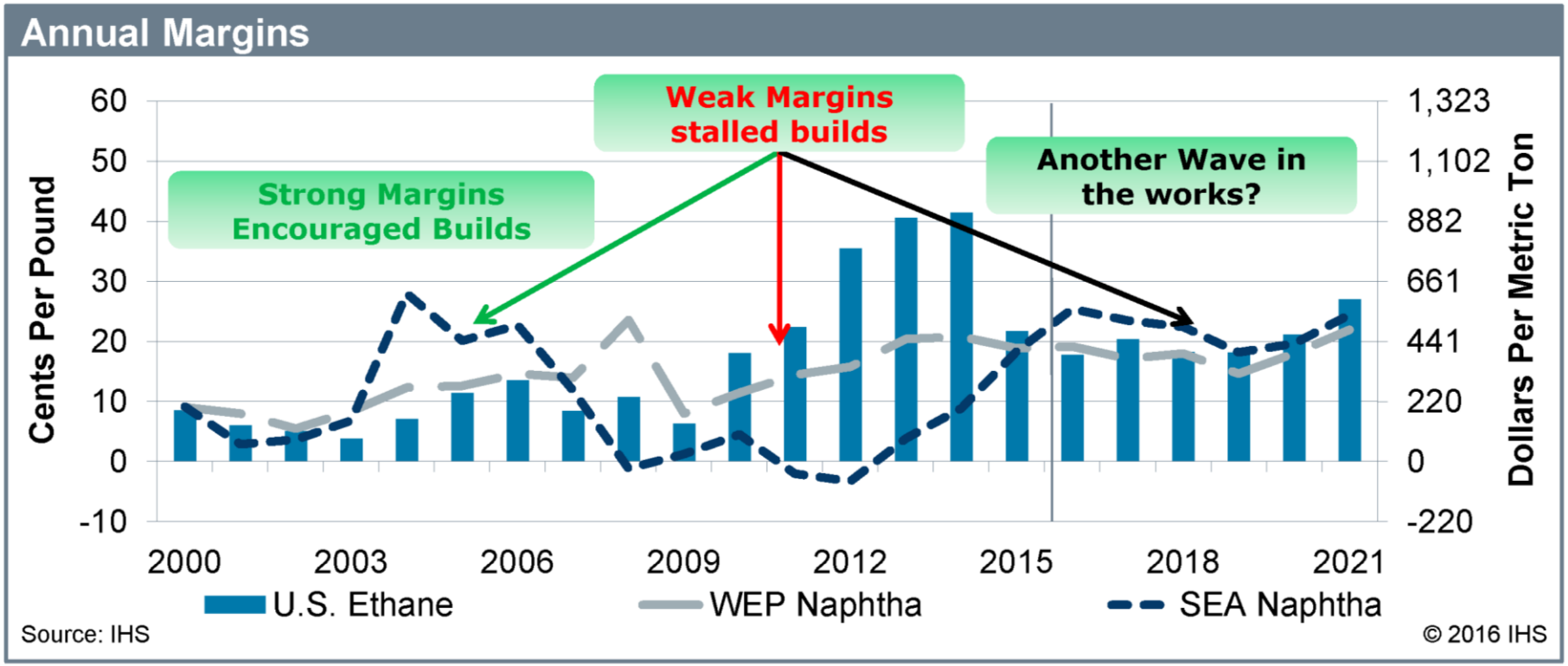


ECONOMIC CONSEQUENCES FOR THE ETHYLENE INDUSTRY

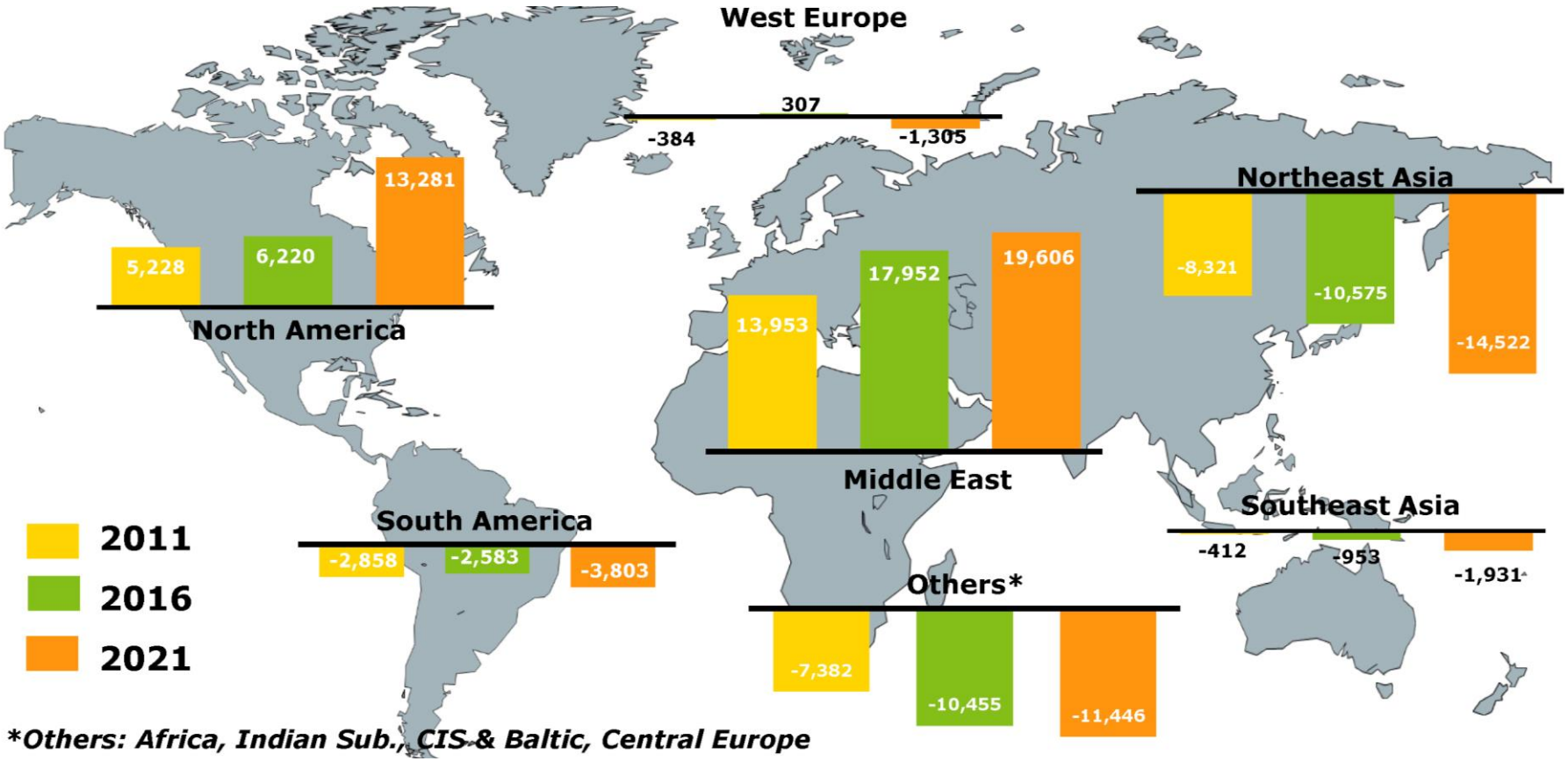
ETHYLENE CASH COSTS TRENDS BY REGIONS



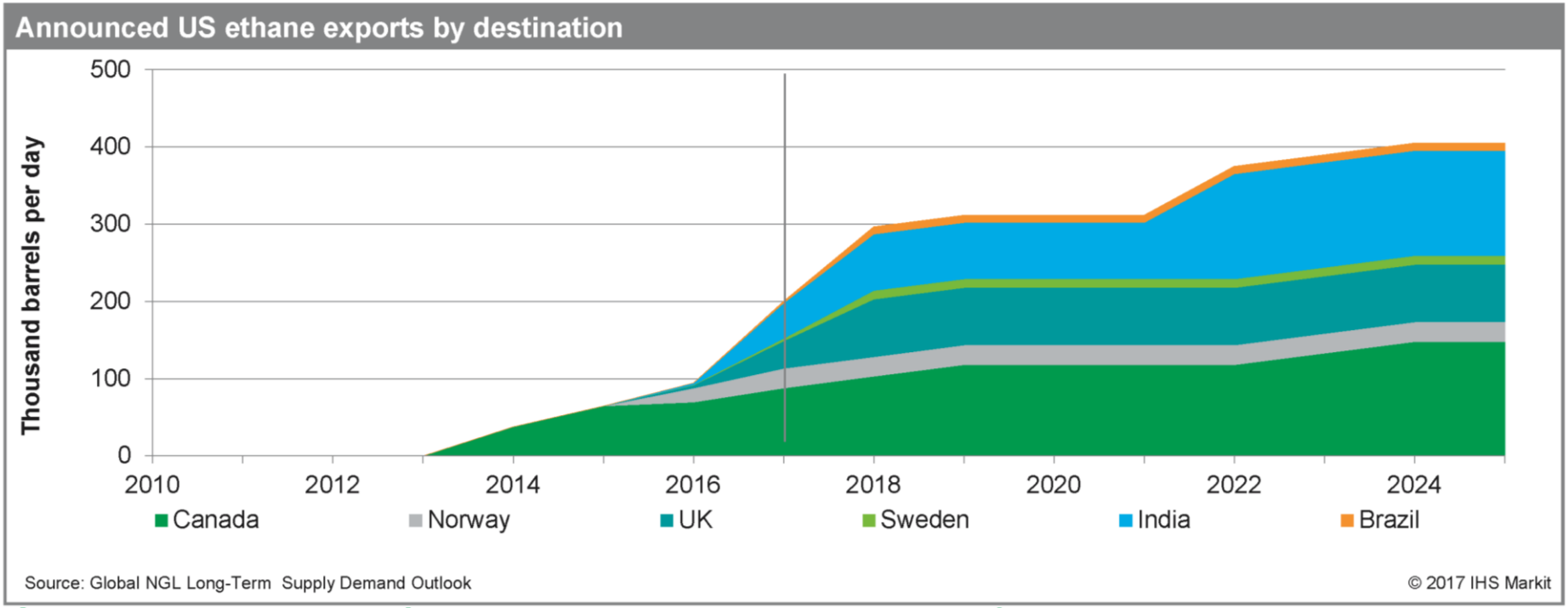
ETHYLENE CASH MARGINS TRENDS BY REGIONS



ETHYLENE EQUIVALENT TRADE FLOW TRENDS



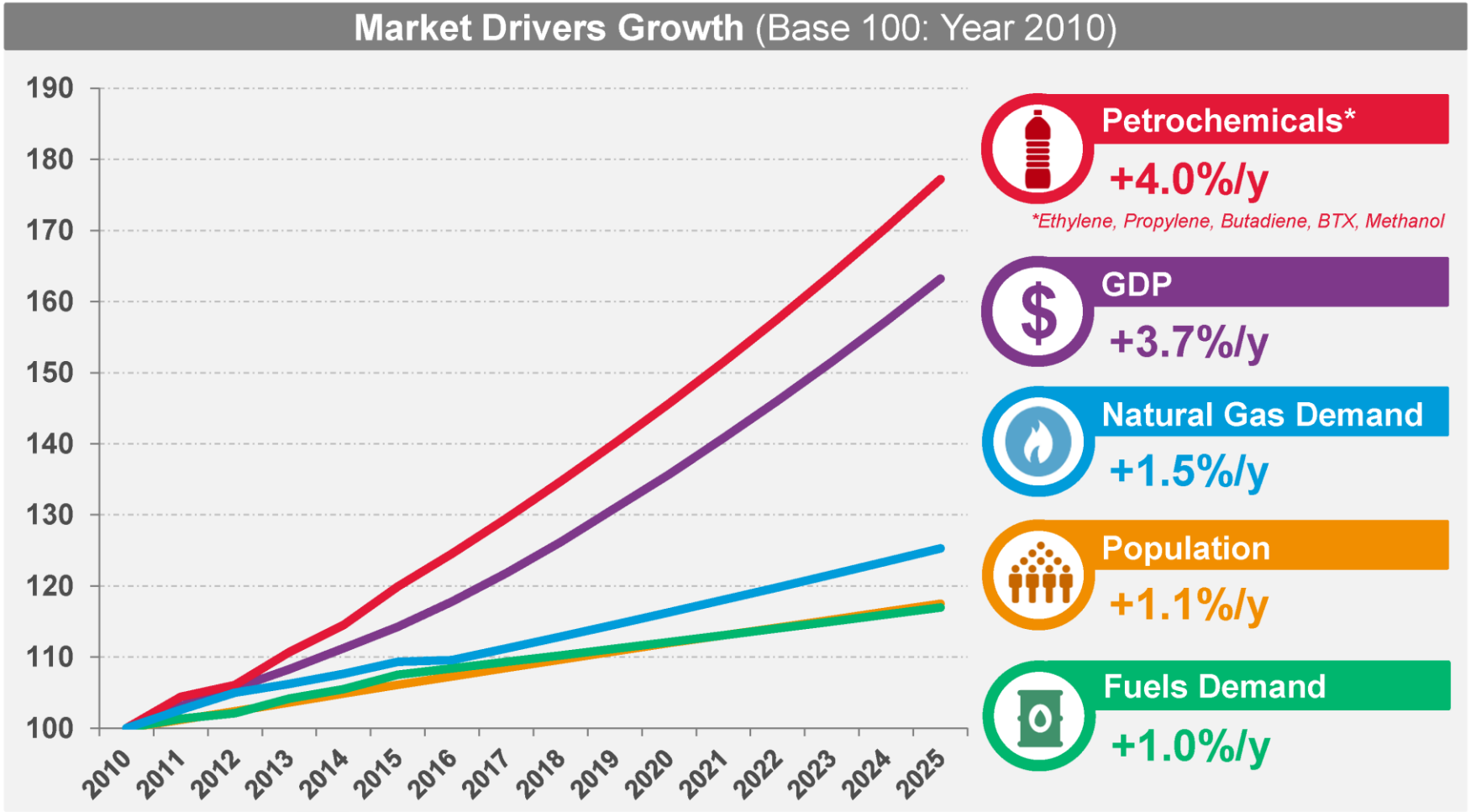
PHYSICAL EXPORT TREND OF US ETHANE



Some additional exports to China, Mexico or other countries might surface

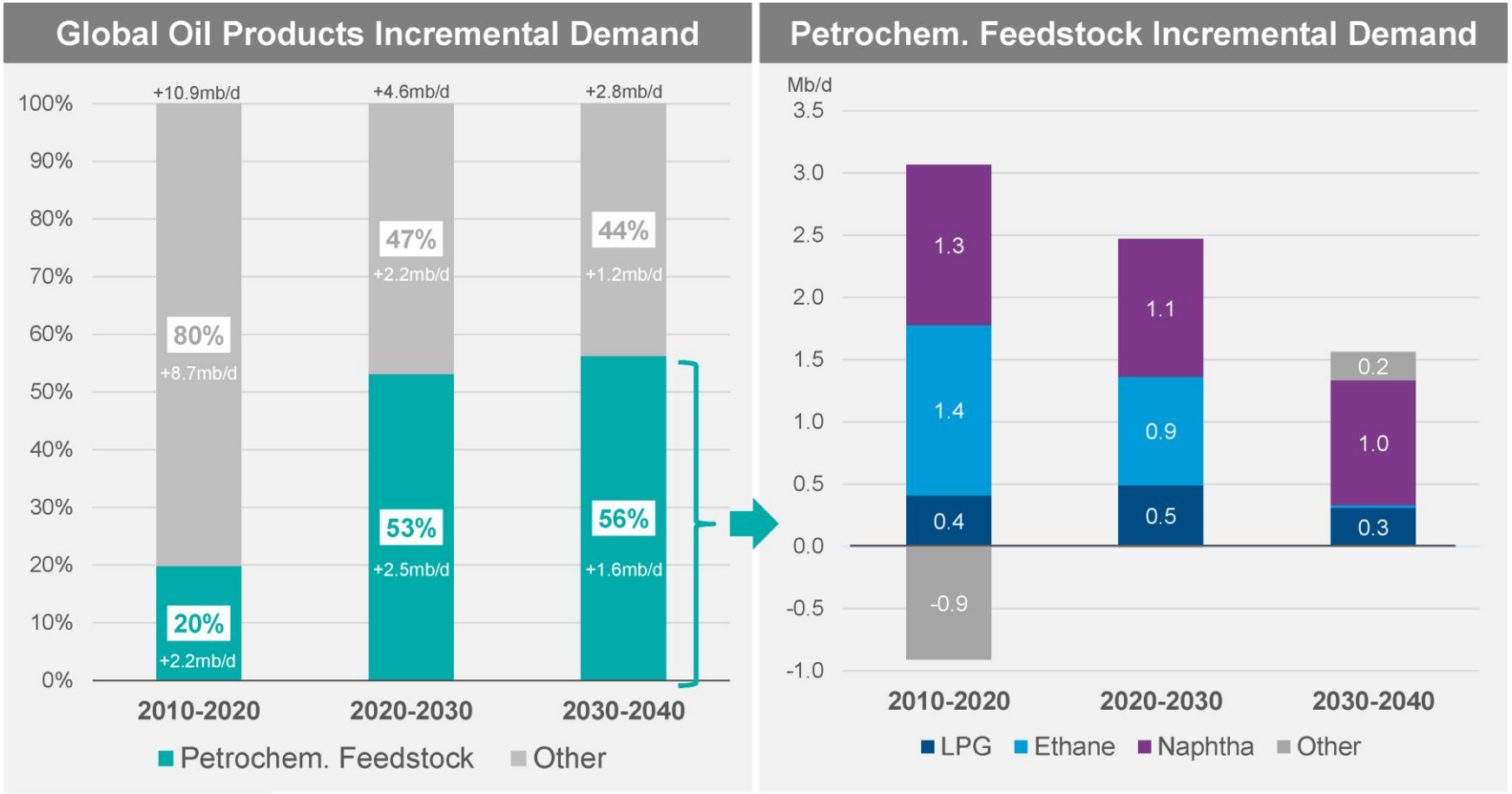
A VIEW BY AXENS OF FUTURE TRENDS FOR PETROCHEMICALS

STRONG PETROCHEMICAL DEMAND GROWTH TREND



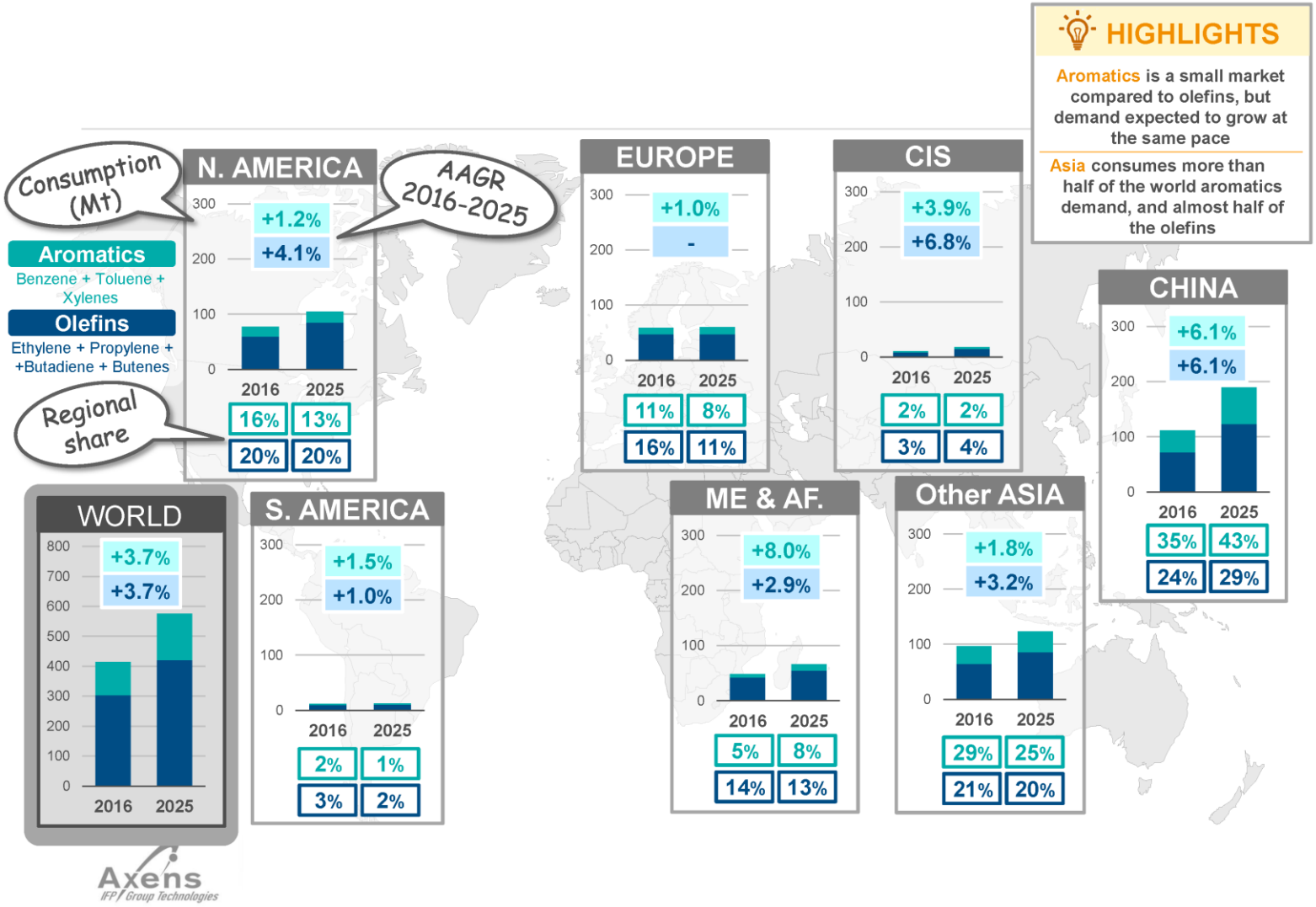
Axens
IFP Group Technologies

PETROCHEMICAL INCREMENTAL FEEDSTOCKS TRENDS

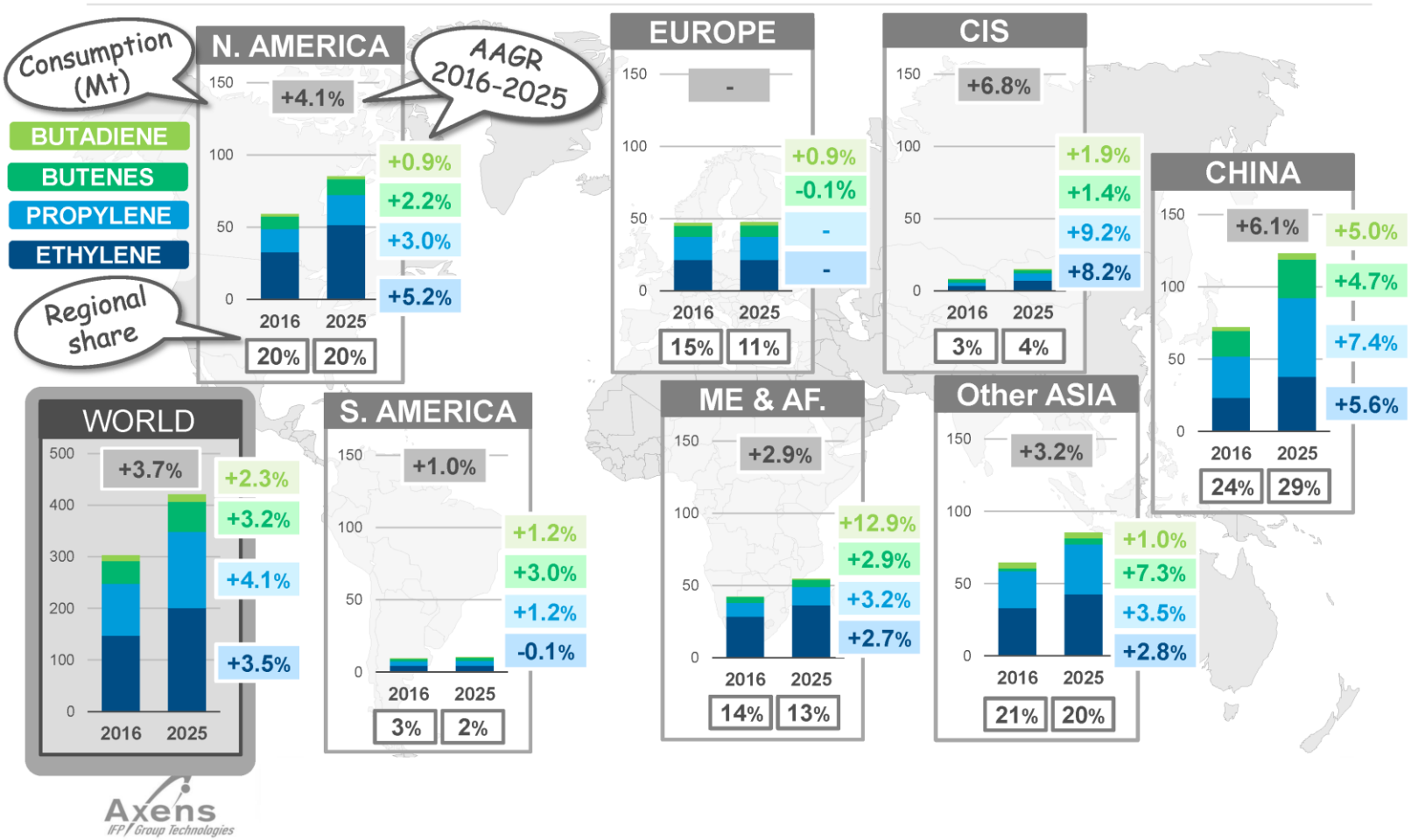


Axens
IFP Group Technologies

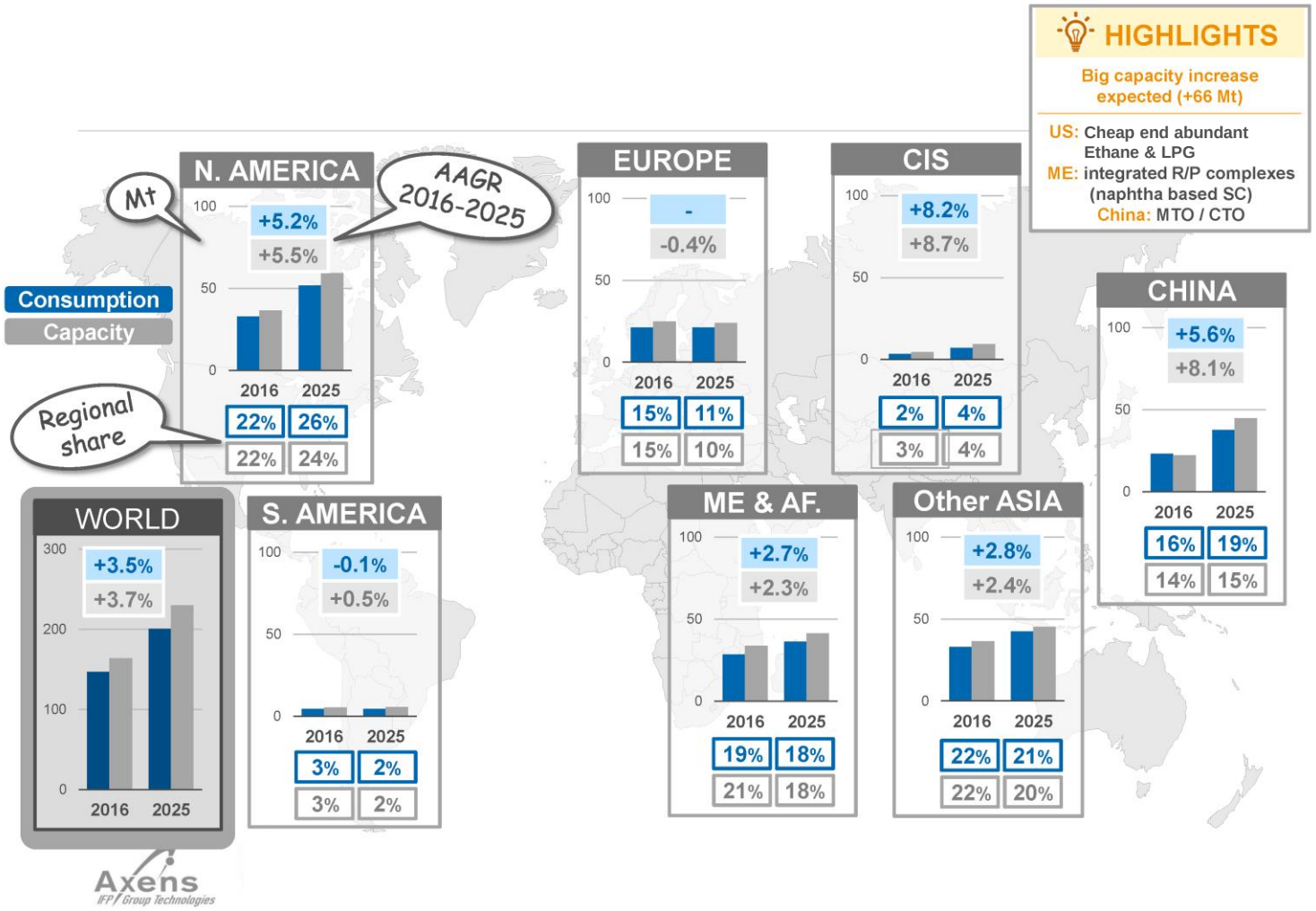
PETROCHEMICALS OUTLOOK REGIONAL TRENDS (2016 – 2025)



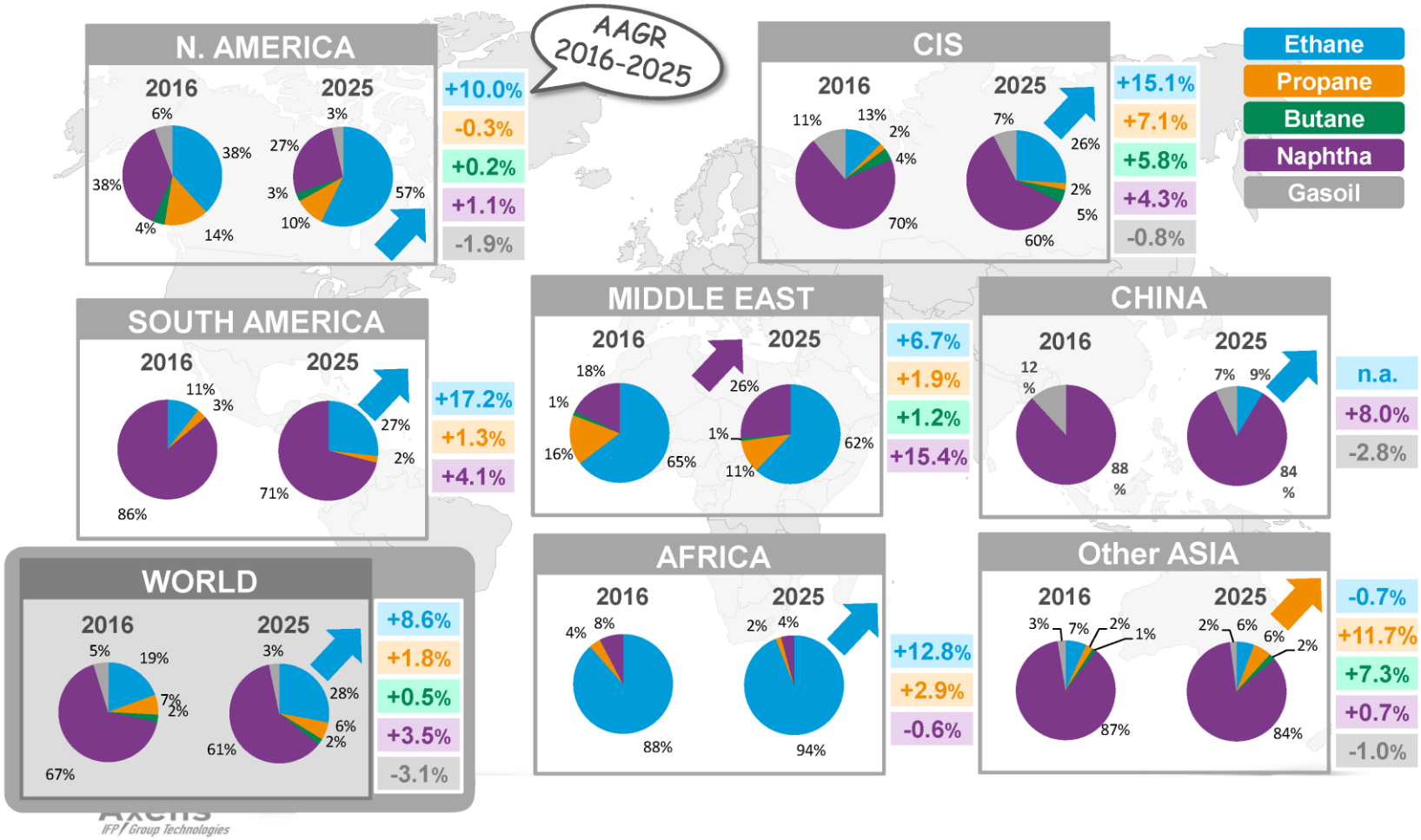
FOCUS ON OLEFINS REGIONAL TRENDS (2016 – 2025)



FOCUS ON ETHYLENE REGIONAL TRENDS (2016 – 2025)



FOCUS ON ETHYLENE STEAM CRACKERS FEED TRENDS (2016 – 2025)



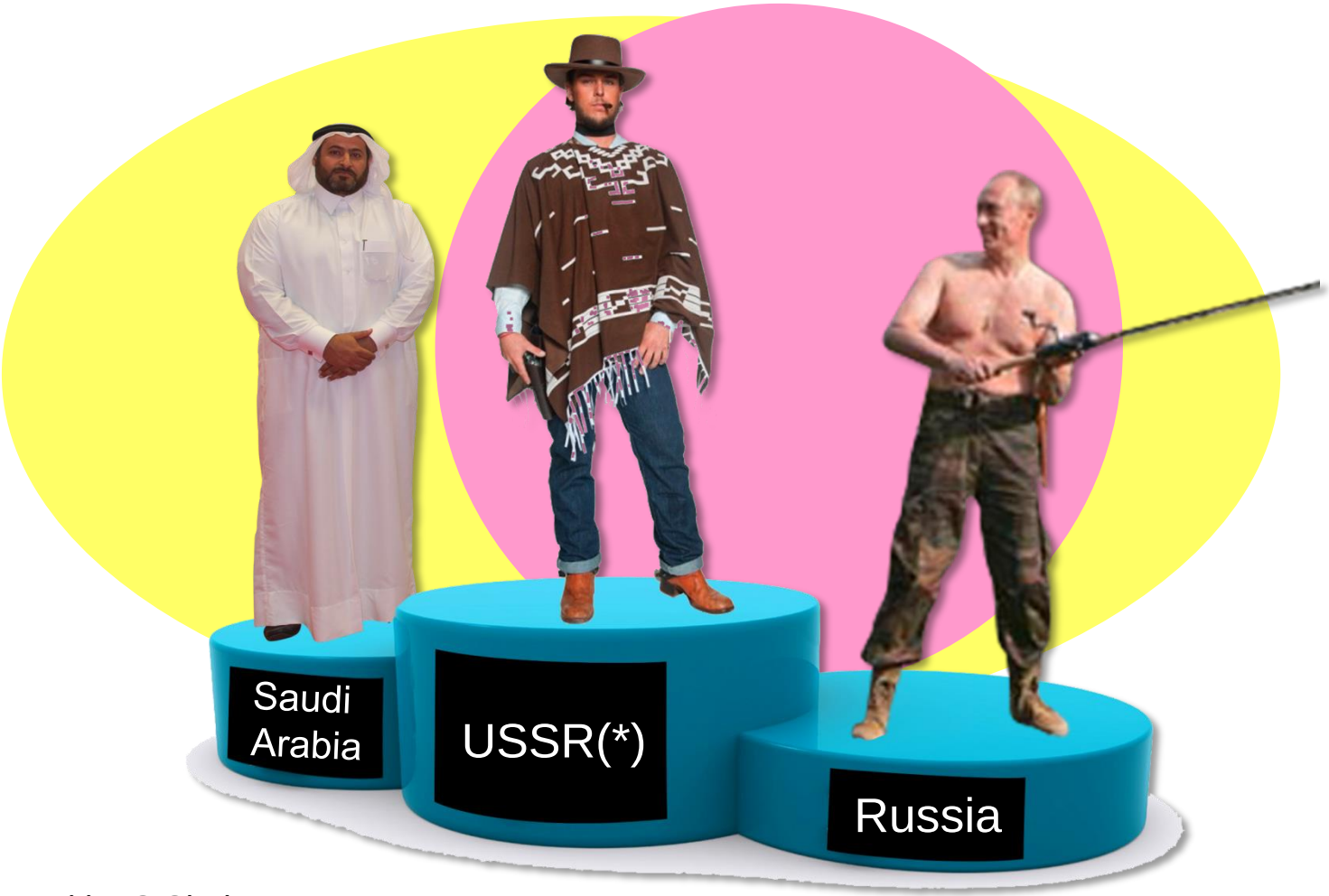
FINAL REMARKS

FUTURE MAJOR TRENDS FOR REFINING AND PETROCHEMICALS

- **Refineries outside USA will incorporate more and more deep conversion and complex chemical units, for more added value**
- **Polymers will continue to grow, as their usage contributes to energy savings by substitution for other materials (steel, glass, etc)**
- **Feedstock cost advantage will remain a key factor for competitiveness but quality grades will also be key for higher value of polymers**
- **Petrochemical final products demand growth will occur in developing countries, where cheap labor will promote the development of manufacturing activities**
- **New feedstock will emerge (biofuels from cellulosic biomass, gas or coal to methanol to olefins, …) requiring also new research, new developments and new investments. However a lot of uncertainties**
- **Plastics recycling will increase…but how fast ? Bio-degradable or self destructible plastics will develop…but when & how much ?**

HOWEVER THE LARGEST POTENTIAL « TREND CHANGER » REMAINS UNPREDICTABLE: WORLD POLITICS !

THREE SUPER PLAYERS FOR OIL PRODUCTION AND PRICES
BUT ONLY TWO FOR GAS PRODUCTION AND PRICES…



(*) US Shale Ressouces

LAST BOOK BY PIERRE RENE BAUQUIS WAS TRANSLATED IN RUSSIAN THANKS TO GUBKIN UNIVERSITY

- Book launch in Moscow 9th december 2017
- This is the third book by PR BAUQUIS on energy translated in russian…and it will be the last one
- Today's presentation in Kazan should also be the last one !

(သင့်ကို) ကျေးဇူးတင်ပါတယ်

Bedankt

gracias

Terima Kasih

Cám ơn

Thank you

谢 谢

شكراً

спасибо

merci

grazie

Obrigado

ขอบคุณมาก

Tusen takk