Evolution du Raffinage et de la Pétrochimie

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14 Janvier 2013
Maison des Arts & Métiers

Plan de la Présentation

- Axens en Bref
- Evolution des marchés
  - À moyen Terme (2017)
  - À long Terme (2030)
- Conséquences sur les outils
  - de raffinage
  - de pétrochimie
- Production de carburants et produits « pétrochimiques » à partir de biomasse

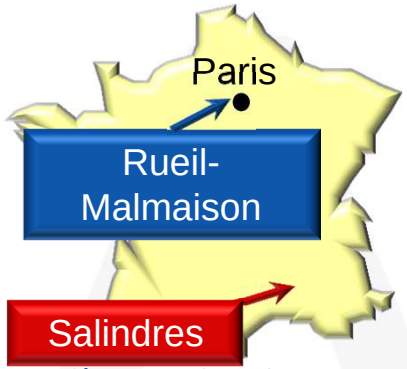
Built on Strong Foundations
Axens' Industrial History

Catalysts & Adsorbents
Procatalyse

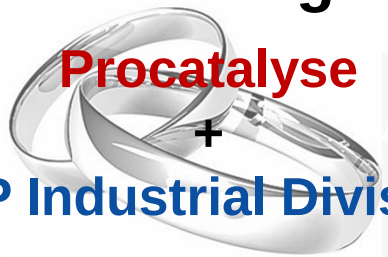
1821 	Al_2O_3 ore is discovered and named "Bauxite" after the Southern French town of Les-Baux-de-Provence.
1855	1st industrial production of Alumina in **Salindres**, near Les-Baux-de-Provence.
1950s	Focus on refining and petrochemistry. Production of alumina-based catalysts.

Technologies
IFP Industrial Division

1944	French Institute of Petroleum is created in **Rueil-Malmaison**, France
1955	Start-up of the 1st IFP-licensed unit
1960s	1st licenses for HDS, Reforming and Cyclohexane production.



2001 Merger



Procatalyse
+
IFP Industrial Division

Axens
IFP Group Technologies

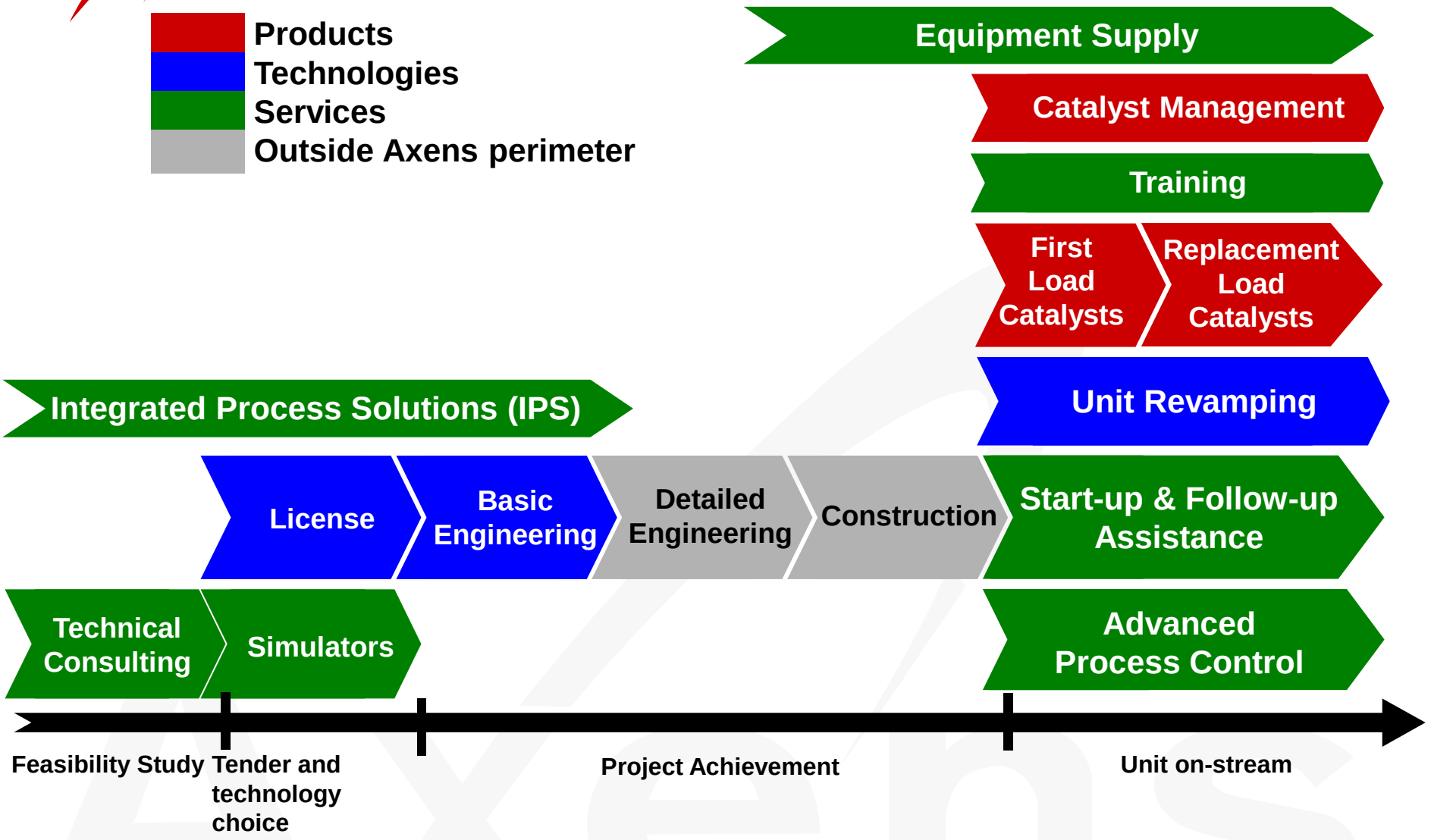
100% subsidiary of IFP Energies nouvelles

Markets Served & Ambitions

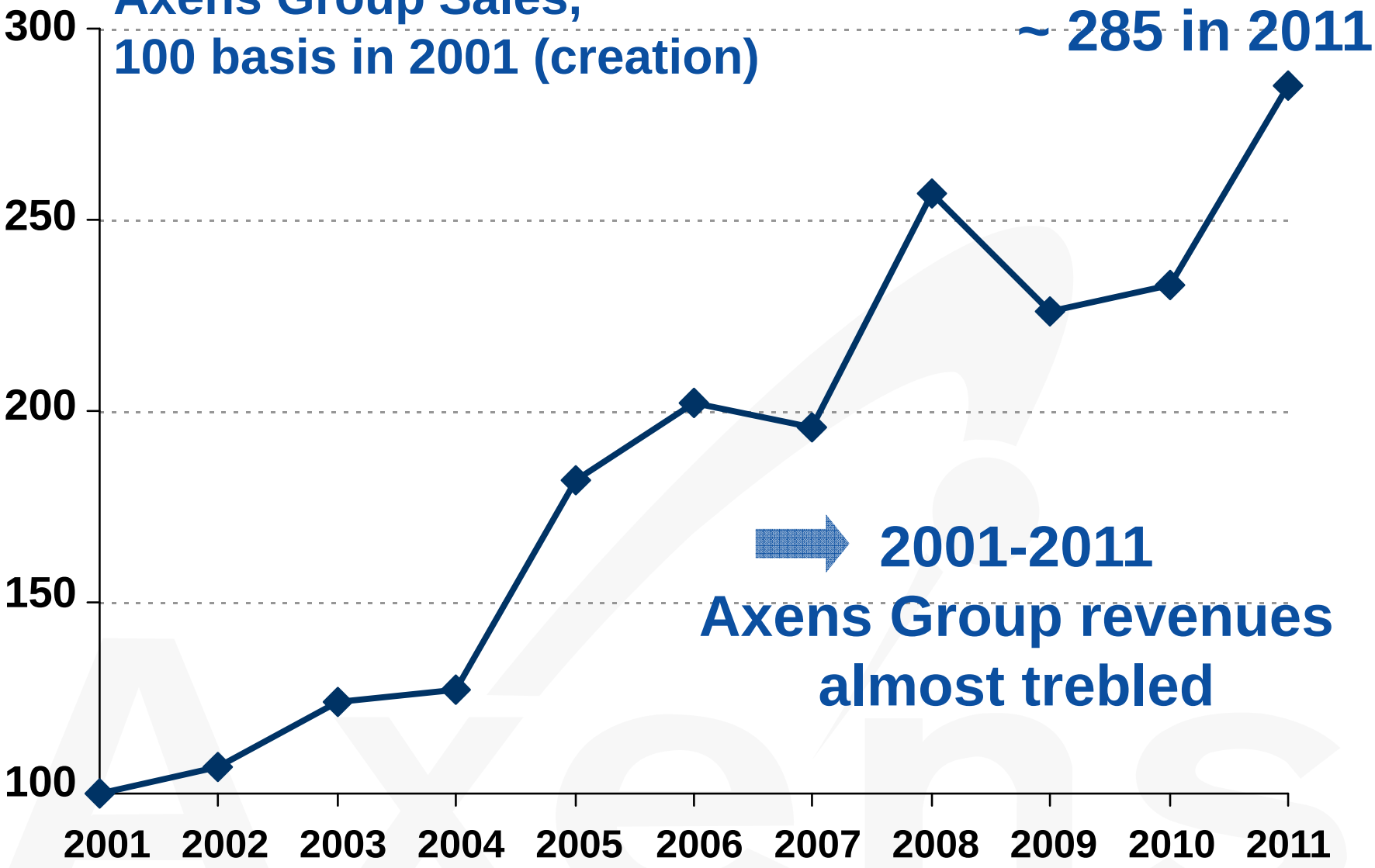
Ambitions

- **Benchmark company for Clean Fuels and Aromatics production,**
- **Leader in purification for olefins/polyolefins, syngas, refining and petrochemical, and natural gas streams,**
- **Innovator in the biodiesel market and syngas to liquids technology.**

How Do We Operate?



Sales Growth



Commercial Network Development

- 2007: Axens (Beijing) Trading Co Ltd
- 2008: Axens Middle East SPC
- 2009: Axens India Private Ltd
- 2010: Axens Vostok
- 2010: Axens Canada Specialty Aluminas Inc.
- 2012: Axens South East Asia Sdn Bhd

Production Facilities Expansion

Brockville (2010)

Willow Island (2011)

Calvert City (2005)

Savannah

Salindres

July 5, 2011 - "Axens and GENTAS to Build Hydroprocessing Catalyst Manufacturing Plant in Saudi Arabia"

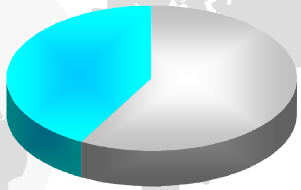
Axens Today

Selected Business Segments

- **Adsorbents and Claus**
  - Synergies from the acquisition of Rio Tinto's activated alumina business make Axens a leader in the segment today
- **Catalytic Reforming**
  - Synergies from the acquisition of Criterion's business make Axens a leader in catalytic reforming catalysts and process technology
- **Selective Hydrogenation & Liquid Catalysis**
  - Axens is a leading pioneer (Nobel Prize) with a high performance product range
- **Hydroprocessing**
  - Gasoline: 50% of the world's FCC gasoline is desulfurized by Axens' Prime-G+™ process
  - Middle Distillates: Over 100 licenses for Prime-D™ & Prime-K™

~ 42%

of worldwide refineries operate at least one refining unit licensed by Axens



~ 20%

of gasoline and diesel used in the world is produced by refining units licensed by Axens

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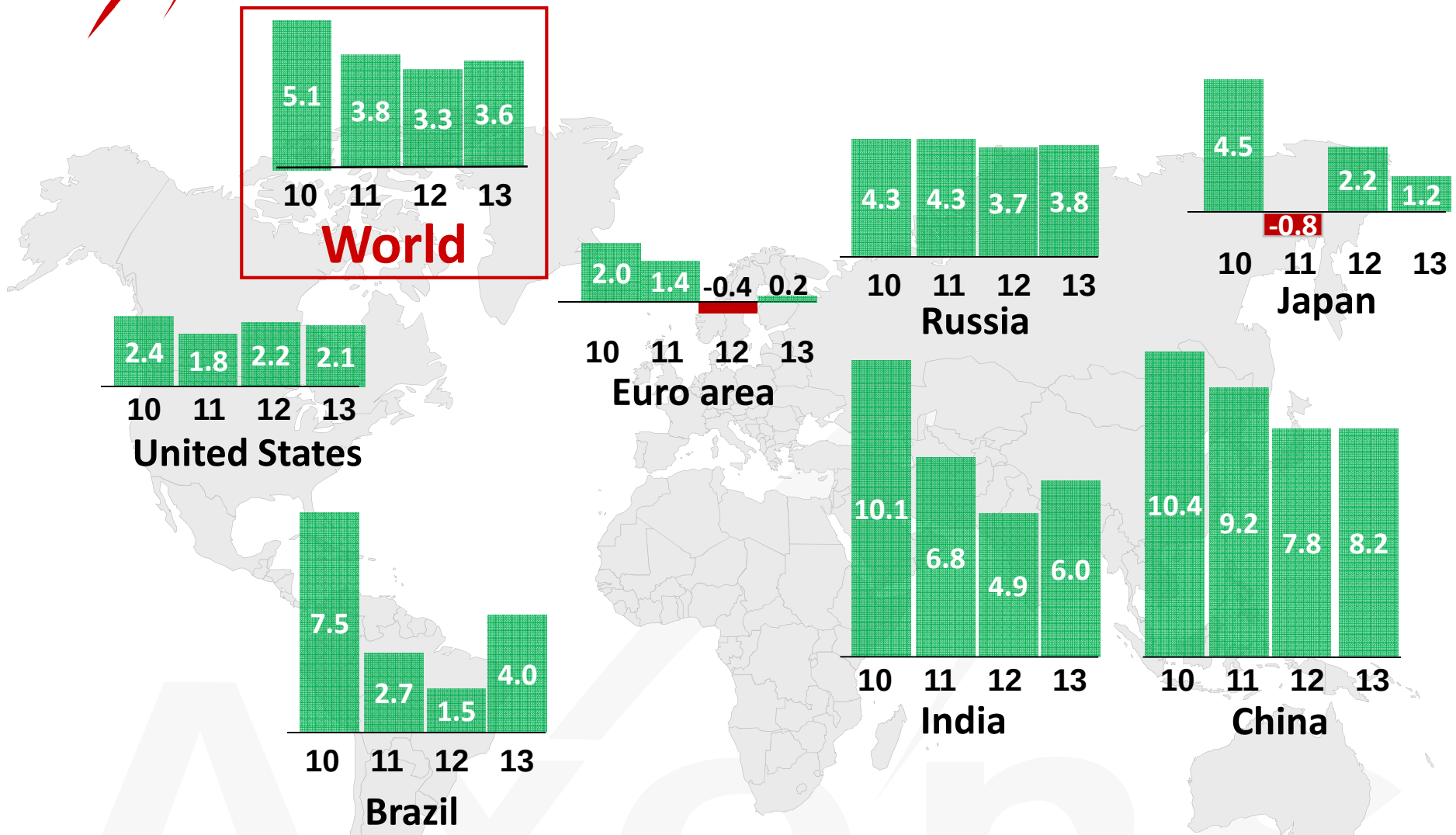
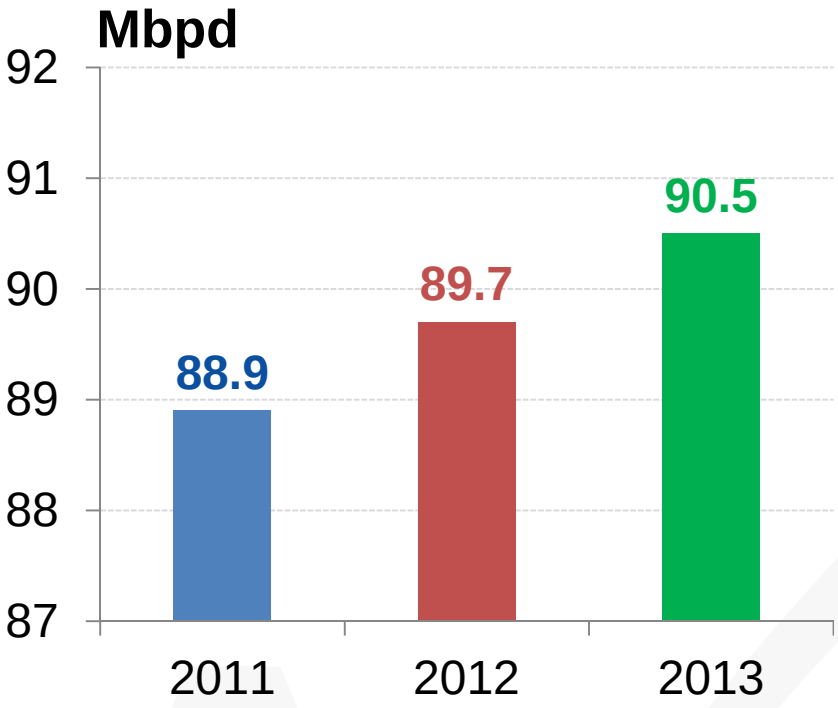
GDP Growth (%)
2010 – 2011 – 2012 – 2013



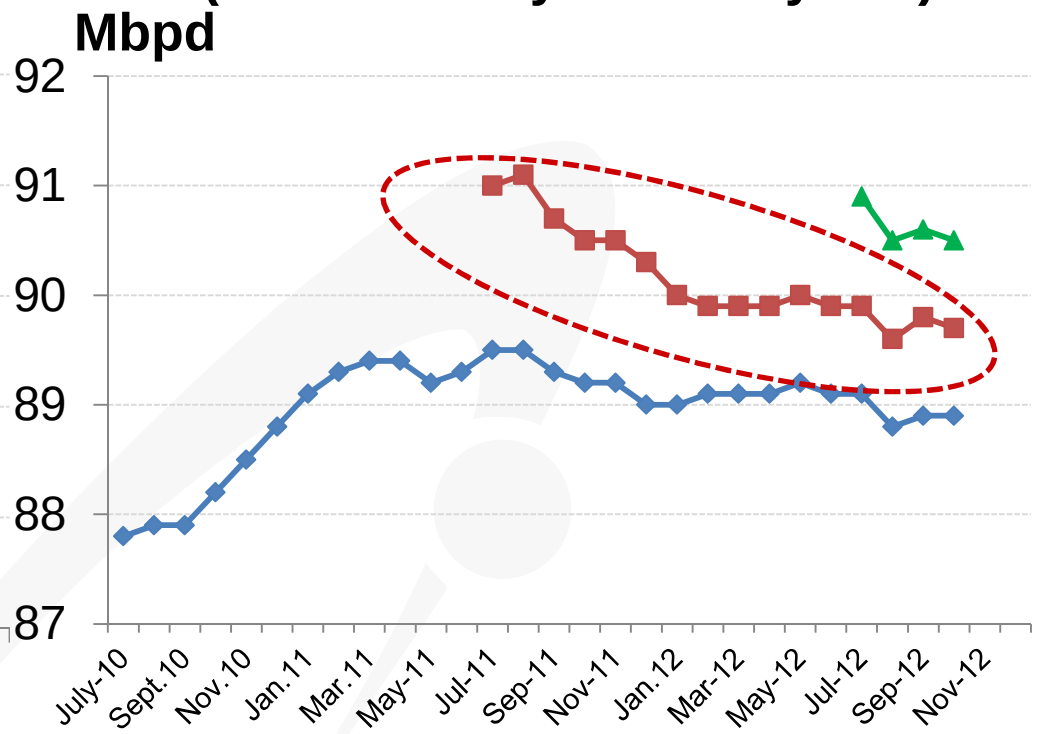
Source: International Monetary Fund (World Economic Outlook, October 2012)

Oil Demand
Short Term Outlook

2011, 2012 & 2013
Oil Demand
Latest estimates



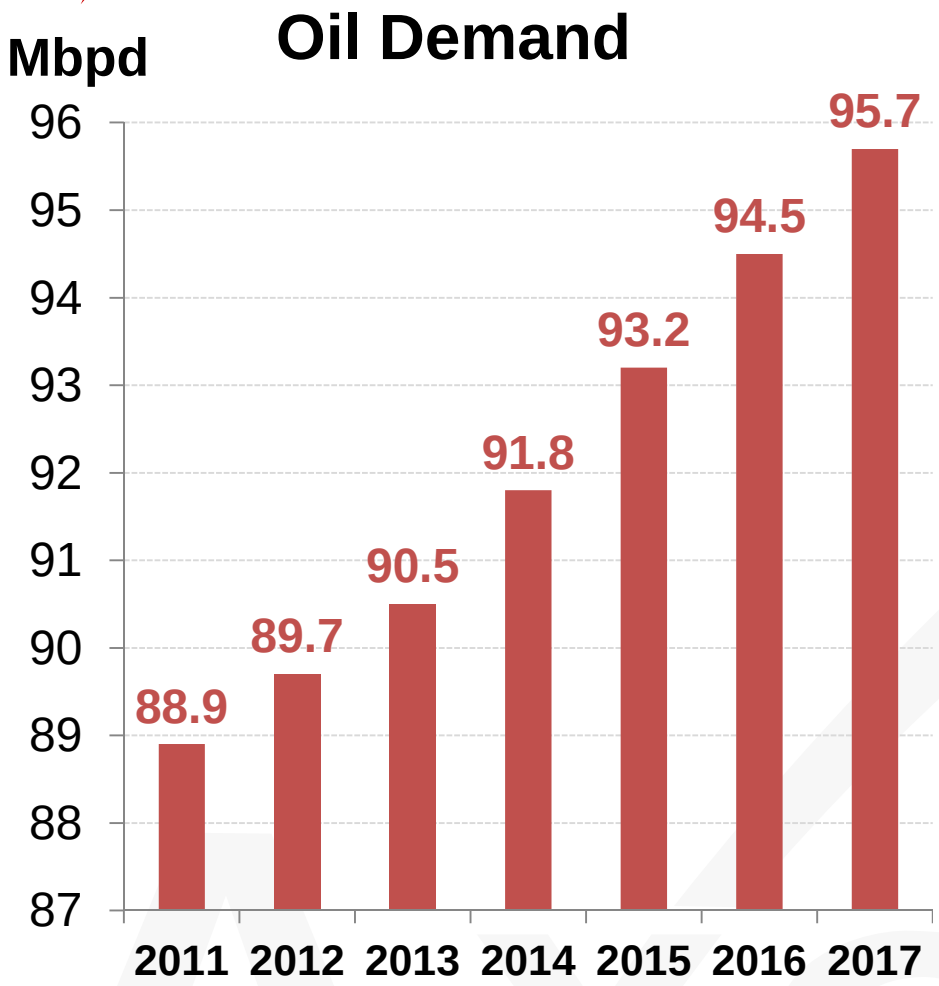
2011, 2012 & 2013
Oil Demand Forecast
(revised every month by IEA)

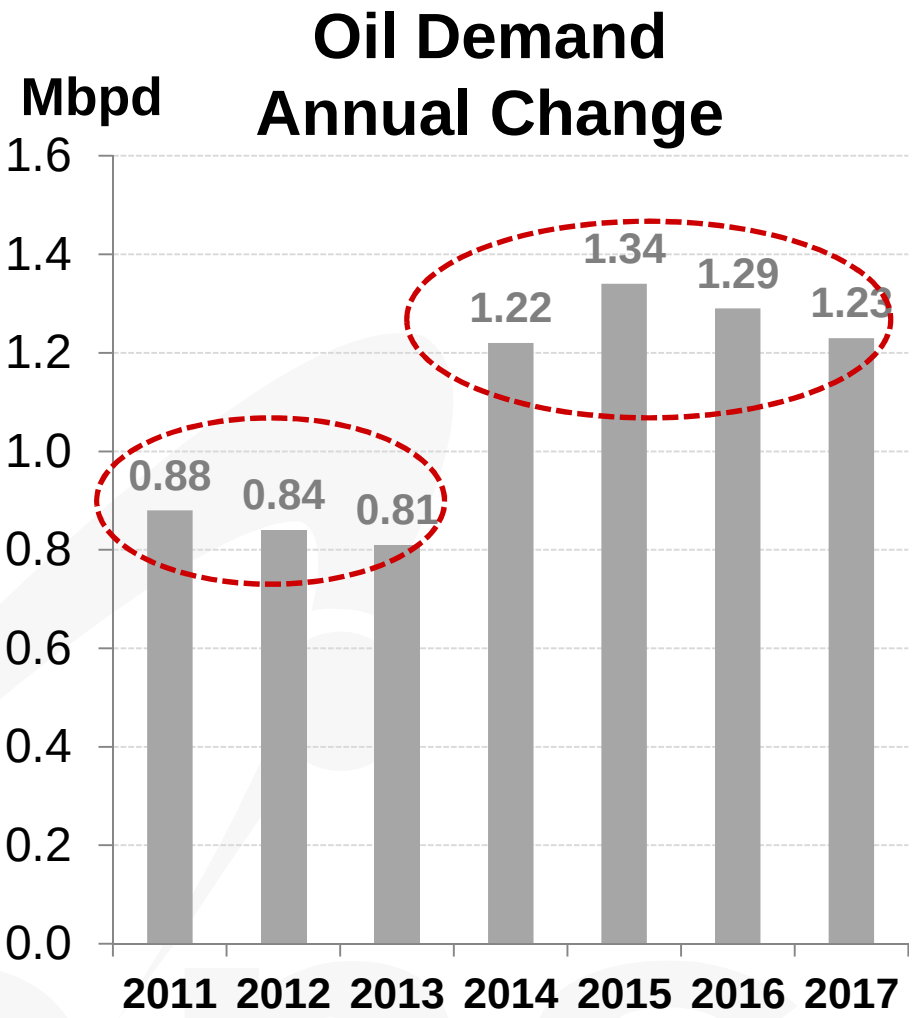


➡ **2012 Oil demand estimates: -1.4 Mbpd**
(from 91.1 Mbpd in August 2011 to 89.7 Mbpd in October 2012)

Source: International Energy Agency (Oil Market Reports)

Oil Demand
Medium Term Outlook

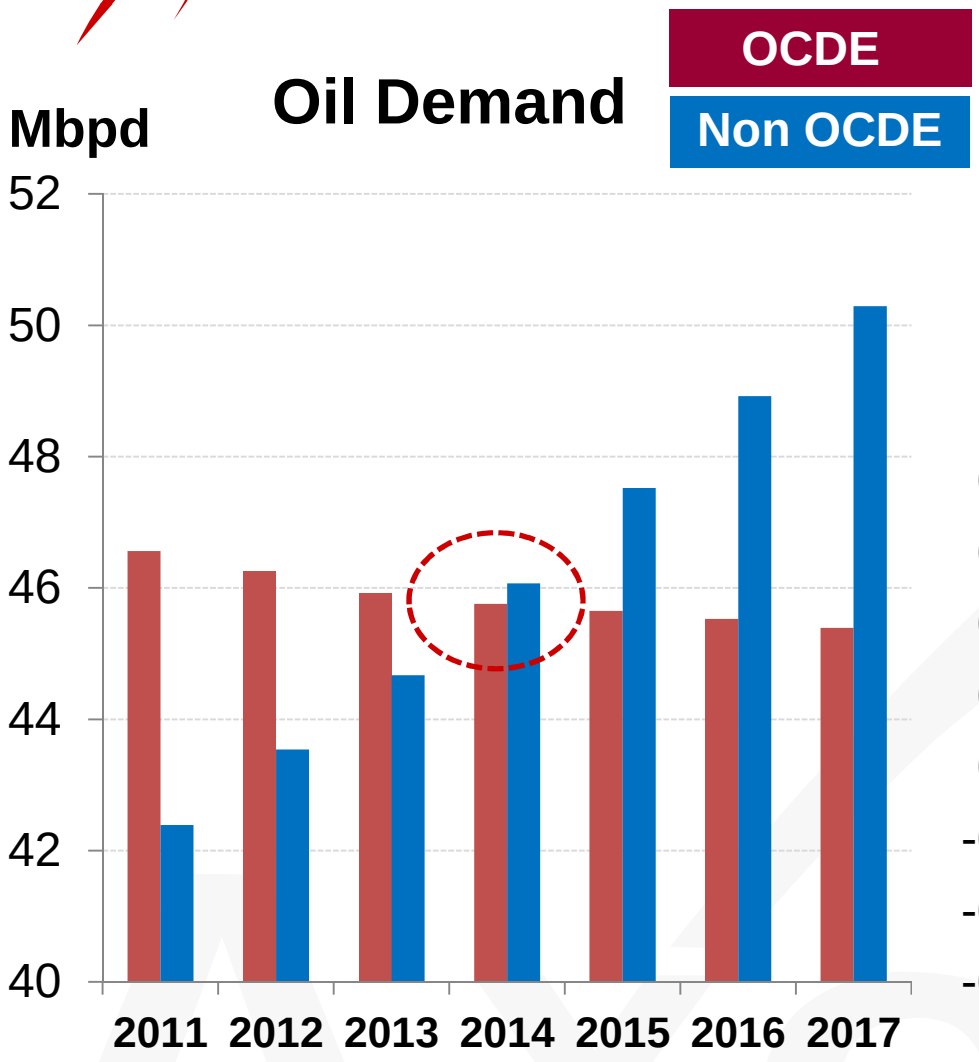


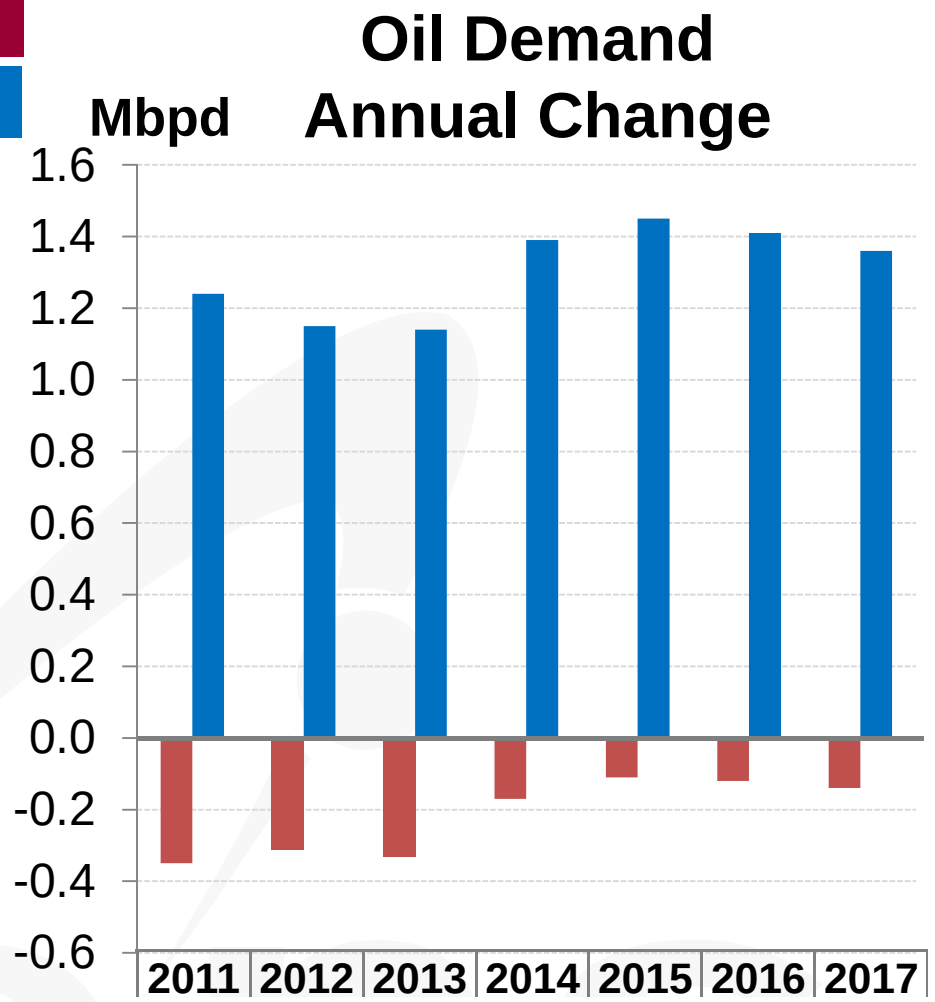


Year-on-year oil demand differential may increase after 2013

Source: International Energy Agency
(Medium Term Oil Market Report, October 2012)

Oil Demand
Medium Term Outlook





➡ **2014: Non-OCDE demand > OCDE demand**

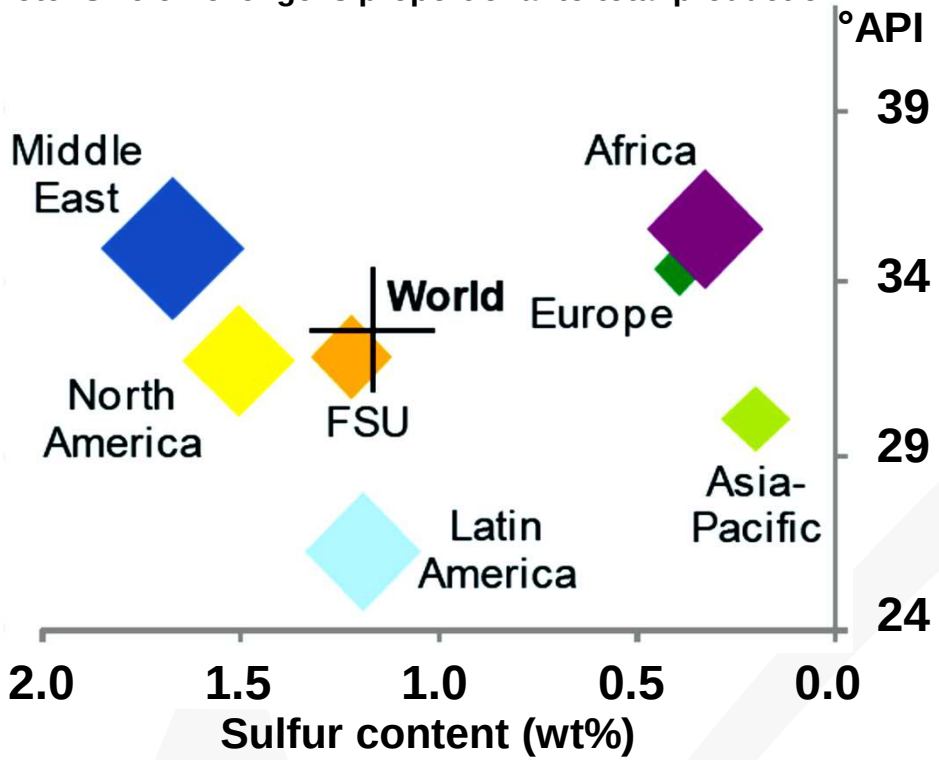
Source: International Energy Agency
(Medium Term Oil Market Report, October 2012)

Refinery Feedstock

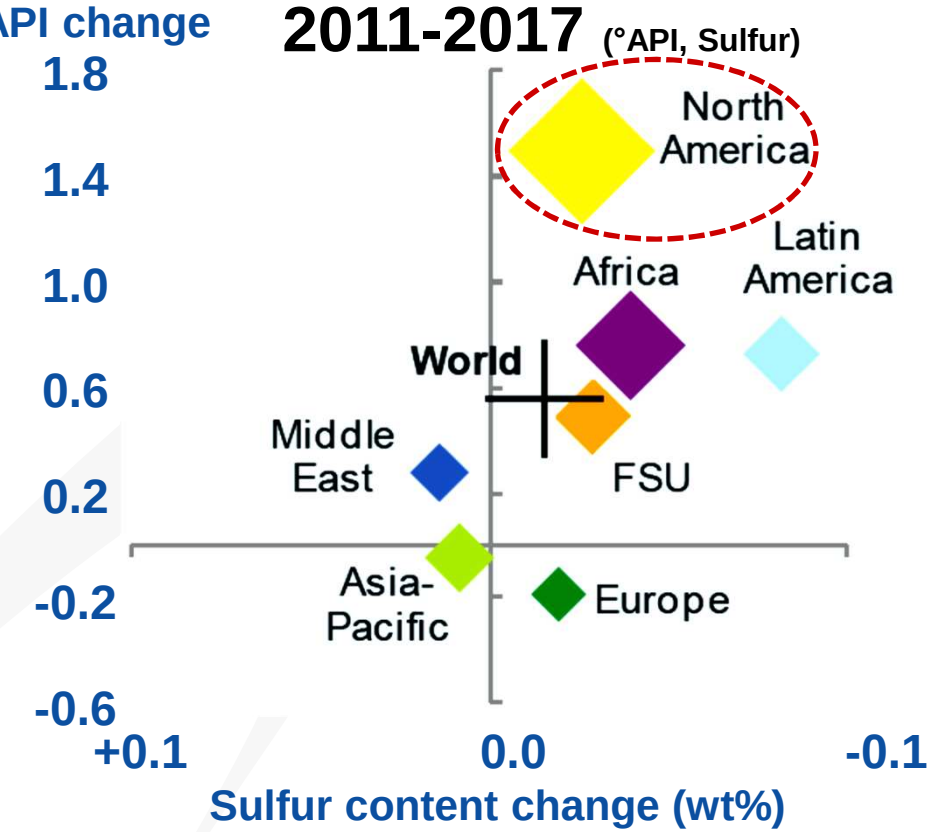
Current Feedstock Quality

(°API, Sulfur)

Note: Size of lozenge is proportional to total production



Changes in Feedstock Quality 2011-2017 (°API, Sulfur)



In contrast with past analyses, by 2017 refinery feedstock is expected to globally become lighter and sweeter

(Strong US tight oil effect during the 2012-2014 period; °API will decrease (heavier feedstock) after 2014)

Source: International Energy Agency (Medium Term Oil Market Report, October 2012)

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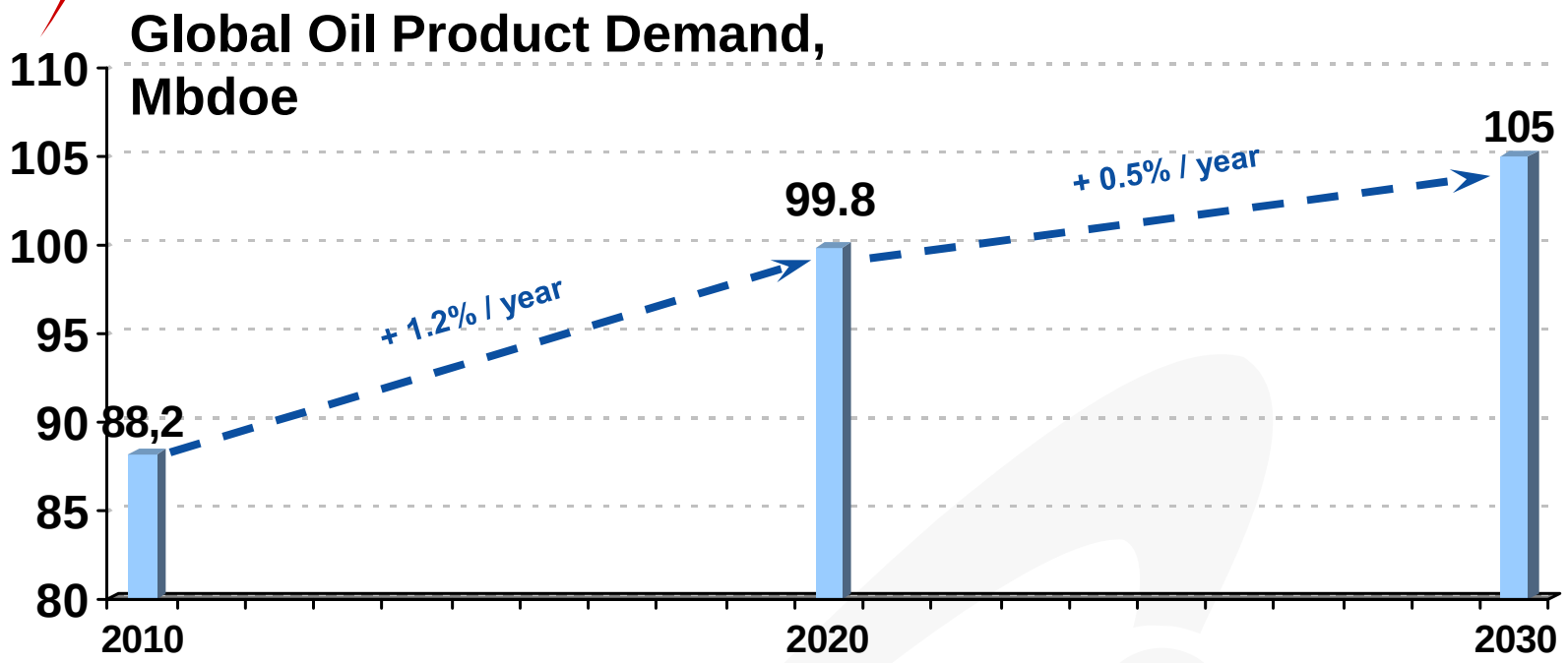
2030 Oil Demand Axens Scenario



- ~ 100 Mbdoe oil demand by 2020
  - 2010-2020 AAGR = + 1.2%
- ~ 105 Mbdoe oil demand by 2030
  - 2020-2030 AAGR = + 0.5%

Mbdoe = Million barrel oil equivalent / day
Source: Axens, IEA & other sources (2010)

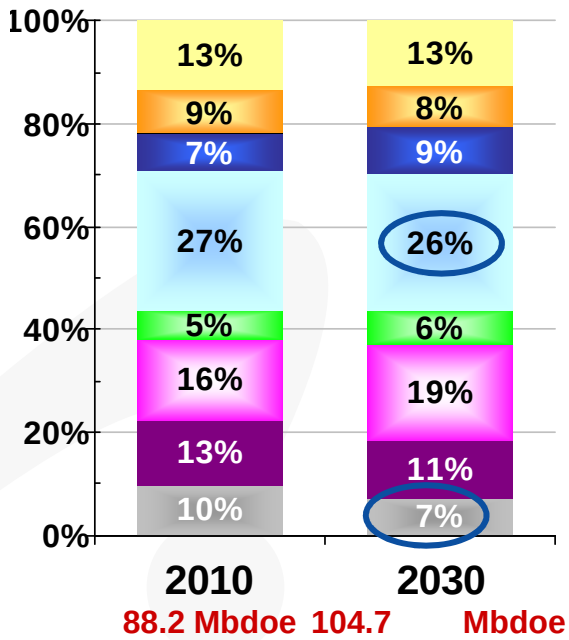
Global Oil Product Demand Outlook

2010-2030 AAGR by Product

Other*	0.7%
LPG	0.5%
Naphtha	2.2%
Motor Gasoline	0.8%
Jet/Kerosene	1.9%
On-road diesel	1.7%
Off-road diesel	0.4%
Fuel Oil	-0.5%

Global 2010-2030 AAGR: 0.9%

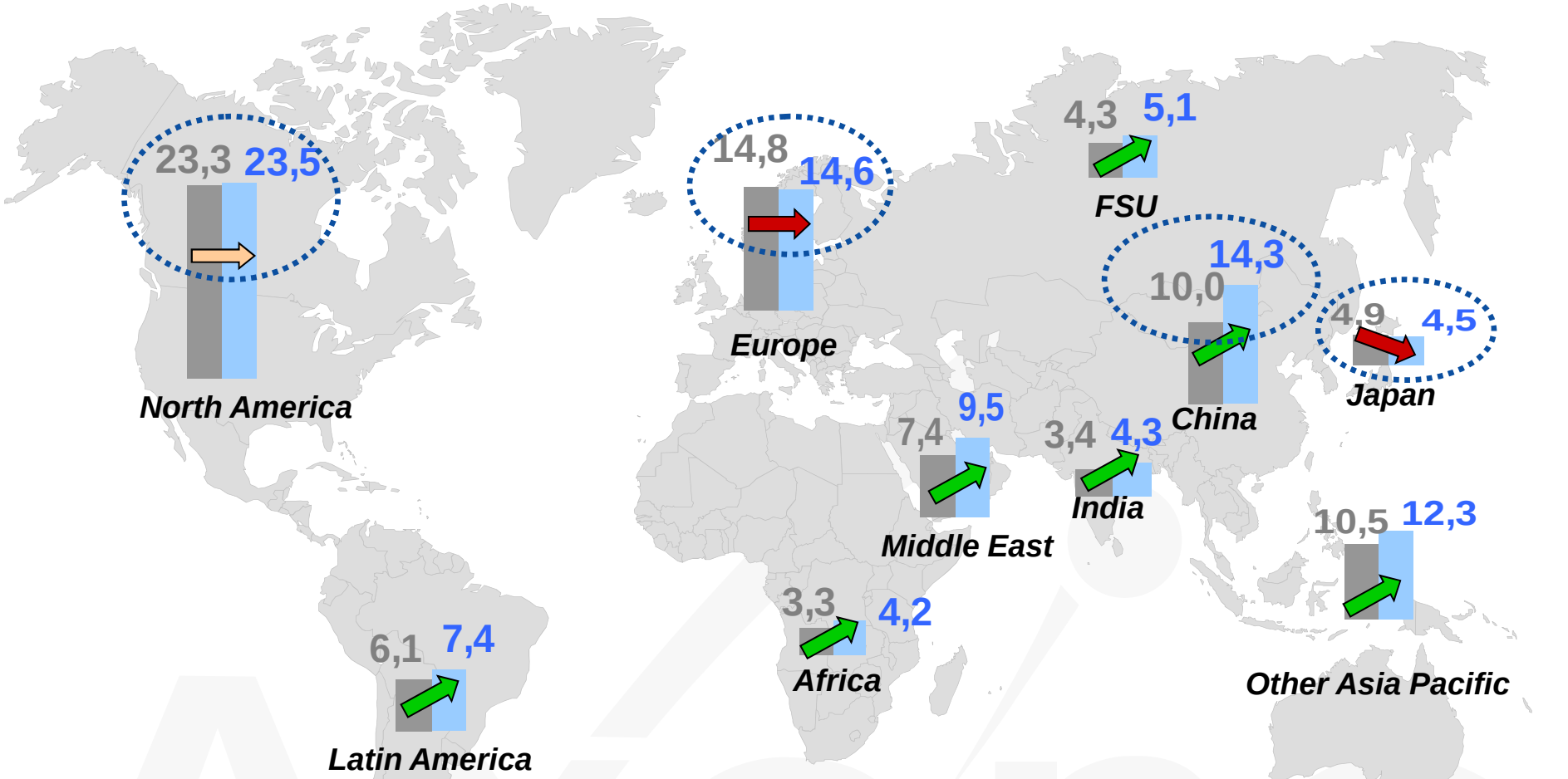
Market Structure 2010 vs. 2030



- **Demand growth driven by transportation fuel**
  - **mainly middle distillates**
  - **Gasoline: lower growth than middle distillates, but main contributor by 2030**
- **Naphtha growth driven by petrochemicals**
- **Heavy fuel oil demand = only 7% of the global demand by 2030**

Source: Axens & Other sources (2011)
Other* = Kerosene (≠ Jet Kerosene), Refinery Gas, Petroleum Coke, NGL, Lubricants, Bitumen, Paraffin Wax, Refinery Losses, …

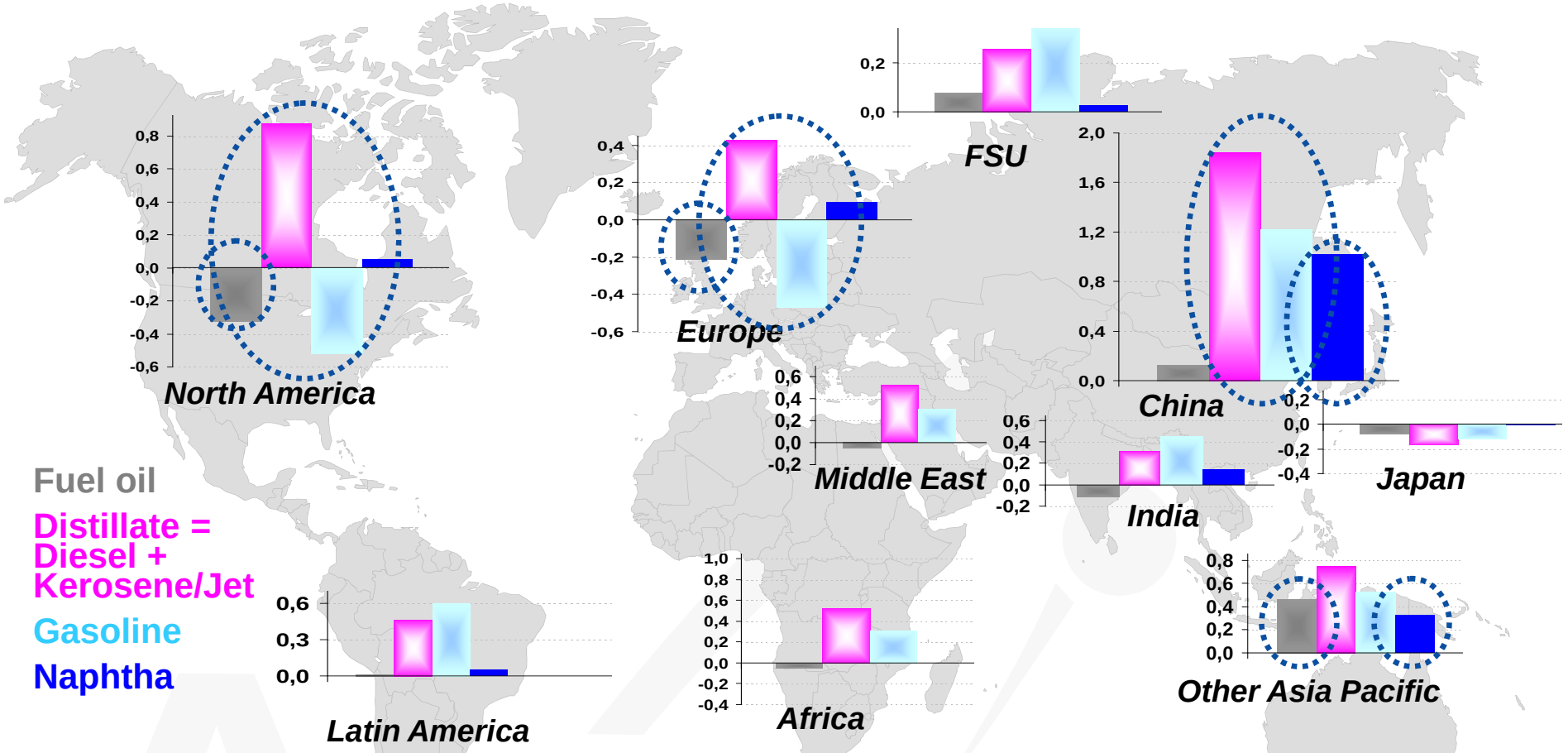
2020 Demand Growth Will be Driven by Emerging Countries…



Global demand	Mbdoe
2010	88.2
2020	99.8

Unit: Mbdoe
Source: Axens Estimates

2010-2020 Incremental Demand by Products



Global demand	Mbdoe
2010	88.2
2020	99.8

Unit: Mbdoe
Source: Axens Estimates

Gasoline Specifications Chart

Source: IFQC, WWFC

	EN 228 1993 Euro II	Dir 98/70 2000 Euro III	Dir 98/70 2005 Euro IV	Dir 98/70 2009 Euro V (Final Proposal)	WWFC Fourth Category
Aromatics, vol%, max	-	42	35	35	35
Olefins , vol%, max	-	18	18	18	10
Benzene, vol%, max	5.0	1.0	1.0	1.0	1.0
Oxygen, wt%, max	-	2.7	2.7	2.7/3.7 (2)	2.7
Sulfur, ppm, max	500	150	50(10) (1)	10	5-10
RVP, kPa	35 - 100	60.0 / 70.0	60.0 / 70.0	60.0 / 70.0 (3)	
Lead, g/l max	0.013	None	None	None	None

(1) 2005 introduction of 10ppm sulphur – Fuel must be geographically available in an appropriately balanced manner
(2) 3.7% by mass in “high biofuel petrol” (Methanol: 3% vol, Ethanol: 10% vol, Iso-propyl alcohol: 12% vol, Tert-butyl alcohol: 15% vol, Iso-butyl alcohol: 15% vol, ETBE: 22%vol, other oxygenates: 15%vol)
(3) The legal vapor pressure limit remains at 60kPa for both gasoline grades and at 70kPa for Member States with arctic or severe weather conditions. However, blending ethanol in gasoline results in a non-linear change of the vapor pressure, and, as oil refiners do not currently produce low vapor pressure gasoline, the commission has introduced a permitted vapor pressure waiver that is directly linkedto the percentage of ethanol blended in gasoline (ranging from 0 vol% to 10 vol%).

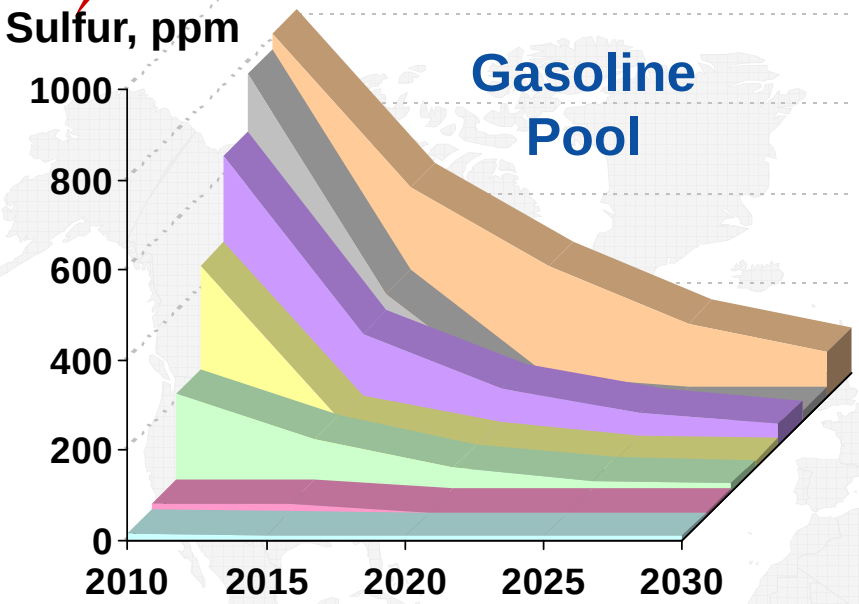
European Diesel Specifications

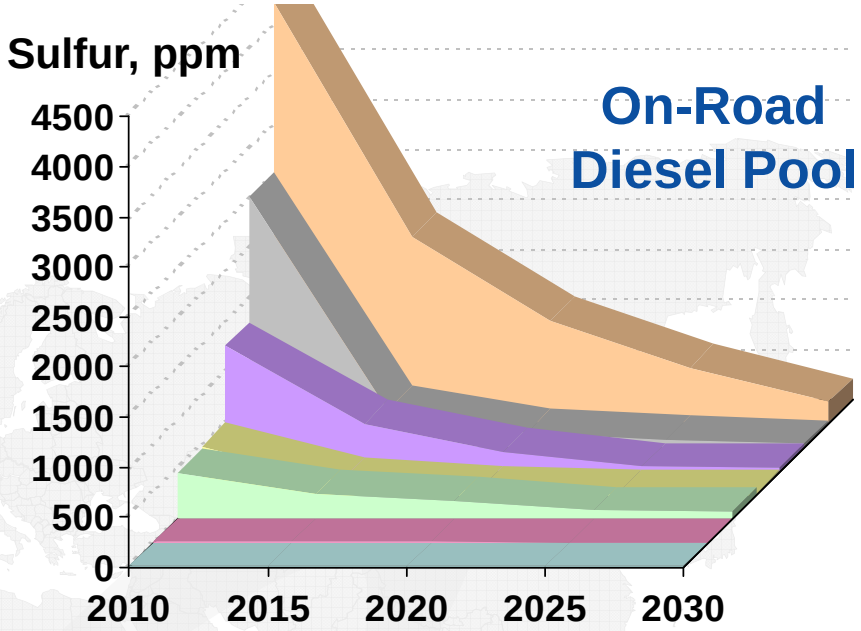
	EN 590 Euro II 1993	Dir 98/70 Euro III 2000	Dir 98/70 Euro IV 2005	Dir 98/70 Euro V 2009
Sulfur, ppm max	2000/500	350	50(10)*	10
Polyaromatics, vol% max	11	11	11	8
Cetane Number, min	46-49	51	51	51
Density, @15°C, kg/m3, min-max	820-860	845	845	845
Distillation, °C, T95, max	360	360	360	360

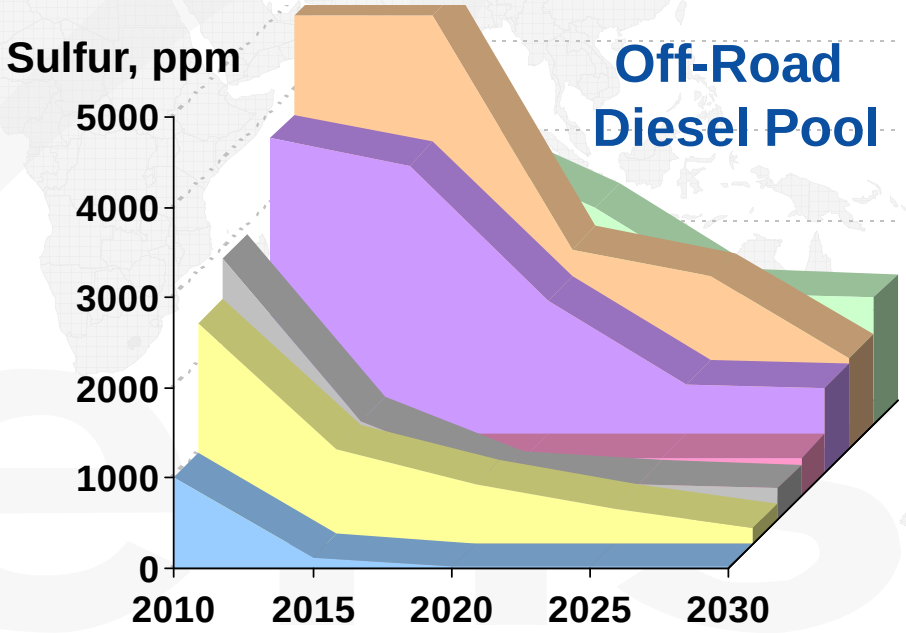
* 2005 introduction of 10ppm sulphur – Fuel must be geographically available in an appropriately balanced manner

Source: IFQC

Regional Gasoline & Diesel Quality Forecasts







Europe
North America
Asia-Pacific
CIS
Latin America
Africa
Middle East

Source: Hart WRFS 10

Sulfur Limits
Marine Bunker Fuel

Emission Control Areas (ECA)

1.5 wt% **1 wt%** **0.1 wt%**

Current **2010** **2012** **2015** ***2018*** **2020** ***2025***

4.5 wt% **3.5 wt%** **0.5 wt%**

Review to assess sufficient availability of 0.5% sulfur FO

If not

Final adoption of 0.5 wt% deferred

Global

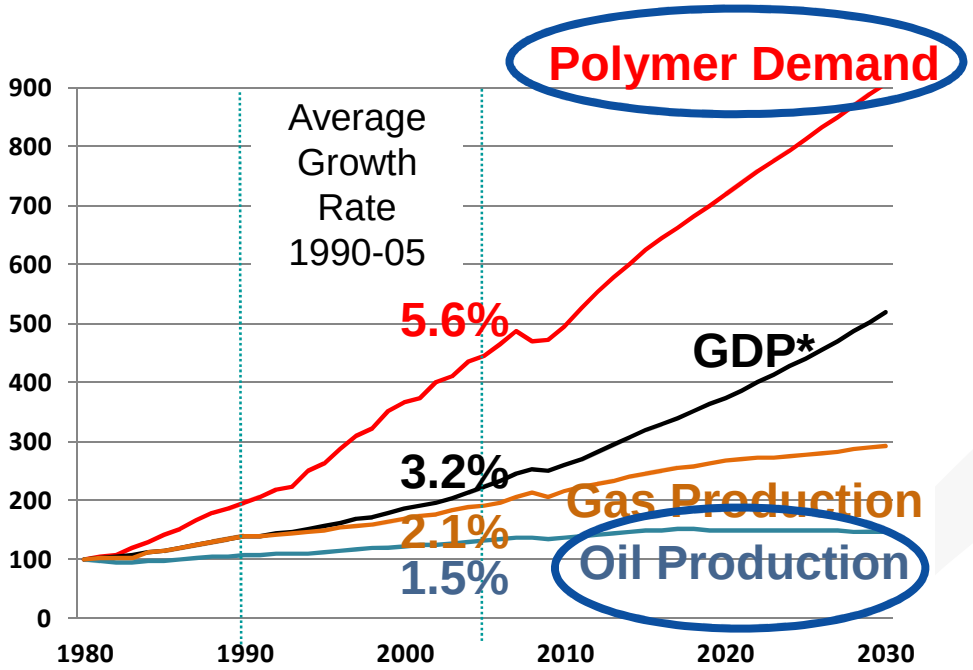
Source: IFQC 2009

Abatement technologies (e.g. exhaust-gas scrubbing) is allowed as an alternative to using compliant fuel

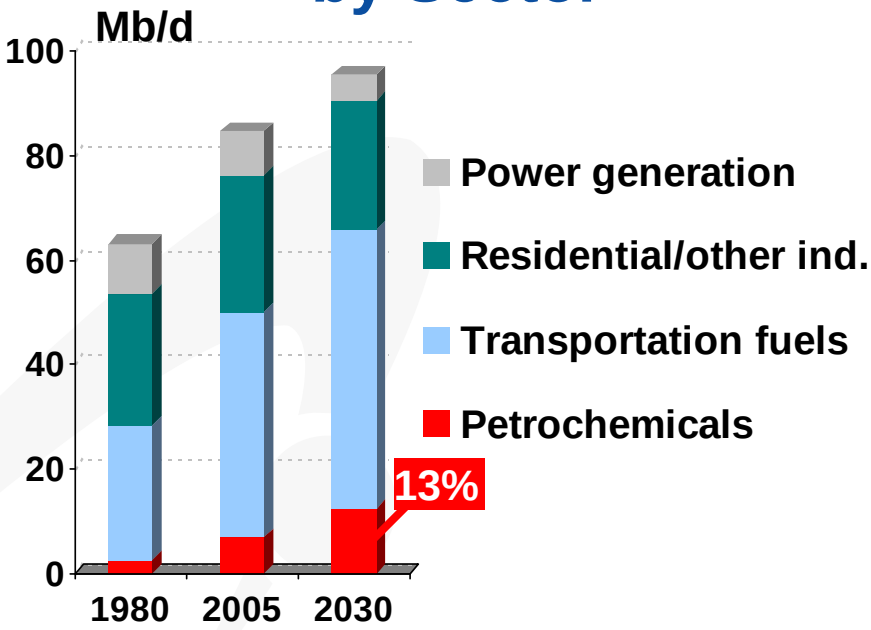
Important Scale Change and Uncertainty

Refining & Petrochemicals Synergies Market Analysis

World Demand Index



Crude Oil Demand by Sector

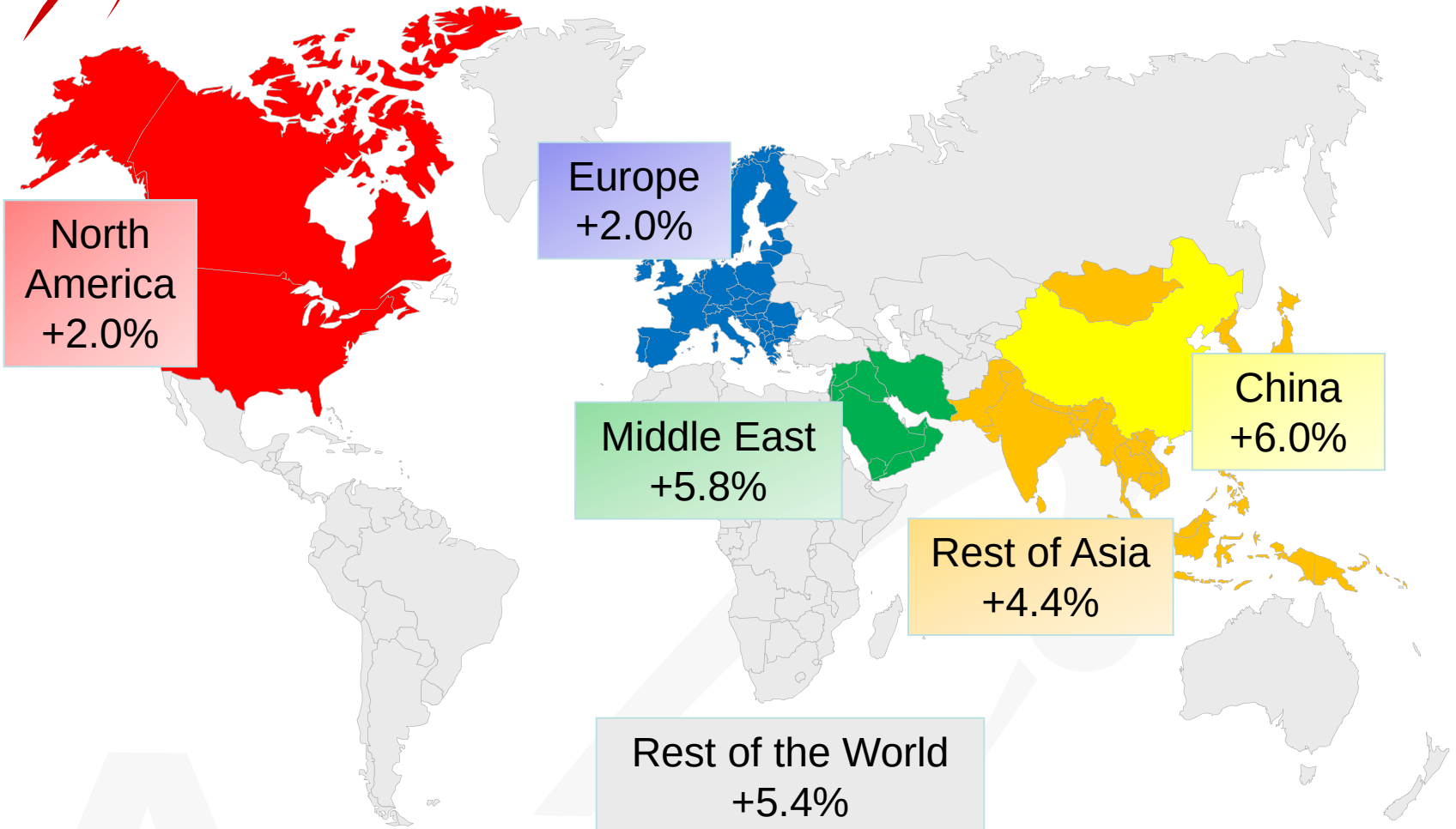


- **Polymer demand growth >> Crude oil production growth**
- **Crude oil demand share dedicated to petrochemicals increases**
- **Let's see the impact on polymer demand**

Source : TOTAL

GDP*: Gross Domestic Product

Polymer Demand 2010-2020
Average Annual Growth Rate



Global Polymer Demand
2010-2020 AAGR: +4.3%

Source: Total

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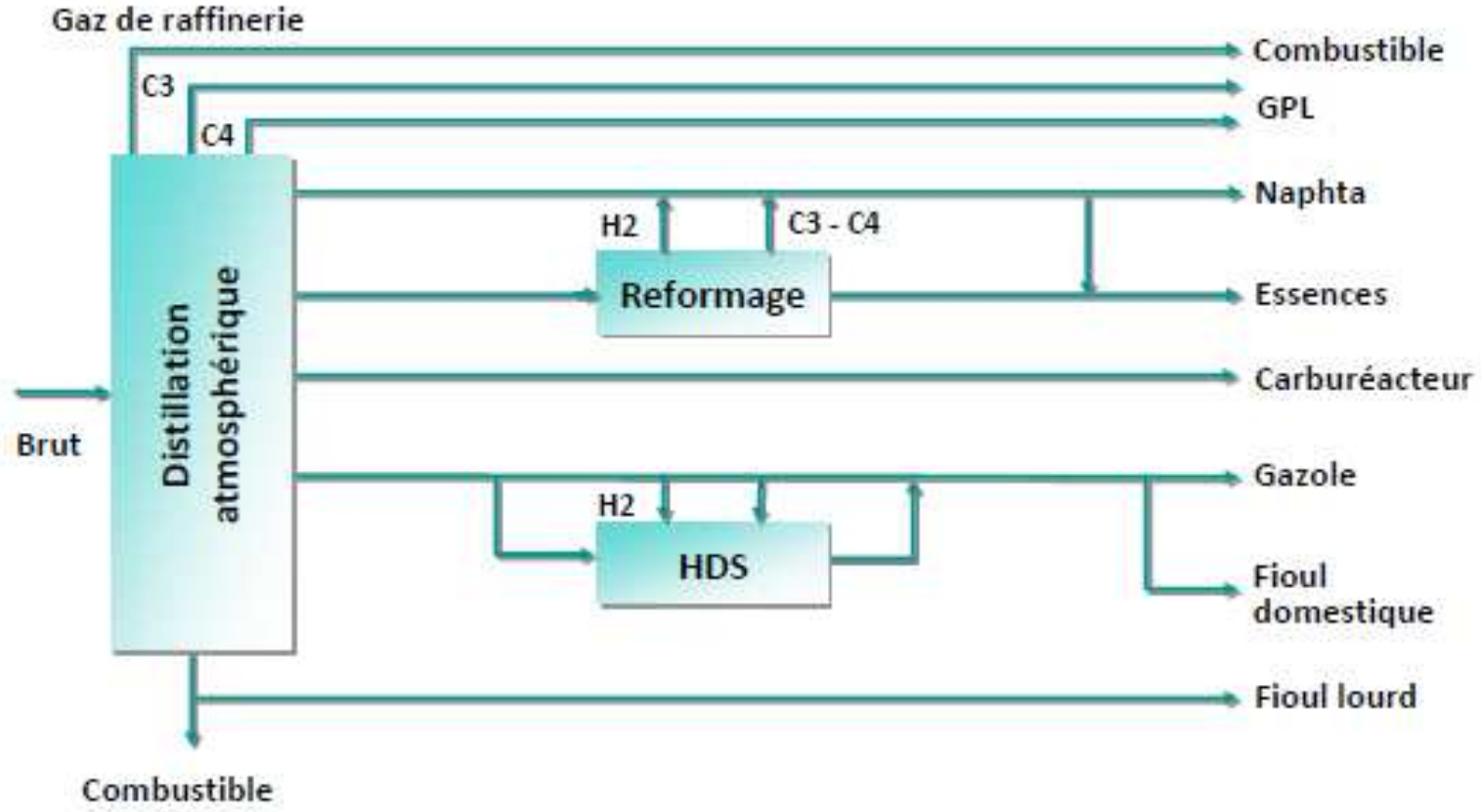
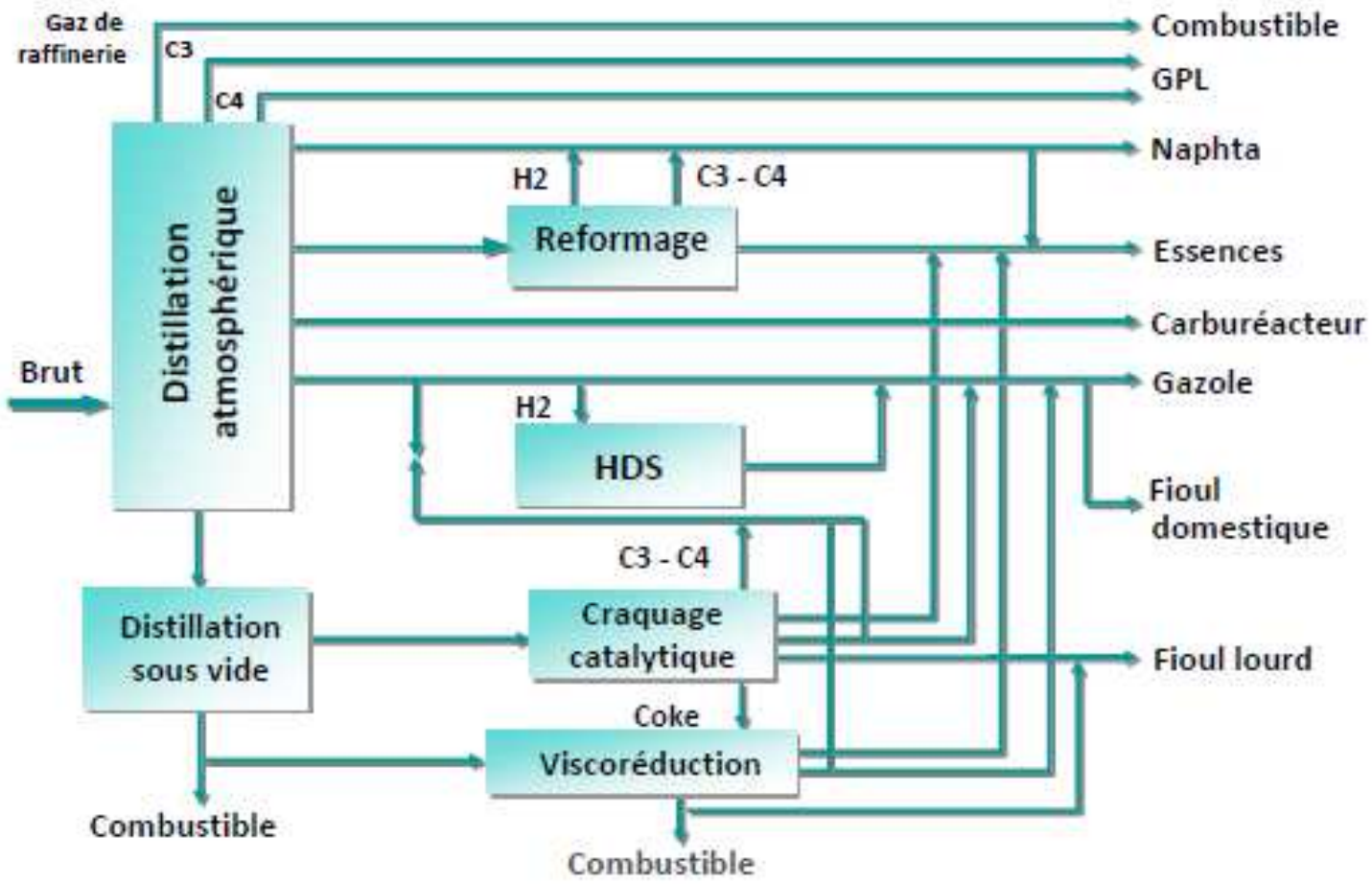
Raffinerie simple - début des années 70



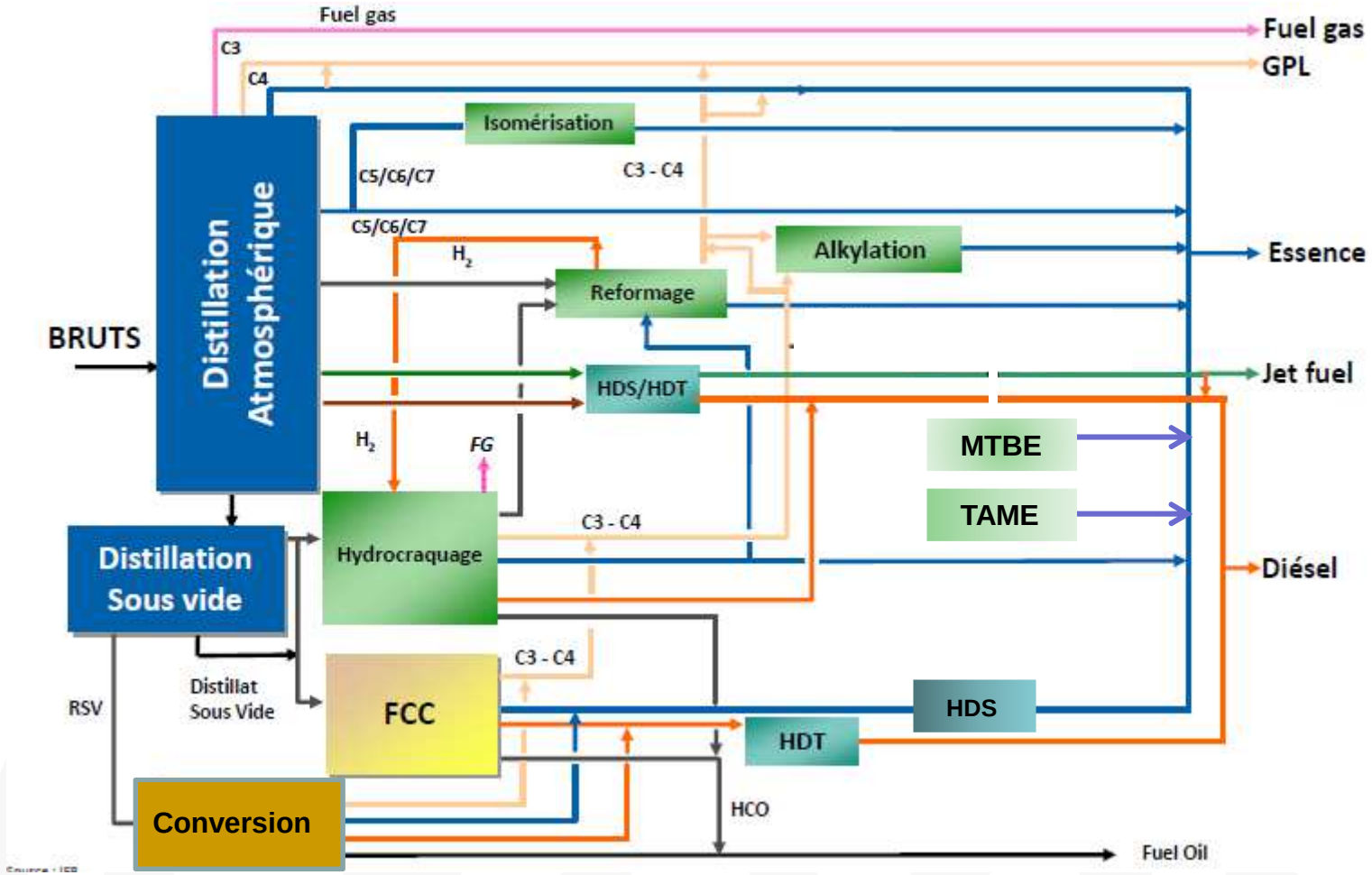
Source: IFP Training

Raffinerie avec conversion classique - années 80-90



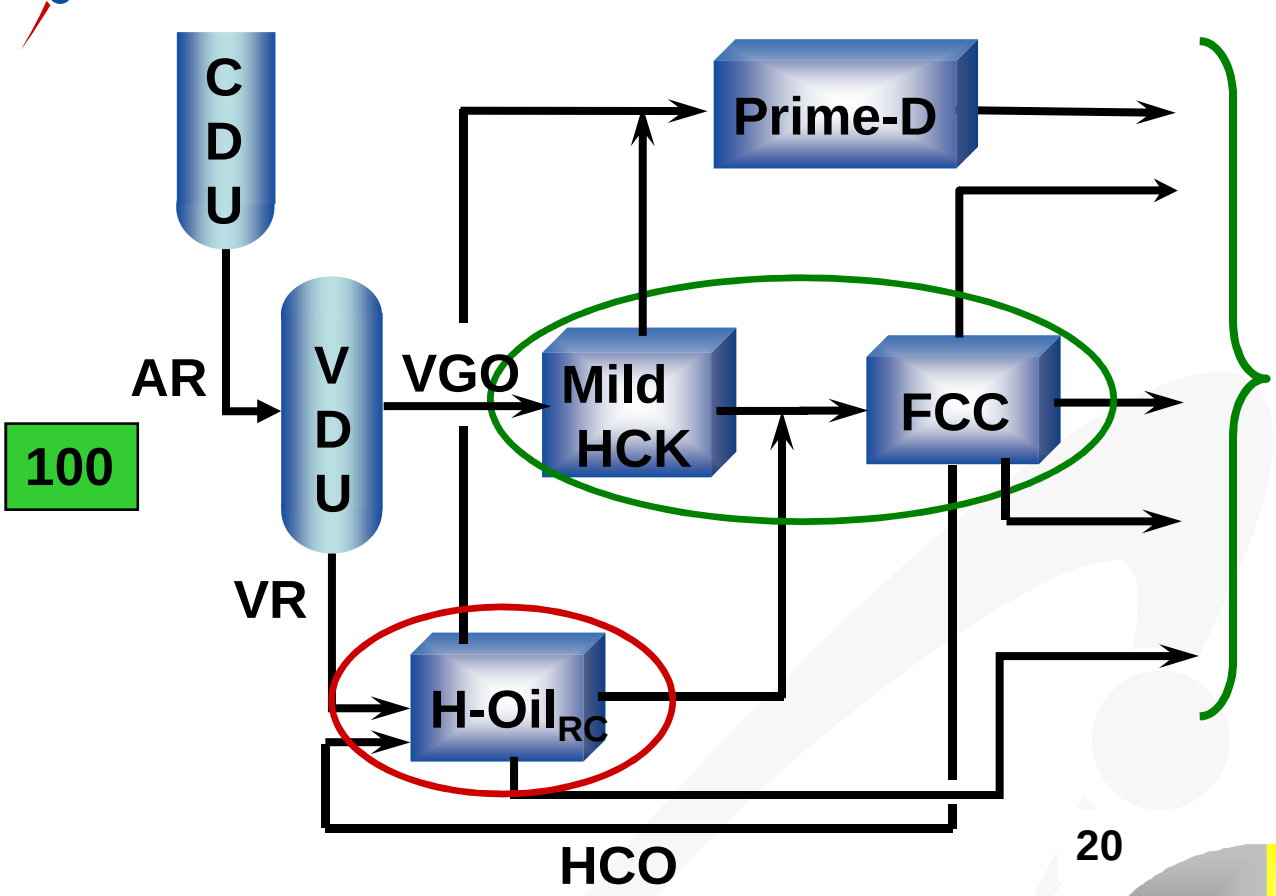
Source: IFP Training

Raffinerie d'aujourd'hui et de demain (2010 - 2020)



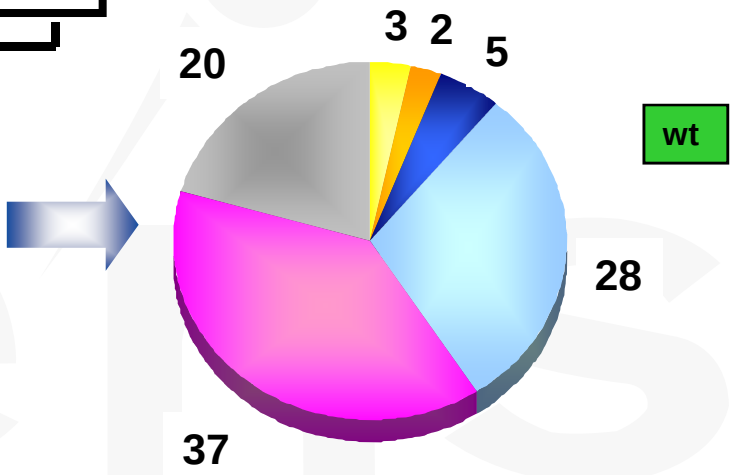
Source: IFP Training

Resid Upgrading
Option 1: H-Oil$_{RC}$ + Mild HCK + FCC

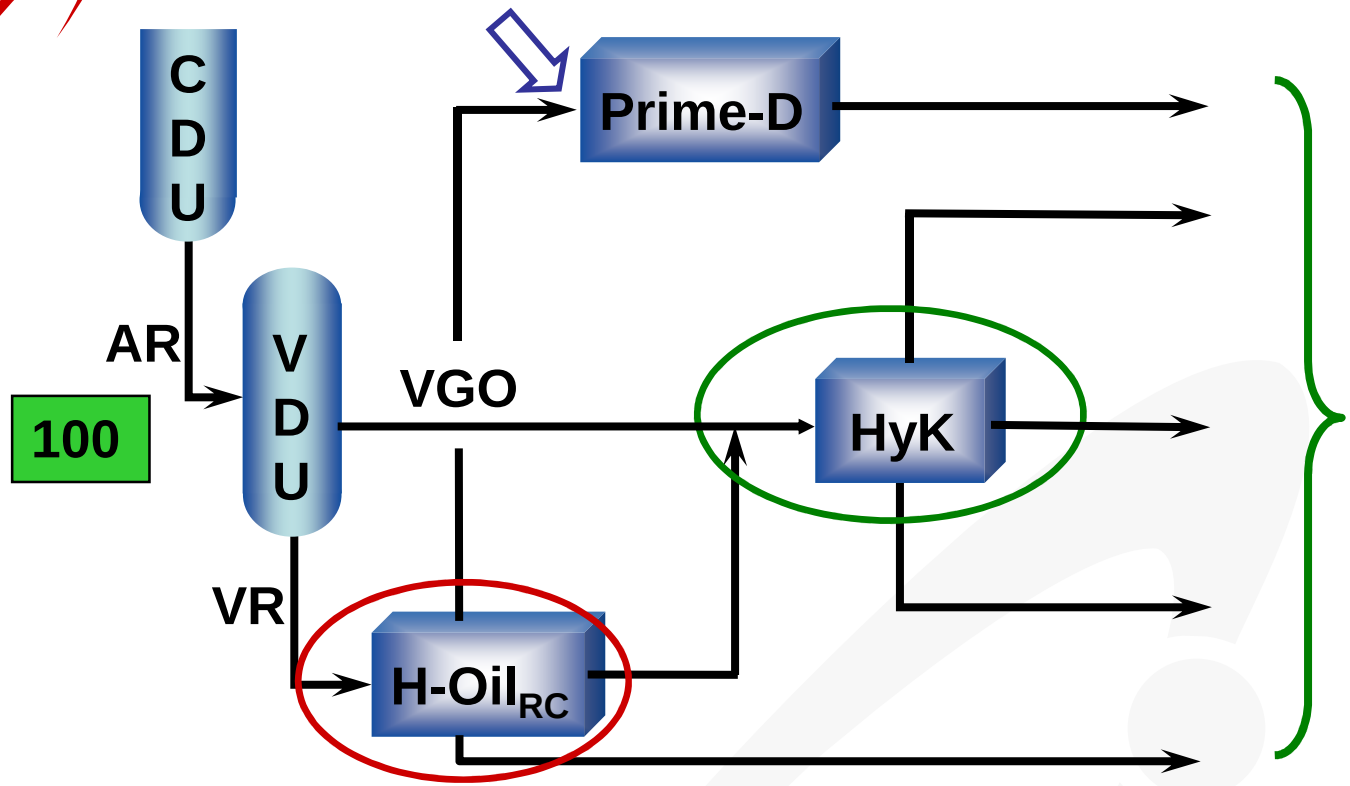


LPG and C_5+ production

Total: 95



Resid Upgrading
Option 2: H-Oil$_{RC}$ + HyK



FG

LPG

Naphtha

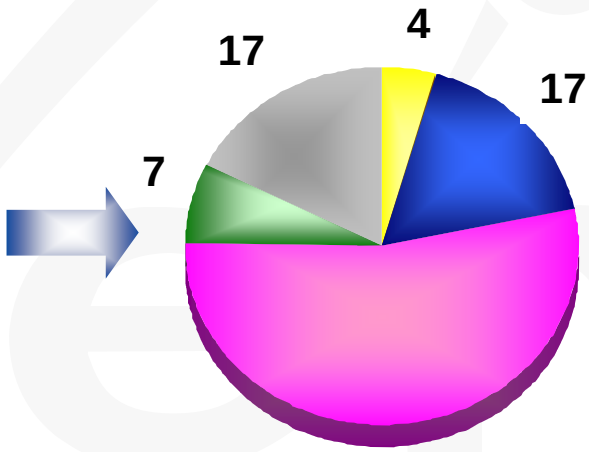
MD

HCK Residue

Fuel Oil

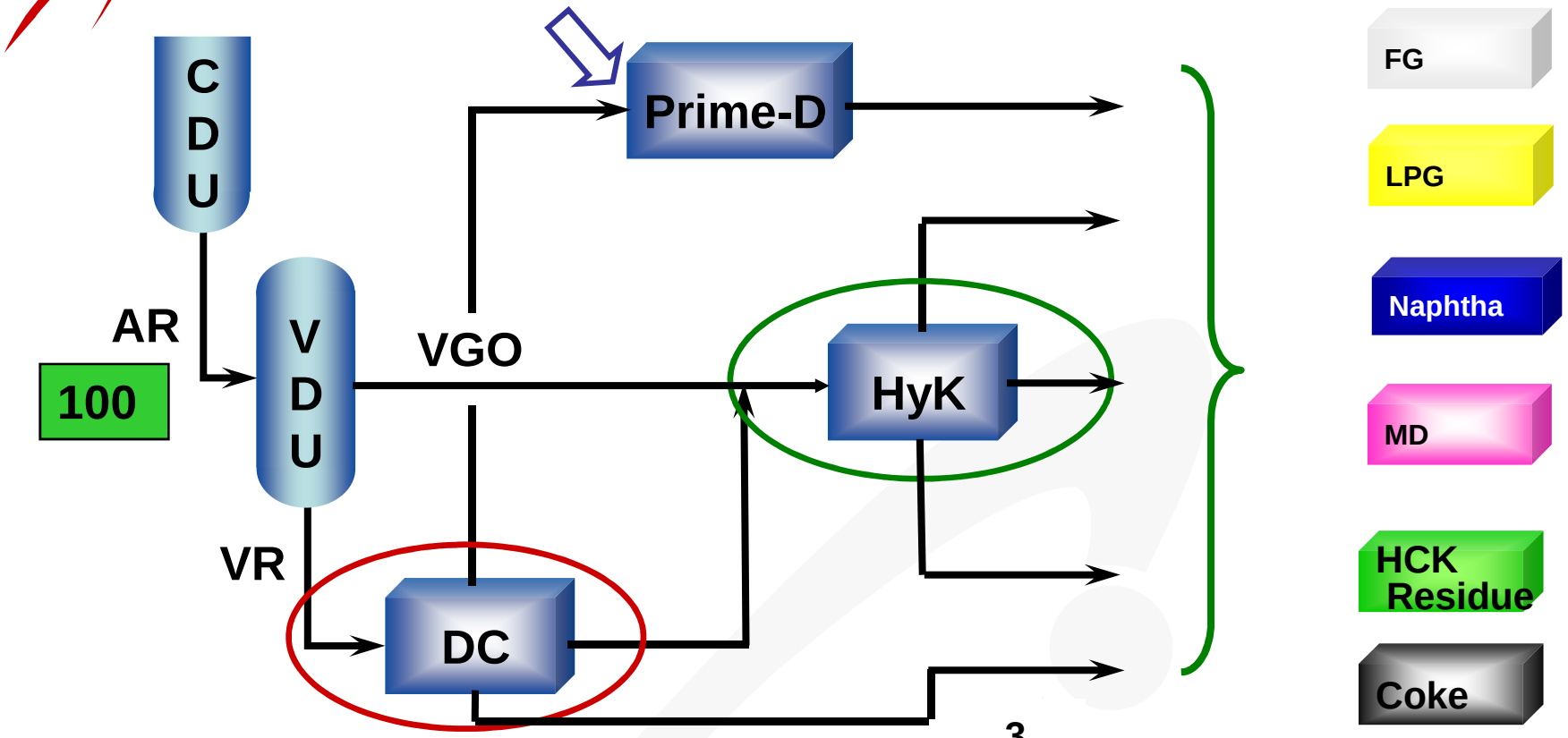
LPG and C_5+ throughput

Total: 97



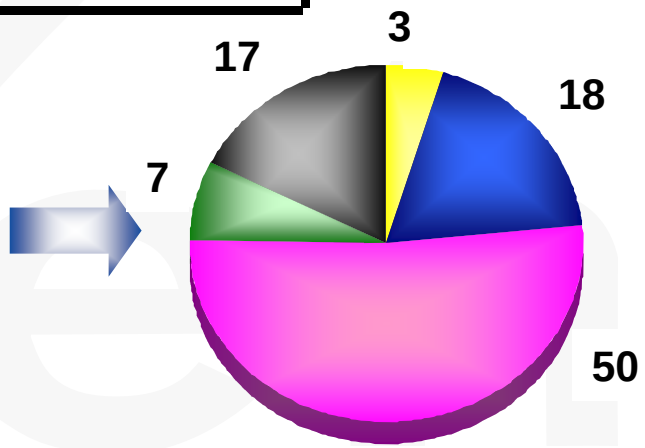
wt

Resid Upgrading
Option 3: Delayed Coker + HyK

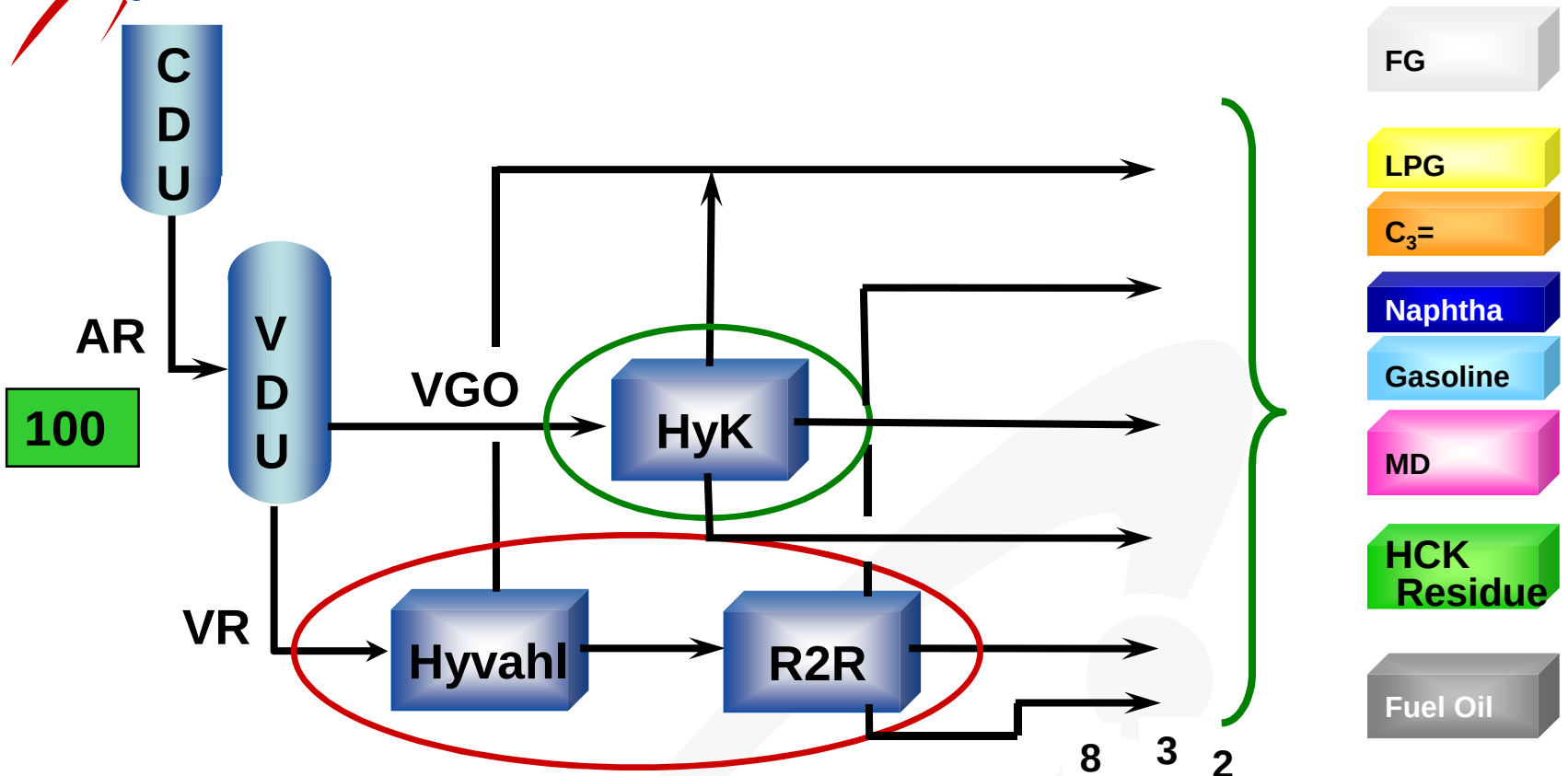


LPG and C_5+ production

Total: 95

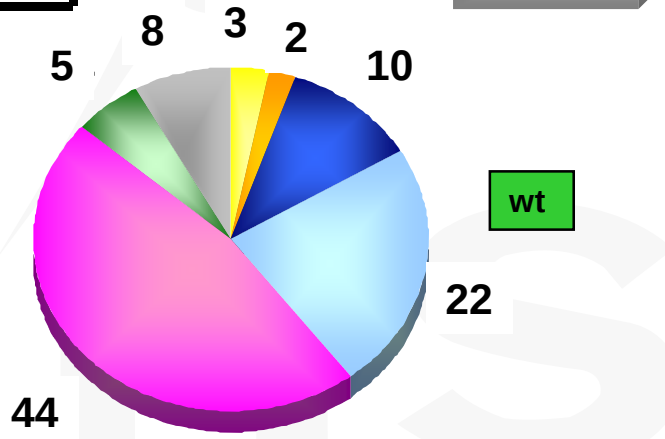


Resid Upgrading
Option 4: HyK + Hyvahl + R2R



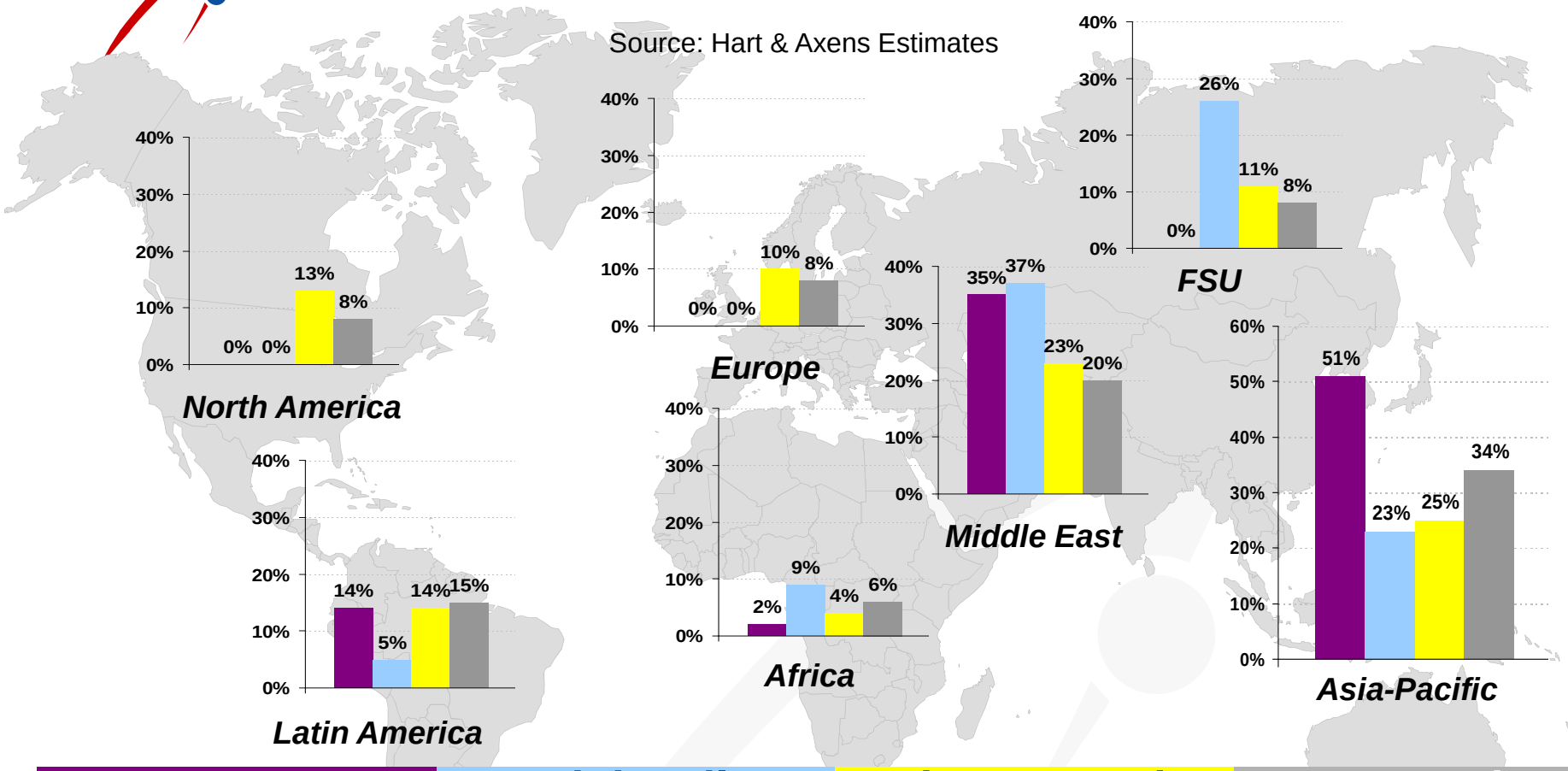
LPG and C_5+ production

Total: 94



Global Capacity Requirements for 2020 Geographical Breakdown

Source: Hart & Axens Estimates



Crude Distillation	Light Oil Processing	Hydroprocessing	Conversion
Δ= + ~ 10.0 Mbpd	(Reforming, Isomerization, Alkylation) Δ= + ~ 1.5 Mbpd	(Naphtha, gasoline, Middle Distillates HDT AR / VRDS) Δ= + ~ 9.5 Mbpd	(HCK, Resid HCK, Coking, RFCC/FCC, MHC) Δ= + ~ 5.0 Mbpd

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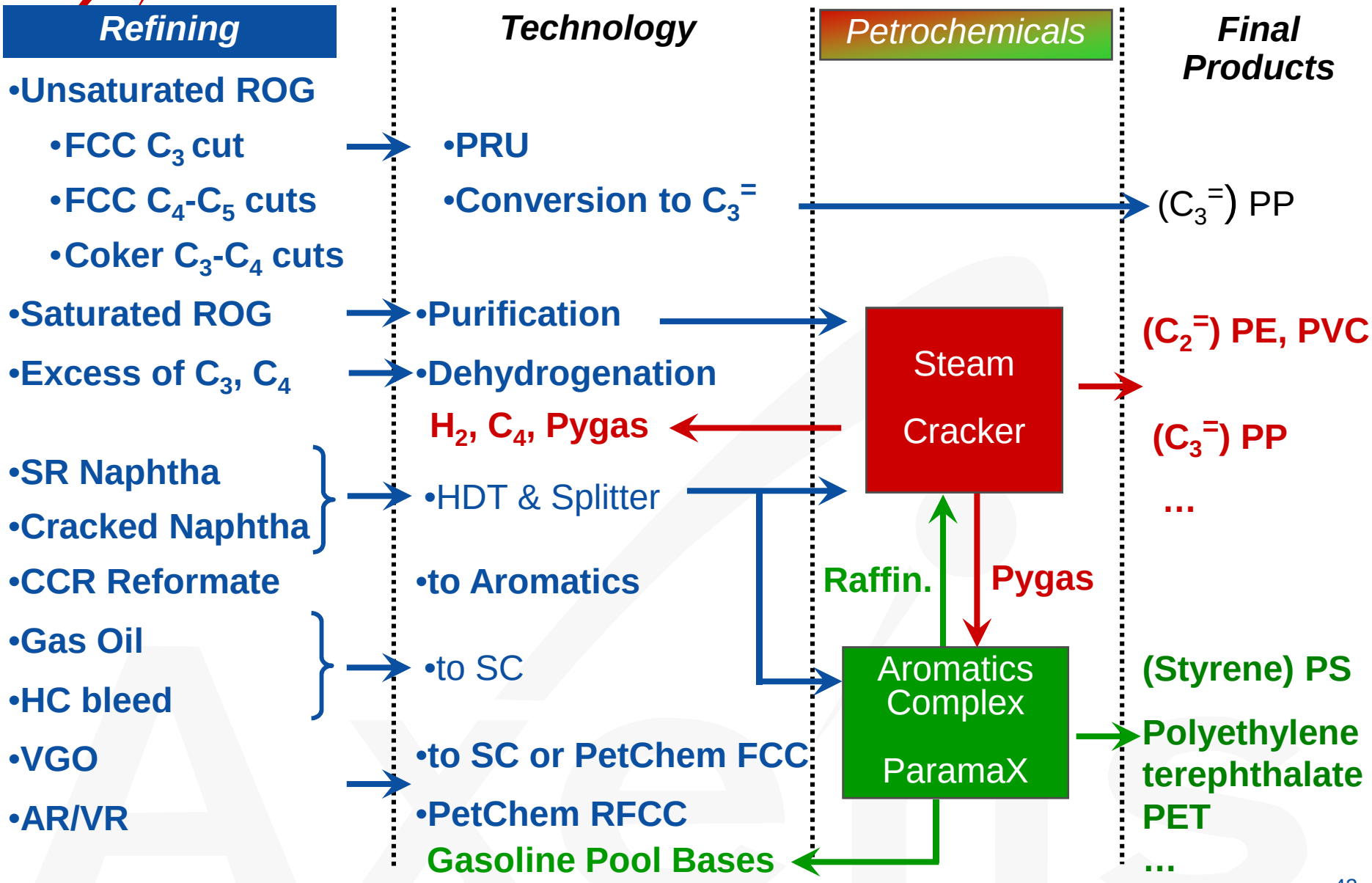
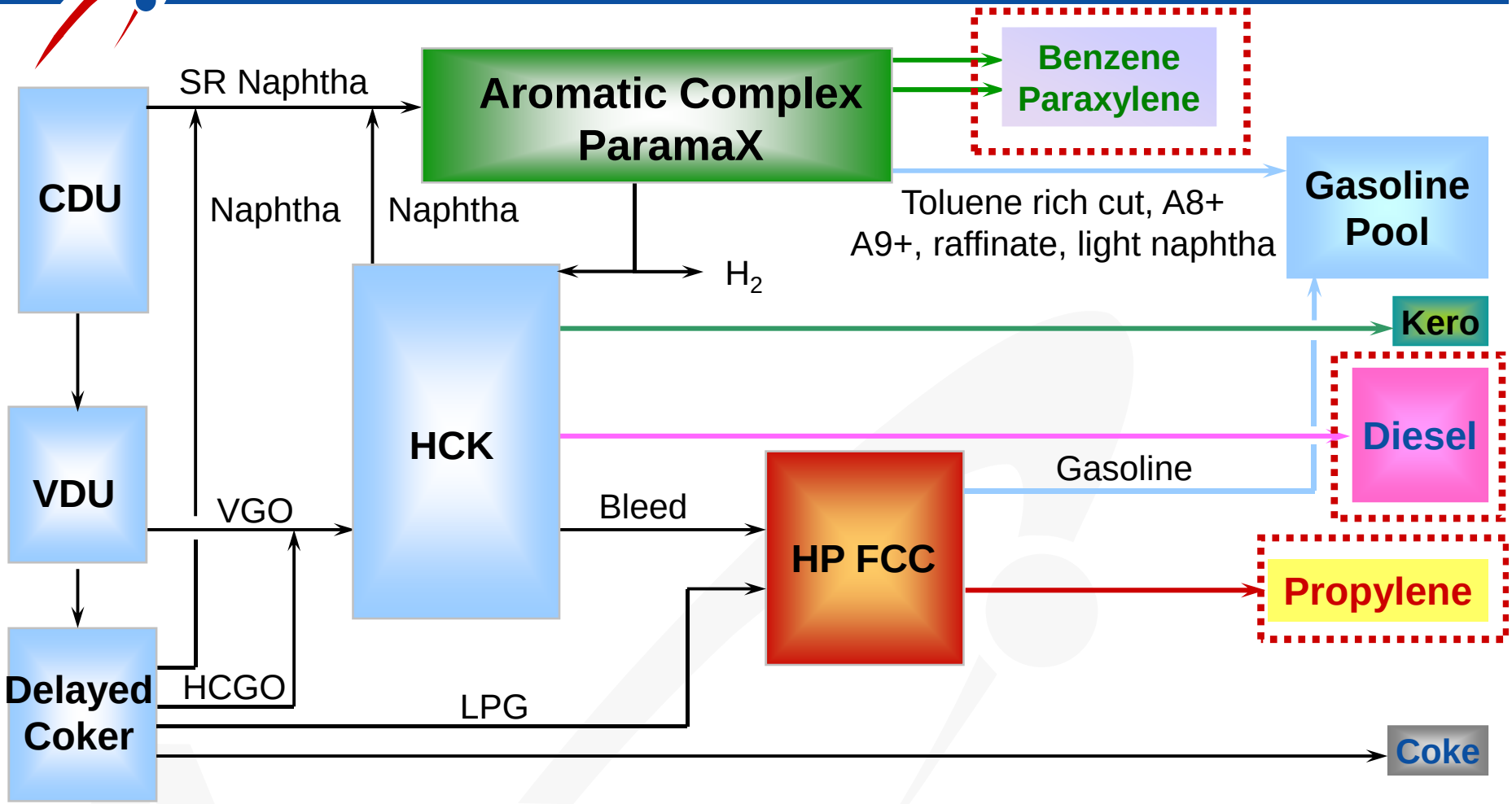
- Production de carburants et produits « pétrochimiques » à partir de biomasse

Refining & Petrochemical Flow Exchanges

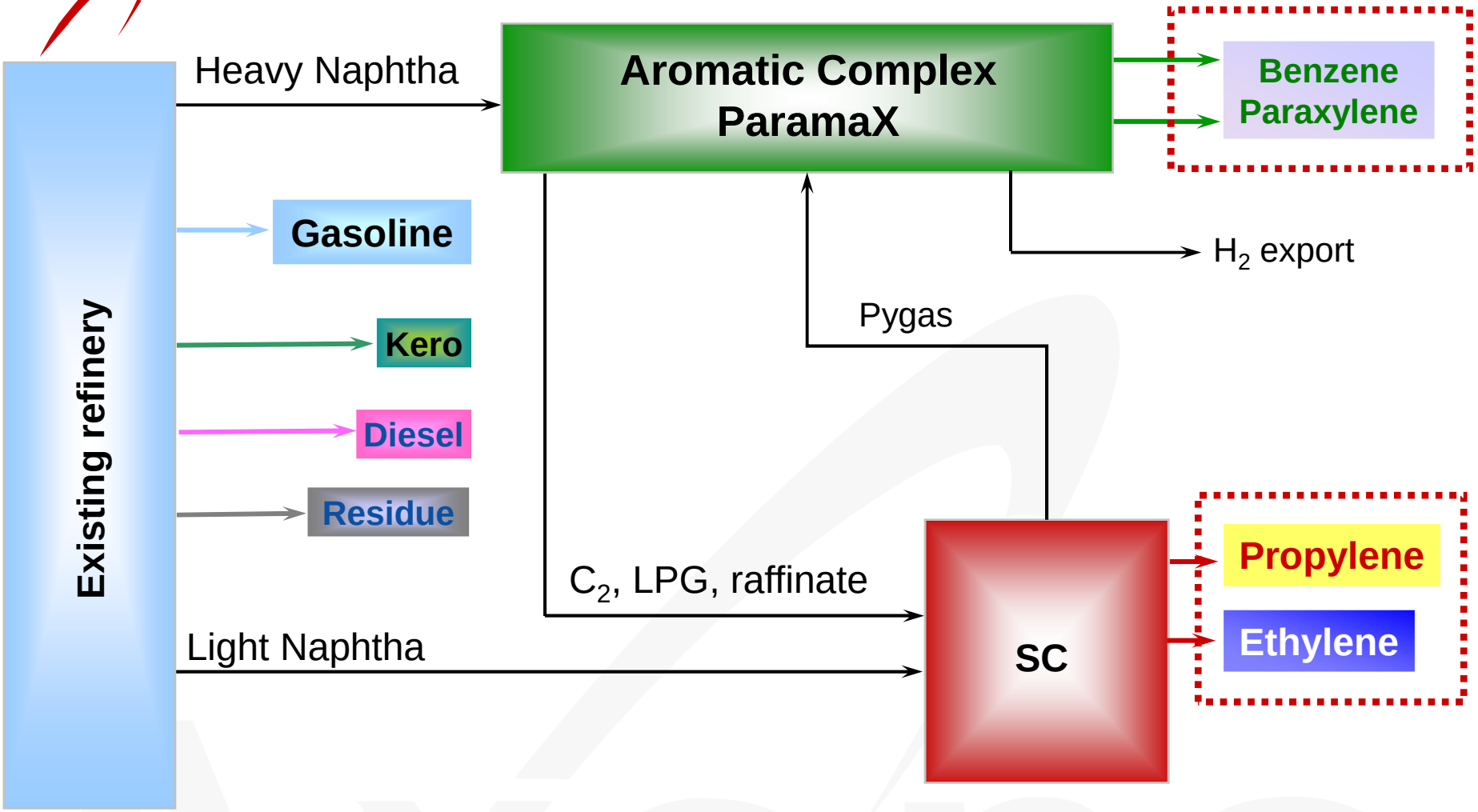


Case Study 1
Refinery with HCK, HP FCC + ParamaX



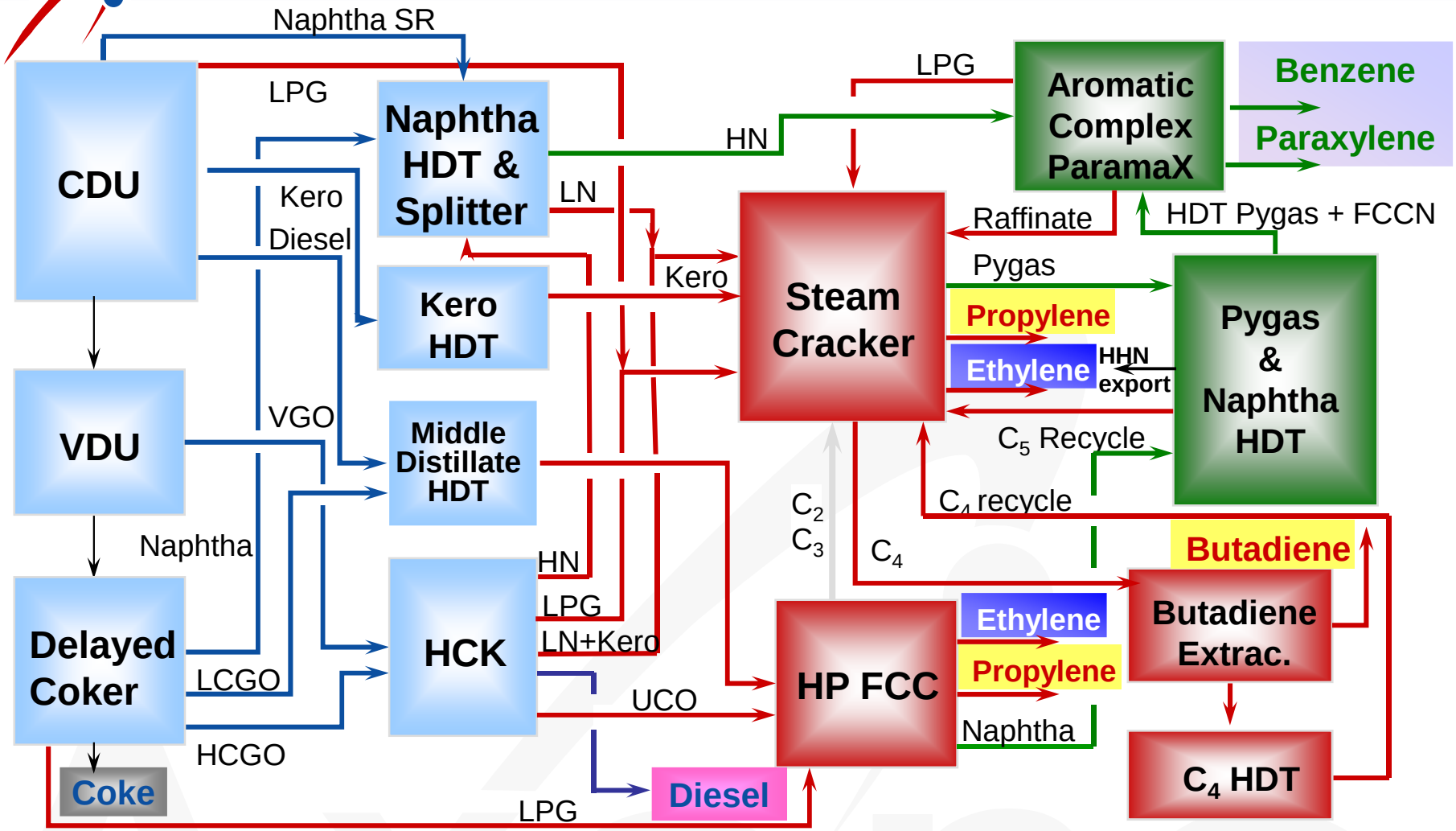
Refinery production	Aromatics production
400,000 bbl/d	Paraxylene: 700 kt/y (2.5% of 2010 PX world production)
	Benzene: 140 kt/y

Case Study 2
Existing Refinery with Steam Cracker + ParamaX



Existing Refinery production	Aromatics production
400,000 bbl/d	Paraxylene: 1,400 kt/y (5% of 2010 PX world production)
	Benzene: 650 kt/y

Case Study 3
Refinery + ParamaX + HP FCC + Steam Cracker



Refinery production

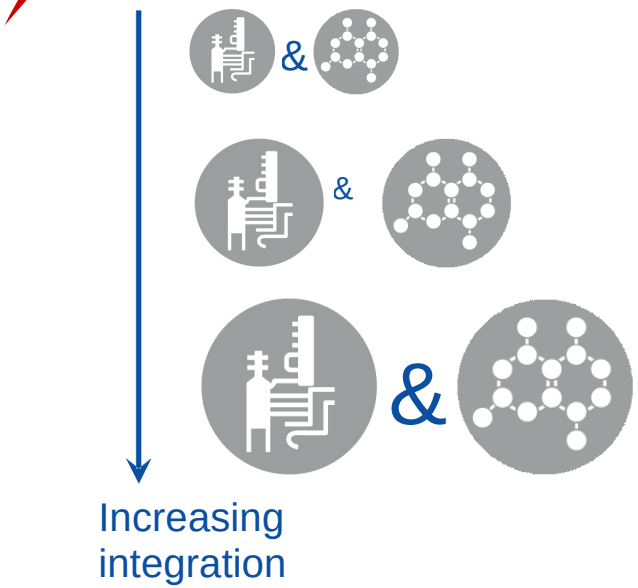
150,000 bbl/d

Aromatics production

Paraxylene: 780 kt/y (2.9% of 2010 PX world production)

Benzene: 690 kt/y

Refining & Petrochemicals Integration Case Studies



	Petrochemical Yield
Case Study 1 Refinery + Aromatic Complex	**6-7 %**
Case Study 2 Refinery + Aromatic Complex + Steam Cracker Complex	**18-19 %**
Case Study 3 Refinery + Aromatic Complex + Steam Cracker Complex + Zero Gasoline	**> 40 %**

Key Message 1

Refining & Petrochemical integration generates

- **CAPEX Advantages: optimized design capacities + shared utility production**
- **OPEX Advantages: ⇗ energy efficiency by ⇘ utilities consumption**
  ⇨ lower CO_2 emissions = positive environment effect

⇨ Technology creates value by increasing asset profitability

Focus on Shale Gas Definitions

- **What is Shale Gas?**
  - **Shale Gas: Natural gas trapped within shale formations**
  - **Shale: Dark fine-grained sedimentary rock formed by the compression of clay-rich sediment**
  - **Shale constitutes about 50-60% of all the sedimentary rock found in the Earth's crust**

- **What makes it different from conventional natural gas?**

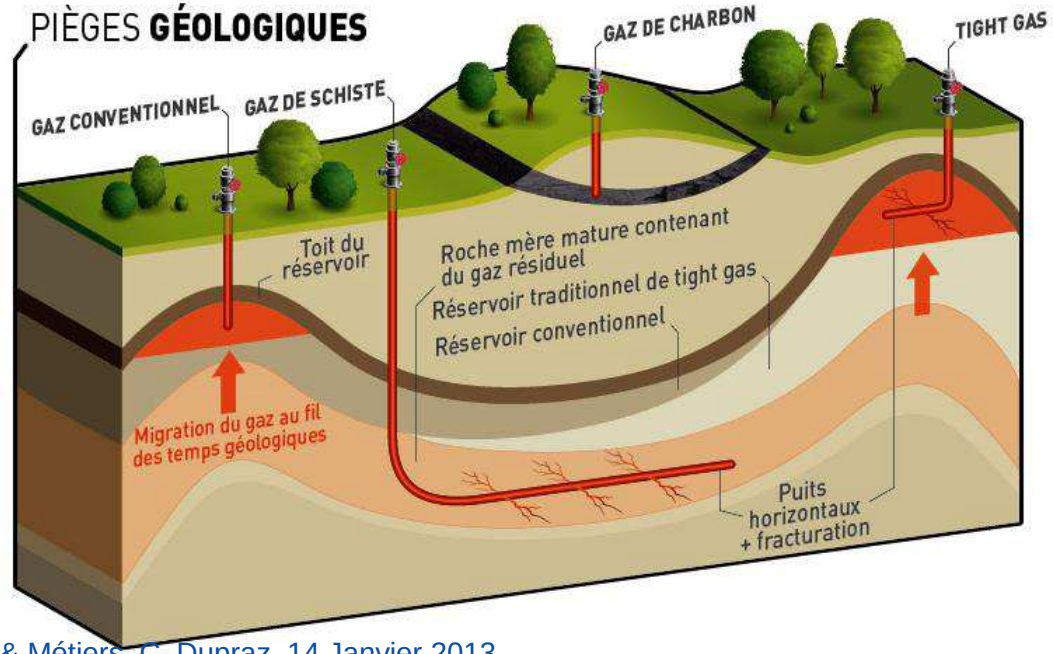
Nature of the reservoirs

Extraction

- **Hydraulic fracturing: In conjunction with horizontal drilling**

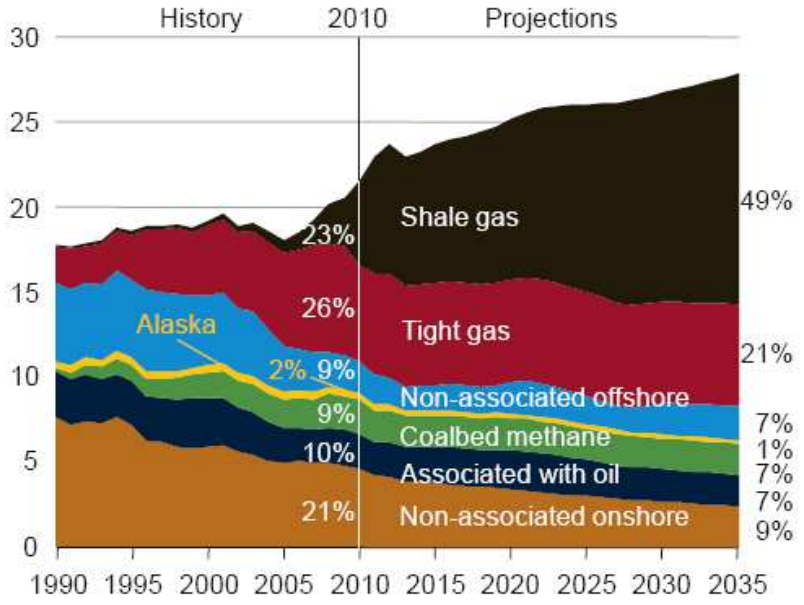
Quality

- **Shale gas ethane content is higher than natural gas ethane content**



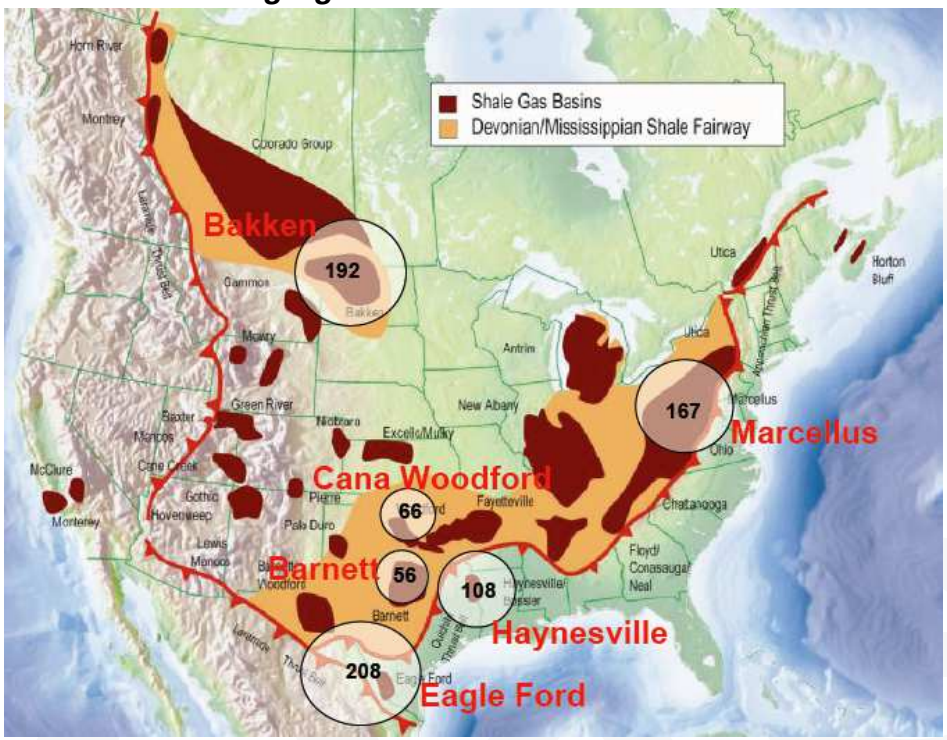
Focus on Shale Gas US

- **In the US, since late 2005, shale gas production increased drastically:**
  - **2010: 142 Gm³ (23% of total U.S. dry gas production)**
  - **2011: ~207 Gm³ (32% of total)**
  - **2035: 385 Gm³ (49% of total)**



Source: DOE EIA

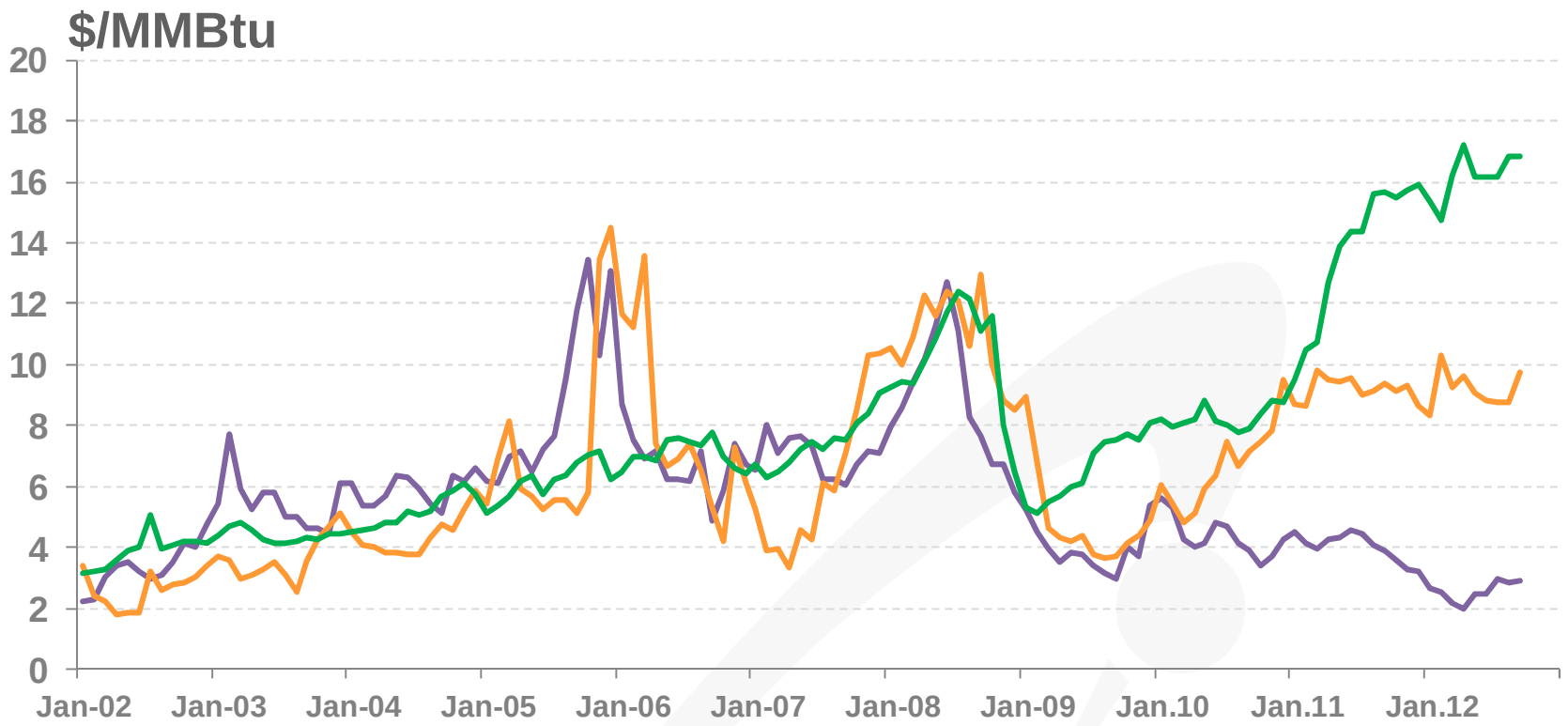
Number of drilling rigs in the US:



Main shale gas fields:

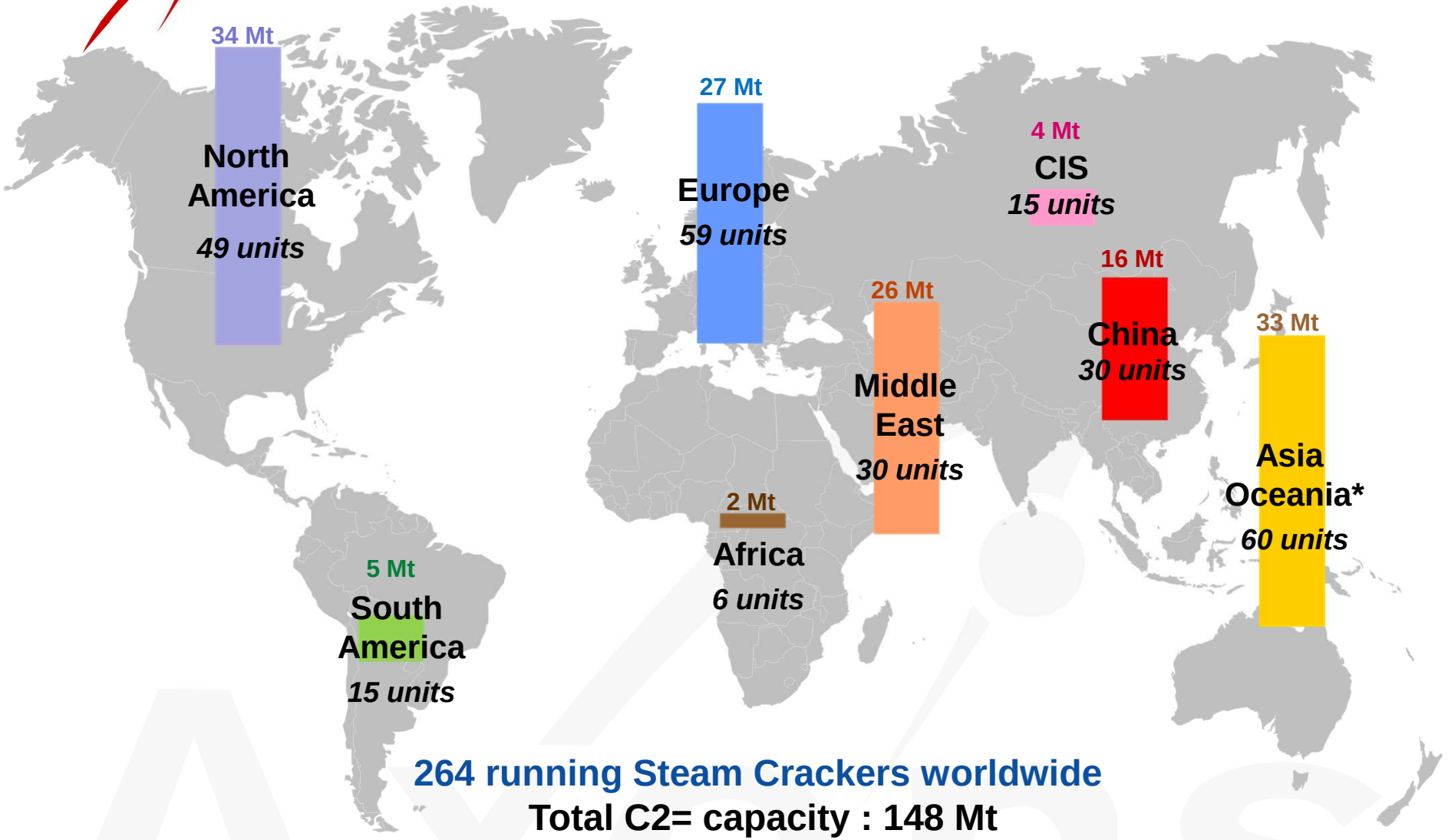
- **Barnett (Texas) - historical**
- **Marcellus (North East) - attractive**
- **Haynesville (Louisiana) - attractive**

Gas Prices



Annual averages ($/MMBtu)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012 (end Q3)
Henry Hub (US)	3.4	5.5	5.9	8.8	6.7	7.0	8.9	3.9	4.4	4.0	2.6
Zeebrugge (NWE)	2.6	3.6	4.4	7.3	7.9	6.1	10.9	4.9	6.7	9.2	9.2
Indonesian LNG (Japan)	3.9	4.4	5.2	6.2	7.1	7.4	10.2	6.6	8.3	13.7	16.2

Unités Vapocraquage En Opération



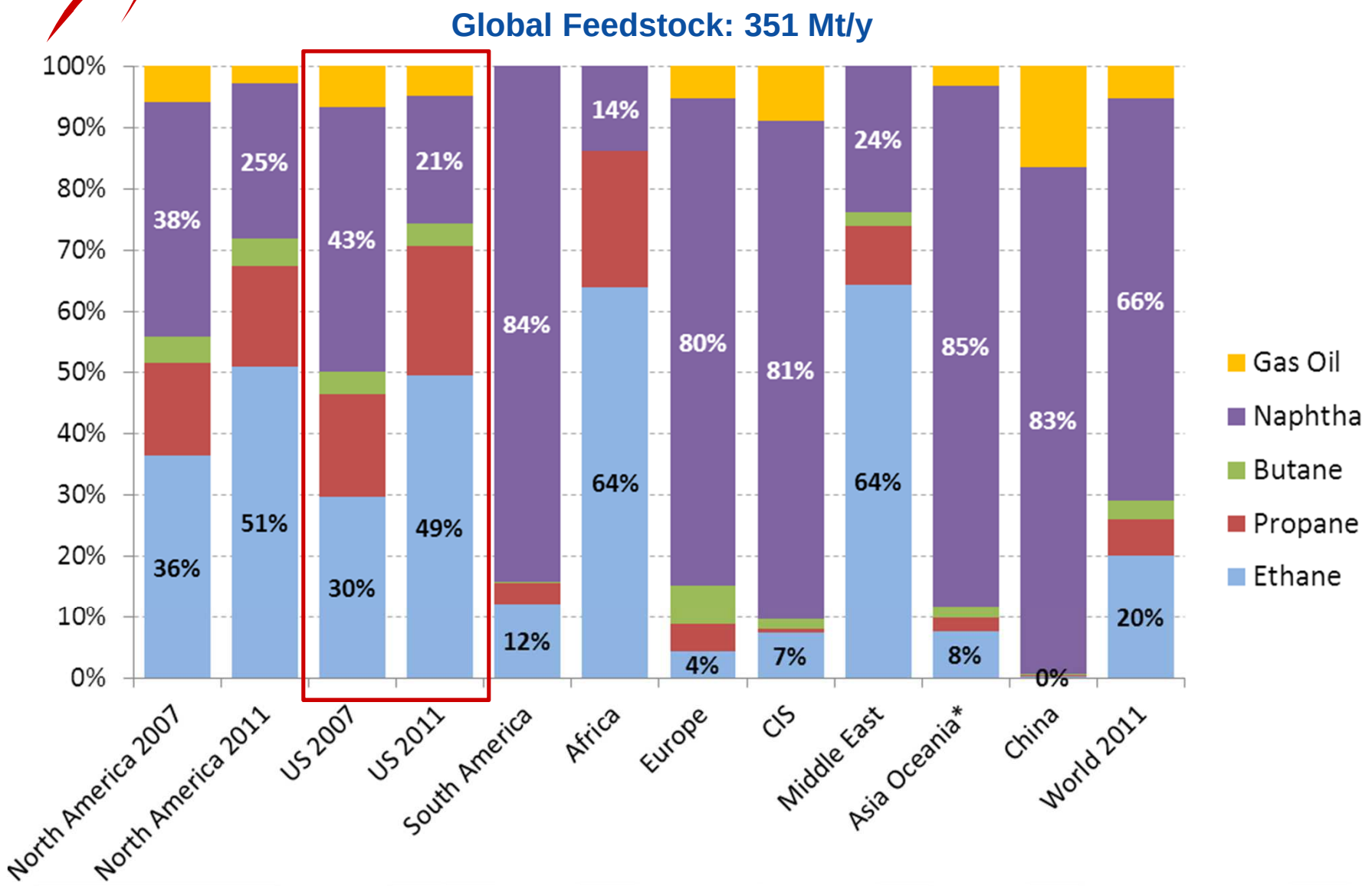
264 running Steam Crackers worldwide

Total C2= capacity : 148 Mt

Utilization rate: 83%

Capacity given for C2= in millions tons
Chart bars given for C2= capacity
*Does not include China

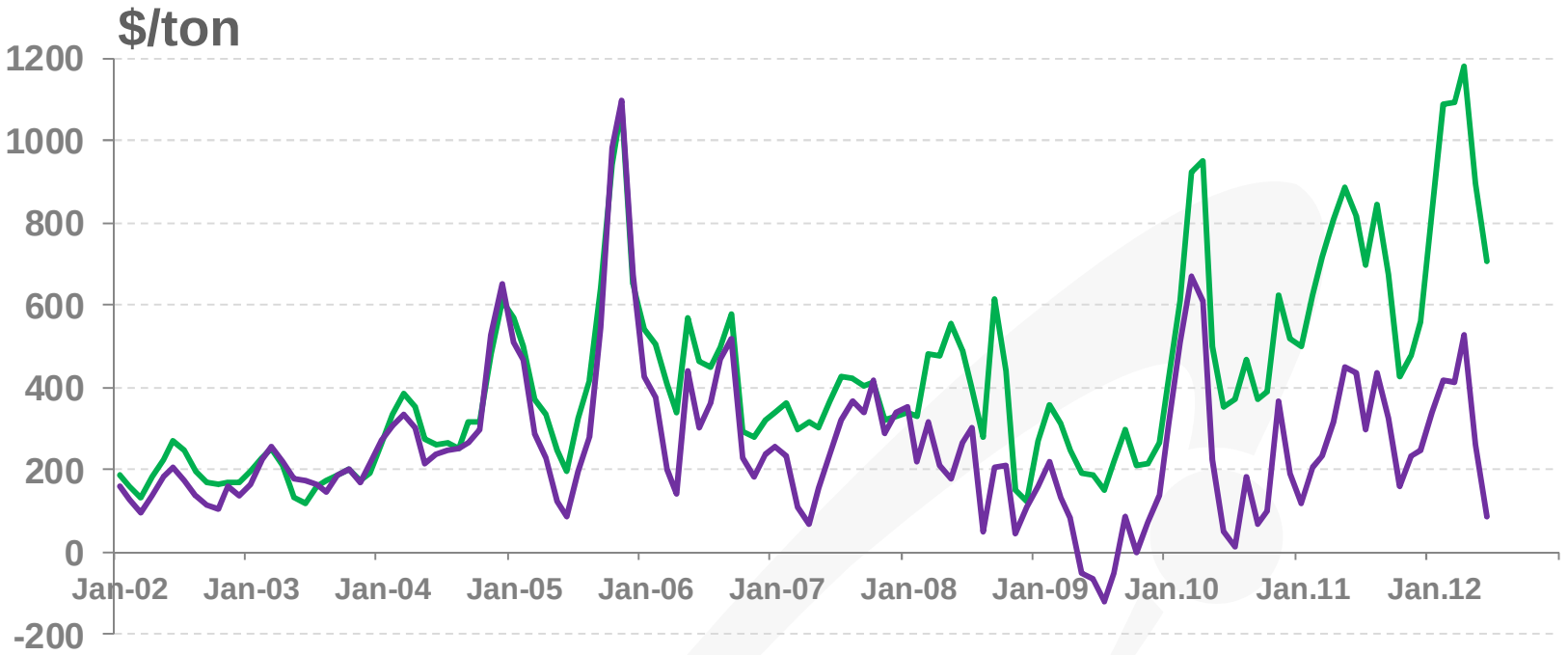
Steam Crackers Feedstock By Region



Source: SuperProud

Shale Development Impacts USGC Olefins Spread

Olefins Margin Naphtha = Δ (Ethylene price – Naphtha price)
Olefins Margin Ethane = Δ (Ethylene price – Ethane price)

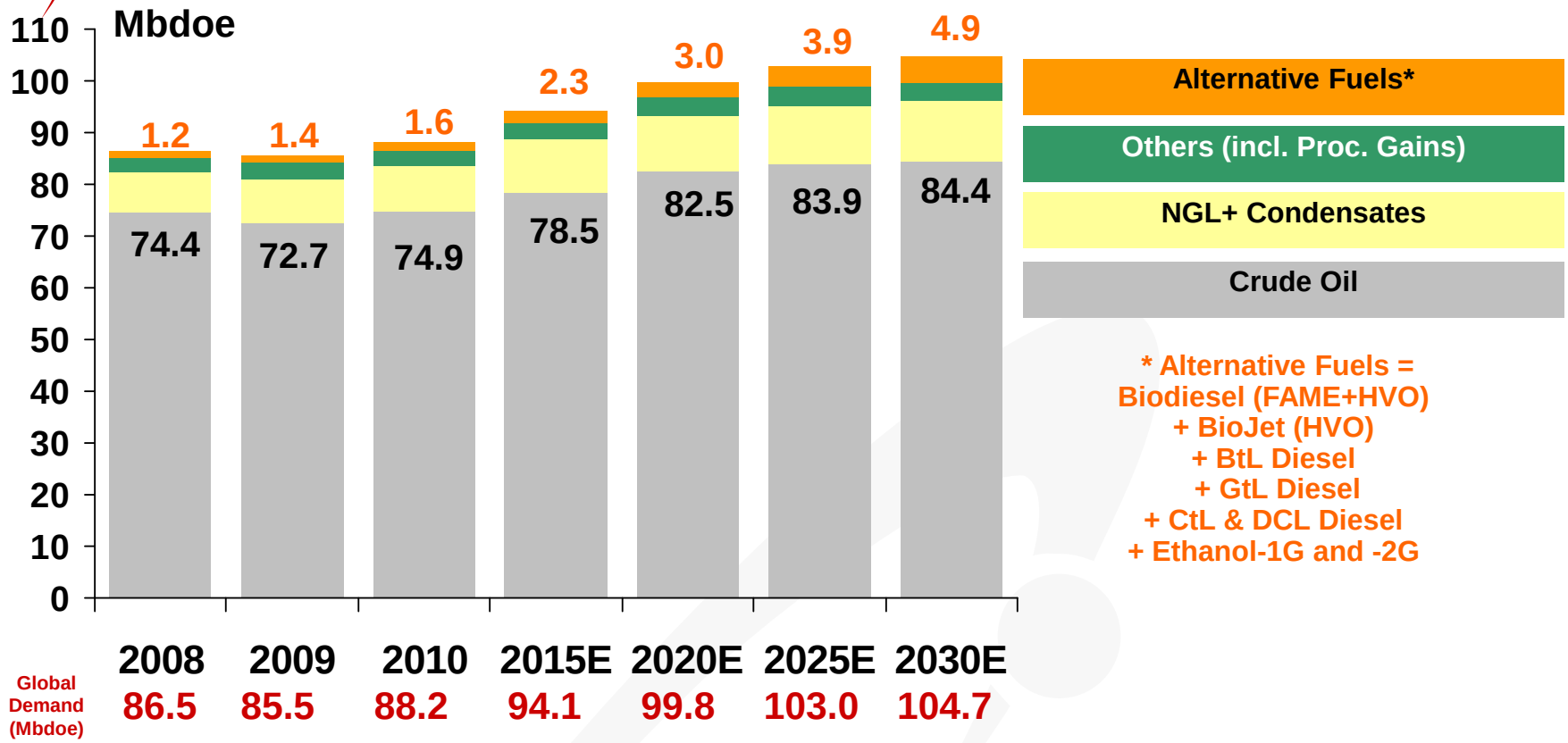


Annual averages $/ton	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012 (end Q2)
Olefins Margin Naphtha USGC	144	191	325	456	323	260	205	49	274	287	341
Olefins Margin Ethane USGC	189	184	342	523	436	357	390	243	520	669	966

Plan de la Présentation

- Axens en Bref
- Evolution des marchés
  - À moyen Terme (2017)
  - À long Terme (2030)
- Conséquences sur les outils
  - de raffinage
  - de pétrochimie
- Production de carburants et produits « pétrochimiques » à partir de biomasse

Global Supply Diversification by 2030

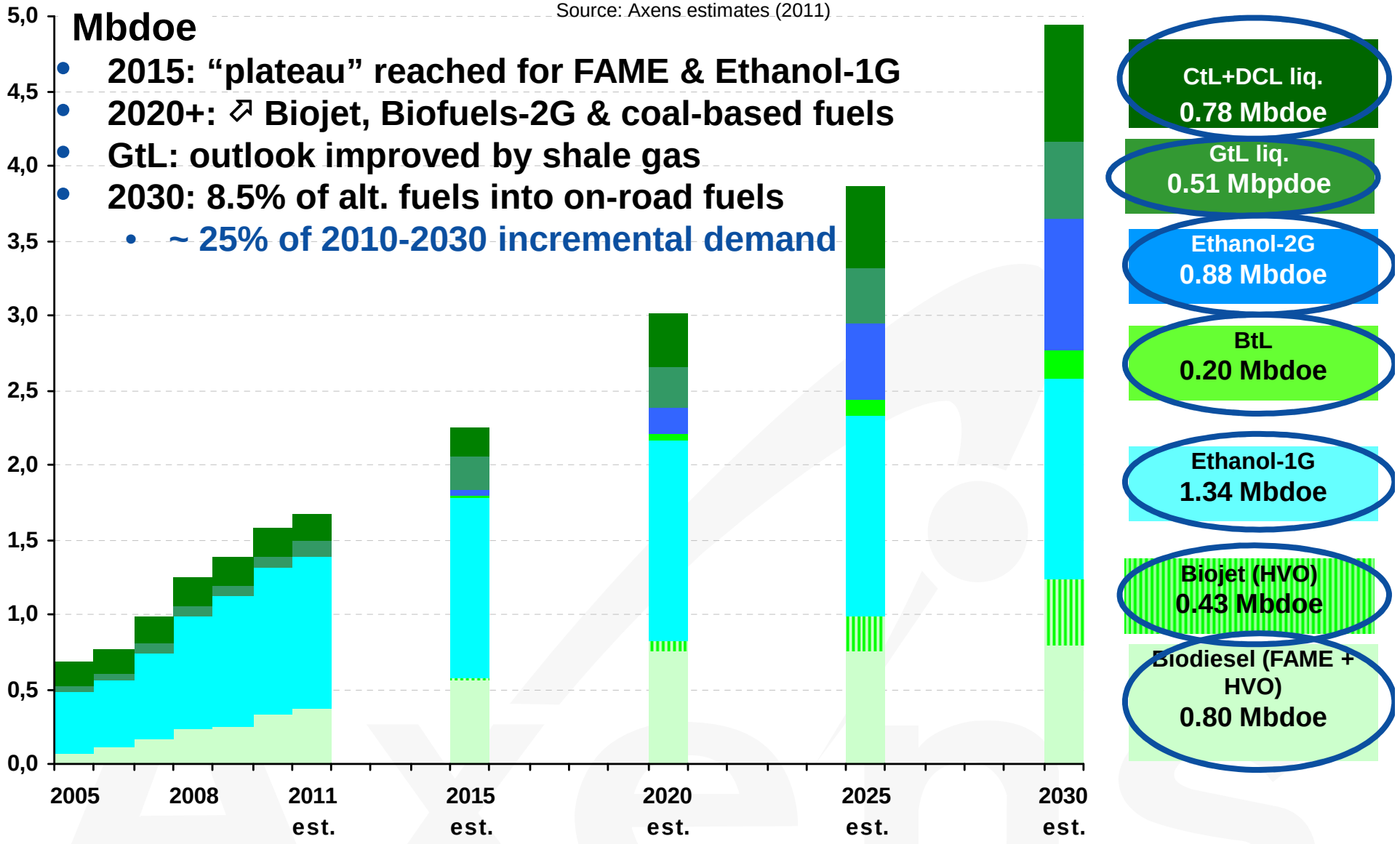


⇨ **Alternative Fuels* could represent ~ 5% of global supply (volume basis) by 2030**

Source: Axens estimates (2011)

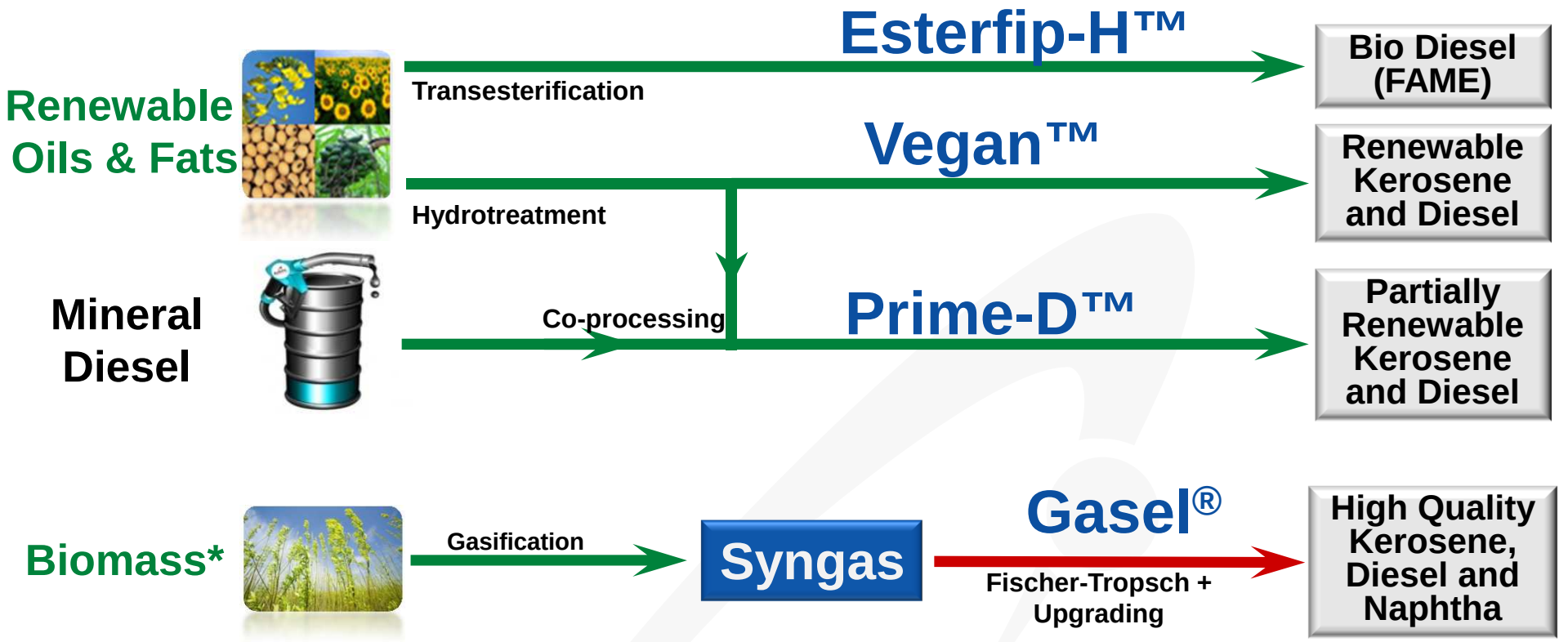
Axens Estimates
Alternative Liquid Fuels 2005 - 2030

Source: Axens estimates (2011)



CtL + DCL liq. = Liquids from Coal to Liquids (CtL) and DCL (Direct Coal Liquefaction). GtL liq. = Liquids from Gas to Liquids
BtL = Biodiesel from Biomass to Liquids ; FAME = Fatty Acid Methyl Ester ; HVO = Hydrotreated Vegetable Oils.

Axens' Biofuels Portfolio



… + other biofuel pathways under development (bio-oil upgrading,…)

** When Biomass replaced by Natural Gas or Coal ⇨ production of GTL or CTL*

Bio-Ethylene from Ethanol

Total Petrochemicals, IFP Energies nouvelles and Axens to co-develop bio-ethylene production technology by dehydration of ethanol

« Back

MARCH 10 - 2011

Total Petrochemicals, IFP Energies nouvelles (IFPEN) and its subsidiary Axens announce an alliance with the objective to develop a new optimized technology for the production of bio-ethylene by dehydration of ethanol. The proprietary technology will address large-scale units and the quality of the monomers will be in line with modern derivative production processes.

Based on Total Petrochemicals original proprietary catalyst development, this new technology will open the way to a competitive production of bio-ethylene from renewable resources with lower energy consumption and lower CO_2 emissions. Bio-ethylene could be integrated in various polymer applications such as polyethylene (PE), polyethyleneteraphthalate (PET), polystyrene (PS), polyvinylchloride (PVC) and acrylonitrile-butadiene-styrene (ABS) in existing unmodified downstream polymerization installations.

The goal of this co-development is to implement a new generation of catalysts, envisioning the highest possible carbon-yield for ethylene and to use advanced techniques to minimize energy consumption for the production of polymer-grade ethylene. Within the agreement, Total will continue its work on the optimization of the catalyst formulation at the research center in Feluy, Belgium. IFPEN will complete the process development at its Lyon site, France. Axens will finalize this development and prepare the technology for commercialization by ensuring the industrial catalyst manufacturing and by providing all process licensing related services to Total Petrochemicals and other potential customers worldwide. It is expected that the technology will be ready for industrial implementation around end of 2011.

The alliance is also covering other olefinic monomers production from bio-derived higher alcohols which will be developed in parallel within the same technology platform.

Conclusion
Axens' Commitment

Developing Markets:
Innovative and market-orientated grassroot schemes

Mature Markets:
Improved Competitiveness of existing assets

Evolution du Raffinage et de la Pétrochimie

14 Janvier 2013

Maison des Arts & Métiers