POSTGRADUATE STUDIES – NATURAL GAS REVOLUTION: IMPACT ON REFINING & SECURITY

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MBA Class

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SVEUČILIŠTE U RIJECI
EKONOMSKI FAKULTET

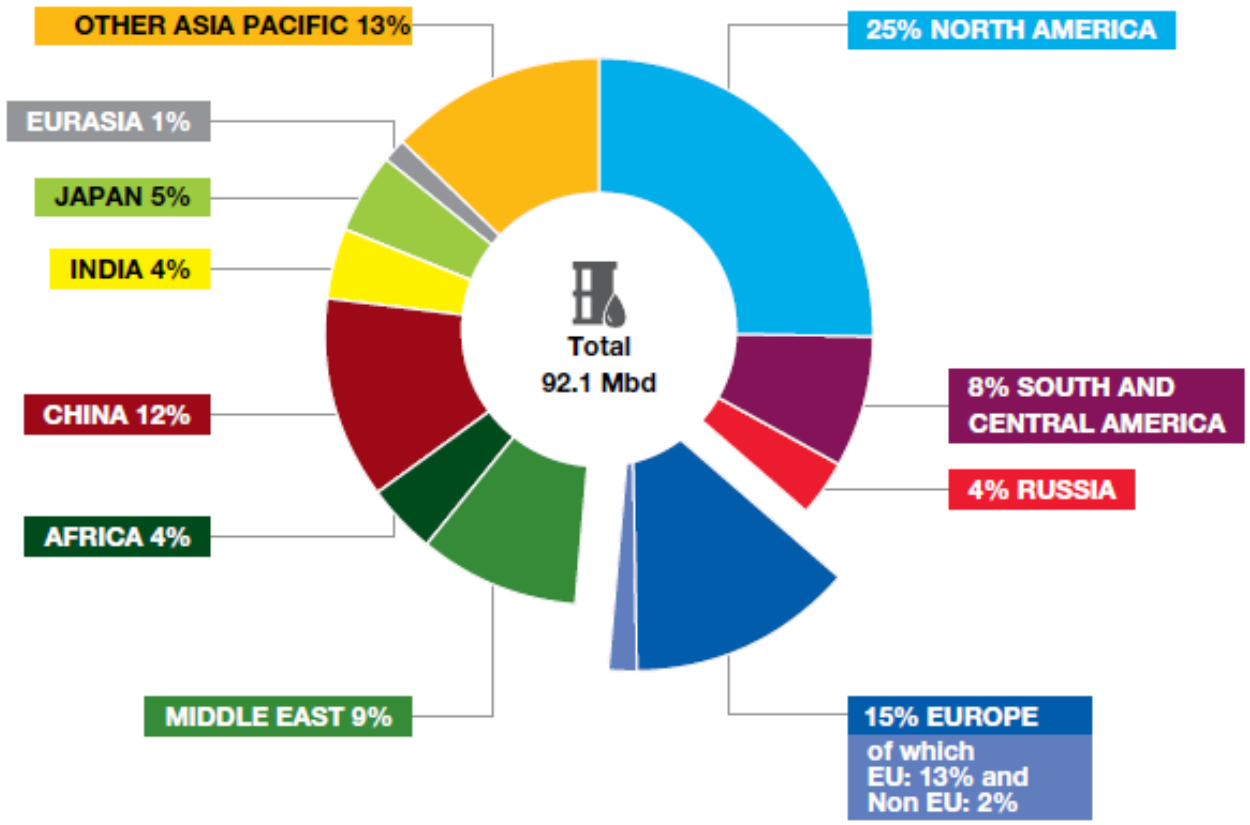
AGENDA

- Overall view
- Natural gas vs Crude: Oil industry converted into oil & gas industry
- NLG, LNG, LPG
- Swinoujscie terminal

OVERALL VIEW

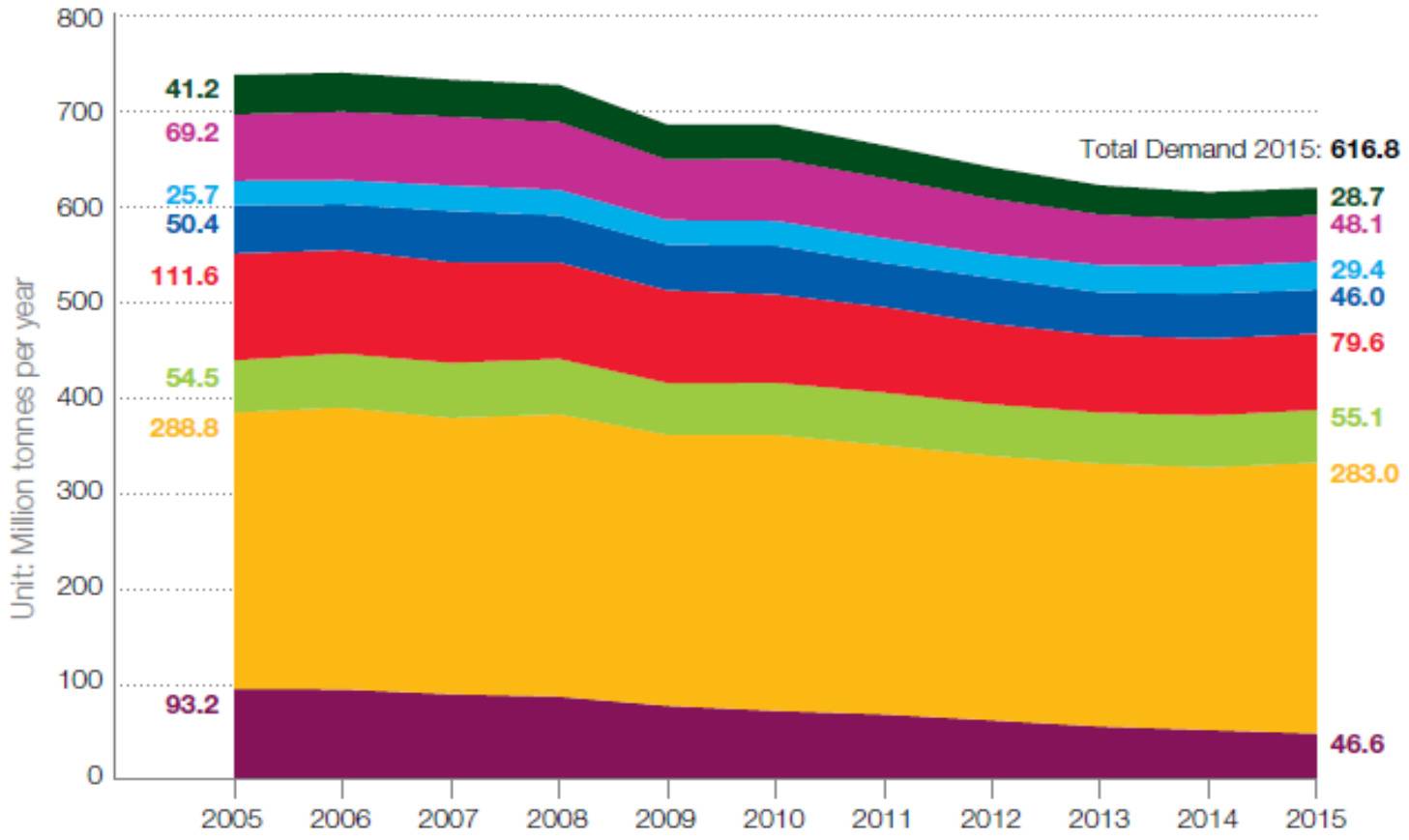
- Refining as a mature business
- Complexity of the refining business – changes in products' mix

EUROPE NOT ANYMORE WORLD'S KEY MARKET BUT STILL COUNTS

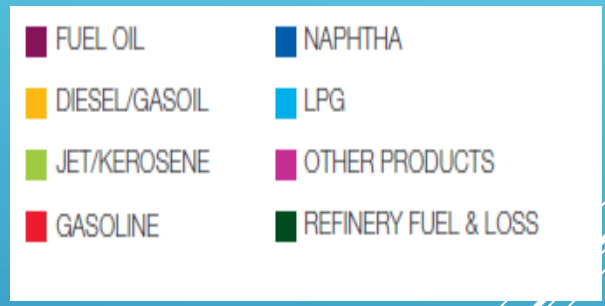


Fuels Europe Statistical Report 2016, p. 10

FALLING DEMAND FOR OIL BASED PRODUCTS

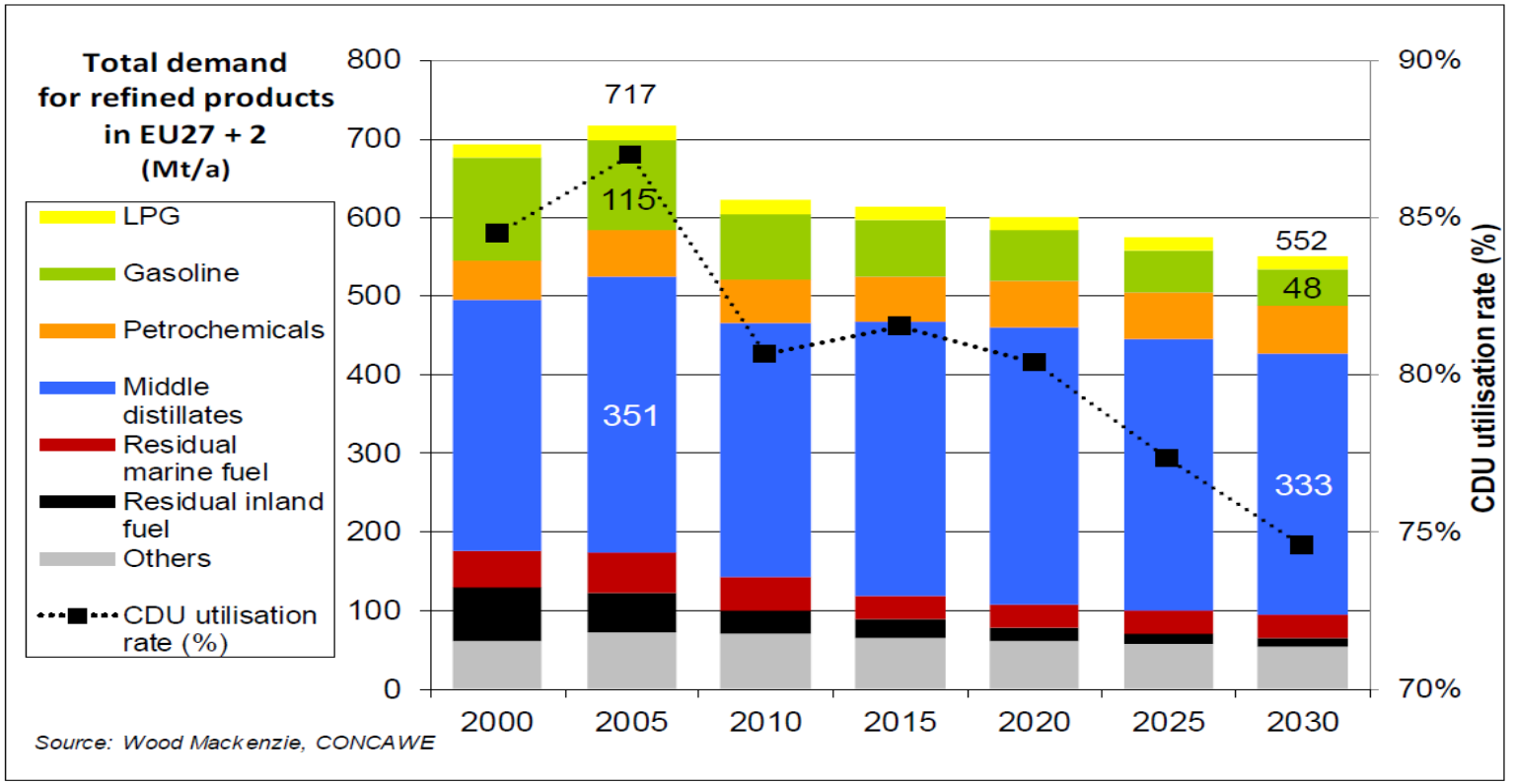


Fuels Europe Statistical Report 2016, p. 13



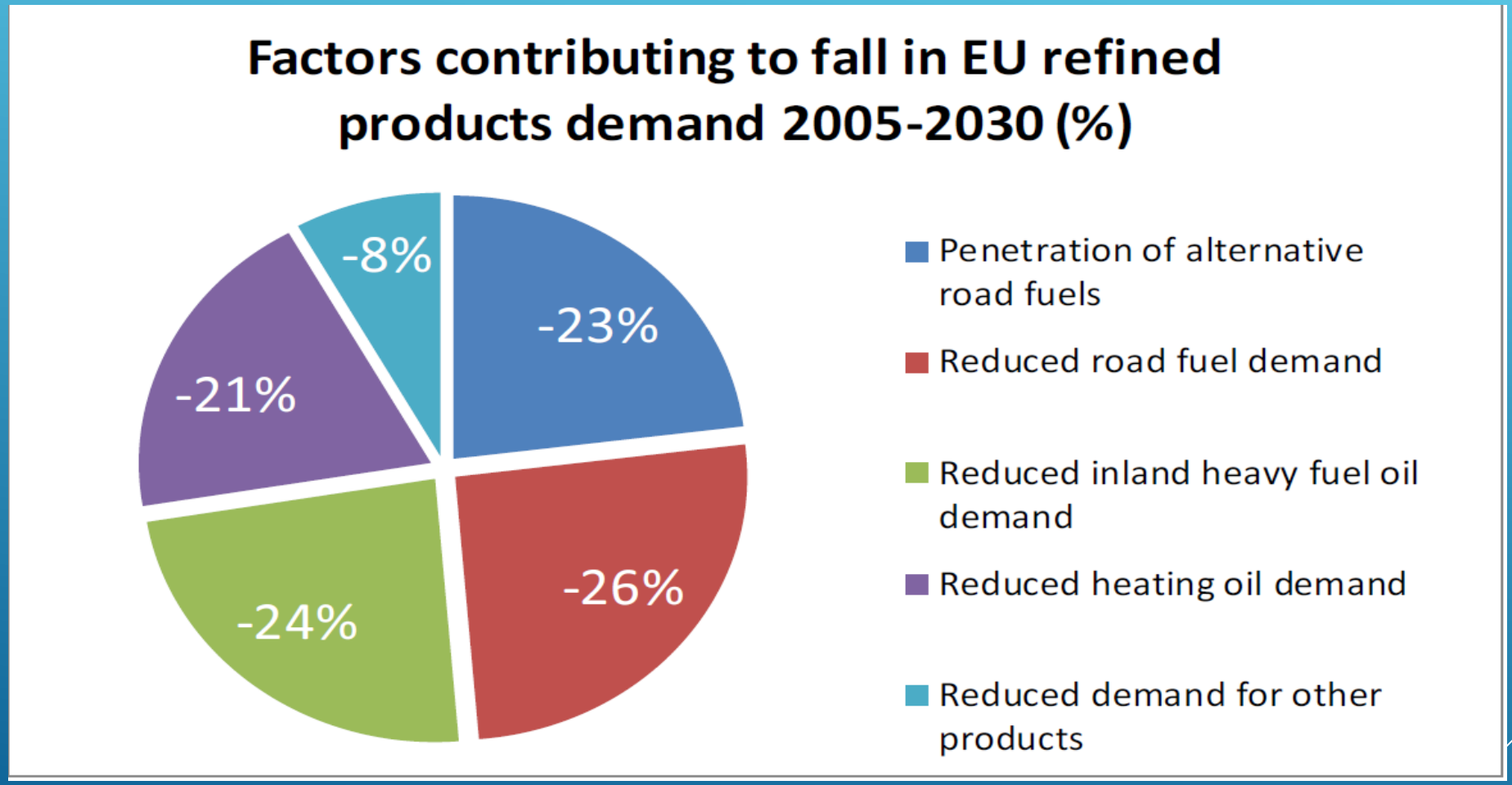
EVOLUTION OF THE EUROPEAN DEMAND SIDE – CUTTING ON EDGES

Figure 3.5.1 EU27+2 Refined products demand (Mt) and CDU utilisation rate (%) trends



„Oil refining EU in 2020, with perspectives to 2030", Concawe Report 1/2013, p. 21.

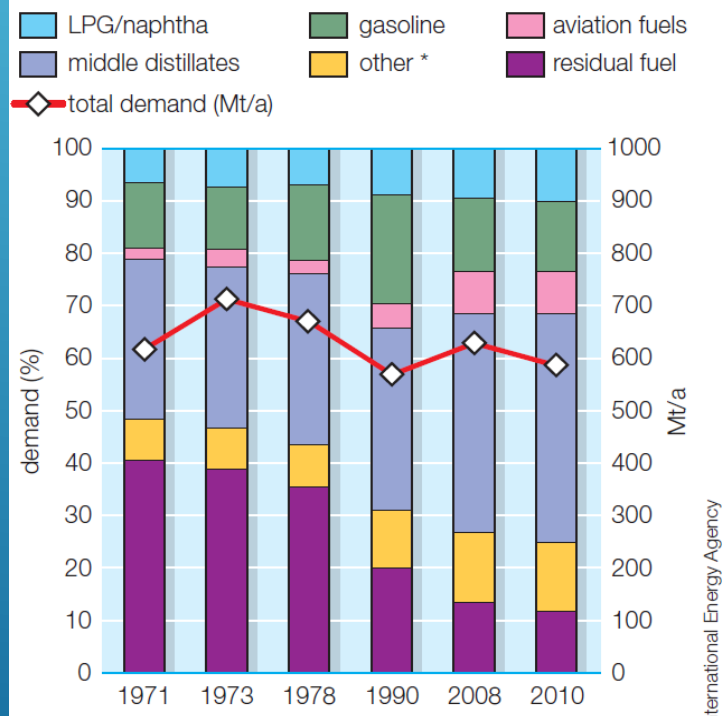
EVOLUTION OF THE EUROPEAN DEMAND SIDE – GASOLINE TO DIESEL



„Oil refining EU in 2020, with perspectives to 2030", Concawe Report 1/2013, p. 19.

PREVIOUS TREND – DIESEL GROWING

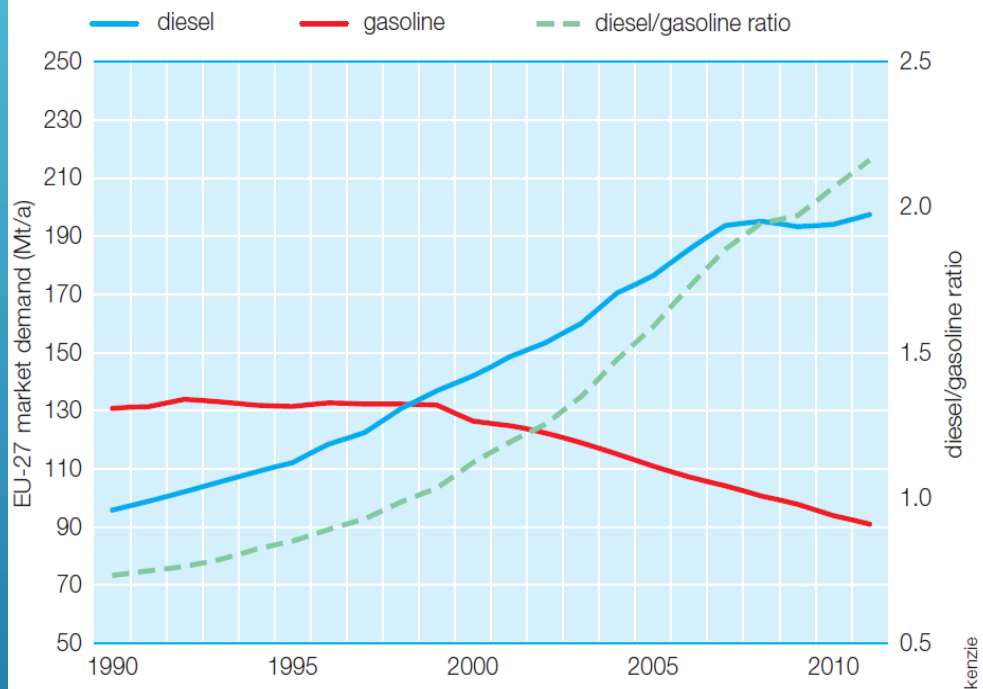
Figure 1 The evolution of petroleum product demand in what was to become the EU-15 over the past 40 years



* The 'other' category mostly consists of speciality products such as lube oils, bitumens, solvents, etc.

Source: International Energy Agency

Figure 2 The diesel to gasoline ratio in EU-27 countries, 1990–2011



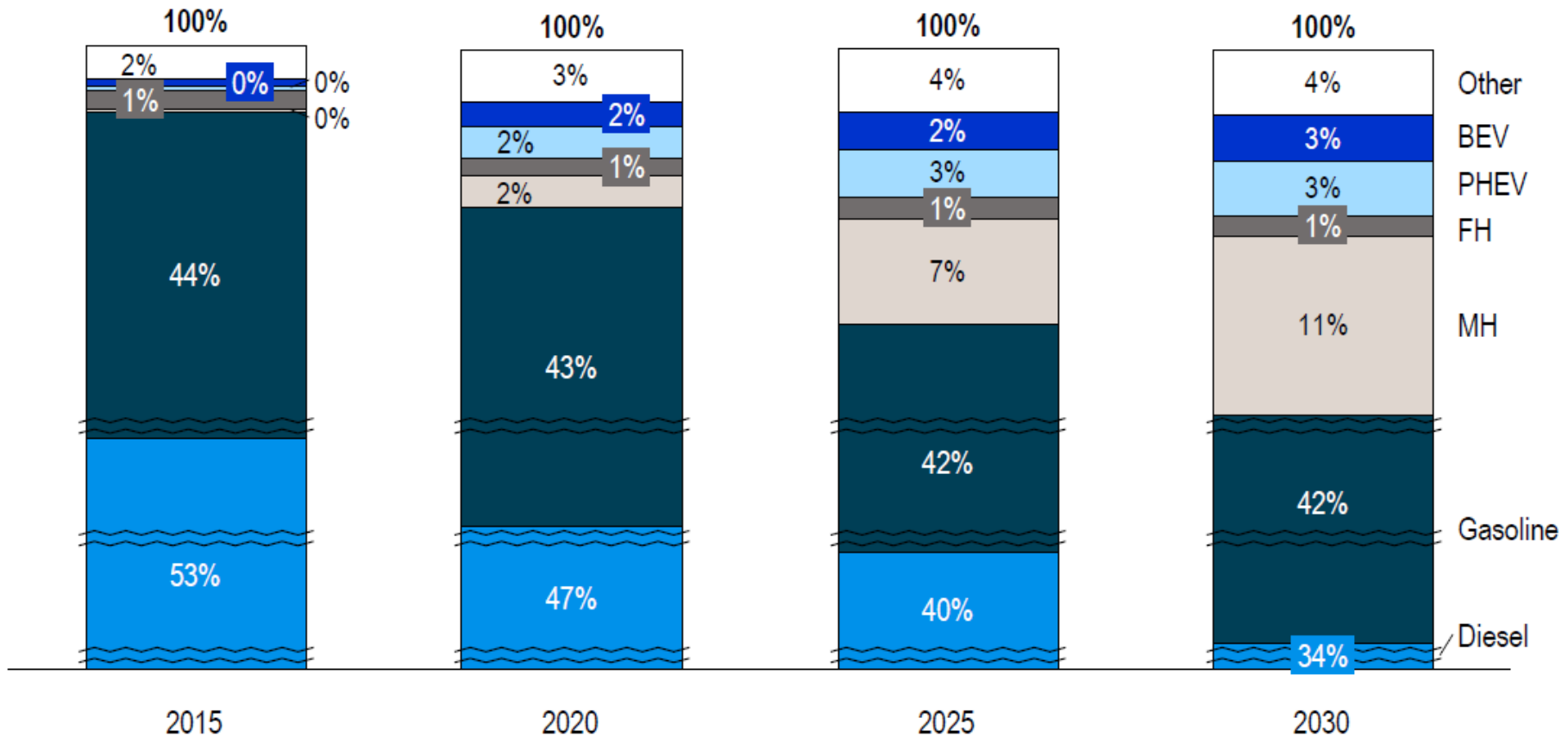
Above: the high uptake of diesel passenger cars and strong road freight growth have caused the diesel to gasoline ratio in EU-27 countries to triple over the past two decades.

Source: Wood Mackenzie

„The evolution of oil refining in Europe", Concawe Review, vol. 22/1, 2013, p. 32.

NEW TREND – DIESEL FALLING BUT NOT NECESSARY GASOLINE GAINING (1)

Figure 21: Powertrain shares in new vehicle sales scenario A, 2015-2030 [%]



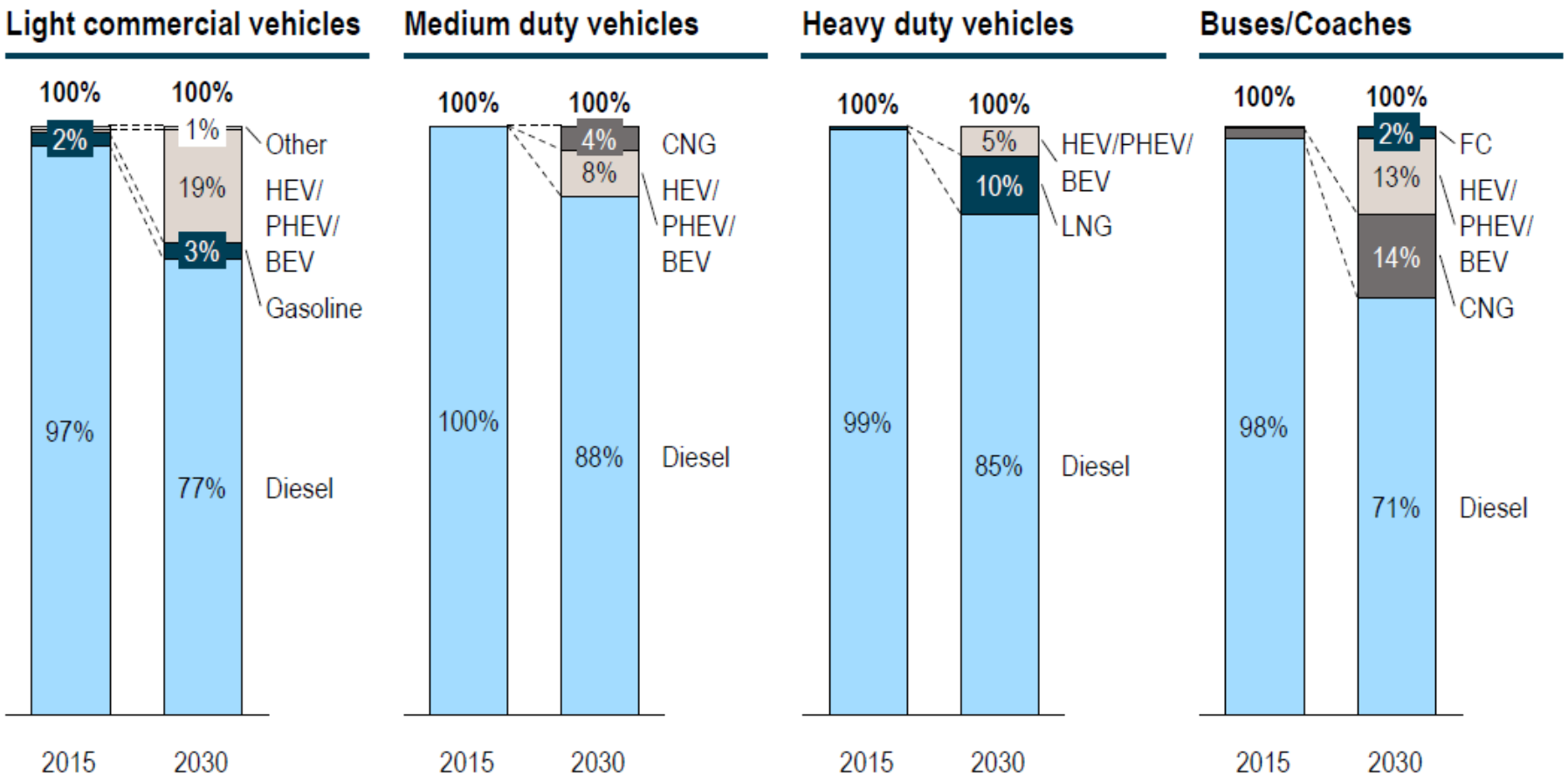
Note: Shares might not add up to 100% due to rounding

„Integrated Fuels & Vehicles Roadmap to 2030 +", Roland Berger p. 46.

BEV – battery electric
PHEV – plug-in hybrids,
FH – full hybrids
MH – mild hybrids

NEW TREND – DIESEL FALLING BUT NOT NECESSARY GASOLINE GAINING (2)

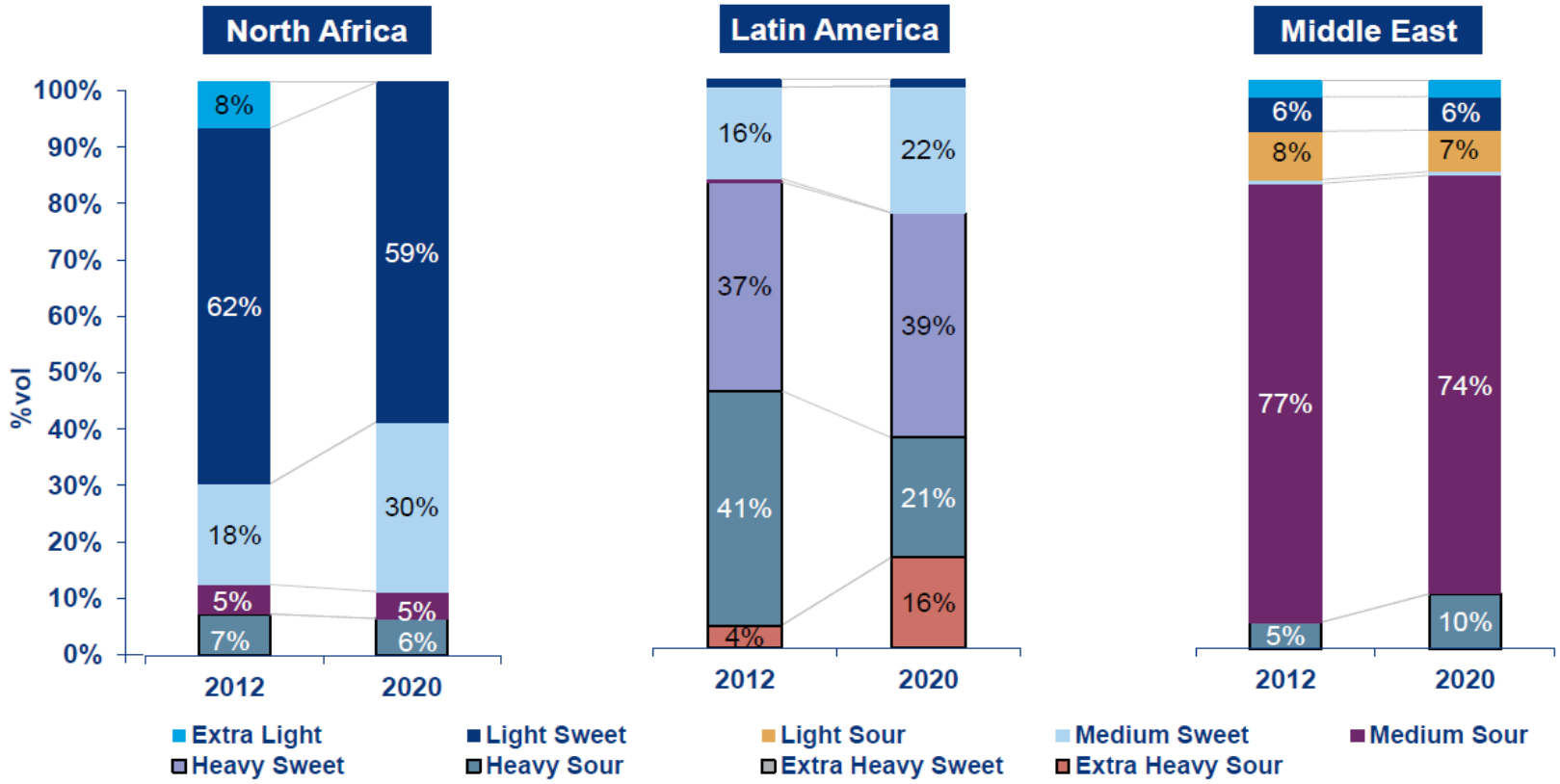
Figure 26: CV powertrain shares, 2015 vs. 2030 [%]



„ „*Integrated Fuels & Vehicles Roadmap to 2030 +", Roland Berger p. 51.*

EVOLUTION OF THE CRUDE SUPPLY AROUND EUROPE

Changing quality of crude will determine future trade flows into Europe; this will be necessary to offset declining long-term domestic supply



Source: Wood Mackenzie

Steve Cooper, „Crude Oil in Europe: Production, Trade and Refining Outllok", WoodMckenzie, London, 2013, p. 12.

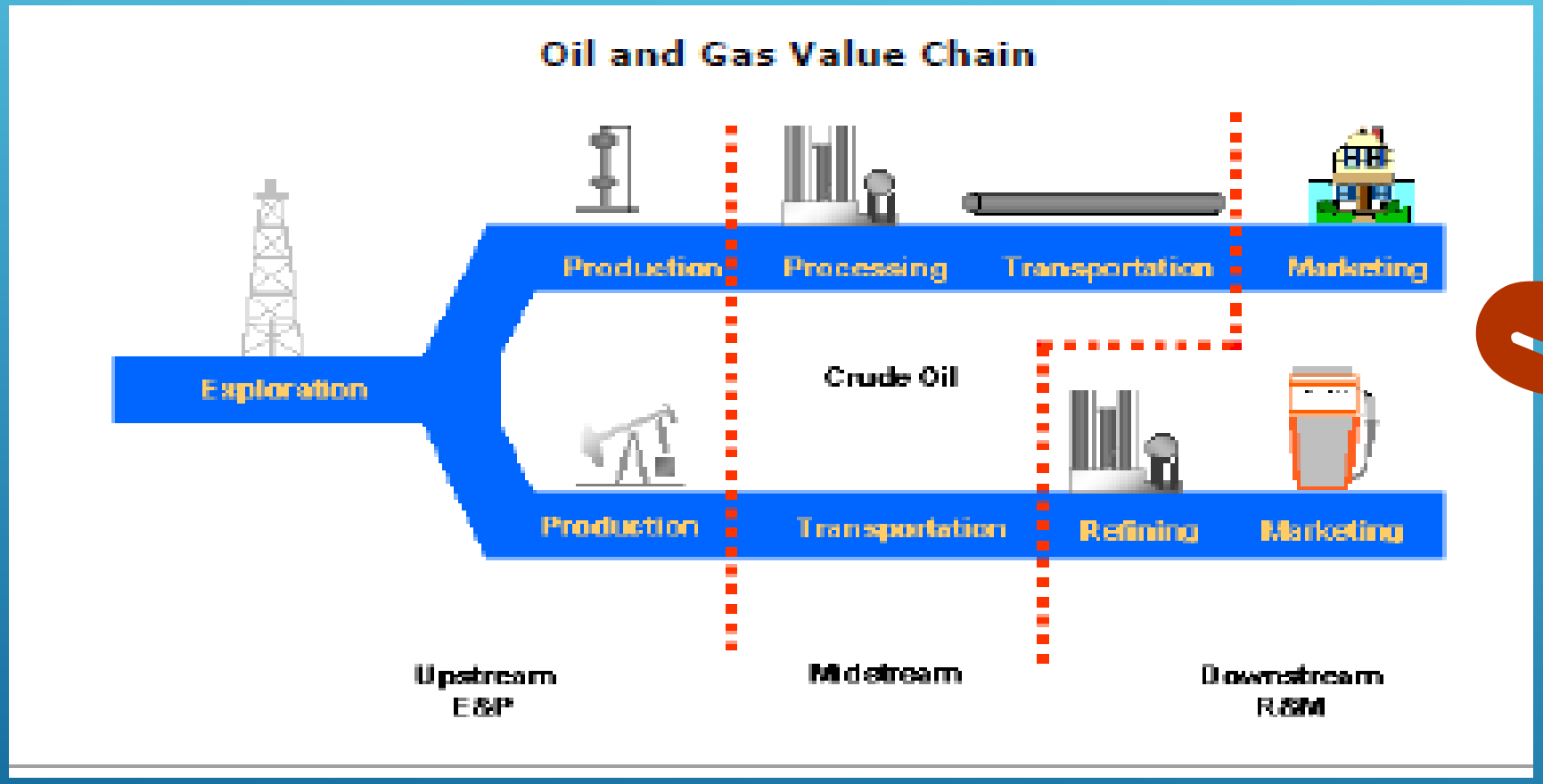
OVERALL VIEW: CONCLUSIONS

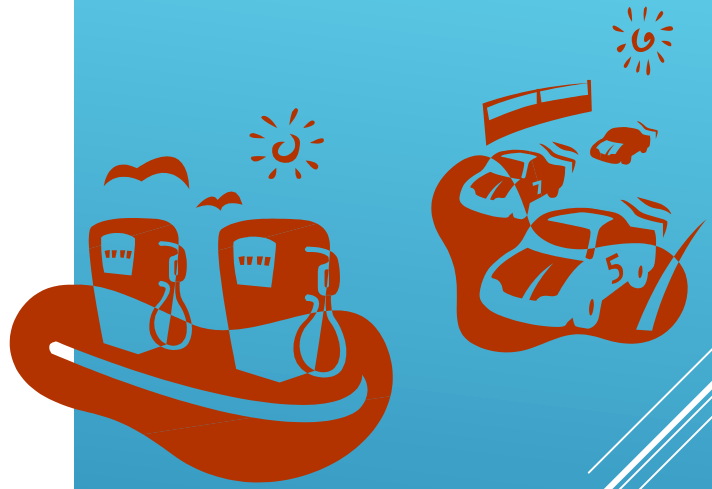
- Light fractions will play more & more important role
- The only factor checking the above trend: dieselization, is going to revert.
- Crude around is getting heavier & heavier
- The space for non conventional feedstocks will be wide opened.

NATURAL GAS VS CRUDE: OIL INDUSTRY CONVERTED INTO OIL & GAS INDUSTRY

- Oil is natural but money made on it is anthropogenic: Research & Development, innovations in downstream
- Natural gas technical challenges
- Gas based market products
- Oil & gas majors

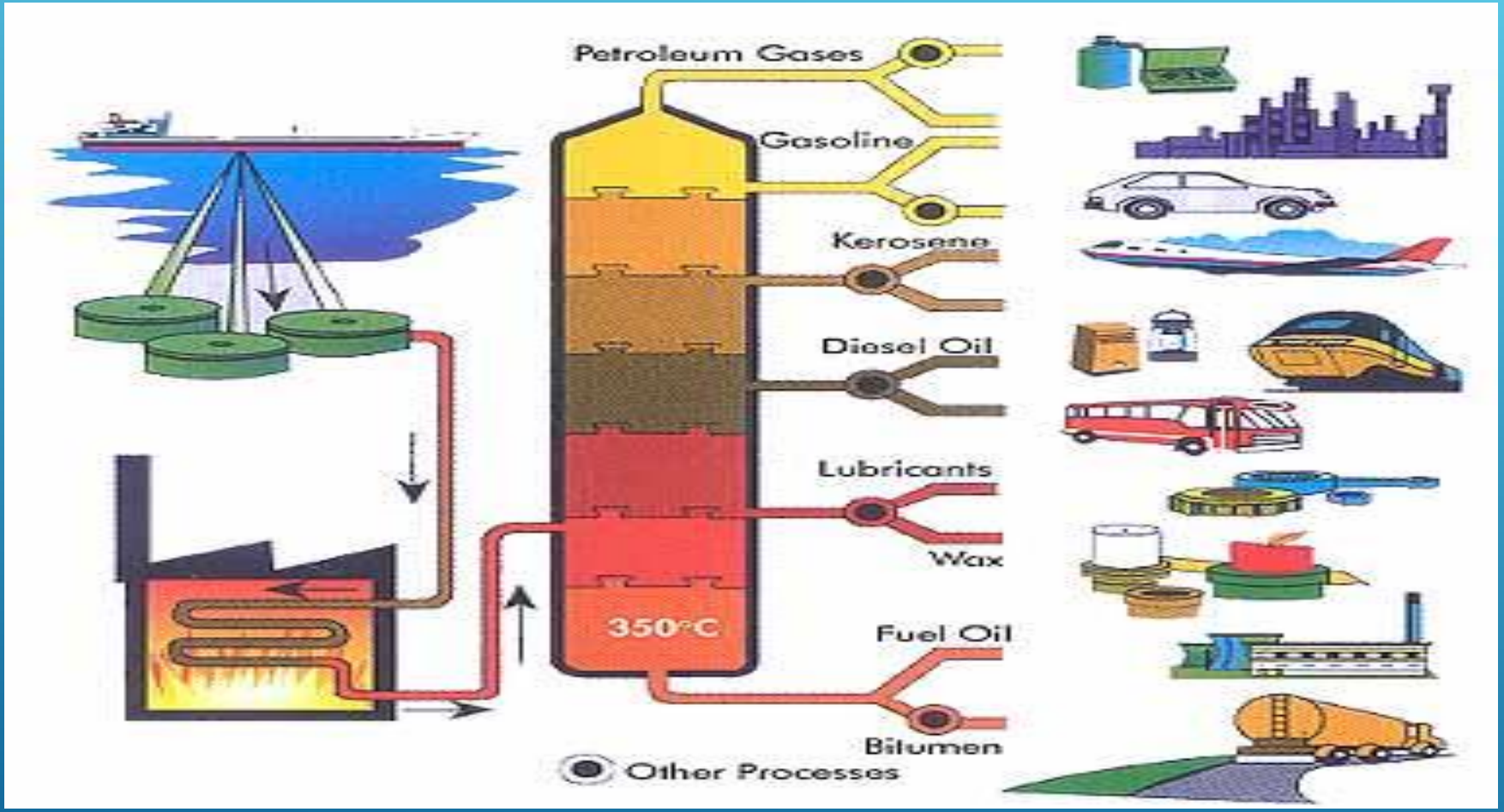
AT FIRST GLANCE OIL IS A VERY SIMPLE BUSINESS (…)





It's, after all, about converting crude in a field into a fuel in an engine.

(…) BUT MORE DEEPER INSIGHT REVILES SOME COMPLEXITY (…)



(…) CONTINUING DOWN TO THAT LEVEL

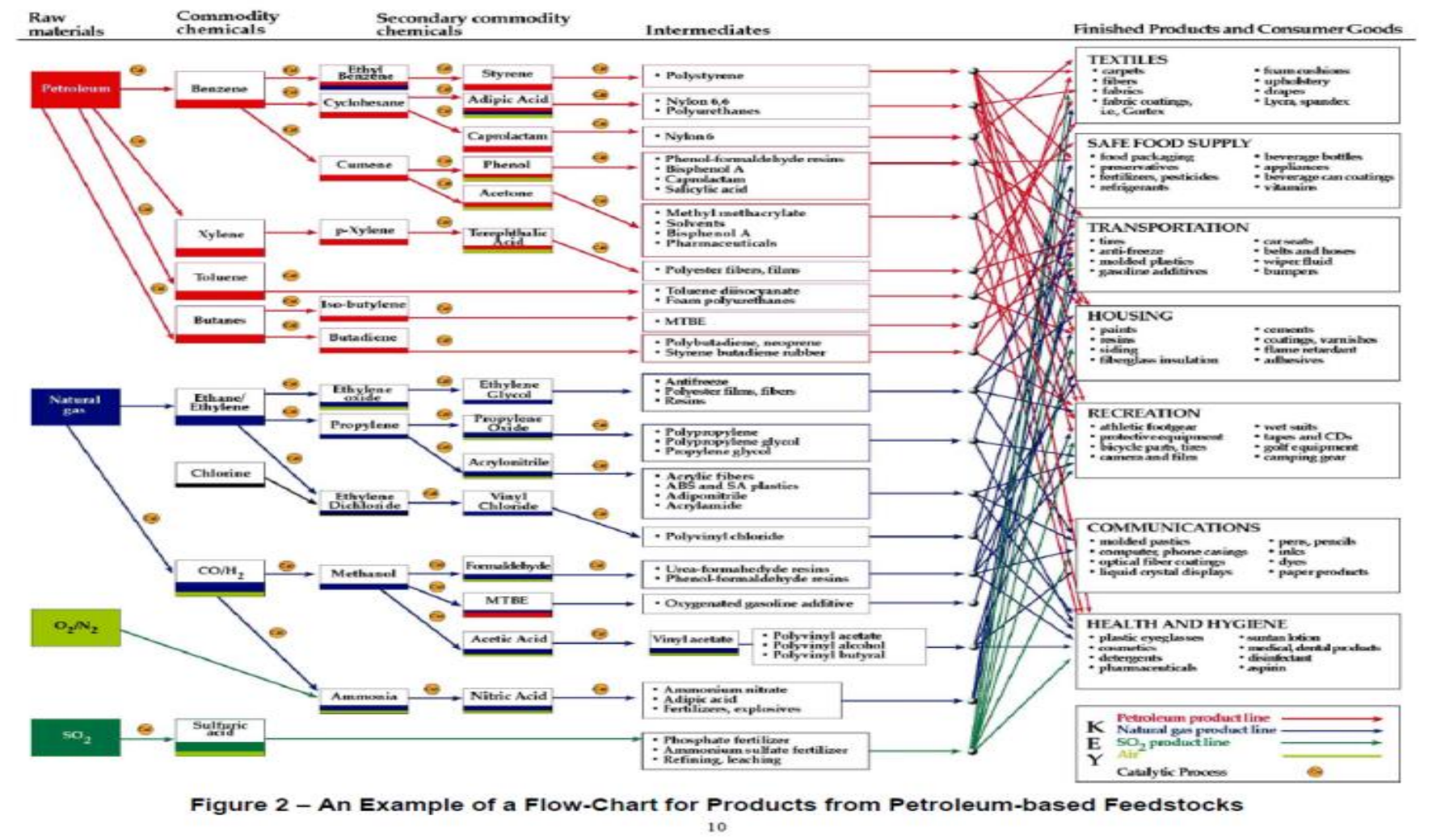


Figure 2 – An Example of a Flow-Chart for Products from Petroleum-based Feedstocks

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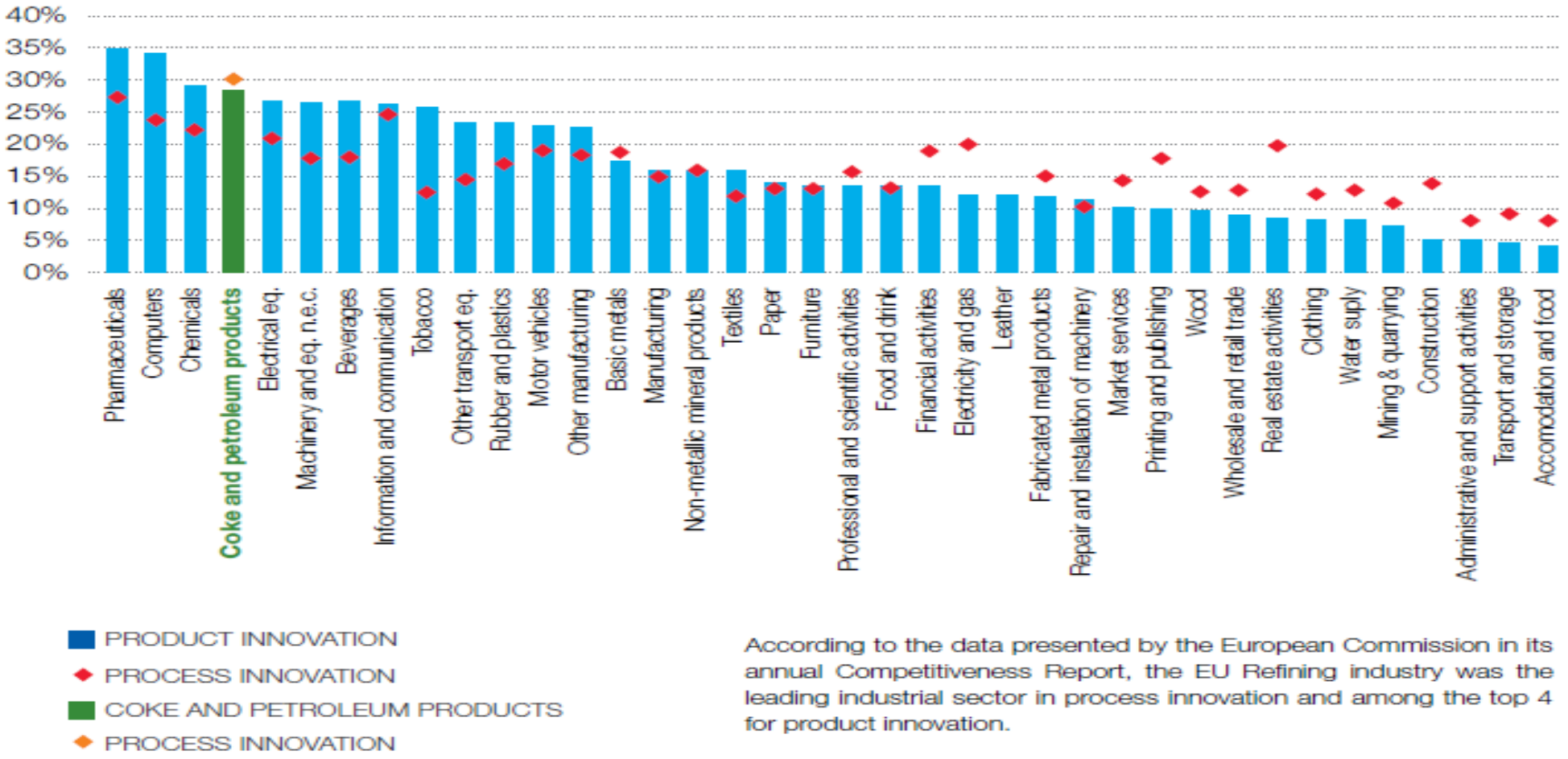
http://denmarkusmgreentour.wordpress.com/page/2/

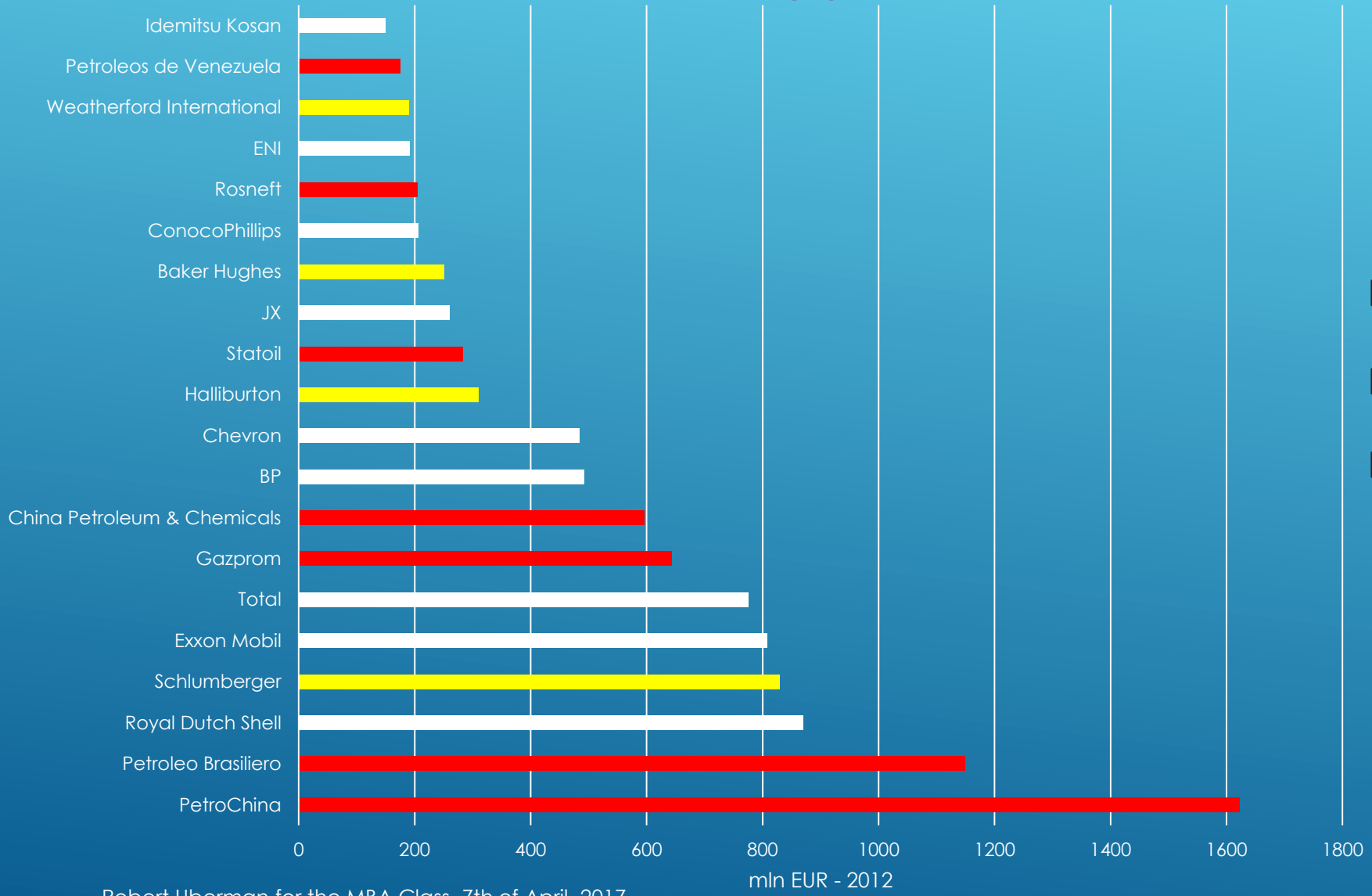
OIL & GAS INDUSTRY RANKS AMONG TOP INNOVATORS



According to the data presented by the European Commission in its annual Competitiveness Report, the EU Refining industry was the leading industrial sector in process innovation and among the top 4 for product innovation.

Fuels Europe Statistical Report 2016, p. 61

R&D EXPENDITURES OF OIL & GAS INDUSTRY



http://www.oilgaspost.com/2013/05/21/top-40-oil-gas-companies-investment/

Service & independents

NOCs

IOCs

BREAKTHROUGH DOWNSTREAM INNOVATIONS: HYDROCRACKING

- Hydrocracking (eg. Converting heavy, long hydrocarbon strings into short light ones) was first patented in Russia in 1881
- Todays hydrocracking units are based on catalytic processes developed 1942-1947. These were first processes capable, at commercial scale, to change natural product structure as defined by crude
- There would be no diesel revolution without hydrocracking

BREAKTHROUGH DOWNSTREAM INNOVATIONS: GTL

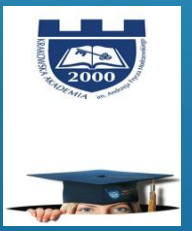
- Origins of GTL technology can be traced to pre II World War period.
- Its first commercial debut after a long period in Shell's Bintulu GTL plant in Malaysia in the early 1990s.
- The Pearl Gas to Liquids (GTL) joint venture project of Shell and Qatar Petroleum - the world's largest GTL plant and in fact one of the biggest refineries though with a natural gas as a feedstock, started 2011/2012
- Consequences remain to be seen but definitely will be far going

BREAKTHROUGH DOWNSTREAM INNOVATIONS: SUMMARY

- Both Hydrocracking and GTL share some common properties:
  - inward process orientation;
  - customers needs definition developed without customers;
  - no new products as a direct result;
  - huge capital expenditures.

CUSTOMER RELATED INNOVATIONS

- Often developed outside industry (petrochemicals by IG Farben, Dow, ICI)
- Promoted by niche players
- Not obviously linked to the refinery business
- Relatively low volume
- Possible if focus of R&D is redirected from internal processes to customer needs



UNATTRACTIVENESS OF CUSTOMER RELATED INNOVATIONS FOR OIL MAJORS

- Low volumes:
  - even if margins per unit are high overall margins are low;
  - oil products are joint products – almost any change in one specification requires at least some alternations across the portfolio;
- Cost of managing risk is very high since applications are made in businesses distant from Oil & Gas: mechanical industries, pharmacy and food, packaging.

CUSTOMER ORIENTED INNOVATION – VGO SOLVENT EXTRACTION CASE

- Traditionally part of VGO has been converted into two external products: base oil Gr. I and waxes;
- Starting from 90s base oil Gr. I has been gradually replaced by Gr II and Gr III base oils which are derived from hydrocracking residue;
- Official reason: Gr II and III have many functional advantages over Gr. I (which is true, by the way)
- Real reason: the only way to increase Diesel output, all other things equal, is to divert VGO from solvent extraction to hydrocracking – consequently Gr I has to disappear;

- Proof: the other external products obtained from the solvent extraction are waxes – they in turn can not be obtained from hydrocracking – customers got informed: you will have less waxes and they will be more expensive. Any problem with that. Oh it's your problem !!!

CONCLUSIONS

- R&D in case of Oil Majors is a supplementary internally oriented activity – such is this business
- Product innovations are not on the top of priority lists
- Majors are very good in networking and taking advantages of various alliances
- NOCs have made heavy investments in R&D – results remain to be seen

ATTRACTIVENESS OF NATURAL GAS VS CRUDE OIL

- It is more difficult to bring to markets:
  - Through more complex logistic systems (Kandyoti, 2012)
  - Through conversion to LNG, LPG or GTL
- Deposits are more dispersed and "safe" countries possess bigger share in reserves
- However: refineries have gas slates (semi-equivalents of natural gas) already in their production processes: LPG, syngas.

EXPANSION OF OIL BUSINESS INTO GAS

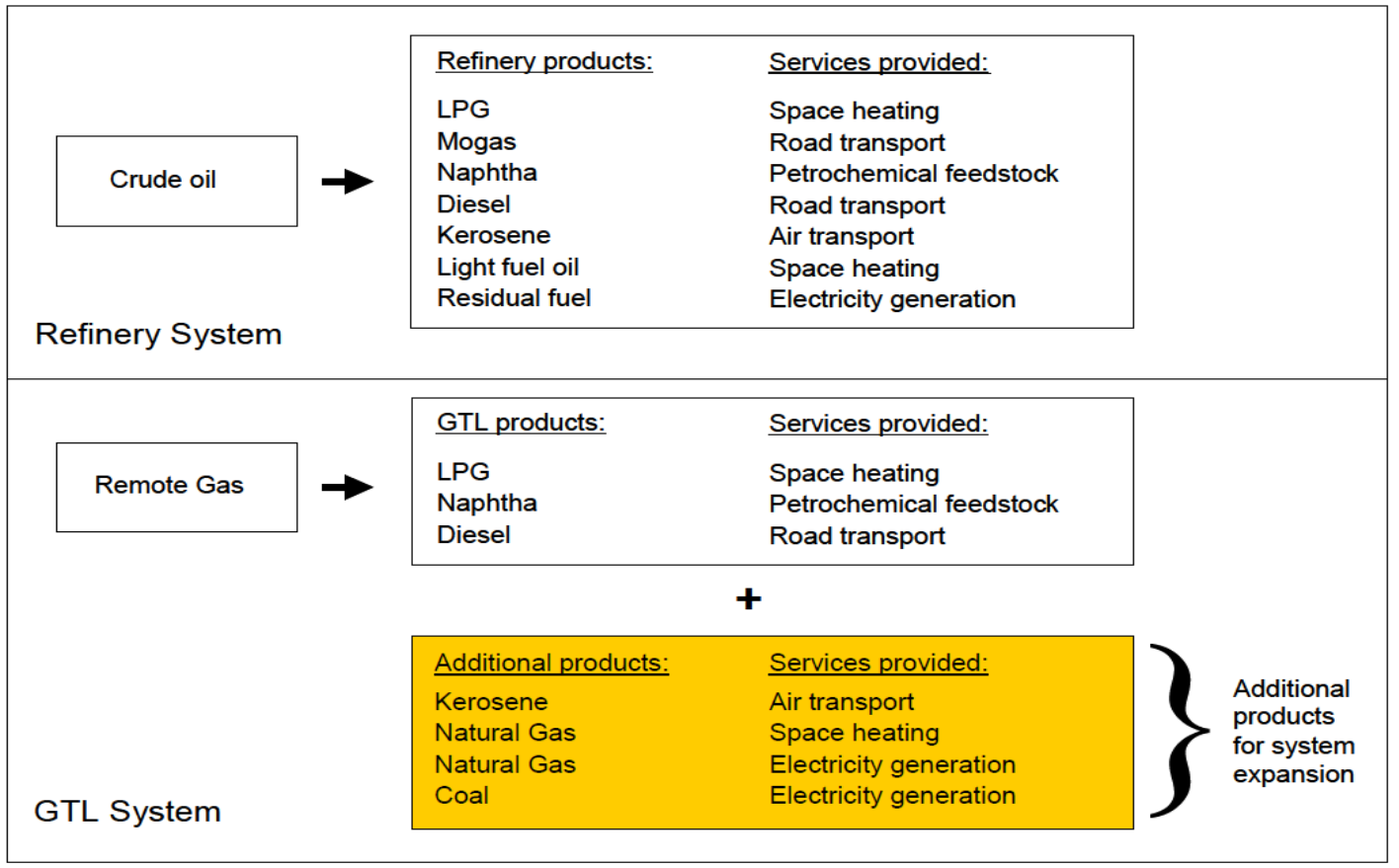
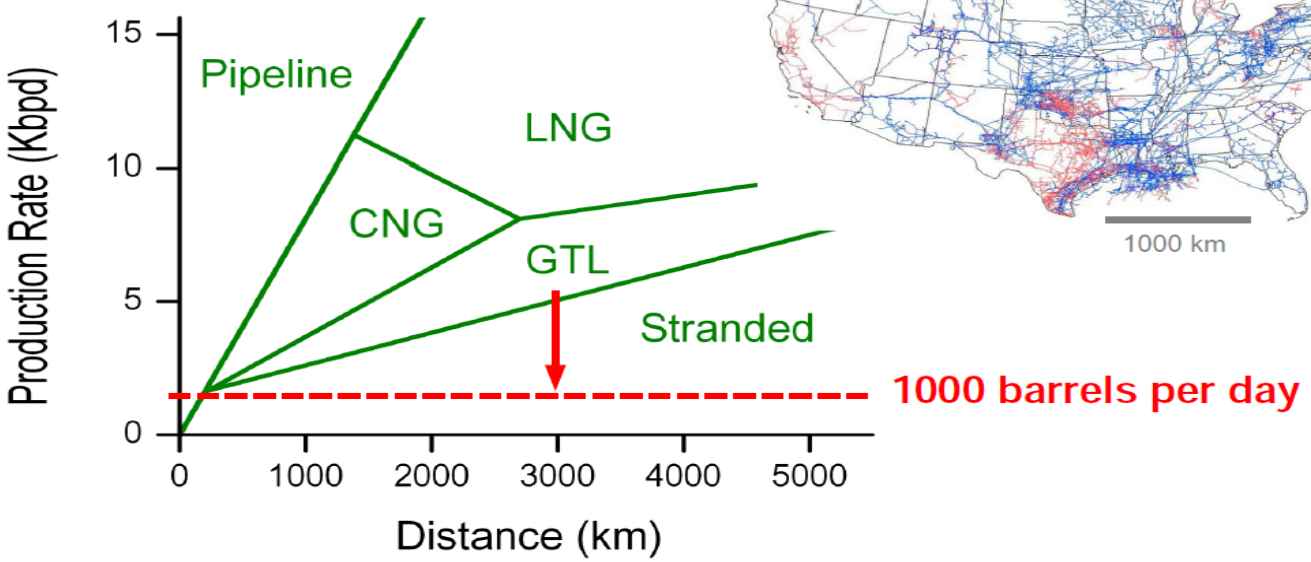


Figure 1: Illustration of the systems studied (Source: modified from PwC, Sasol Chevron study)

Five Winds International 2004: *Gas to liquids. Life cycle assessment synthesis report*. page. 13

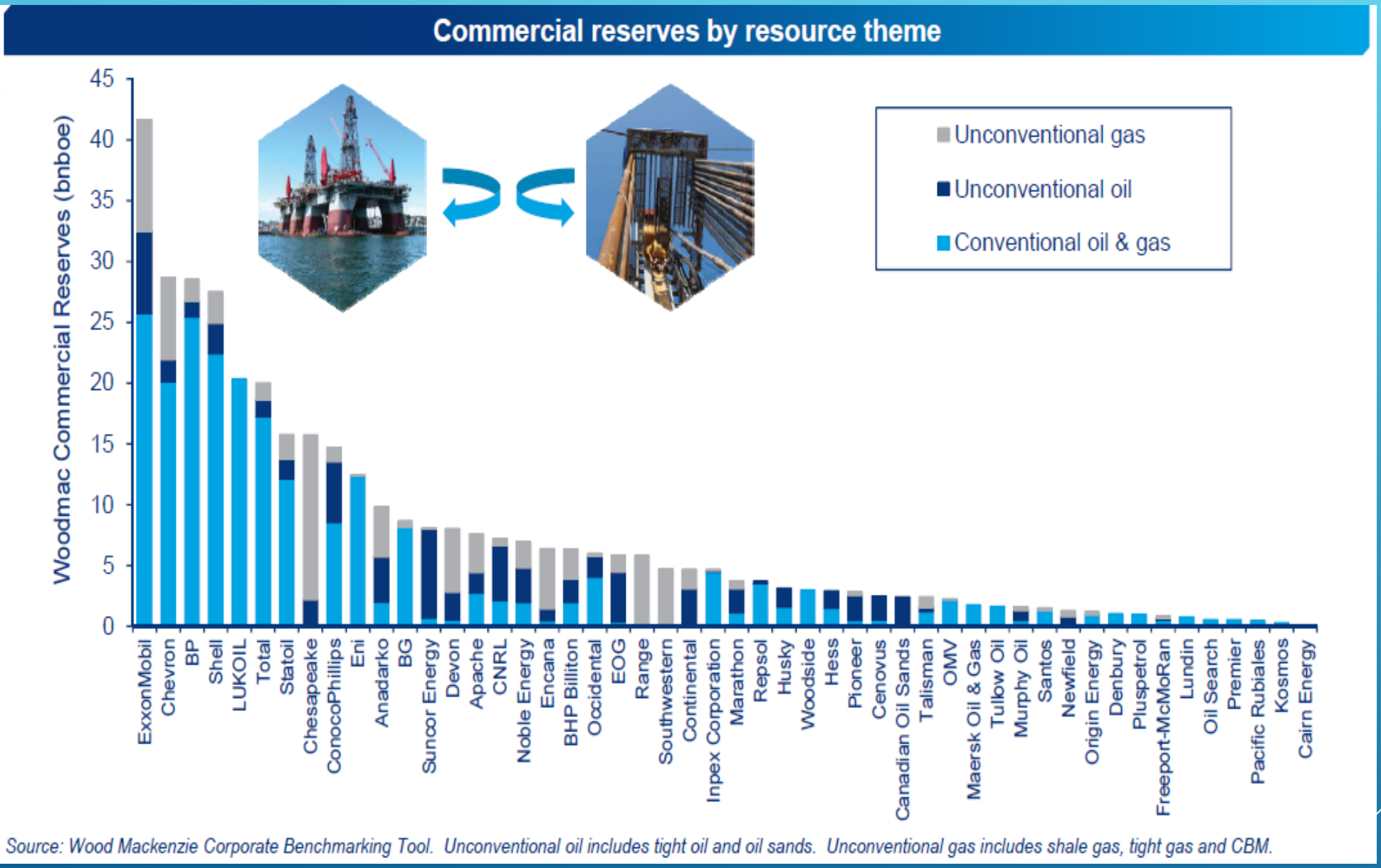
LOGISTIC IS THE KEY ISSUE

ECONOMICS OF TRANSPORTING NATURAL GAS



[1] D. Hawkins, TransOcean,Global, Gas Flaring Reduction Conference, Paris Dec 13-15, 2006

Natural gas share in Major's reserves is growing (Bain 2012)



Source: Wood Mackenzie Corporate Benchmarking Tool. Unconventional oil includes tight oil and oil sands. Unconventional gas includes shale gas, tight gas and CBM.

WoodMackenzie 2014: Oil & Gas *exploration trends and company performance*. page. 9

GAS TAKEOVERS SURPASSING OIL TAKEOVERS

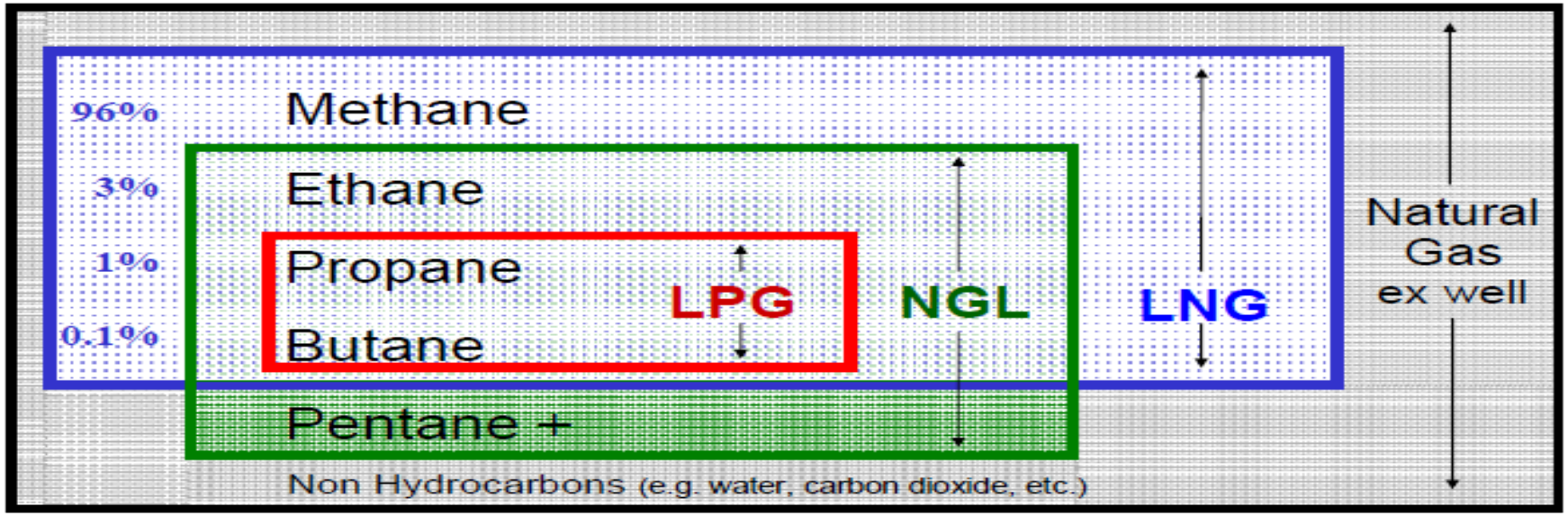
- Mega buyouts now regard natural gas: Exxon buying XTO Energy for 41 bn USD (2009/2010) and Shell paid 52 bn USD for British Gas (2016). The former was driven by shale gas, the latter by LNG

- The purchase of BG is also a reminder that the oil majors are really oil and natural gas majors. BG will give Shell major LNG positions in Australia, and to a lesser extent in East Africa. By 2018, Shell will have twice the liquefaction capacity as ExxonMobil.

LPG, LNG, NLG

- LNG – a logistic solution
- LPG and CNG – leap forward in transportation fuels
- GTL – bringing gas to the core of refinery processes

KEY VOCABULARY

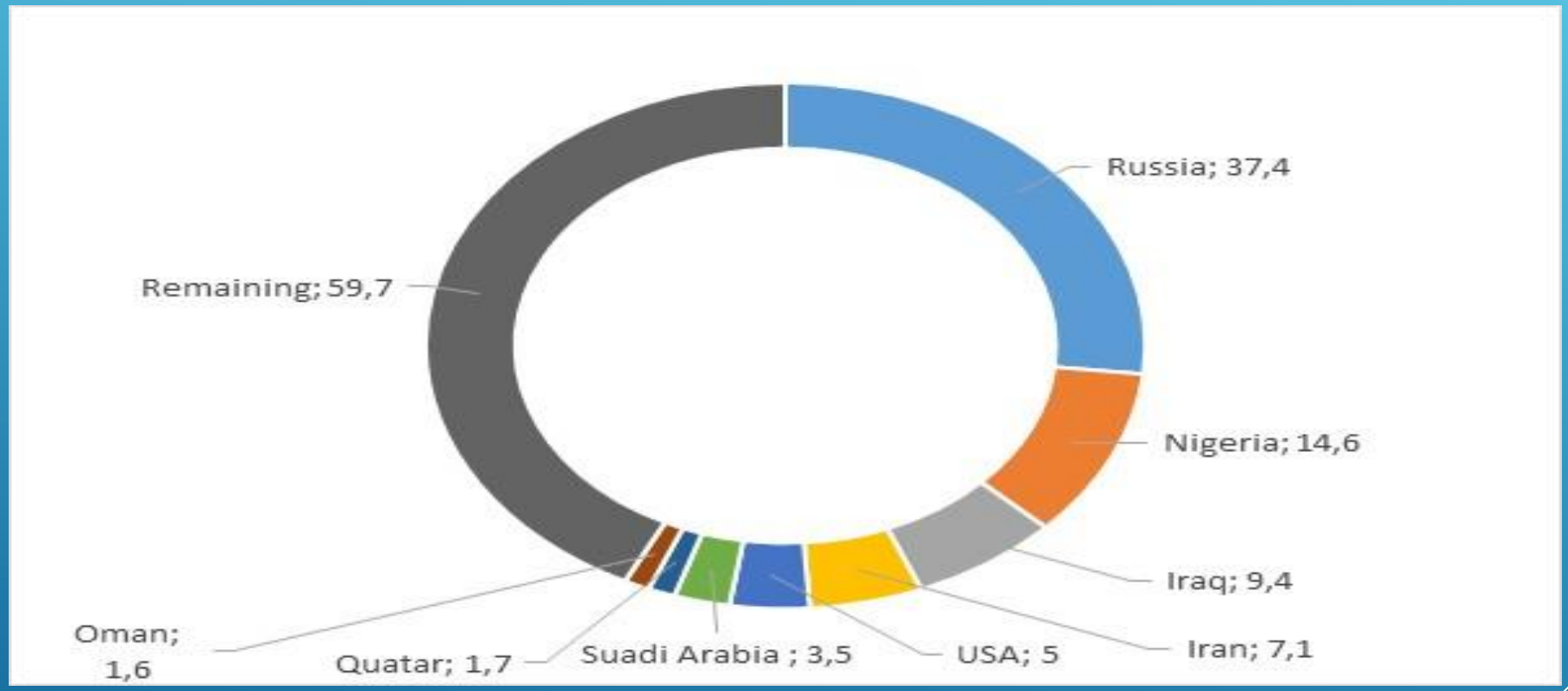


LPG – Liquid Petroleum Gas
NGL – Natural Gas Liquids
LNG – Liquid Natural Gas

- CNG: Compressed Natural Gas used for transportation competing with LPG
- NGL and LNG used as competing mode of movement

ABUNDANT GAS SUPPLY BASE IN SOME DISTANT PLACES

Volumes of gas flared in bcm, 2011.



OVERALL SCHEME OF LNG BUSINESS

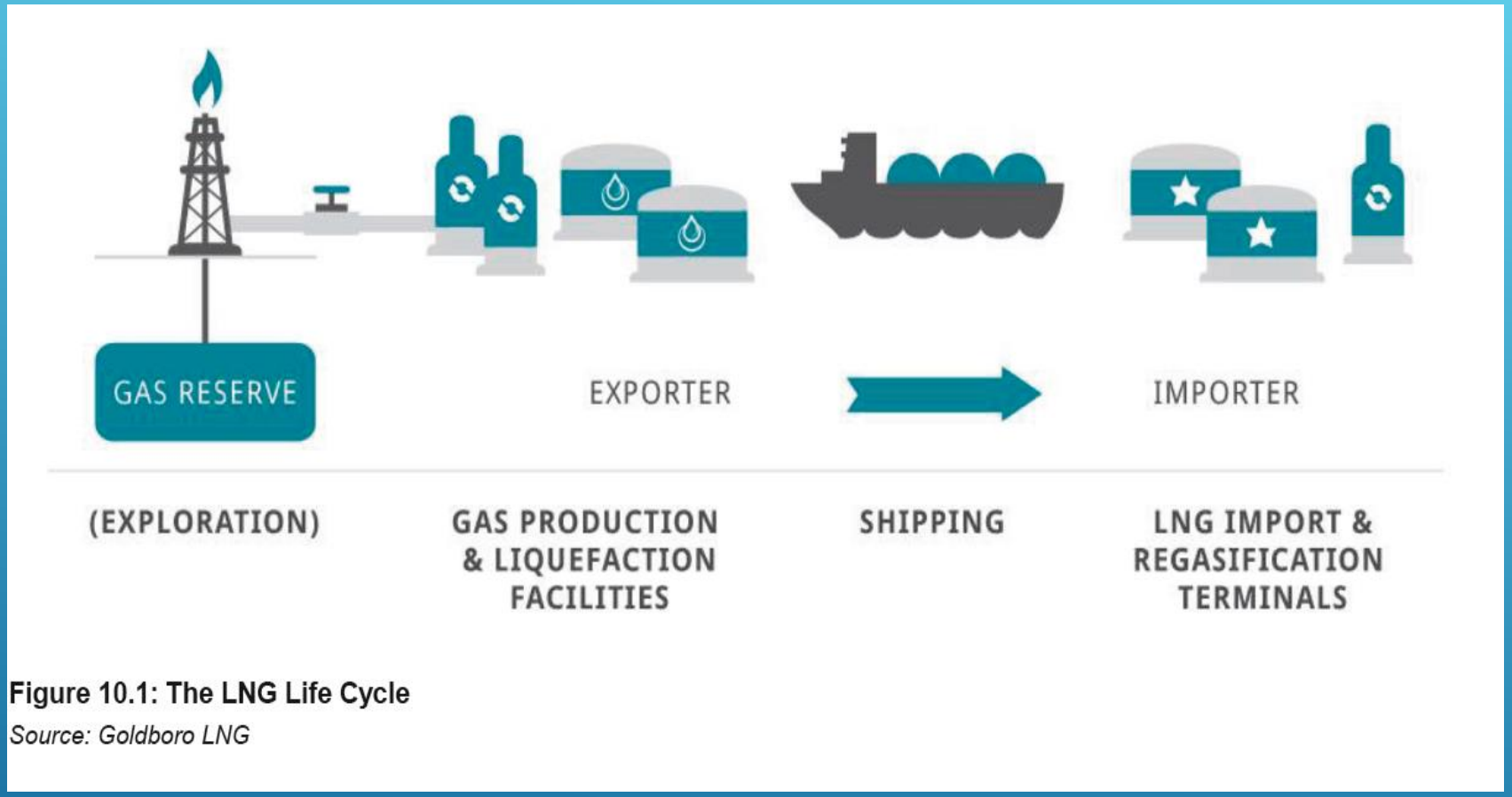


Figure 10.1: The LNG Life Cycle

Source: Goldboro LNG

Pipelines

Final customers

- IGU, World LNG Report, 2015

LNG TECHNOLOGY

- The first LNG plant was built in Arzew, Algeria in 1964 and had a capacity of 400 kT annually.
- The first shipment to Japan, opening East Asian market for LNG occurred in 1969.

LNG TECHNOLOGY

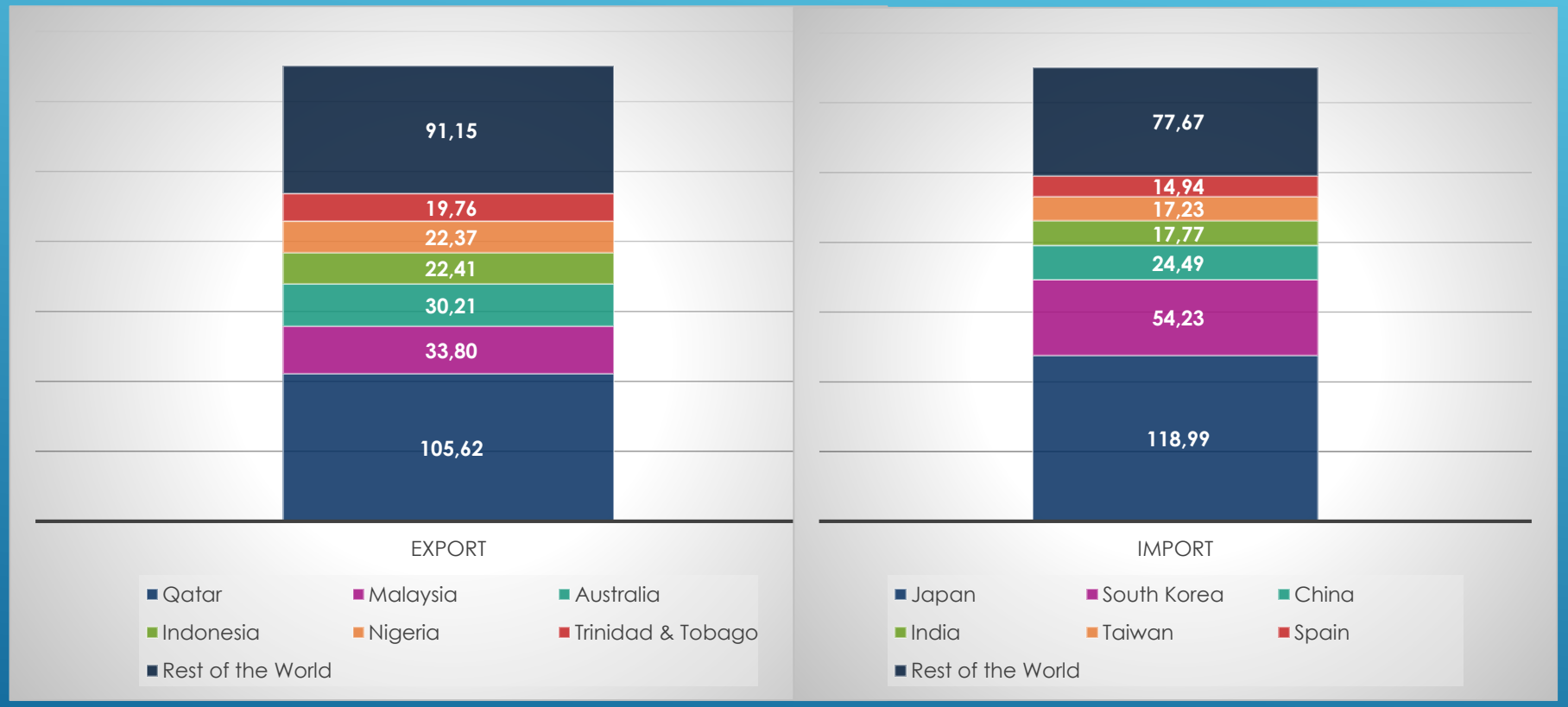
- LNG technology is based on chilling natural gas down to -160 C what reduces the volume by a factor of roughly 600. This volume reduction forms the key advantage for transportation over long distances especially where marine transportation can be used (where pipelines in turn become more expensive).
- However, the low temperature creates a substantial disadvantage:
  - Firstly reducing the temperature of the gas to -160 C requires energy. Typically about 10% of the natural gas delivered to a LNG plant must be burned to provide the energy needed for cooling down.
  - Secondly the refrigeration machinery is expensive as low temperature of processing requires special materials.
  - Thirdly LNG must be stored in tanks made of aluminum, stainless and high nickel steel, or other more expensive specialized materials. In case of natural gas pipelines operating at ambient temperature can be made of carbon steel materials.

LNG MARKET GLOBALIZATION

- The globalization of natural gas is leading to product specification problems related to "gas interchangeability."
- Traditionally gas was produced for a local market to meet its respective specifications resulting from equipment and appliances designed for that local specification.
- The key LNG markets: European, Pacific Rim, UK and US are characterized by wide differences in the specifications. This invoking interchangeability problem.
- Typically the gas can come from two sources: associated with oil and non-associated. Associated gas has a high concentration of heavy components and must have propane and butane (also known as liquid petroleum gas, LPG). At some point gas has to be conditioned to final customers' specifications. Although gas interchangeability is important from gas marketing and technology perspectives, the cost of providing interchangeability is relatively low.
- It looks like the industry is heading in a direction of conditioning the gas at the receiving end. This provides the receiving terminal with flexibility on supply side. Durr Charles et al. *LNG technology for the commercially minded*. Gastech 2005.
- The most fundamental obstacle for LNG growth is the high transportation costs. EIA estimates that liquefaction and forwarding costs from US Gulf Coast to Japan surpass 8 USD/MMBtu thus being twice more than purchasing cost at point of origin Houser, loc. 2454).

LNG TRADE GLOBALLY

LNG trade in bcm equivalent below accounts for less than 10 % of natural gas consumption



It has been estimated that a LPG terminal with all infrastructure and tankers for 8,4 bcm/year would cost 4 bn USD. *(Kandiyoti, p. 15), LNG Terminal alone 212 USD/MT according to*

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GLOBAL LIQUEFACTION PLANTS

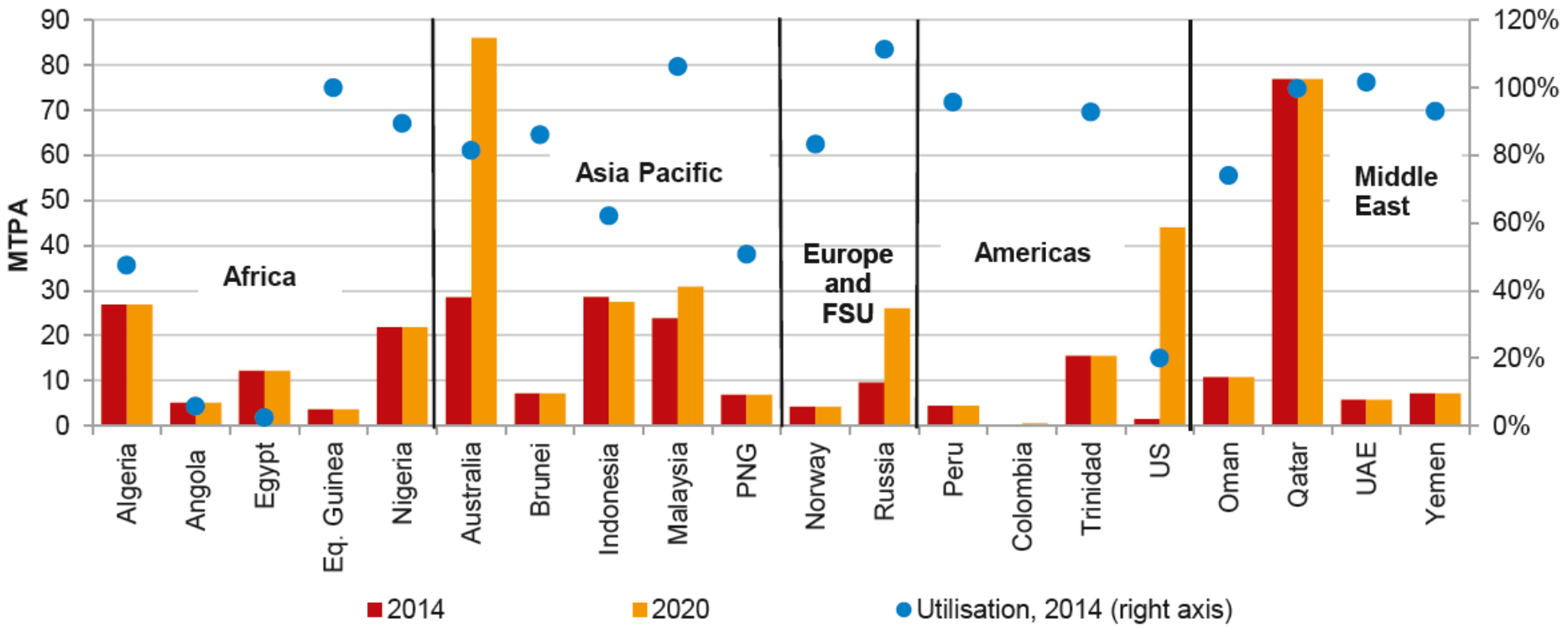


Figure 4.4: Liquefaction Capacity by Country in 2014 and 2020

Note: Liquefaction capacity only takes into account existing and under construction projects expected online by 2020.

IUG 2016, p.21.

Global capacities PA, 2014:

operating: 301,2 MT
under construction: 128,1 MT

LNG RECEIVING CAPACITY

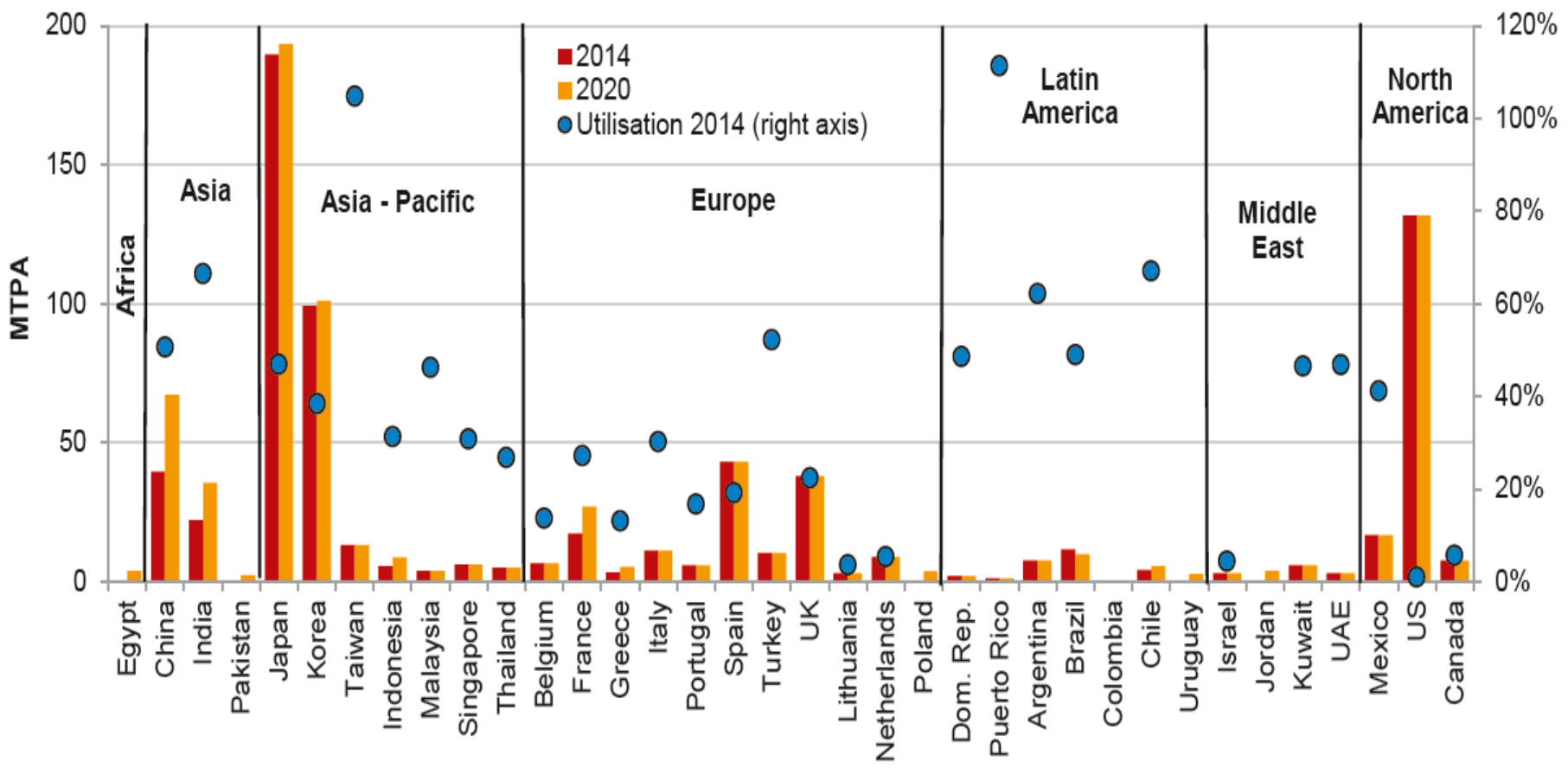


Figure 6.6: Receiving Terminal Import Capacity and Utilisation Rate by Country in 2014 and 2020

IUG 2016, p.51.

Global capacities PA, 2014:

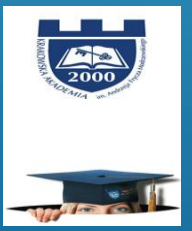
operating: 724 MT
under construction: 74 MT

LPG ON CROSSROADS OF CRUDE AND GAS

- LPG is derived either from crude-oil refining or from natural-gas production. At present, more than 60% of global LPG comes from natural gas processing plants.
- LPG is generally refrigerated for large-scale bulk storage and seaborne transportation as a liquid, but it is transported and stored locally in pressurized tanks or bottles (cylinders).

LPG DIRECT GASOLINE COMPETITOR?

- Has more than 1,000 applications: apart from transportation, it is used in commercial business, industry, farming as well as for domestic heating and cooking.
- By far the biggest consumer is chemical industry with 40 million tonnes per year in US and Saudi Arabia.
- Personal vehicles is the best known and one of the fastest growing sectors, representing almost 9% and 22.87 million tonnes of global LPG consumption worldwide (2010).



LPG GLOBAL MARKET

- Total LPG production was 280 million tonnes and only 1/3 of that was traded internationally.
- Asia-Pacific, North America and Middle East count as both producers and consumers with the former being net importer while the latter two running surpluses.
- Shale gas revolution will impact LPG.

GTL TECHNOLOGY

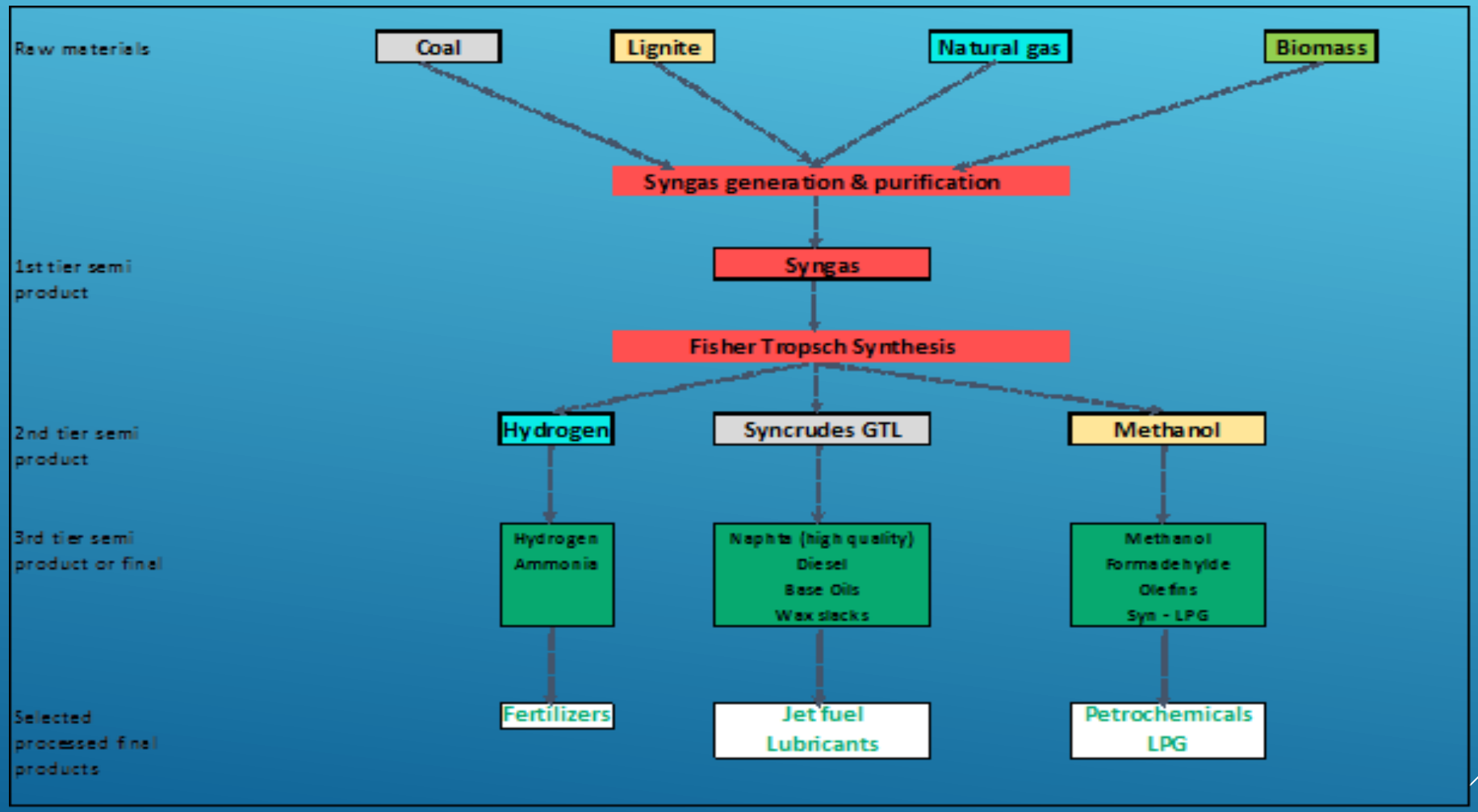
- Historical background of crude oil substitutes based on gases
- Description and key products of GTL technology
- Competitive position of natural gas as feedstock for refinery business
- Conclusions – Will gas substitute crude oil as a primary refining feedstock?

GTL REINVENTED

Operator	Location	Commencing year	Nameplate capacity (bbl/d)	Construction costs (USD 1 000 K)
Shell	Bintulu/Malasya	1993	12,000	1,500
Sasol	Sasolburg/RSA	1994	5,600	n/a
Shell	Bintulu/Malasya	2006	2,700	n/a
Sasol/Chevron	Oryx/	2006	34,000	1,500
Shell	**Pearl/ Qatar**	**2011**	**140,000**	**20,000**
Chevron	Escravos/Nigeria		34,000	10,000
Source: Based on (EIA 2013, p. 9)				

- Three plants in the United States—in Lake Charles, Louisiana; Karns City, Pennsylvania; and Ashtabula, Ohio—are proposed. Of these, only the Lake Charles facility is a large-scale GTL plant.

GTL VALUE CHAIN



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GTL R&D

- Research and development trends have to address the following challenges :
  - capital cost reduction as, even by energy and refinery standards Fischer – Tropsch is a very capital intensive technology;
  - expanding feedstock base through development of efficient least-cost gasification technologies for biomass, coal etc.;
  - improving selectivity and catalyst lifetime.
- GTL is still a nascent technology with potential for improvements

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SWINOUJSCIE CASE

- Political & economic context
- Technical challenge
- Impact as seen today

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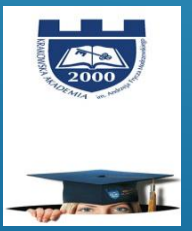
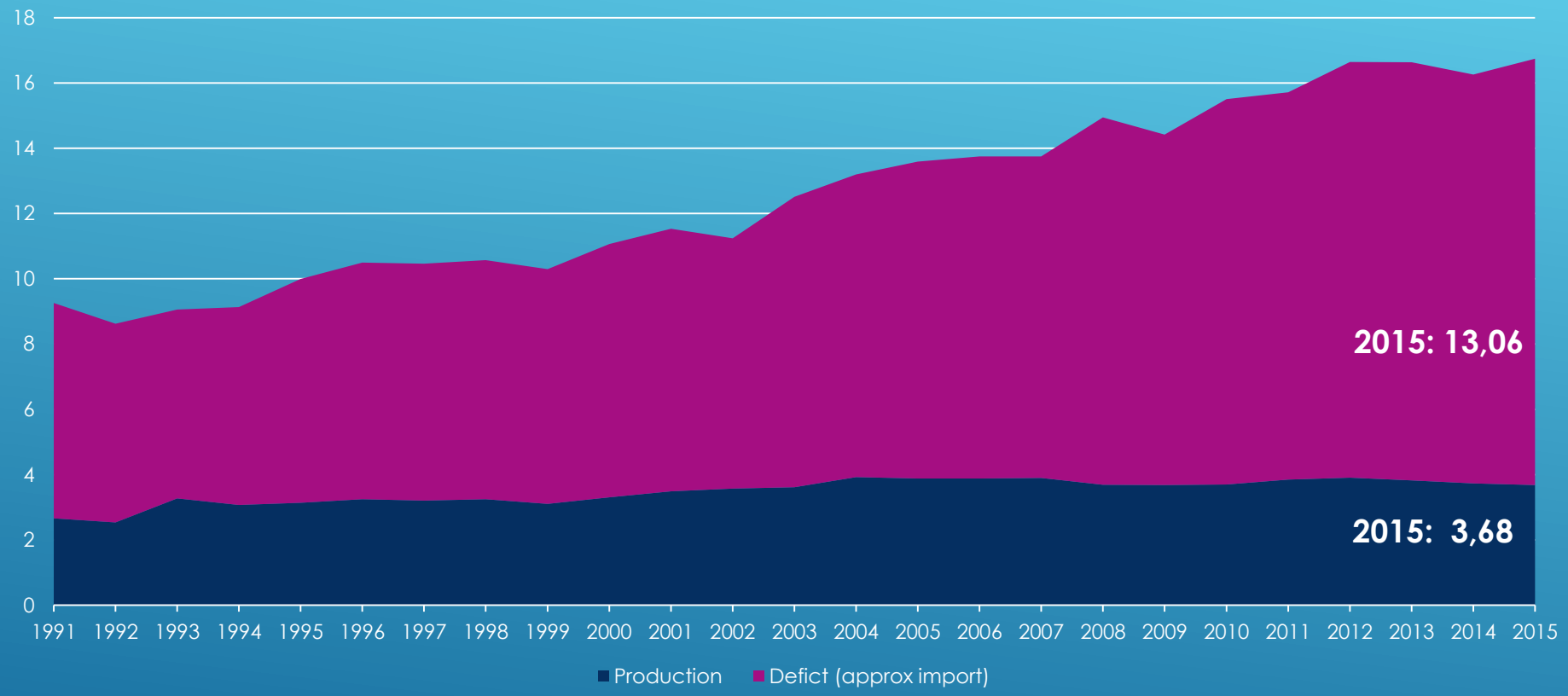
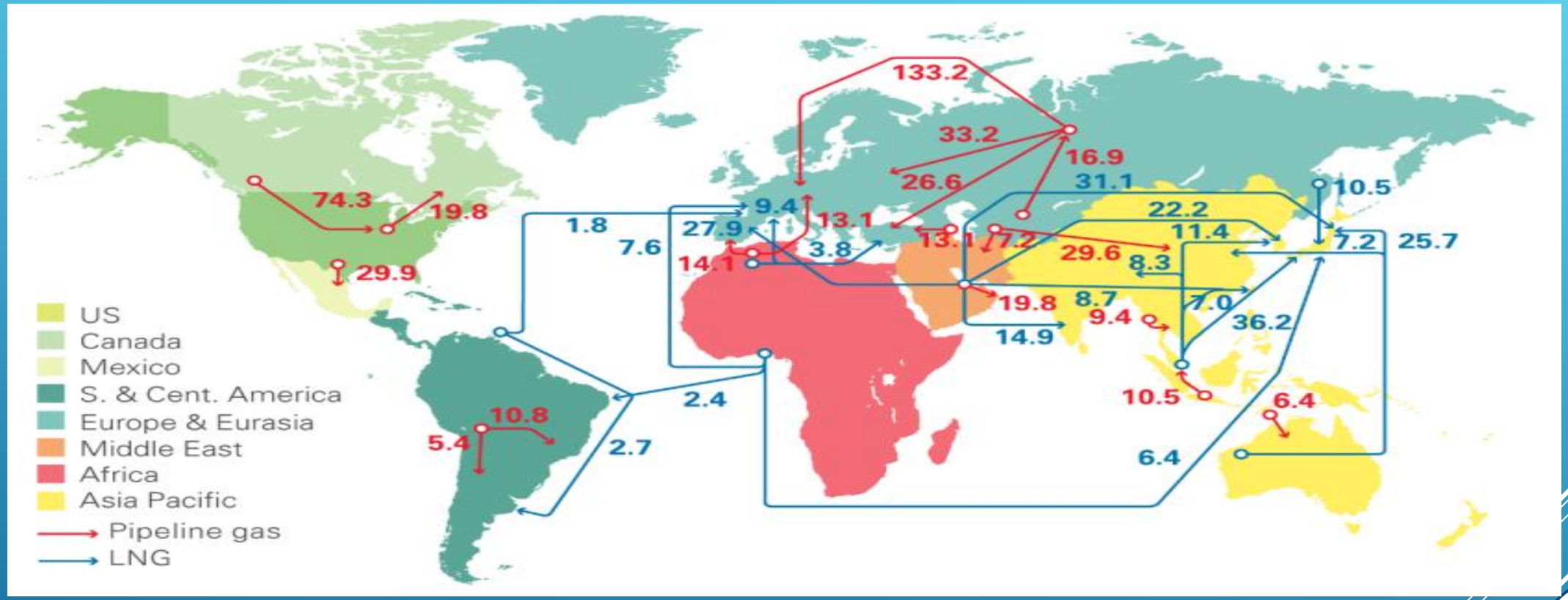


POLAND: SOURCES OF NATURAL GAS (BLN CM)



- BP Energy Statistics, 2016

GLOBAL NATURAL GAS TRADE



- BP Energy Statistics, 2016

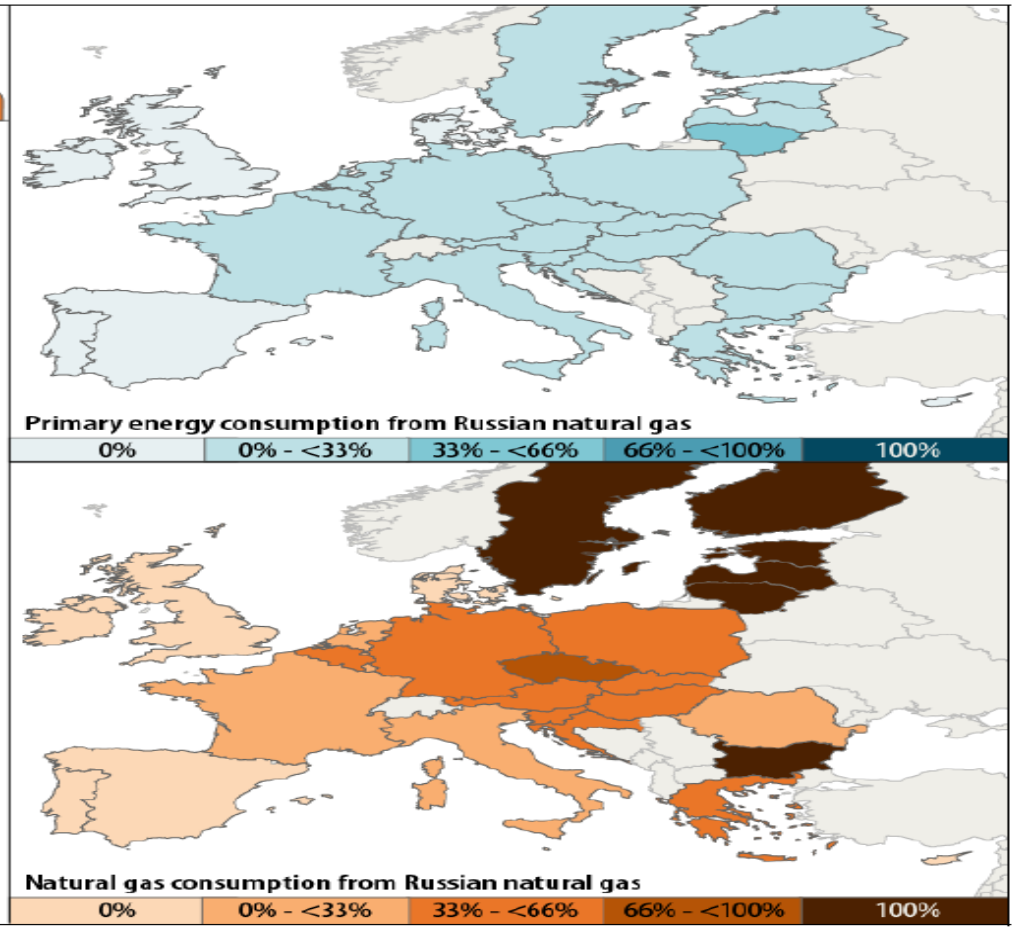
POLAND'S OVERALL ENERGY DEPENDENCE ON RUSSIAN GAS LIMITED

Figure 2. EU Dependence on Russian Natural Gas

EU Energy Consumption of Russian Natural Gas (%)

	Primary Energy	Natural Gas
Austria	12.8%	52.2%
Belgium	10.9%	43.2%
Bulgaria	13.6%	100.0%
Croatia	9.4%	37.1%
Cyprus	0.0%	0.0%
Czech Republic	14.2%	80.5%
Denmark	0.0%	0.0%
Estonia	10.0%	100.0%
Finland	10.6%	100.0%
France	2.7%	17.2%
Germany	8.7%	39.9%
Greece	7.2%	54.8%
Hungary	19.7%	49.5%
Ireland	0.0%	0.0%
Italy	7.5%	19.8%
Latvia	31.0%	100.0%
Lithuania	50.0%	100.0%
Luxembourg	6.1%	27.9%
Malta	0.0%	0.0%
Netherlands	2.1%	5.8%
Poland	8.3%	54.2%
Portugal	0.0%	0.0%
Romania	8.8%	24.2%
Slovakia	20.3%	63.3%
Slovenia	6.3%	57.4%
Spain	0.0%	0.0%
Sweden	1.9%	100.0%
United Kingdom	0.0%	0.0%

Source: Gas data from Eurogas, BP Statistical Review of World Energy 2013, and U.S. Energy Information Administration; boundary data from ESRI, 2005.
Graphic created by CRS.
Borders are not necessarily authoritative.



Source: CRS Graphics compiled this graphic.

Notes: For primary energy, which is the base source of energy used to produce electricity and perform other work, Russian natural gas does not comprise greater than 50% for any EU country.

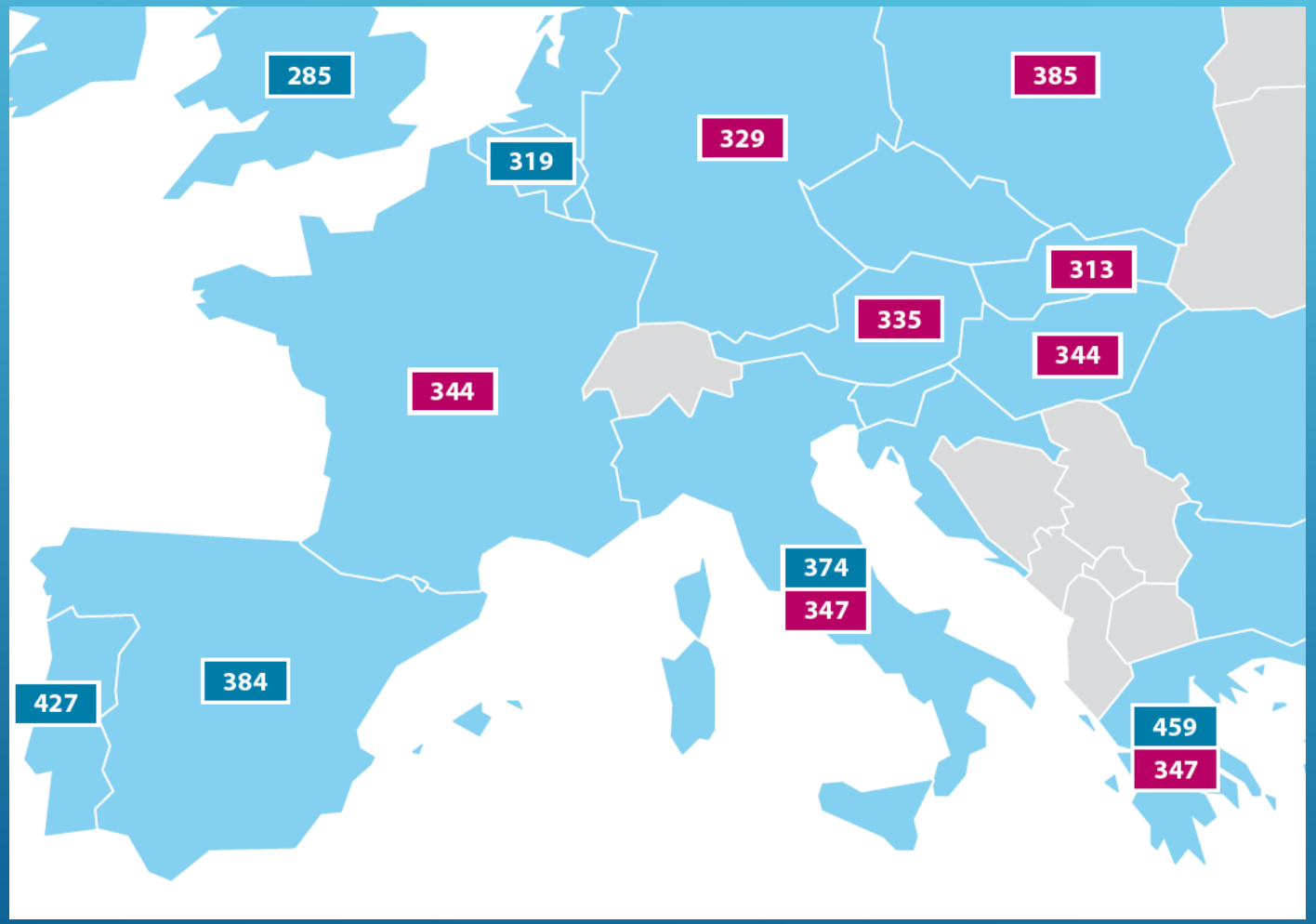
- Poland imports from Russia more than half of natural gas demand and satisfies that way only 8 % of primary energy.
- However: In some of natural gas applications it's hard to substitute
- Ratner et al, *Europe's energy security: Options and Challenges to Natural Gas diversification, p.10*

POLITICAL & ECONOMIC CONTEXT

- Opportunity: Russia as the obvious & competitive supplier
- Threat: Gazprom as the 4th formation of Russian army
- Developments:
  - Old balanced set up in which Poland (and Ukraine, Belorussia) was dependent on Russian supplies but Russia was dependent on pipeline system serving the most attractive EU market in cashing it's potential violated by the North Stream construction.
  - EU protection appeared to be virtually non-existent.

FINANCIAL CONTEXT

2014 gas prices in USD/1000 cm: red – Russian pipes, green - LNG



- For almost 20 years Poland paid the highest prices for Russian gas.
- Even after renegotiations and EU support it pays 25 % more than Slovakia.
- Source, PWC, *Polski rynek nafty i gazu 2015.*

GLOBAL LNG LIQUEFACTION PLANTS

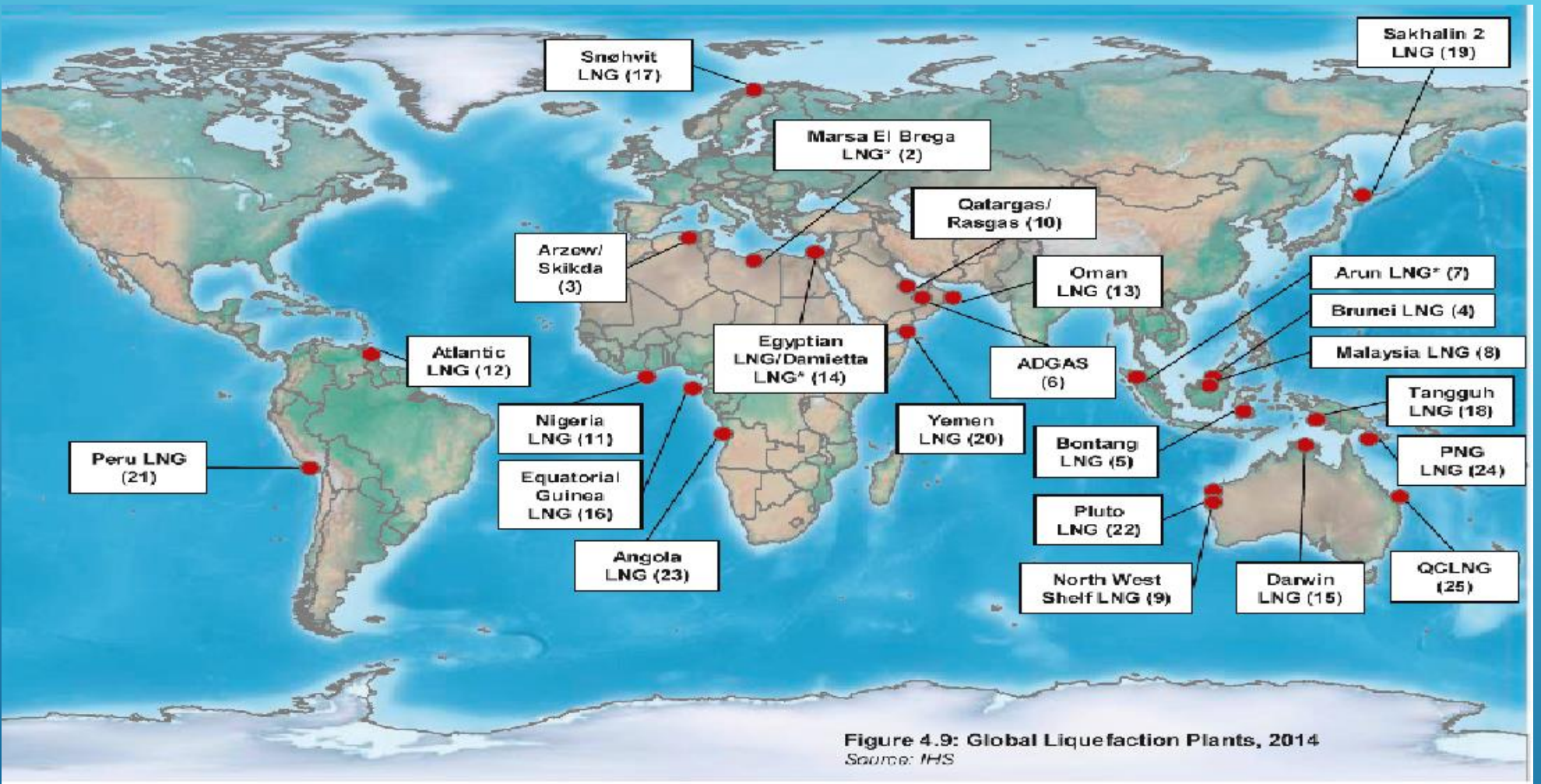


Figure 4.9: Global Liquefaction Plants, 2014
Source: IHS

...ion on each of these plants can be found in Appendix 1 by referring to the reference numbers listed in parentheses above. The liquefaction projects are numbered in the ...re brought online.
...ypt has not operated since the end of 2012; operations at Egyptian LNG have been greatly reduced since the start of 2014. The Marsa El Brega plant in Libya is included ... it has not been operational since 2011. Kenai LNG restarted operations in 2014, but is only permitted to operate until early 2016. Arun LNG was decommissioned in late ... converted into a regasification terminal in early 2015.

TECHNICAL & FINANCIAL CHALLENGES

- Baltic: a shallow "inland" sea.
- Interception with Nordstream I (pipeline limits depth of LNG carriers).
- Polish national gas grid oriented East-Westward.
- Lack of domestic construction companies capable to carry out such project.
- The original cost estimates were around 350-450 M EUR, finally the bill was 950 M EUR, financed partially by EBRD (200 M EUR) and partially by a consortium of 10 commercial banks (750 M EUR, 10 % each).

SWINOUJSCIE AS SEEN TODAY

- In view of expiration of long-term contract with Russia for transit (2019) and purchase of her natural gas:
  - For the first time Poland can risk not reaching an agreement.
  - For the first time Poland has an upper hand since it would be very difficult for Russia to loose 3 bln USD annual stream (at 300 + per 1000 cm).
- EU environmental policy can jeopardize the above forcing to switch from coal to gas – a second LNG project in Gdansk under discussion (but not planned).

SUGGESTIONS FOR CROATIA

- Swinoujscie project has been strongly driven by geopolitics. For Poland it seems to make sense.
- For Croatia:
  - Are you really dependent on one source or proximity to old EU pipelines gives an access to many supply options?
  - Is your domestic market big enough to justify full scale terminal (see Klaipeda solution)?
  - To what extend your internal gas grid would have to be reconstructed?
  - If your problem is not supply security but keeping domestic Oil&Gas industry alive you should think about a leap forward (say: GTL in Rijeka) to capitalize on general refinery trends mentioned earlier.