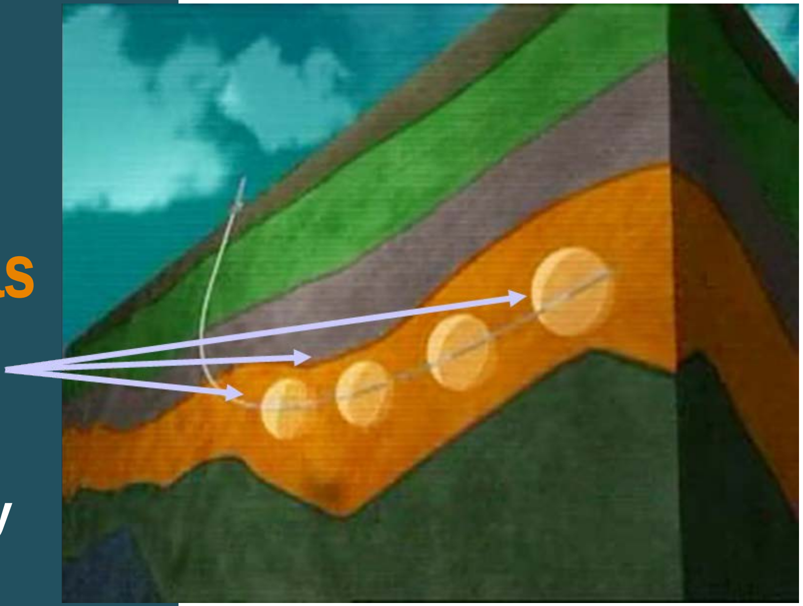
Fossil Energy, Shale Oil & Gas



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Mario Marchionna

Contents of the presentation

Fossil Energy: reasons for the success and risks for the future

1. From primary sources to energy services
2. Conventional resources
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4. Energy outlook 2020
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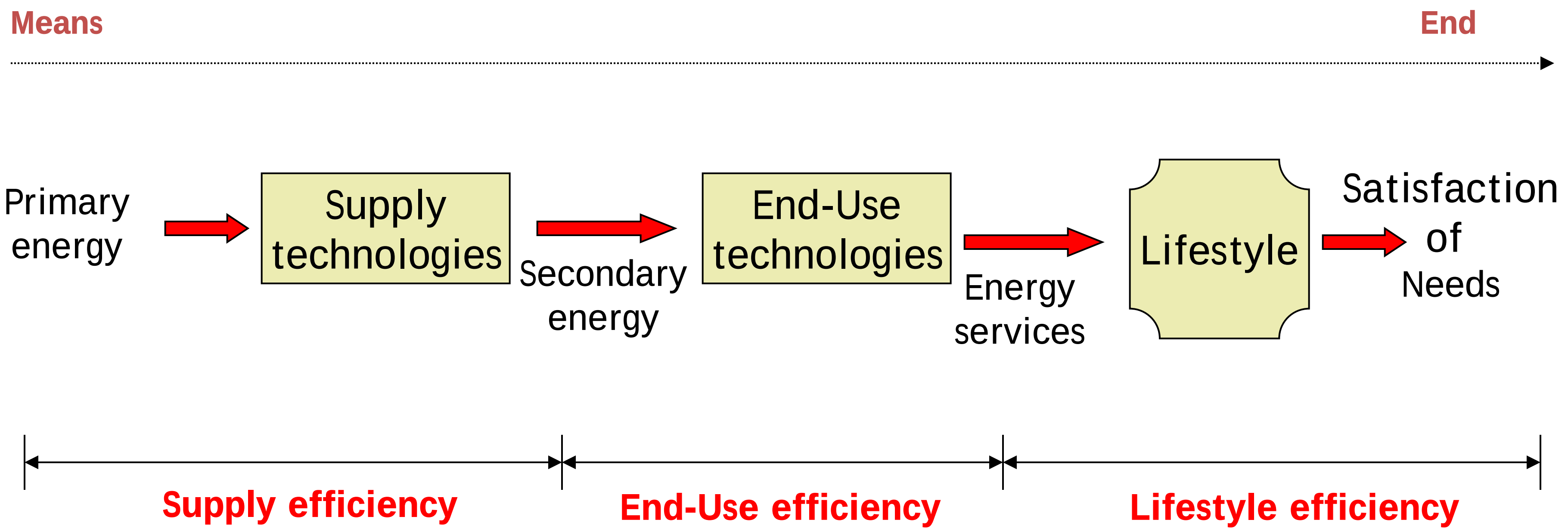
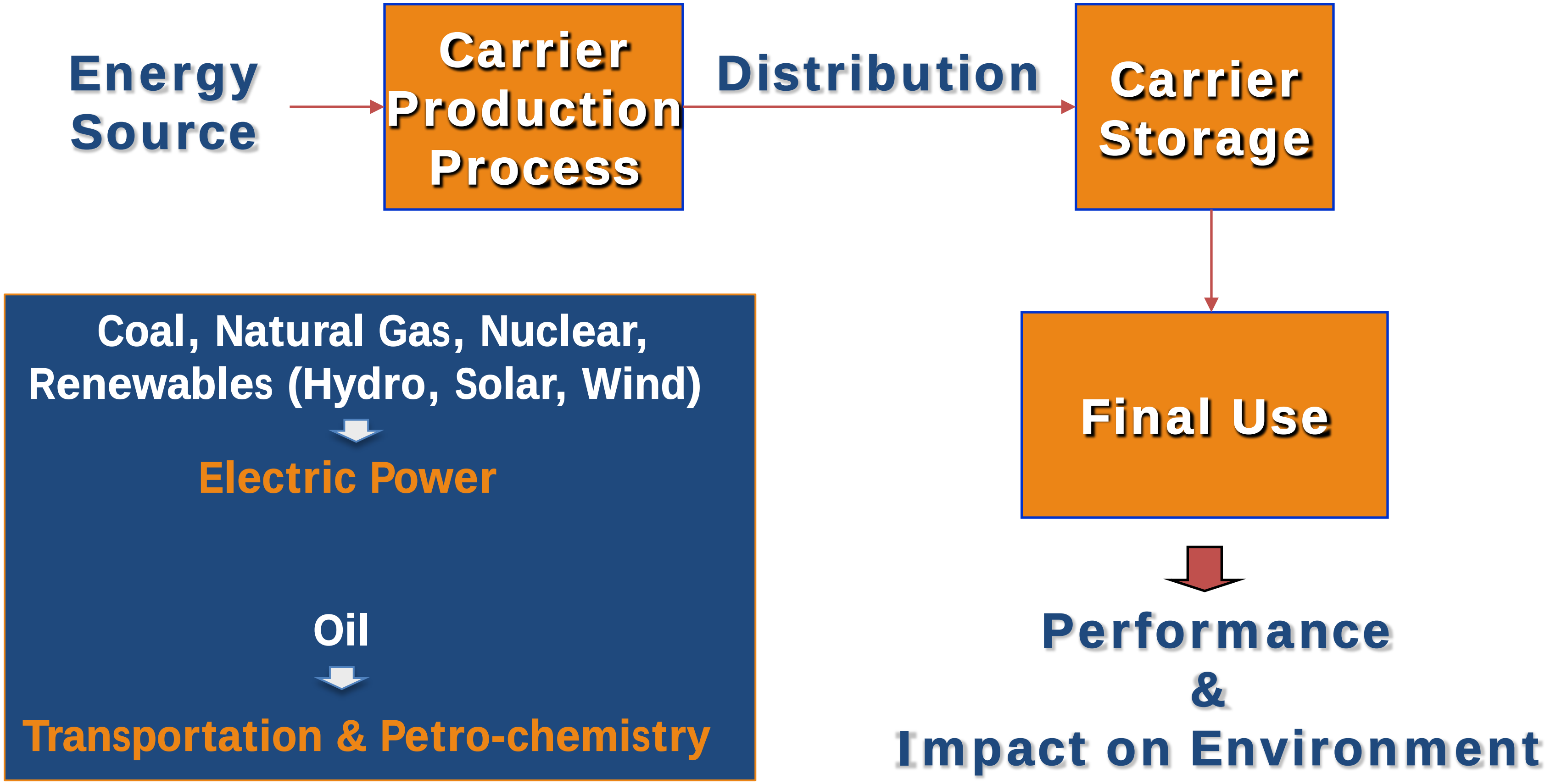
6. Impact on Oil & Gas industry – role of technology innovation
7. A few examples of technology innovations in Saipem

1. From primary sources to energy services

Conversion of primary energy to energy services



From source to energy carriers to final use



The availability of energy sources for its production and the variety of uses are certainly the strong points of the carrier; nevertheless, the intermediate phases of storage and distribution are even more decisive

M. Marchionna, *Treccani Encyclopedia of Hydrocarbons*, 2007, Ed., 3 (4.1), 301-317

From source to energy carriers to final use

Oil → **Carrier Production Process** → **Distribution** → **Carrier Storage** → **Final Use**

Gasoline, Diesel, Jet fuel (through refinery processes)

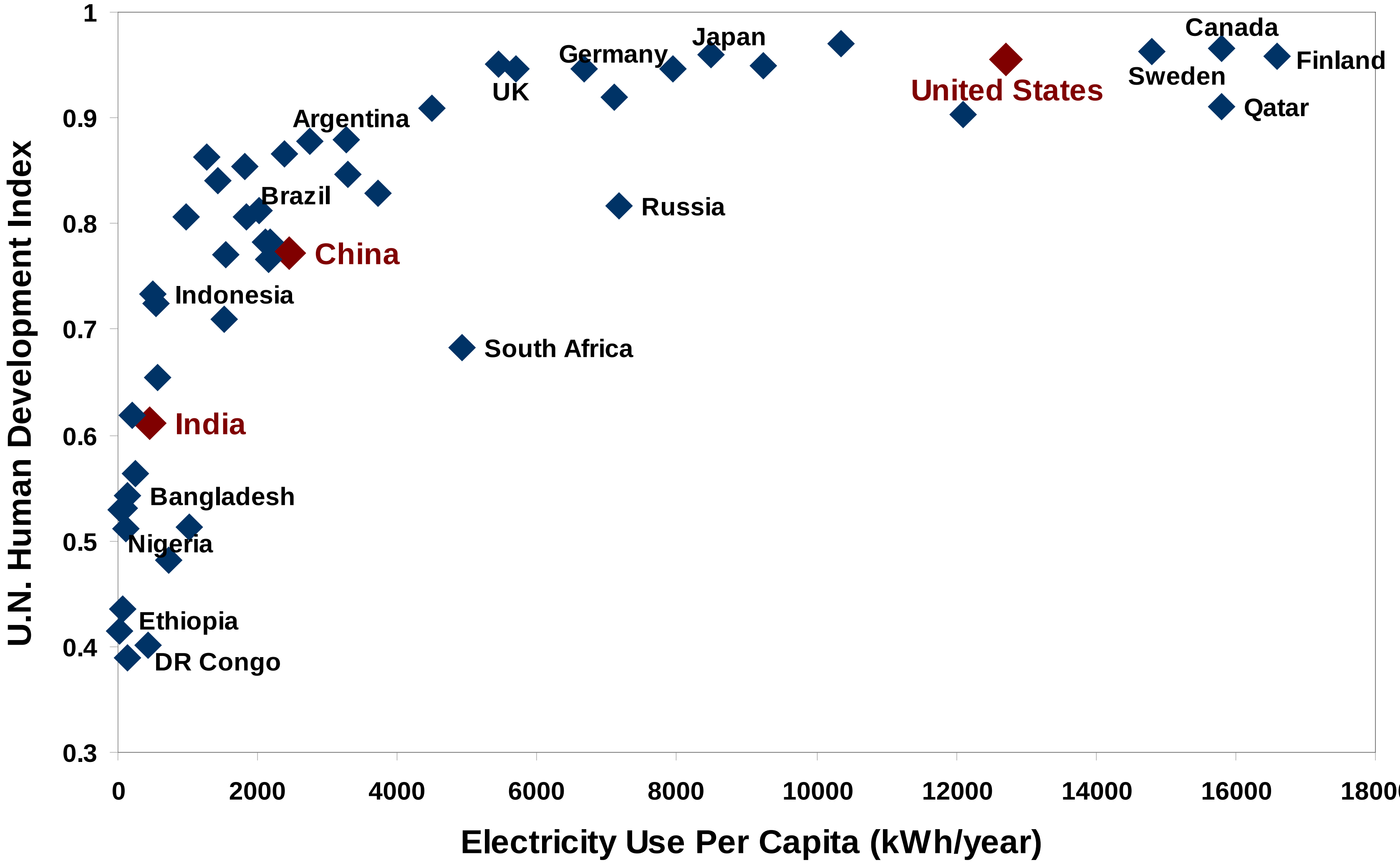
Performance & Impact on Environment

Liquid carriers *considerably simplify the transport and storage phases.*
This is probably one of the keystones in the use of oil as a primary fuel, as it is not only relatively cheap and available in great amounts, but also able to produce ***highly appreciated liquid carriers with very high energy density per volume unit***

The case of Fuel Oil & Electric Energy

M. Marchionna, *Treccani Encyclopedia of Hydrocarbons*, 2007, Ed., 3 (4.1), 301-317

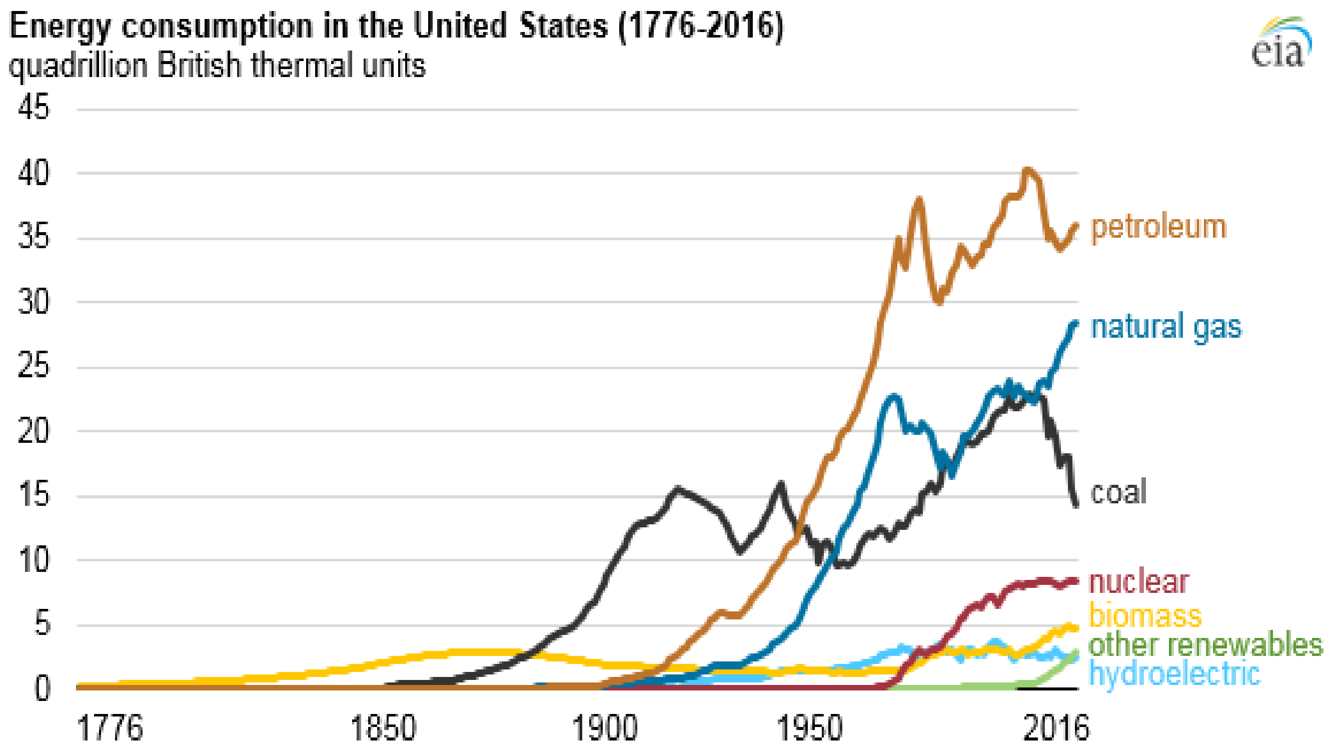
Electricity (very appreciated energy carrier) allows people to live better and longer



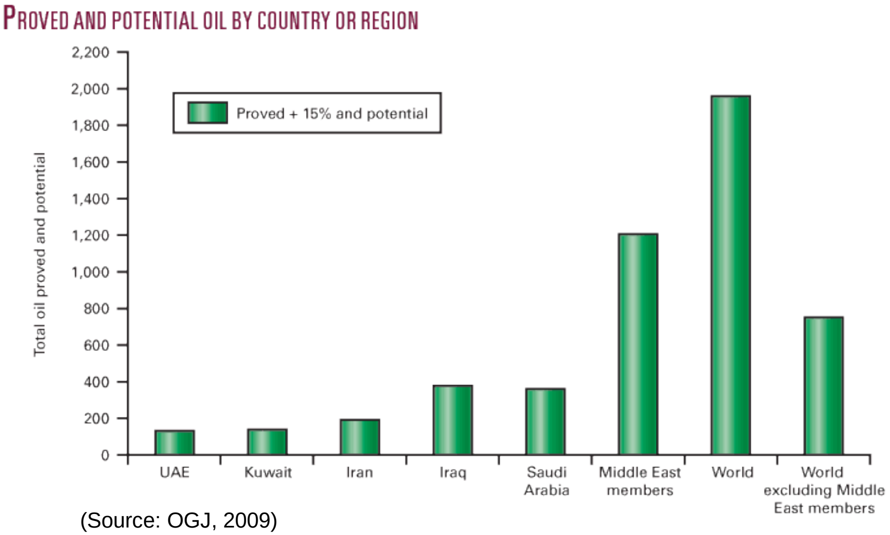
Source: CIA World Fact Book 2009, United Nations Development Program's Human Development Report, 2009.

2. Conventional resources

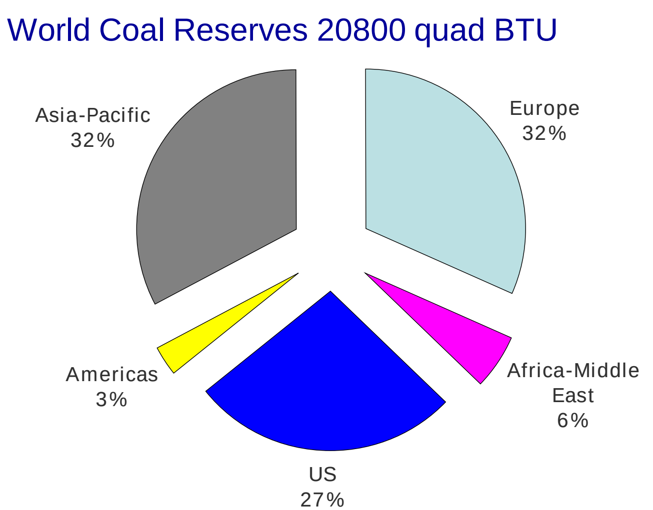
Fossil Fuels are still the major energy sources



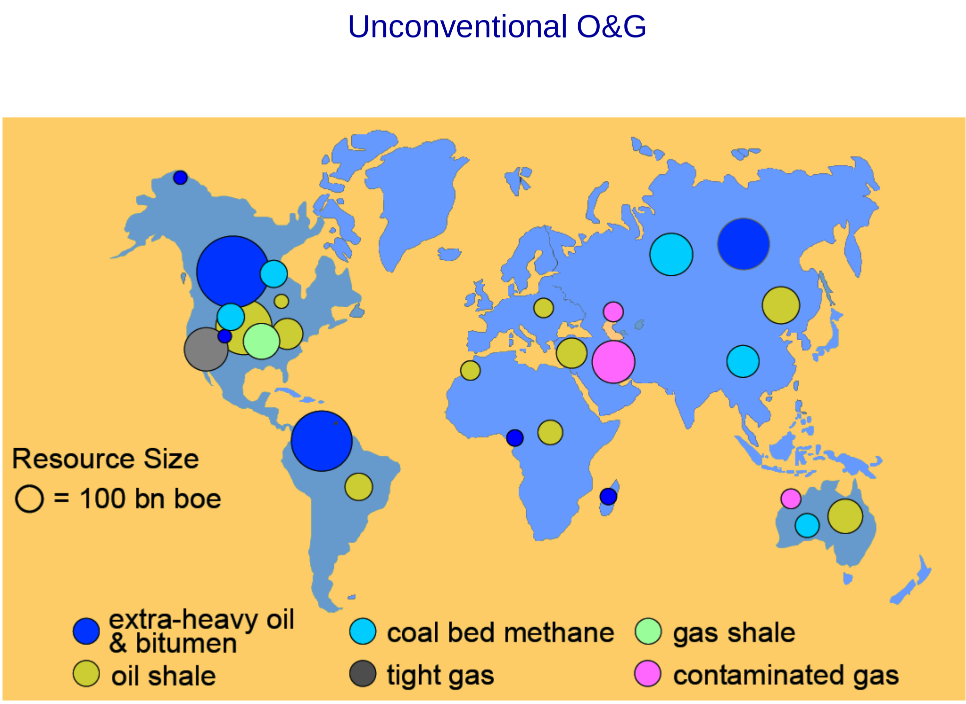
Global distribution of fossil resources



(Source: OGJ, 2009)



(Source: OGJ, 2007)



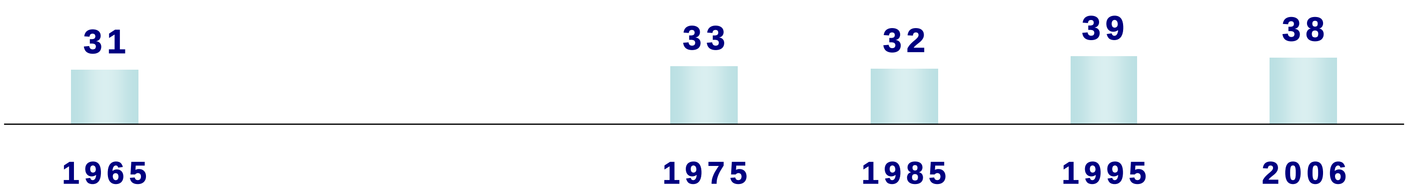
(Source: Shell, 2006)

Impending reserves' depletion myth is groundless

- Proved oil reserves (only a part of oil resources in place) have increased thanks to exploration activities, improved technology and market conditions.
- Despite production increase, oil life index has grown up on average from time to time.
- Moreover, oil life index doesn't take into account future discoveries.

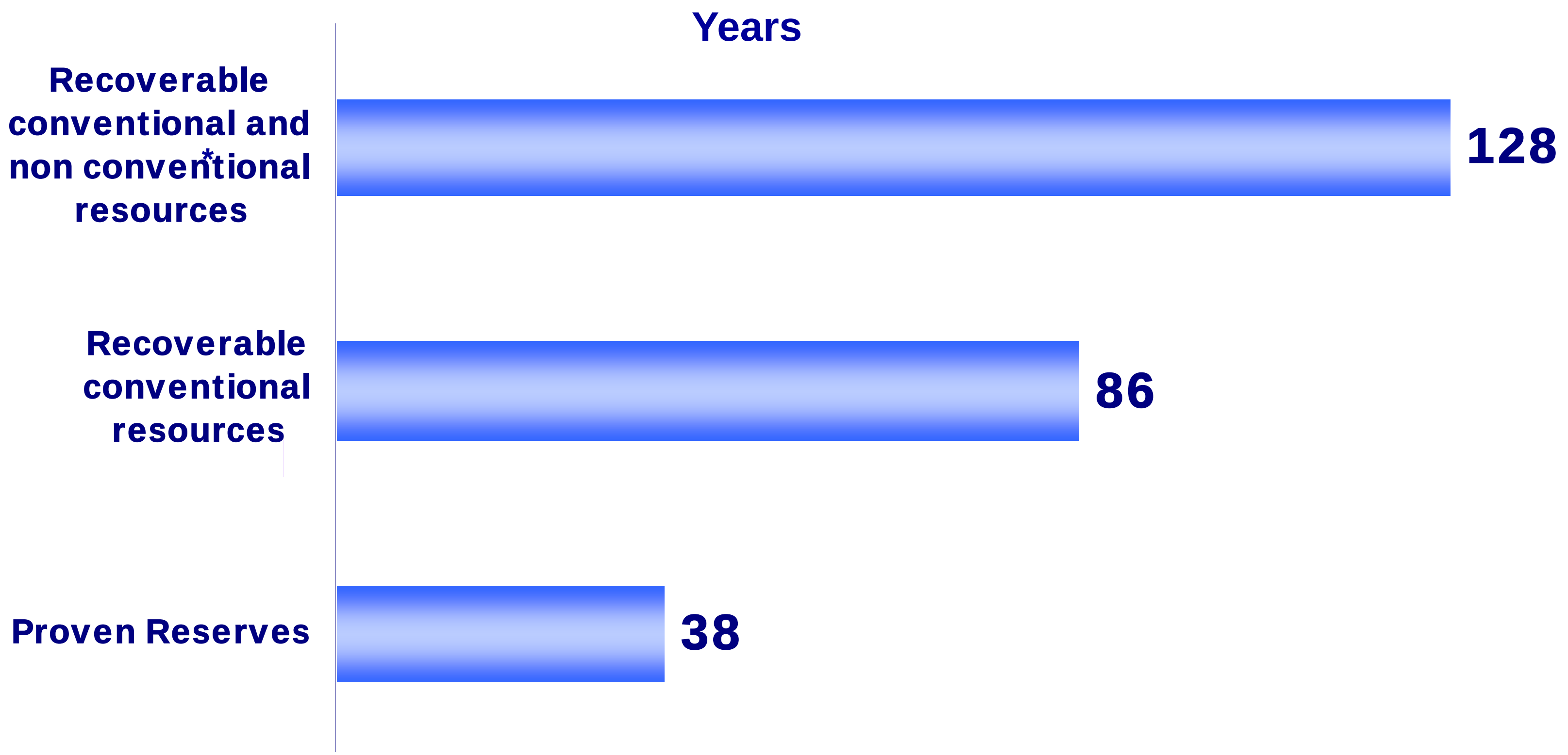
World oil life index

(Years)



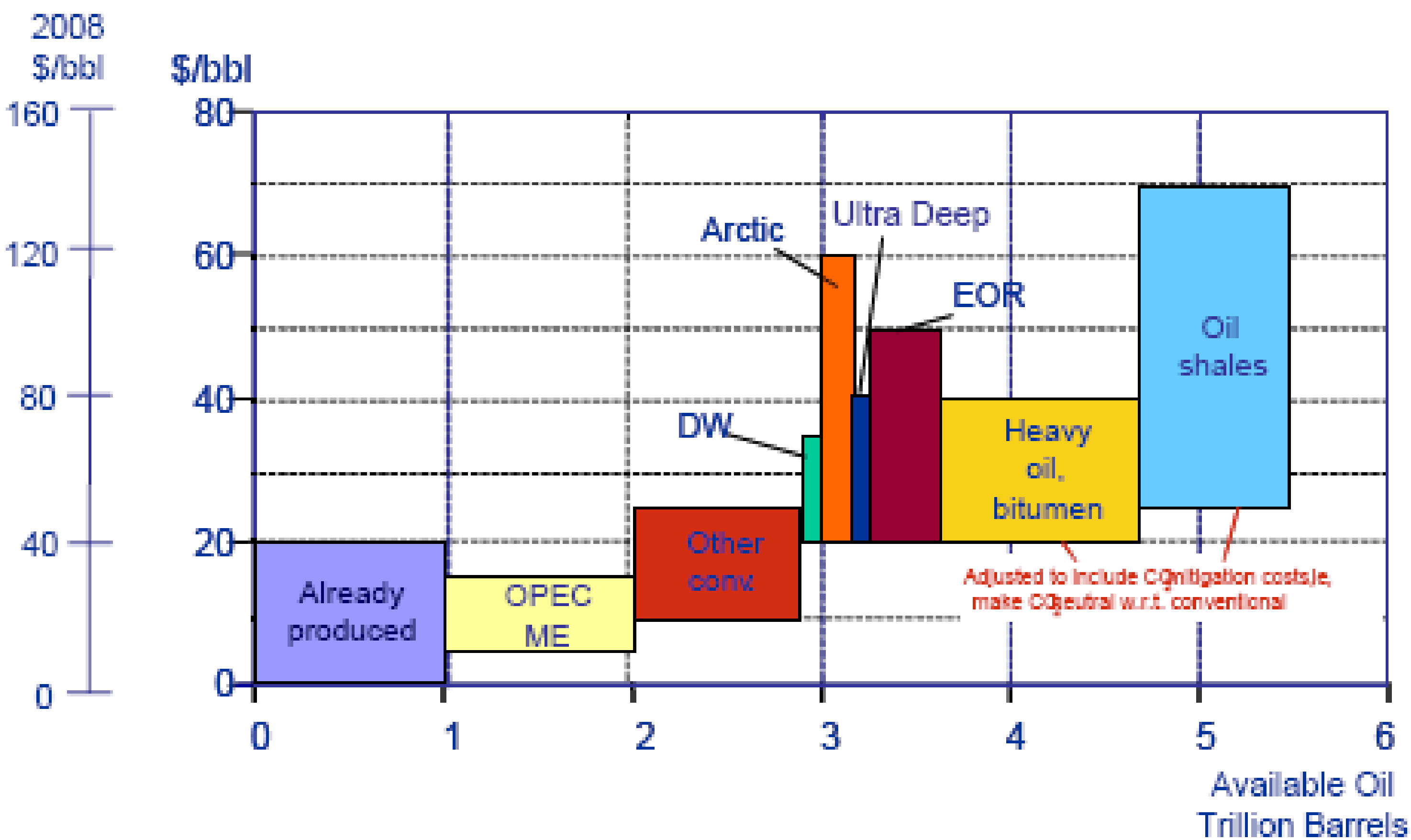
Production (Mbl/d)	
1965	2006
32	83

… but 128 years including non conventional resources



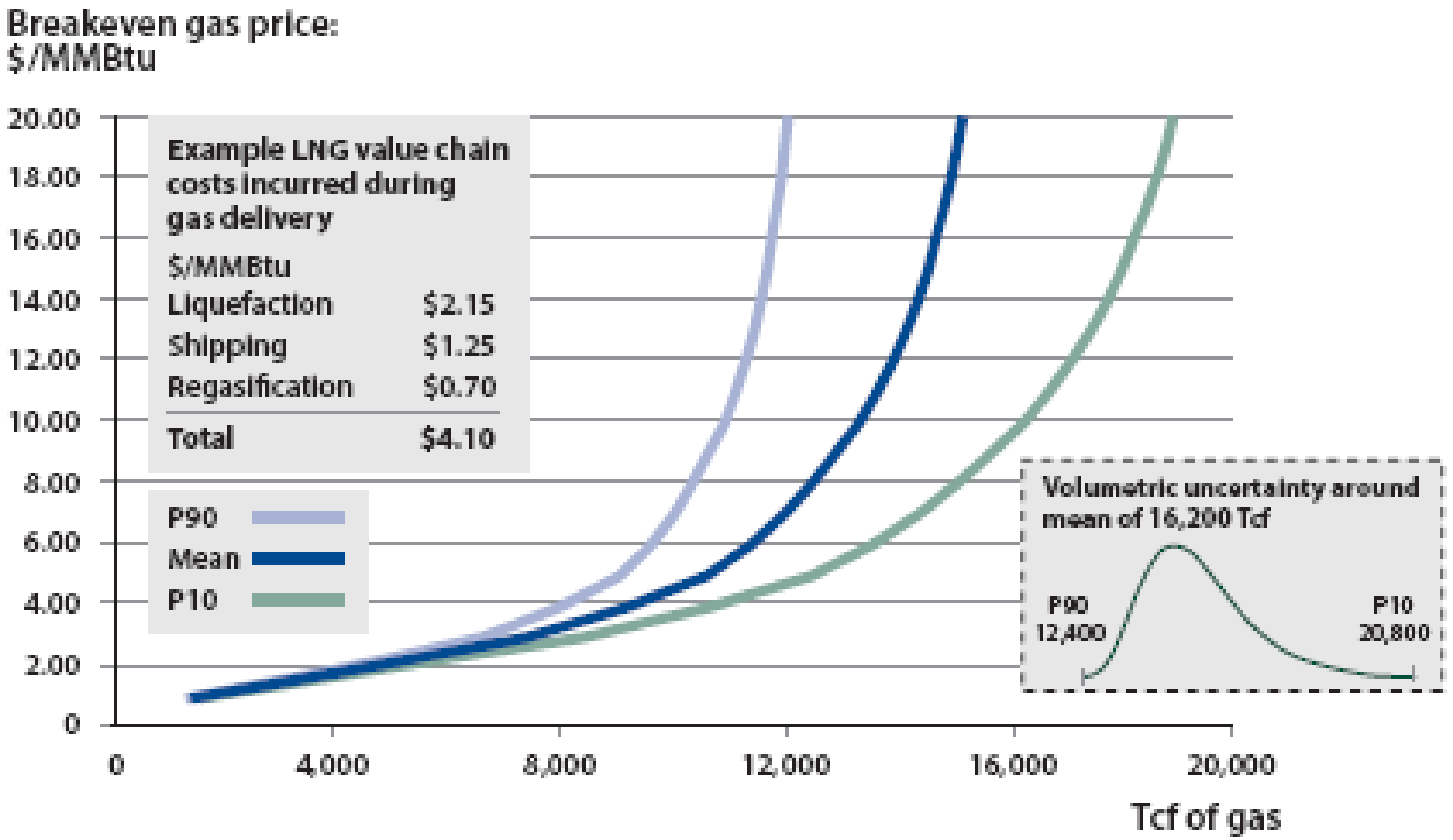
THERE IS PLENTY OF RESOURCE …

But it may cost more to produce, and may be CO2 intensive



Source: IEA

Resources of Natural Gas are very abundant



Source: MIT, The future of natural gas - 2010

High potential in unconventional oil & gas

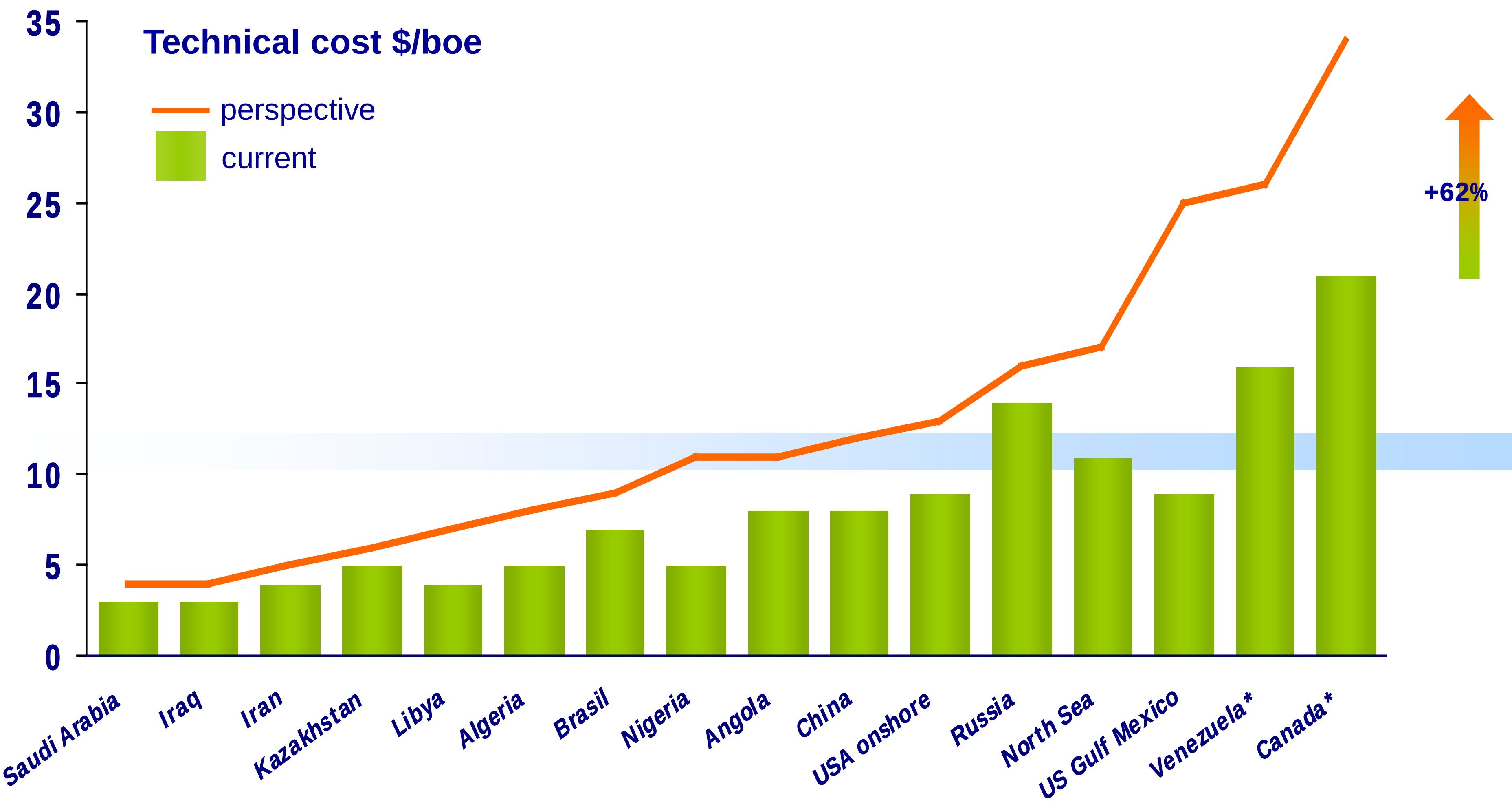
- **Deep water basins** hold around 10% of hydrocarbon exploration potential
- **Unconventional oil** technical reserves volume is 1,300 Bn boe, mainly located in Canada (tar sands), Venezuela (extra heavy oil) and Russia
- Production of tar sands and extra heavy oil will represent 7% of 2020 global supply (3% in 2006) while 67% of production will be converted to synthetic crude oil (SCO)
- About 90,000 bcm of recoverable reserves are **stranded gas**
- Unconventional gas resources are huge: 400,000 bcm of **tight gas** (mostly in USA) and 180,000 bcm of **coal bed methane**(3) (mostly in Russia, Canada and China)
- Currently, **reinjected, vented or flared gas** is 20% of the world gas production

Oil Characteristics

Heavy oil Characteristics	Categories USGS* definitions
Light oil	API gravity >22° Viscosity < 100 cp
Heavy oil	API gravity <22° Viscosity >100 cp
Extra heavy oil	API gravity<10°
Tar sands - bitumen	7°< API gravity<12° Viscosity > 10 000 cp

USGS* : US Geological survey

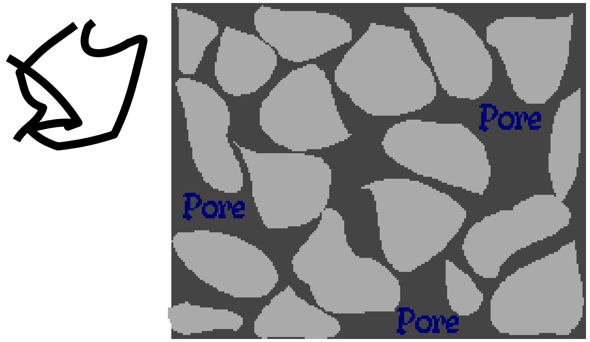
“Easy” oil mainly located in the Middle East and Africa



What is a reservoir?

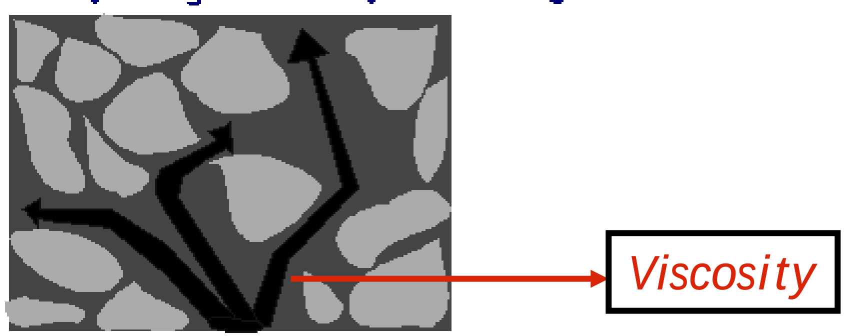
Oil occurs only in pores of reservoir rocks (Carbonates & Sandstones).

A pore is a small open space in a rock.

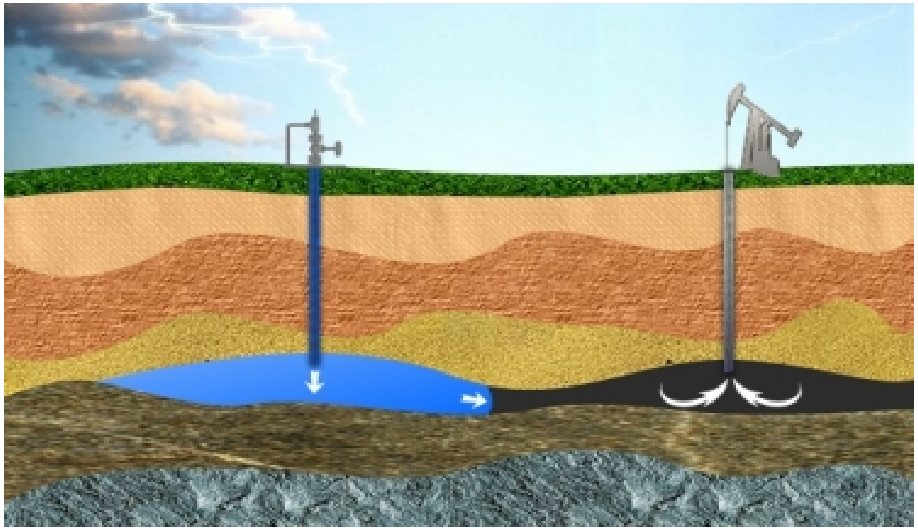


Reservoir rocks have to be permeable ➔ Its pores must be connected for oil to flow

Connected pores give a rock permeability.



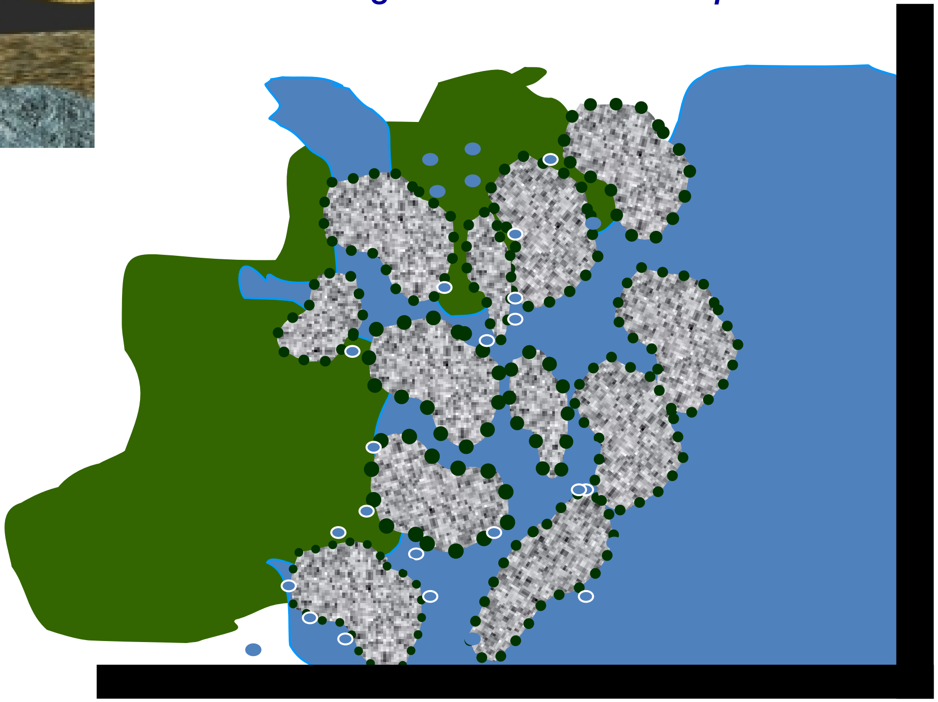
Improved Oil Recovery Methods: to recovery mobile oil



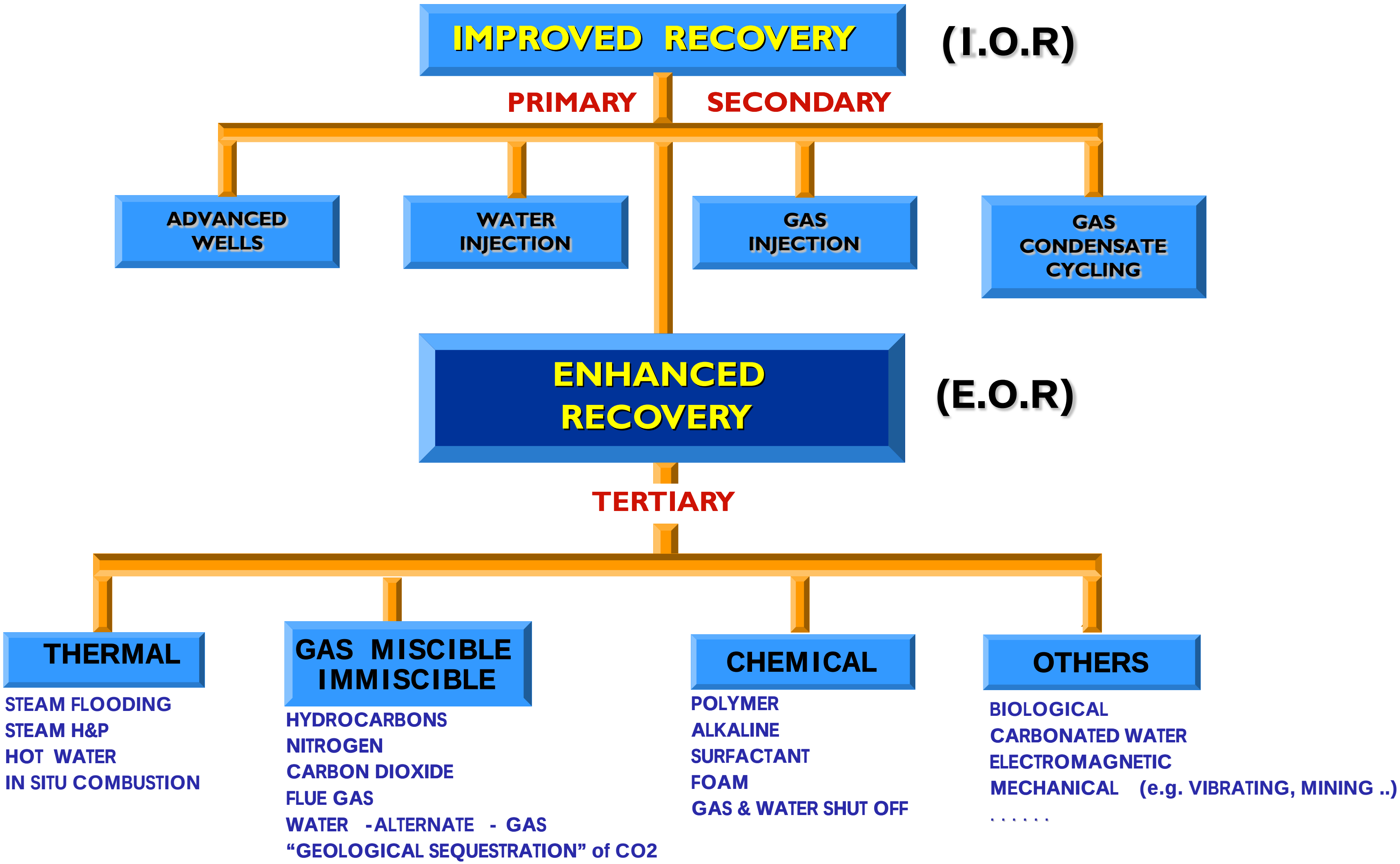
Supplying energy to reservoir by means of

- Immiscible Gas Injection
- Waterflooding

Waterflooding – *Mechanical Displacement*

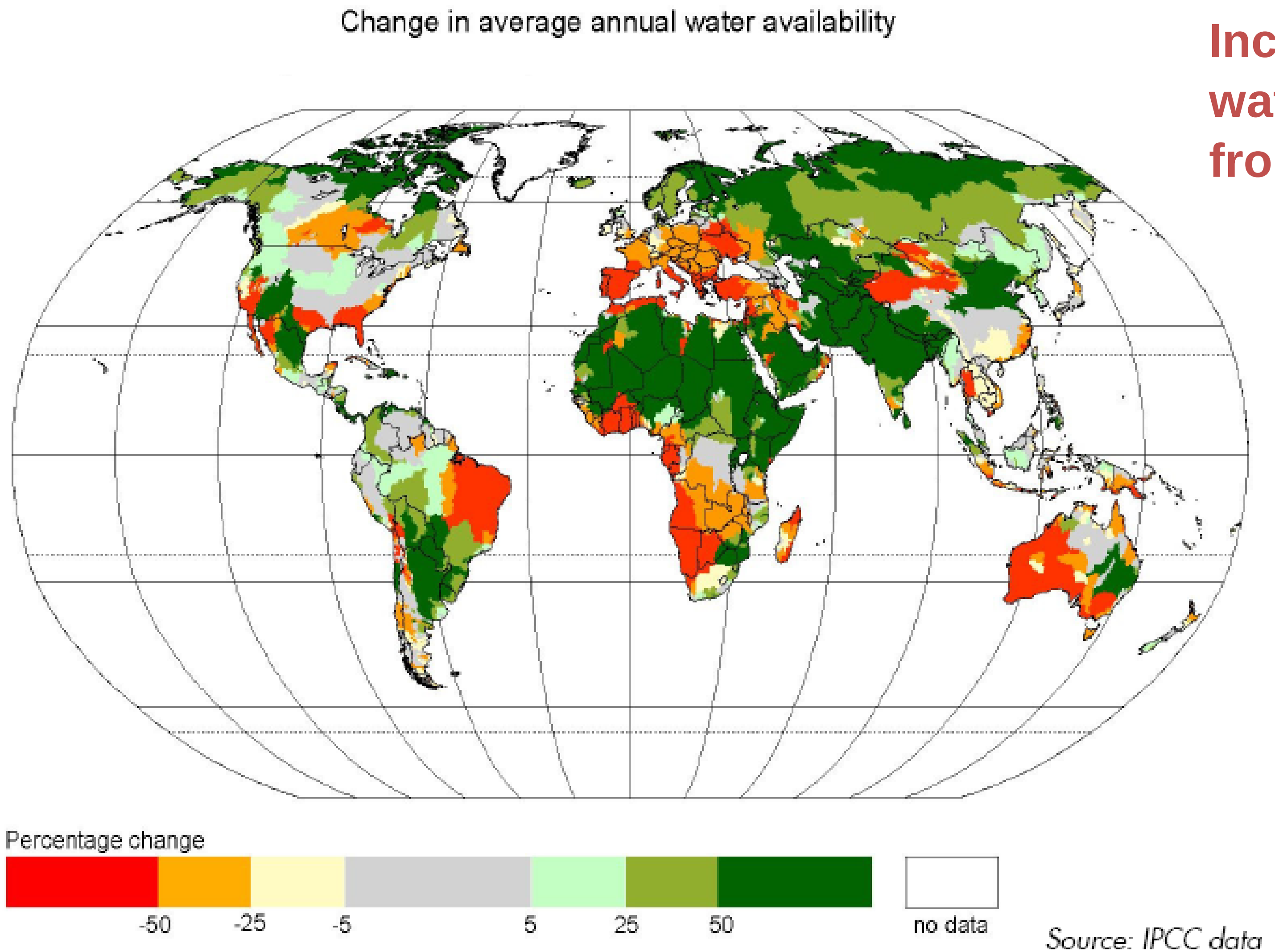


Increase of reservoir recovery factor



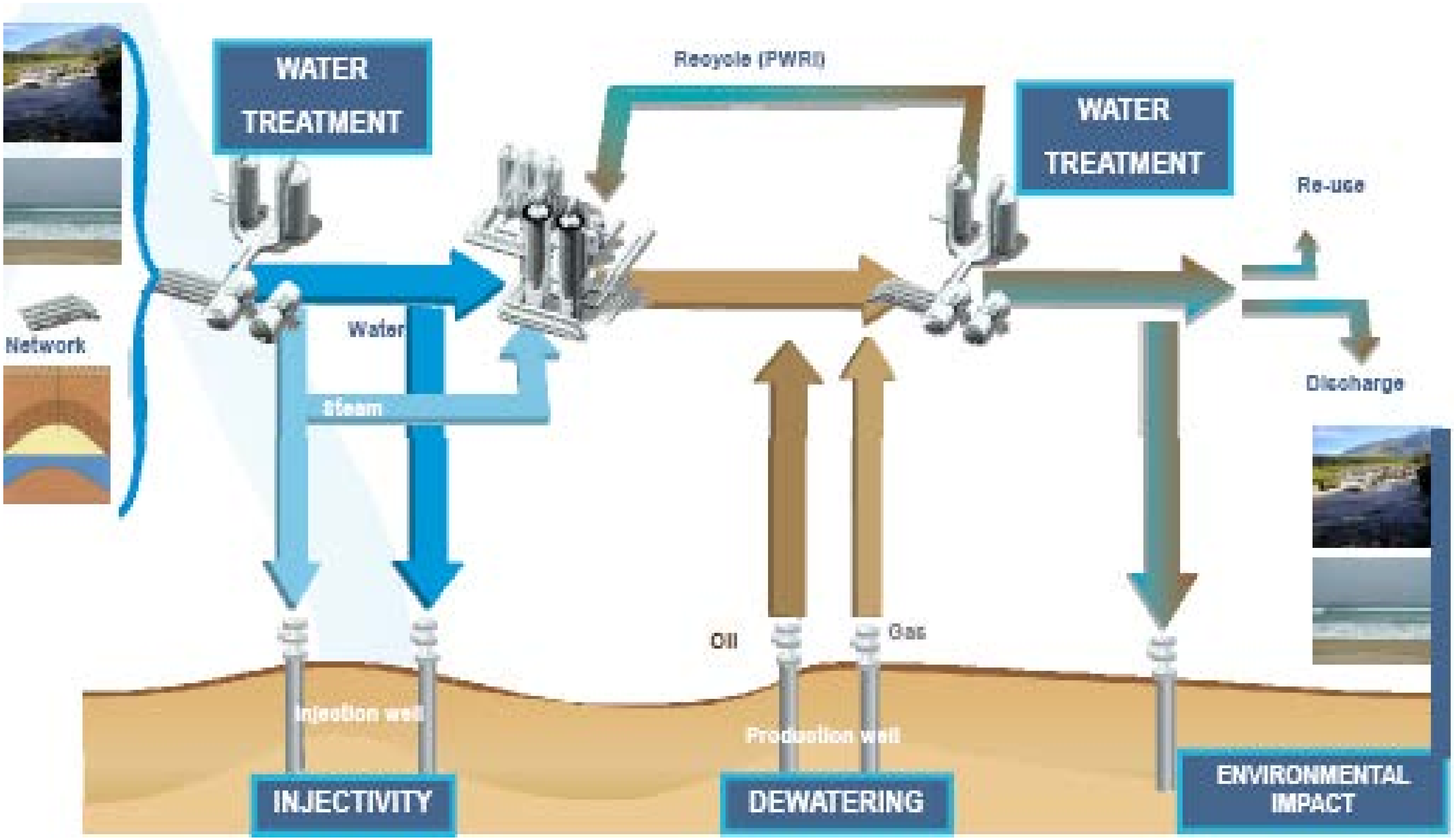
Challenges and Dilemmas

Sustain
ability



Increasing of water production from oil reservoirs

Water Management



Uses of Water in Upstream O&G Systems

- Drilling operations
- Desalting of crude oil
- Assist oil dehydration (water recycling)
- Well completion, well workovers, well kill
- EOR operations, e.g. water injection, WAG, polymer or surfactant floods, SAGD for heavy oil (steam)
- Heat Exchangers / Heaters / Cooling water
- Separation train sand jetting operations/tank jetting
- Make up water for chemicals
- Potable water
- Fire water
- Safety systems (deluge)

Exploration & Production (E&P) Companies Are :

- **Major Water Producers**
  - 86 million bbl/day global oil production
  - 220 million bbl/day global water production, typically brine
  - Water "cut" up to 95 percent in certain older fields
  - Most is re-injected at significant cost ($2-$14/bbl)

- **Major Freshwater Users**
  - 14 million bbl/day in stimulation of unconventional gas resources
  - 0.5 million bbl/day in thermal recovery of heavy oil
  - 1 million bbl/day in secondary recovery (waterflood) of conventional oil

- **Major Water Production/Use Trends**
  - Unconventional gas will require hundreds million bbl/day of water by 2025
  - Coal bed methane dewatering in US will contribute 4 million bbl/day by 2025

Challenges and Dilemmas

Environment protection

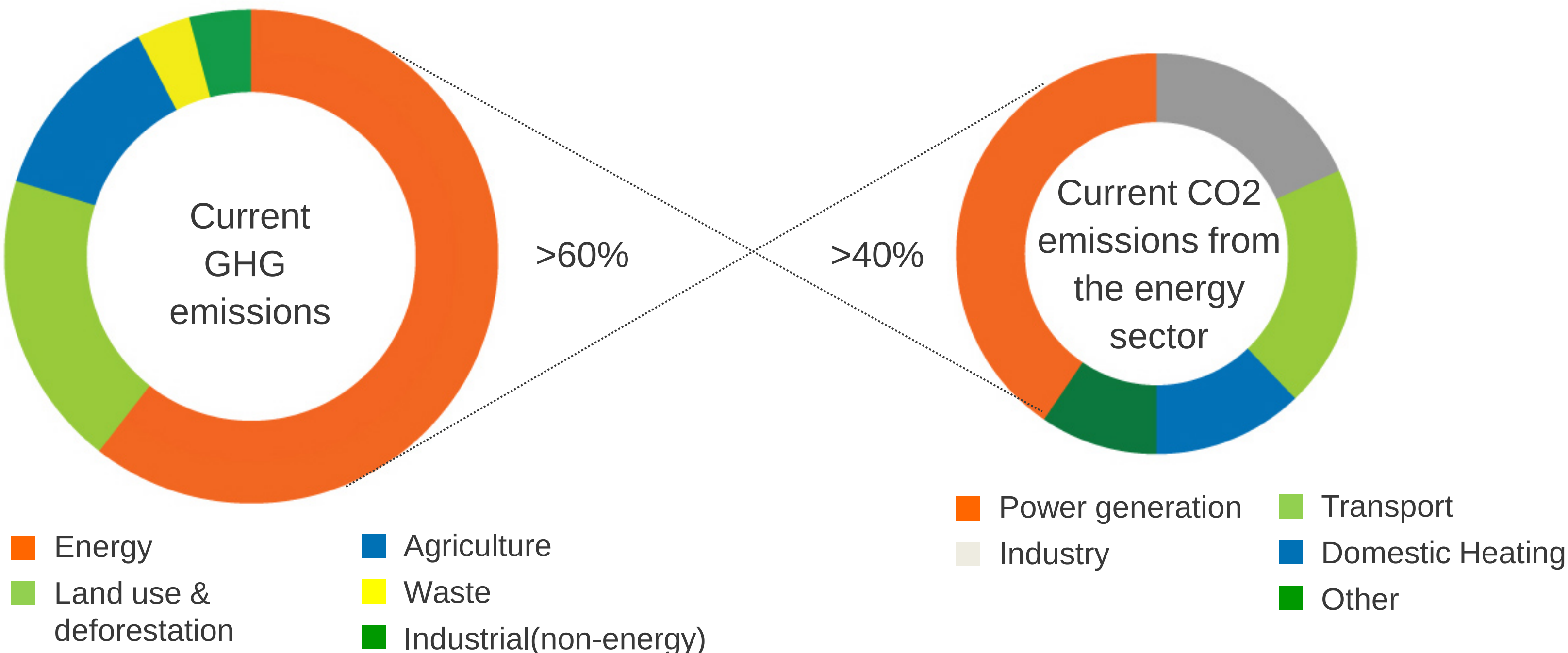
Increasing attention of producer countries towards impact (foot printing) of projects of exploration and hydrocarbons production on the environment

Need to cope with the issue of climate changes

Environmental concerns represent the real obstacle to fossil fuel based growth

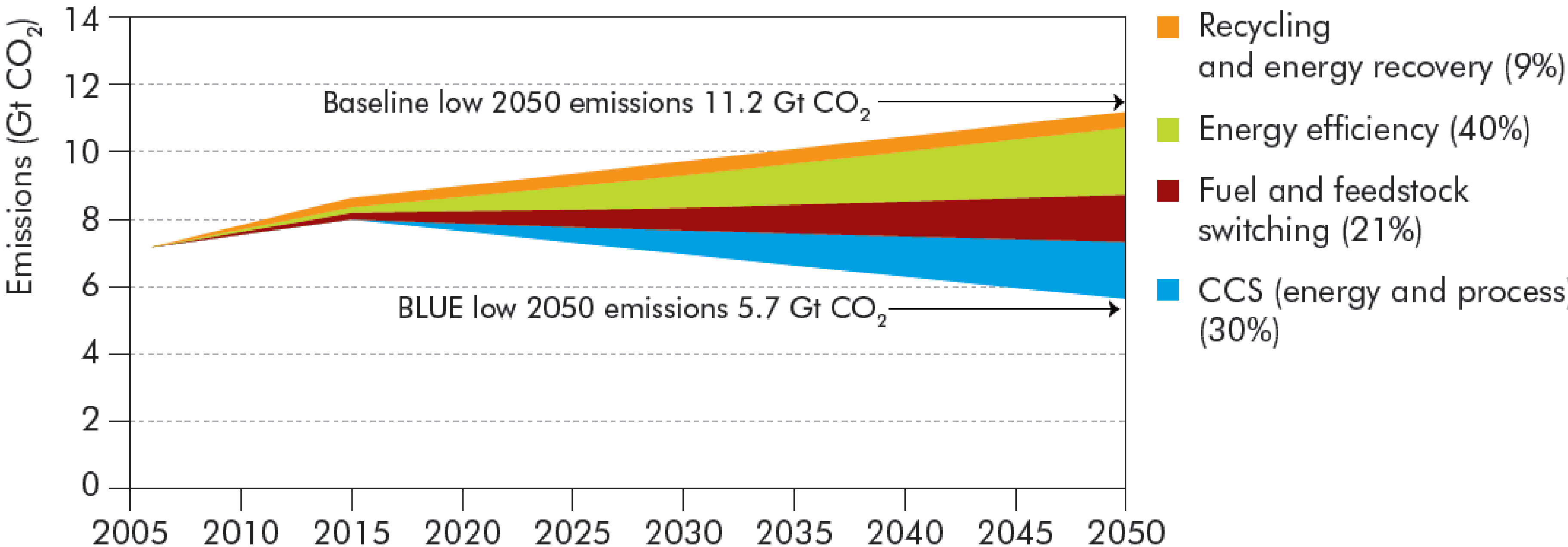
Environment protection

Total global man-made CO_2 emissions



Source: World Resource institute, 2006

Technologies for reducing direct CO_2 emissions from industry



Key point

Direct emissions in industry can be significantly reduced through a combination of energy efficiency, fuel and feedstock switching, recycling and energy recovery, and CCS.

SULPHUR MANAGEMENT
CURRENT FORMING, STORAGE & SHIPPING TECHNOLOGY

- **Storage of sulphur above ground is typically used to manage high quantities of Sulphur recovered by Production facilities upstream Sulphur chain**

- **Conventional sulphur blocks are subject to deterioration leading to environmental issues including:**
  - **Acid run-off due to the action of micro-organisms (Thiobacilli Oxidans)**
  - **Sulphur dust blown from site**

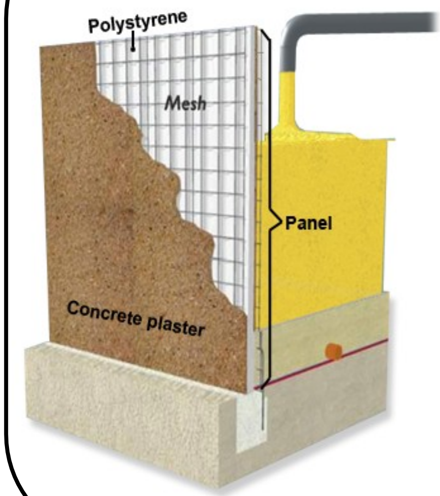
- **Significant maintenance is required for Long term storage sulphur blocks to ensure adequate protection of the environment and also to maintain sulphur quality.**

- **This require ongoing investments.**

SAIPEM INNOVATIVE APPROACH TO SULPHUR MANAGEMENT

TWO SOLUTIONS: LONG TERM STORAGE AND «HANDLING» SYSTEM (SSMS)

STORAGE SYSTEM

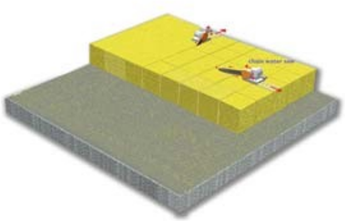


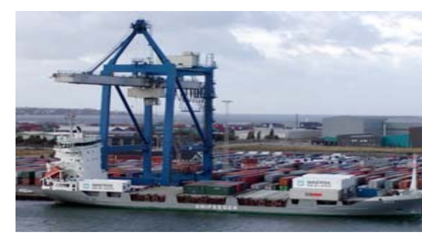
Solid Sulphur Box

made using

“CONCREWALL PANELS”

Pouring → **Cutting** → **Wrapping** → **Transportation**





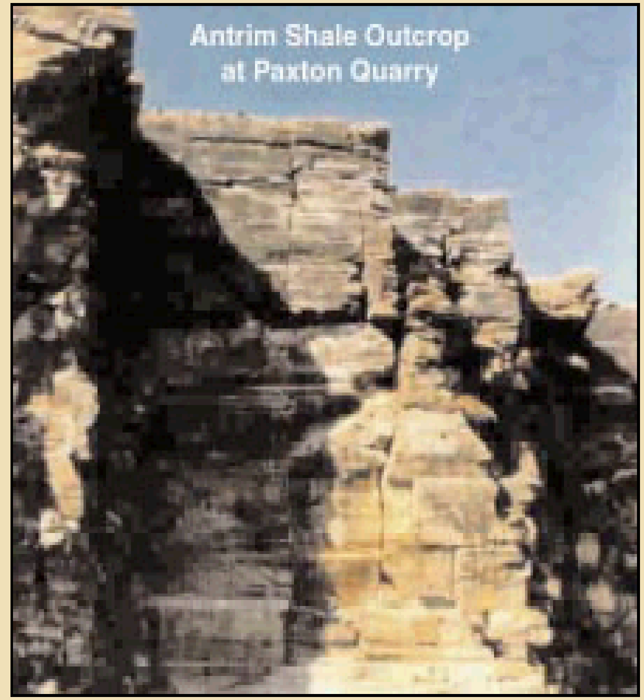
Tailor-made solutions have been developed for the managing of solid sulphur, such as a safe “Long term storage” and a “zero emissions” transportation

3. Unconventional Resources
THE “SHALE” REVOLUTION

Oil & Gas - containing shales

◆ Shale Characteristics

Shale is the most commonly occurring type of sedimentary rock, being typically deposited on river floodplains and on the bottoms of lakes, lagoons, and oceans. It is formed by the consolidation of fine-grained detrital rock fragments or mineral particles and normally contains at least 50 percent silt, around 35 percent clay, and 15 percent chemical or authigenic materials. Silt and clay are differentiated from one another on the basis of their particle diameters. Silt consists of rock or mineral particles having diameters between 1/256 and 1/16 mm whereas clay consists of rock or mineral particles having a diameter less than 1/256 mm. Shale has a finely laminated, fissile structure and readily breaks into thin, parallel layers. Mudstone is compositionally similar to shale, but lacks a finely laminated or fissile structure and commonly disintegrates upon exposure to water (Bates and Jackson, 1980). The color of shale ranges from green and gray to black depending on the organic matter content. The higher the organic matter content, the darker the shale color. Black shales are common source rocks for natural gas and crude oil.



Shale is fissile and laminated (meaning that the rock is made up of thin layers)

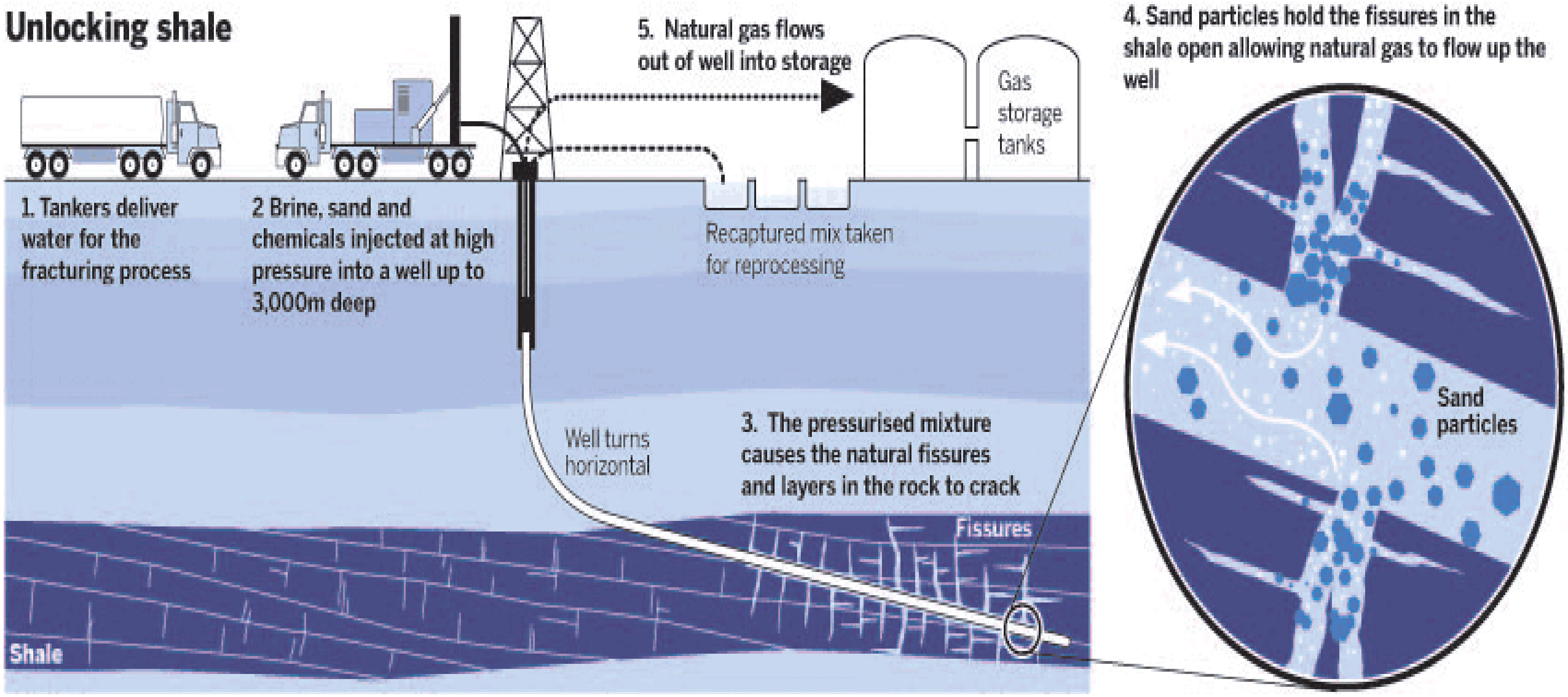
Shales may contain organic material that sometime breakdown to form NG and oil

THE REALITY ABOUT SHALE

It is sodium carbonate and calcium carbonate. Shale is ubiquitous. More countries with shale than without.

The energy glut was caused by US shale producers initially recovering 3%-5% of the hydrocarbons in a shale development. With better technology, we will soon recover 10%-12%. Production costs are declining.

Shale Gas Production Technology



(Source: Financial Times, March 2010)

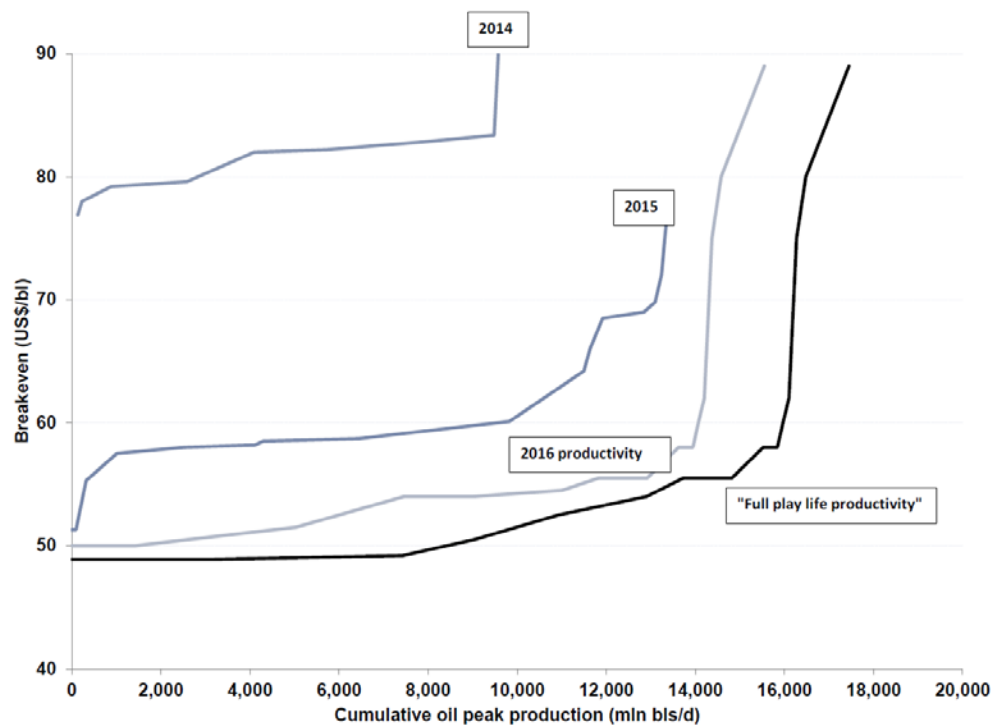
Technical improvements and squeezed supply have driven the cost fall

SHALE STILL GETTING CHEAPER

-40%

The decline in average shale breakevens, now at 55 $/b, down from 80 $/b in 2014.
With well productivity still improving, breakevens could fall to 50 $/b by 2018

- Technological improvements such as **bigger, better placed fractures and longer laterals** combined with **unsustainably low service industry costs** and expansive monetary policies have lowered the breakeven price to around US$ 55/bl (40% lower)
- A more modest reduction in breakevens is expected going forward, as service costs increase, but we believe further productivity gains will be able to offset potential cost inflation and further flatten the cost curve at **US$50/bl**.



Source: Goldman Sachs, Top 400 Projects (May 2016)

Shale Oil producers in the US

Table 2. Crude oil production and proved reserves from selected U.S. tight plays, 2014-15

million barrels

Basin	Play	State(s)	2014 Production	2014 Reserves	2015 Production	2015 Reserves
Williston	Bakken	ND, MT, SD	387	5,972	421	5,030
Western Gulf	Eagle Ford	TX	497	5,172	565	4,295
Permian	Bone Spring, Wolfcamp	NM, TX	53	722	66	782
Denver	Niobrara*	CO, KS, NE, WY	42	512	58	460
Appalachian	Marcellus*	PA, WV	13	232	16	143
Fort Worth	Barnett	TX	9	47	5	33
Sub-total			**1,001**	**12,657**	**1,131**	**10,743**
Other tight			56	708	83	859
U.S. tight oil			**1,057**	**13,365**	**1,214**	**11,602**

Note: Includes lease condensate. Bakken/Three Forks tight oil includes proved reserves from shale or low-permeability formations reported on Form EIA-23L.

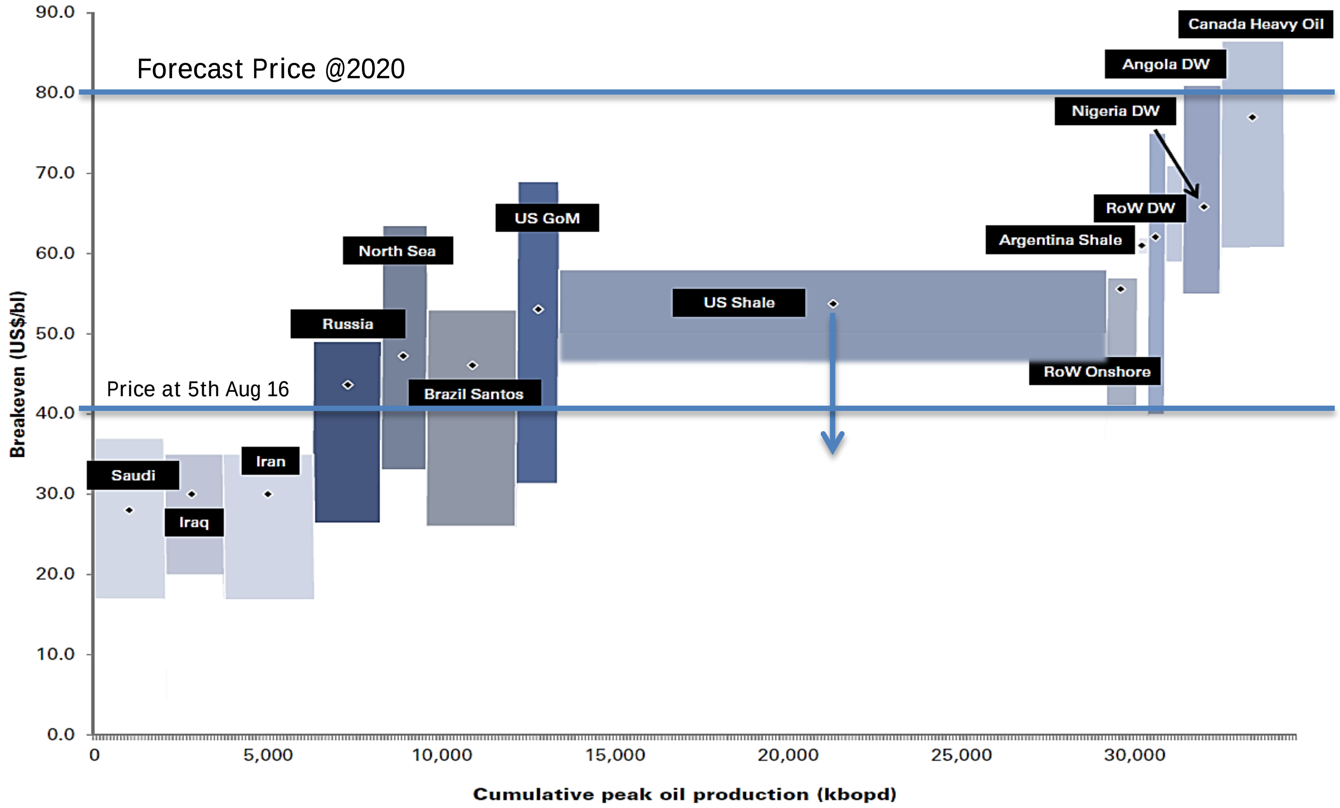
Other tight includes proved reserves from shale formations reported on Form EIA-23L not assigned by EIA to the Bakken/Three Forks, Barnett, Bone Spring, Eagle Ford, Marcellus, Niobrara, or Wolfcamp tight plays.

* The Niobrara estimate may contain some reserves from the Codell sandstone. The Marcellus play in this table refers only to portions within Pennsylvania and West Virginia.

Source: U.S. Energy Information Administration, Form EIA-23L, Annual Report of Domestic Oil and Gas Reserves, 2014 and 2015

Table 1. EIA 2015 Tight Oil Reserves. Source: EIA U.S. Crude Oil and Natural Gas Proved Reserves, 2014 https://www.eia.gov/naturalgas/crudeoilreserves/

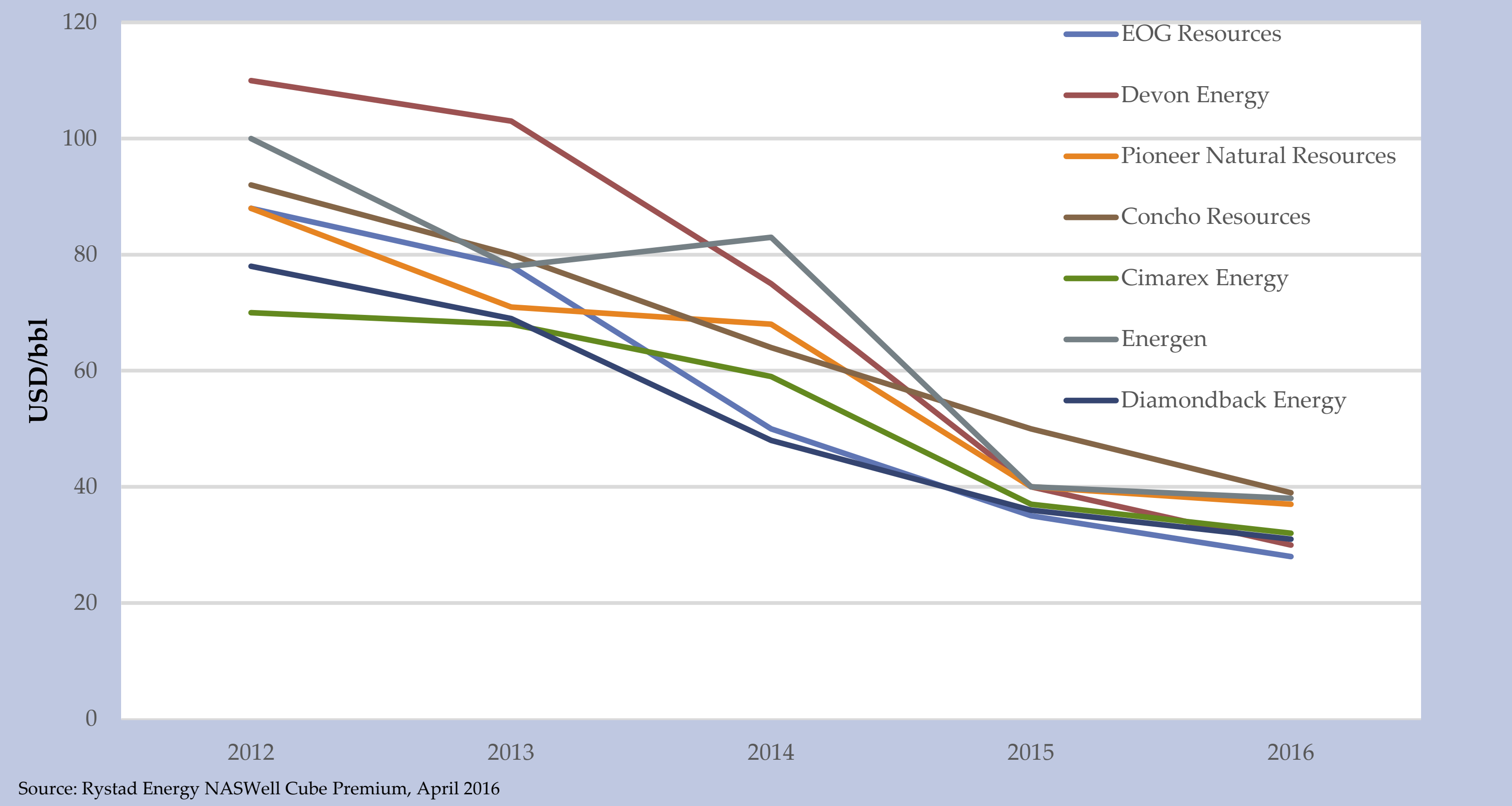
At current oil price levels many new initiatives are at risk



US shale today is the marginal producer, managing the market rebalance

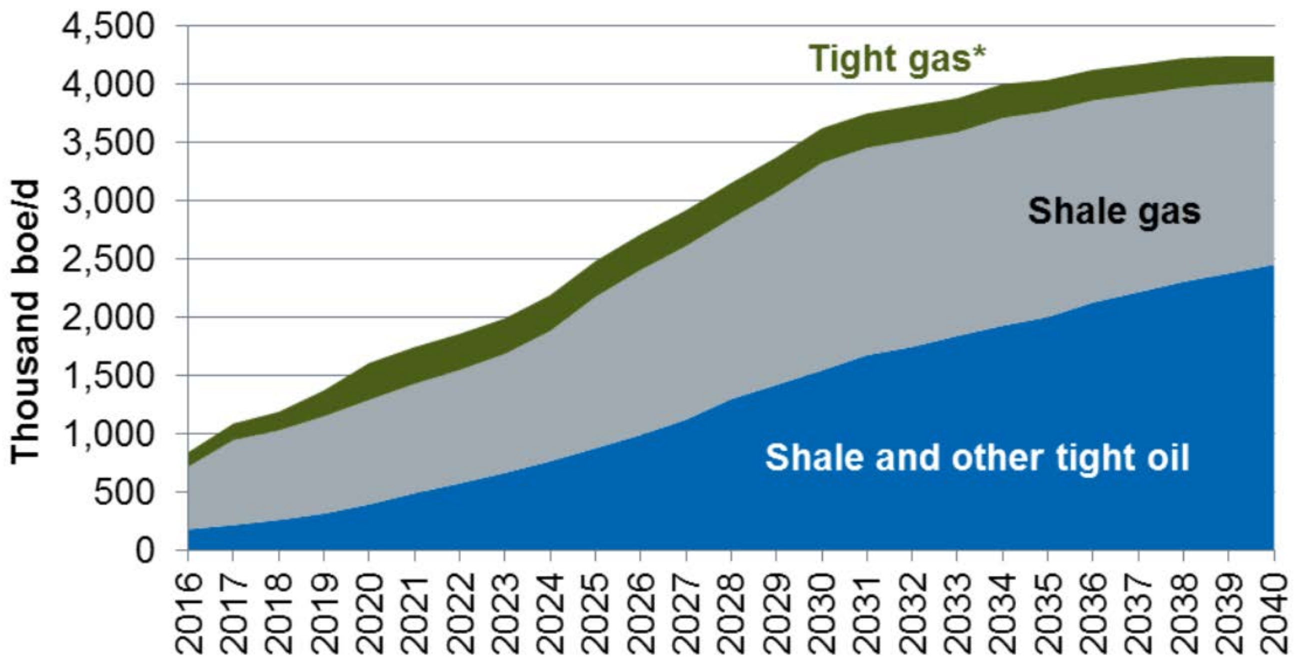
Source – elaboration on Goldman Sachs, June 2016

Average Wellhead Breakeven Oil Price For Horizontal Shale Wells



Unconventional Oil & Gas Outside North America

Potentially significant in the long term



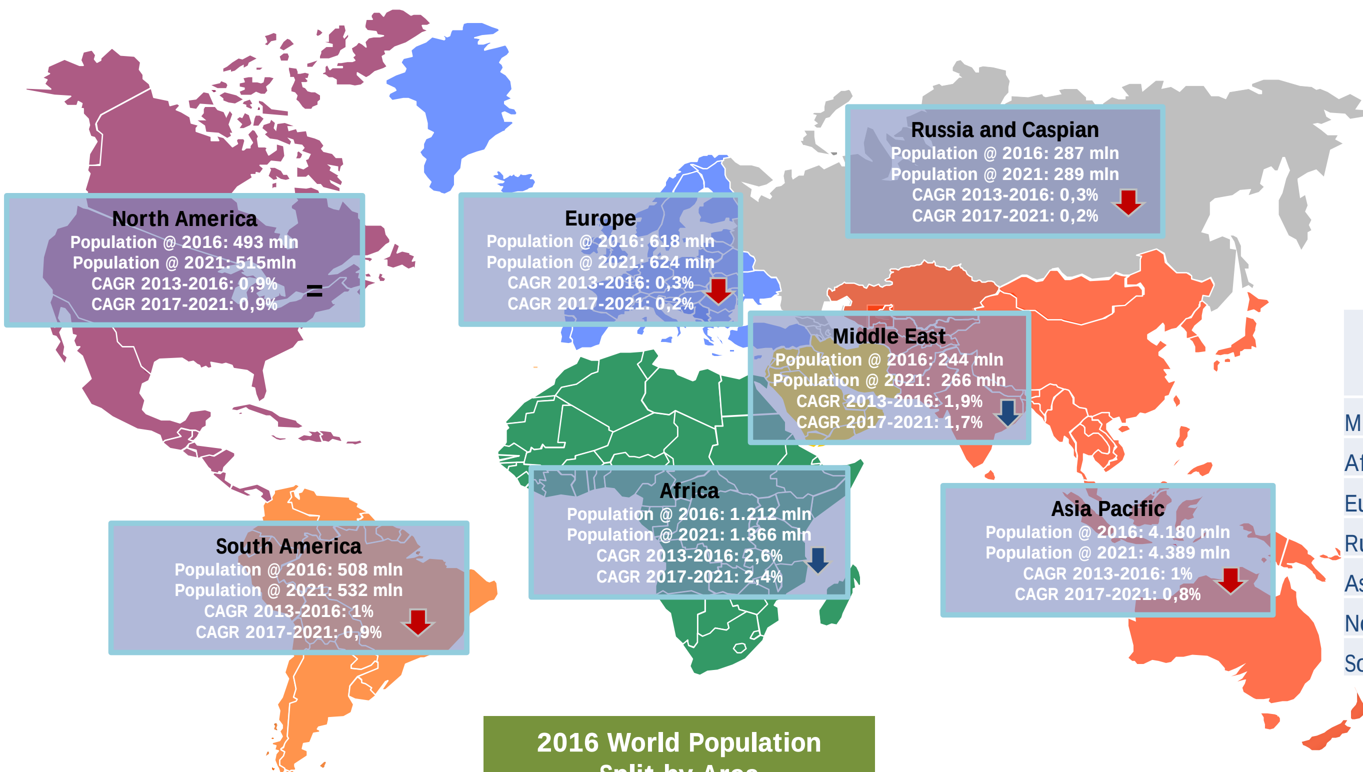
- Significant production from shale in this decade will be limited to Russia, Argentina, and China
- Production from shale and tight formations outside North America will represent ~ 3% of global supply in 2040 for both oil and gas

Source: IHS (July 2016)

4. Global Energy Outlook 2020

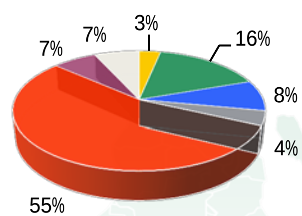
World Population Trend

Total Population @ 2016: 7.403 Mln



Δ Population increase by Area 2016 vs 2021 (total ~ 404,7mln)	
Middle East	22,1
Africa	154,8
Europe	6,2
Russia & Caspian Sea	2,7
Asia Pacific	172,5
North America	22,6
South America	23,9

2016 World Population Split by Area

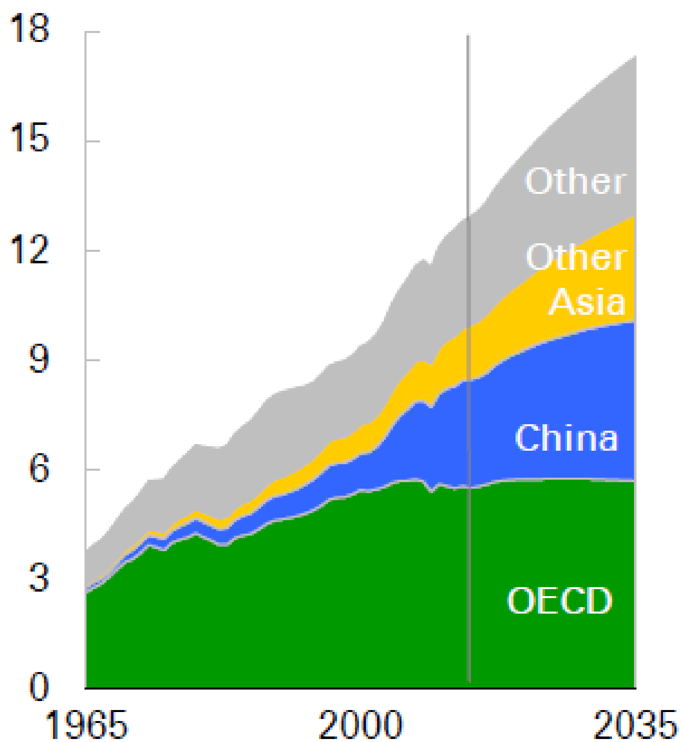


Source - IHS Energy Rivalry Scenario – Summer 2016

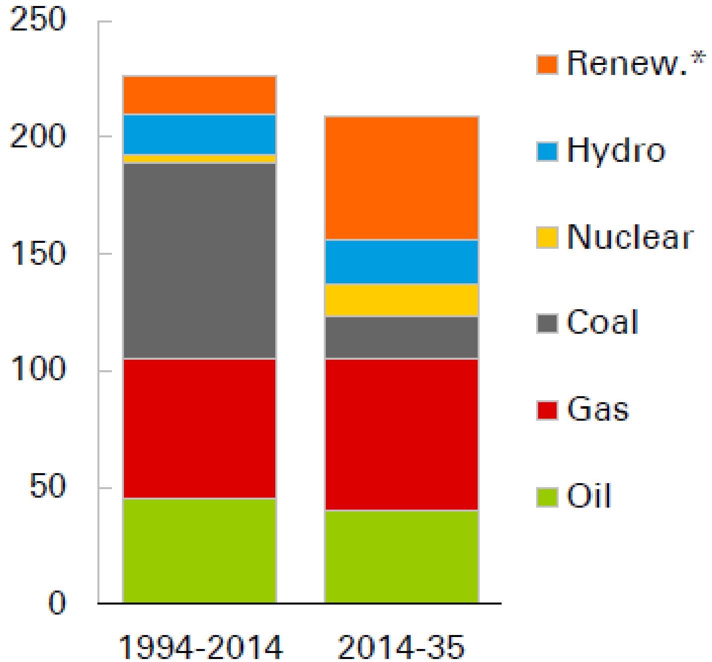
Energy growth driven by world economy
The energy mix is changing

- Consumption driven by China and Asia. OECD almost flat
- Coal offset by renewables, stable hydrocarbons, with gas growing more than others

Consumption by region (Bn toe)

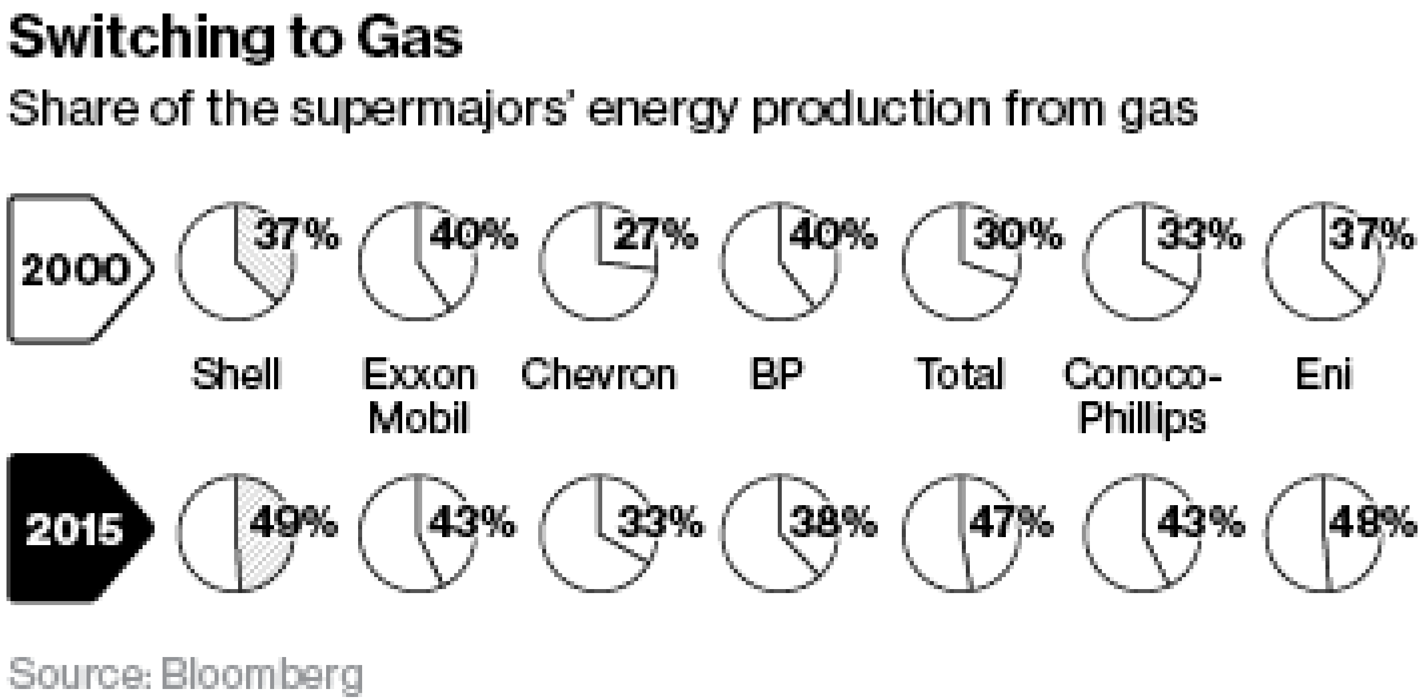


Annual demand growth by fuel (Mln toe per annum)



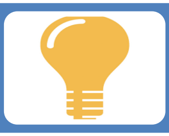
Source - BP Energy Outlook-2016
**Includes biofuels*

Natural Gas Market: more and more attracting the Majors

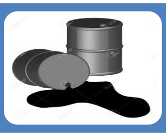


MAIN TAKE AWAYS (outlook to 2020)

Average growth of world GDP ~ 3% per year…



…sustains recovery of energy demand…



…which together with spare capacity reduction…

…triggers a humble oil price increase…

However cheap shale abundance and slow down in energy demand may be an hurdle for price recovery

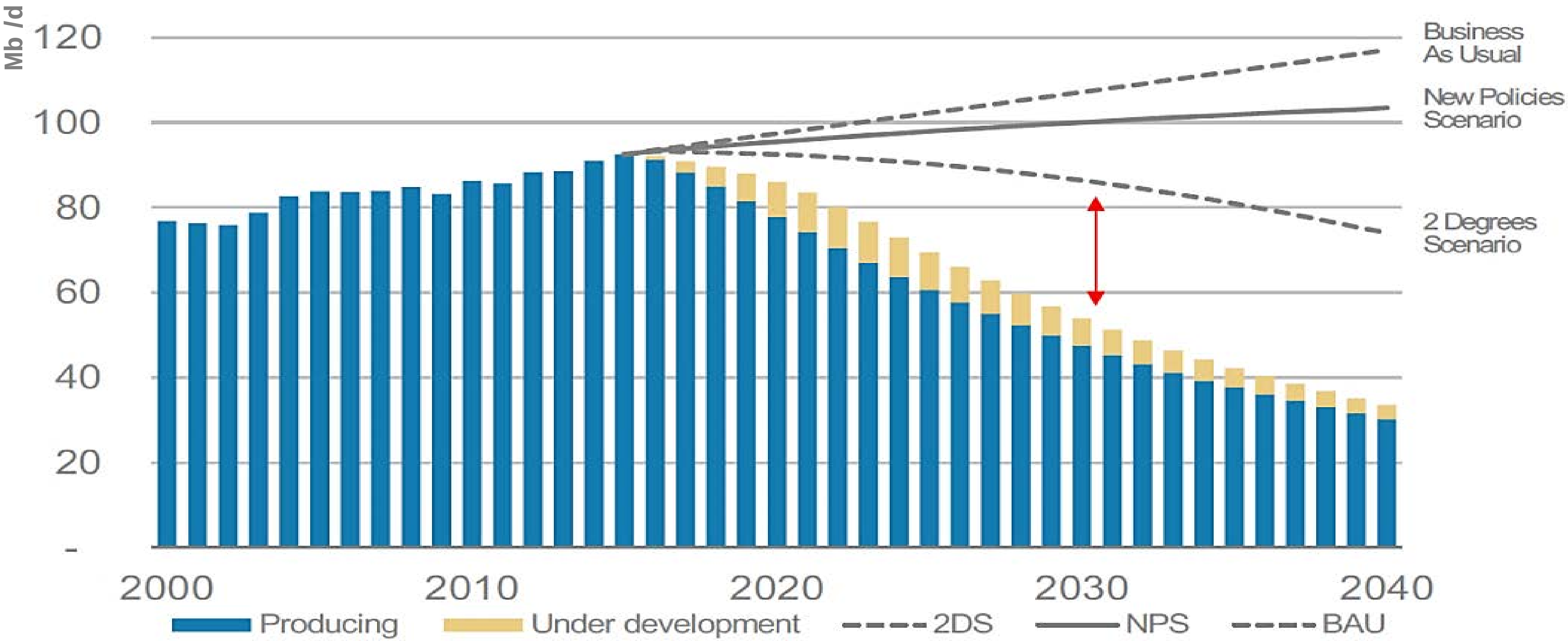
With the current price trends many initiatives (especially the most costly such as deep water) are still at risk

Oil Companies focus on more cooperation in the supply chain and new technologies in order to bring costs down

COP21 · CMP11 PARIS 2015

Long term drivers for O&G are still solid, but environmental issues and increasing efficiency of alternative sources trigger the need to evaluate alternative scenarios for the long term

… Meanwhile depletion requires new investments even to maintain production



… and excessive delay in investments could be a trigger for an oil price shock

Sources – IEA, Rystad Energy, Morgan Stanley Research June 2016

5. Global Energy Outlook 2040

Energy Outlook 2040 – Signals we cannot ignore…

- World **energy demand is expected to increase by almost 30% in next two decades**, with a **change of mix** resulting from the sustained growth of new forms of energy but with **still a major role for oil and gas** (about 50% of total energy demand)
- **US Shale revolution has unlocked huge amounts of oil and gas resources**
- **Coal will see its largest fall**

On one side:

- **Oil and Gas will continue to be a bedrock of the global energy system for many decades to come**

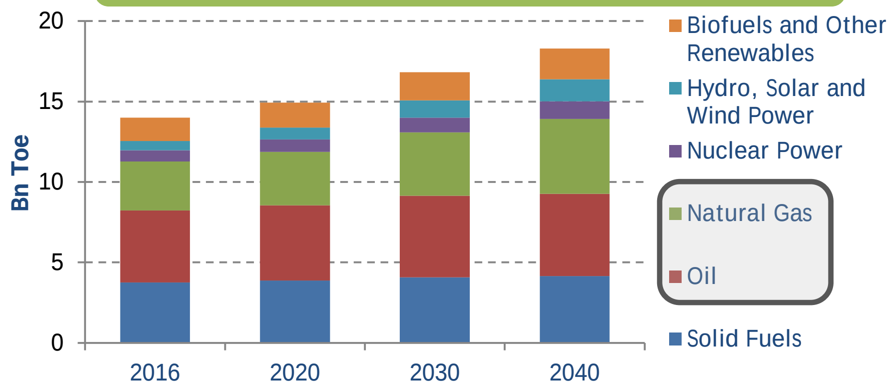
On the other side:

- **Renewable Energy is the fastest growing source of energy.**
- **The growth of Electric Vehicles in road may displace from 1 to 6 mbl/d of crude oil in 2035**

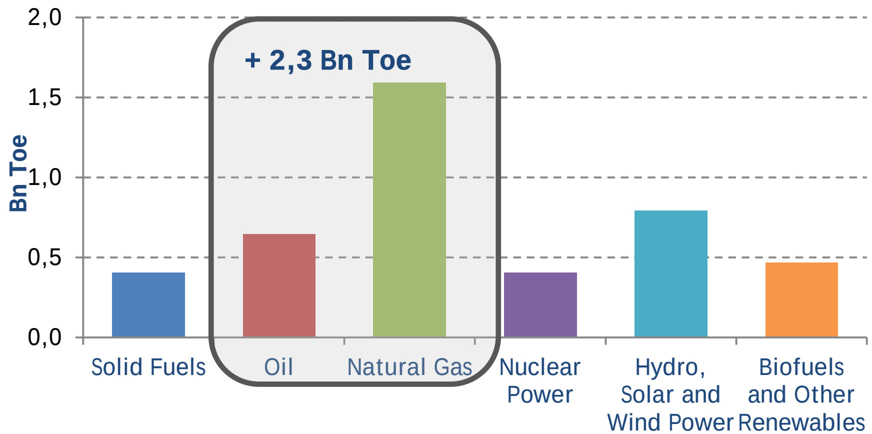
The current base scenario

Fossil fuels dominating the energy mix in the long term

World Energy Trend 2016-40

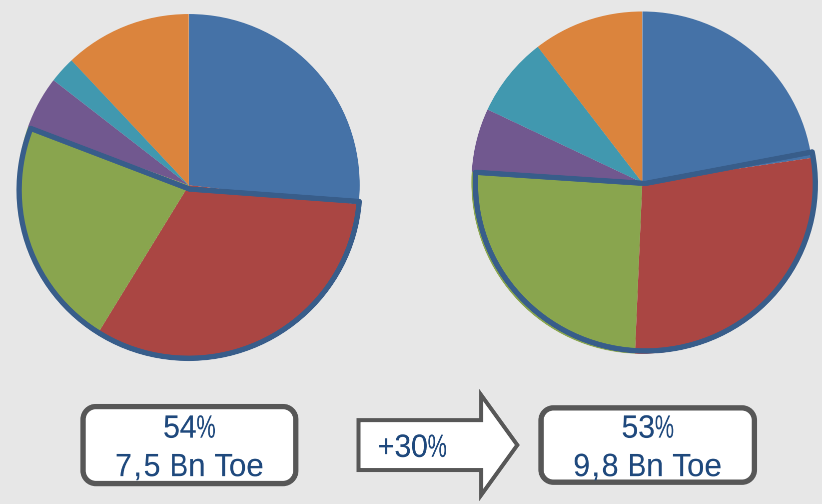


World Energy Requirement 2016-40
(+ 4,3 Bn Toe)



2016
14,0 Bn Toe

2040
18,3 Bn Toe



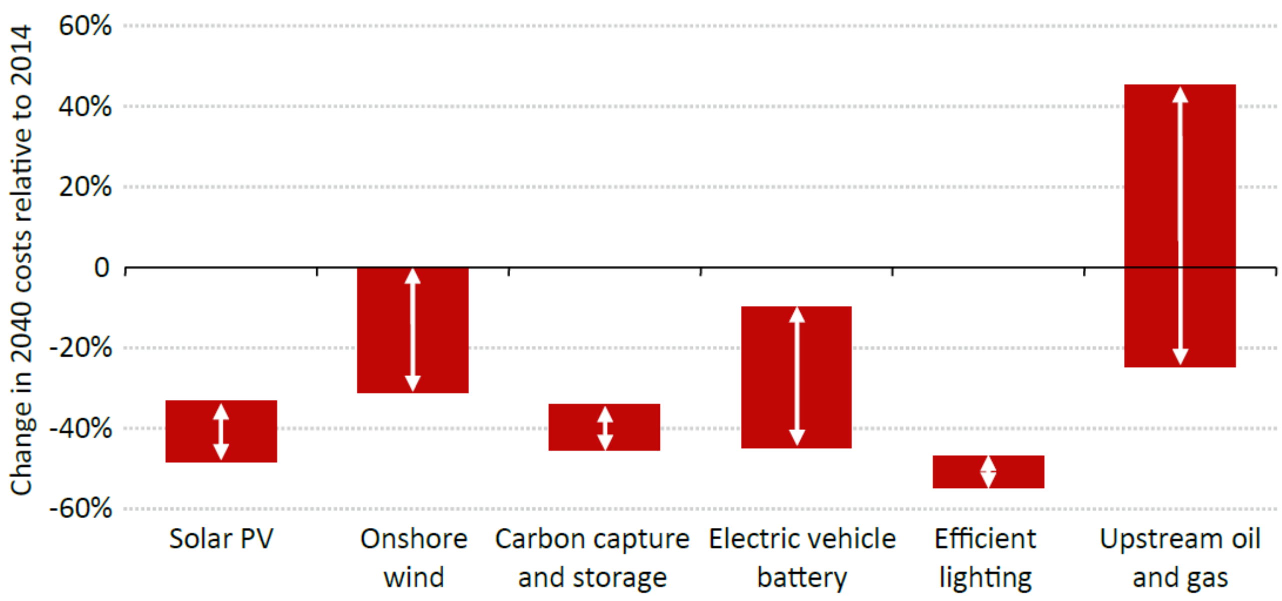
- In the base scenario, no revolutions are expected: fossils still satisfy most of energy demand by far.
- In absolute terms, natural gas is the most growing source, replacing the role of coal

Notes
Oil consumption includes international marine/aviation bunkers; does not include biofuels, which at the primary energy level are not associated with petroleum.
Coal includes steam and coking coal.
Renewables include solar, wind, geothermal, and tide/wave/ocean energy.

Source - IHS Energy Rivalry Scenario – Summer 2016

Savings in every source, less in oil & gas…

Each source is undertaking a process of improvement and new sources are better positioned than O&G (also due to different level of maturity)

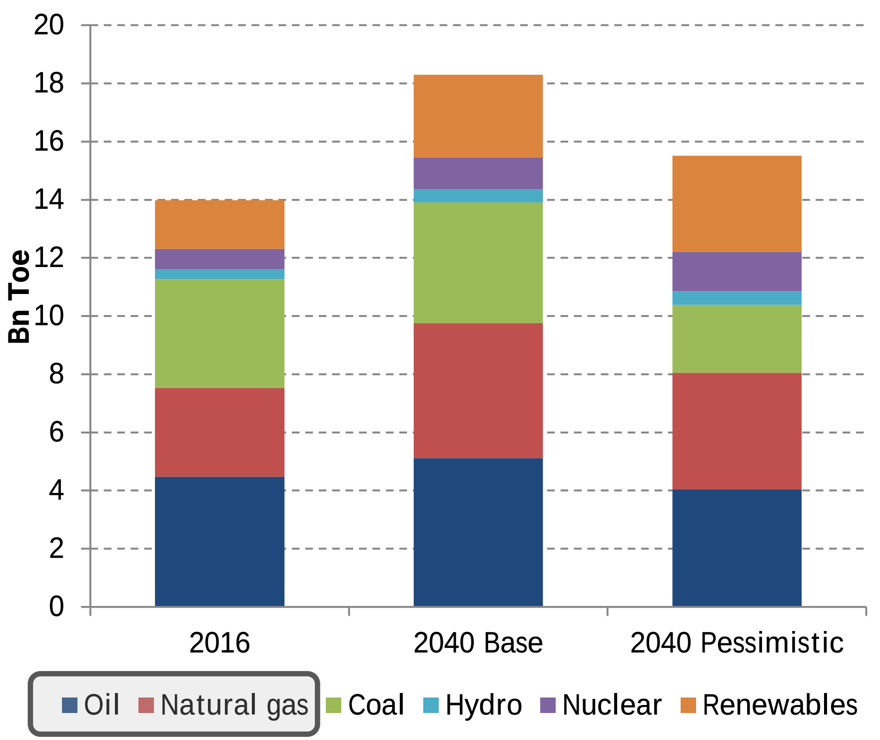


Source: IEA, World Energy Outlook 2015

But alternative scenarios tell a different story

Change in demand pattern may be mainly driven by:

- **ongoing social and political concerns over the environment** (also in China & India)
- **combined with improvement in technology and costs for renewable energy and batteries: cheaper to be clean**



Source - IHS Energy – Summer 2016

- **Very strong expansion of environmental policies and actions**
  - The Paris COP21 Agreement results in greater-than-expected success in countries meeting their targets and expanding their goals further
- **Weaker global energy demand**
  - Driven by weaker economic growth over the near term and stronger environmental policy, efficiency, and changing consumer behavior over the longer term
- **Stronger renewables technology and cost advances**
  - Driven by very strong environmental policies and rising commercial "pull" from the power sector
- **Stronger battery technology and cost advances**
  - Driven by very strong environmental policies and rising commercial "pull" from the automotive and power sectors.
- **Stronger integrated solar photovoltaics (PV)/battery installations** (mainly in developing economies)
  - Micro grid development in Africa, rural India, and other unconnected parts of the world.
  - Grid-integrated development in urban areas of emerging markets
- **Stronger electric vehicle (EV) penetration and expansion**
  - Driven by policy support, tech advances, cost improvement, and commercial "pull" from evolving transport sector (car sharing, autonomous vehicles, etc.)
- **Mixed success of natural gas**
  - Cheap/abundant gas that is also supported by environmental and energy security policy outpaces coal in India, China, and parts of SE Asia
  - Growth in gas use suffers in some places due to inroads by cheap renewables and grid-scale battery storage
- **Falling carbon dioxide (CO_2) emissions** (as a result of all of the above)
  - 2040 levels remain above the 2 degrees Celsius (°C) target

The Game Changers

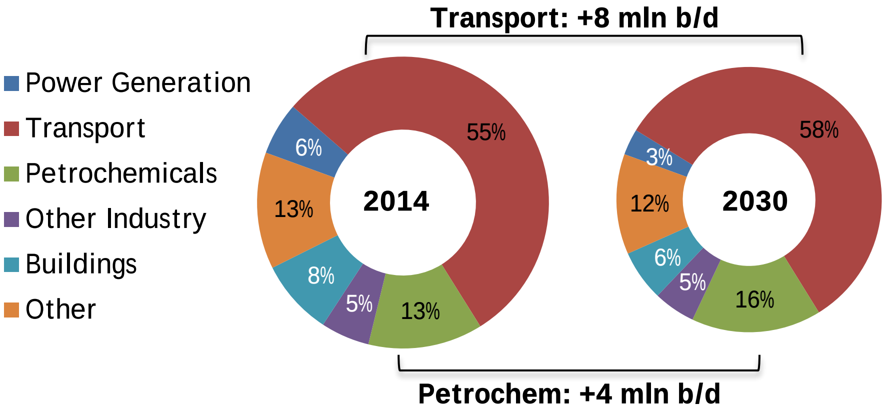
	Time horizon for breakthrough	Impacts on Oil&Gas Industry	Current hinders
Electrical Vehicles	Around 10 years	Lower oil demand: <2 mb/d Potential upside for gas (power generation)	Driven by Li batteries maturity
US & Non-US Shale	On going in US	Up to 10 mb/d of oil supply at peak (US + Non-US)	Logistic and environmental issues (outside US)
Energy Storage (excl. EV batteries)	>10 years	Difficult to determine, probably lower gas demand	Low maturity of technologies (other than batteries and hydro)
Nuclear Energy	>20 years (fusion)	Potentially reducing coal and gas consumption for power generation	HSE issues (fission) Feasibility (fusion)
CO_2 Constraints	Progressive enhancement	Significant reduction on coal Gas could replace oil and coal in the medium term	Economics of constraints enforcing
Zero Flaring	Around 10 years	increase in upstream infrastructures (gas monetization)	Economics of constraints enforcing

Oil demand and electric vehicles

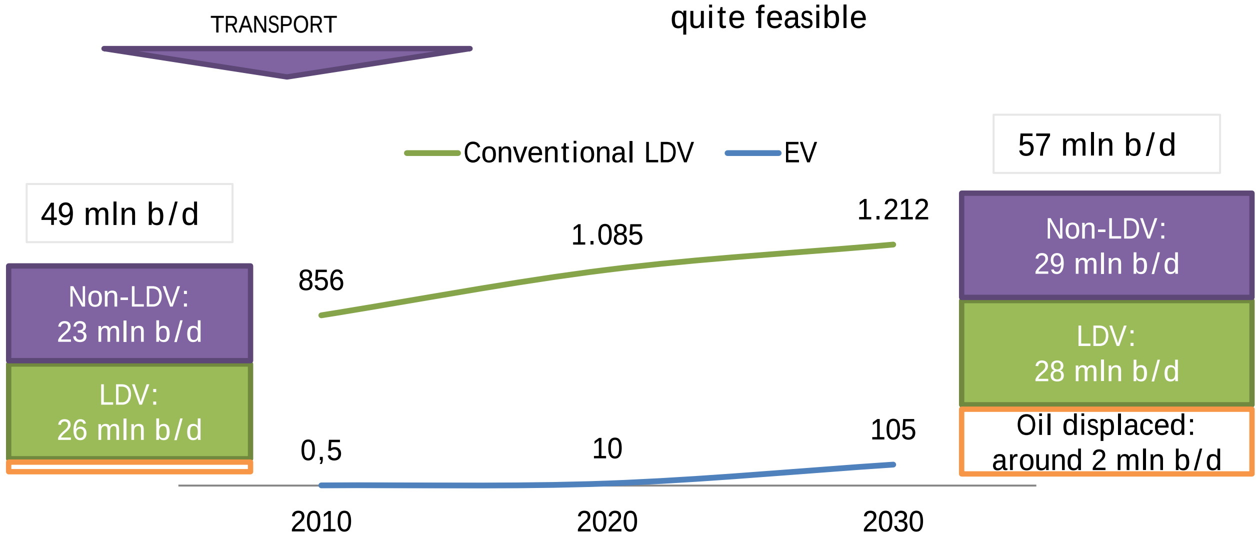
In the long term Transport continue to tow oil

Light Duty Vehicles (LDV*) will be responsible for just a part of the future demand

World oil demand by sector



- Oil demand will be driven by transport (+8 mln b/d) and petrochemical (+4 mln b/d) sectors up to 2030
- Almost all growth is due to non-OECD countries
- Demand growth prospects for both aviation and commercial trucks look extremely strong, driven mainly by non-OECD markets, and breakthrough changes in these areas look far less clear-cut.
- Aggregate chemicals demand growth of ~50% by 2040e looks quite feasible



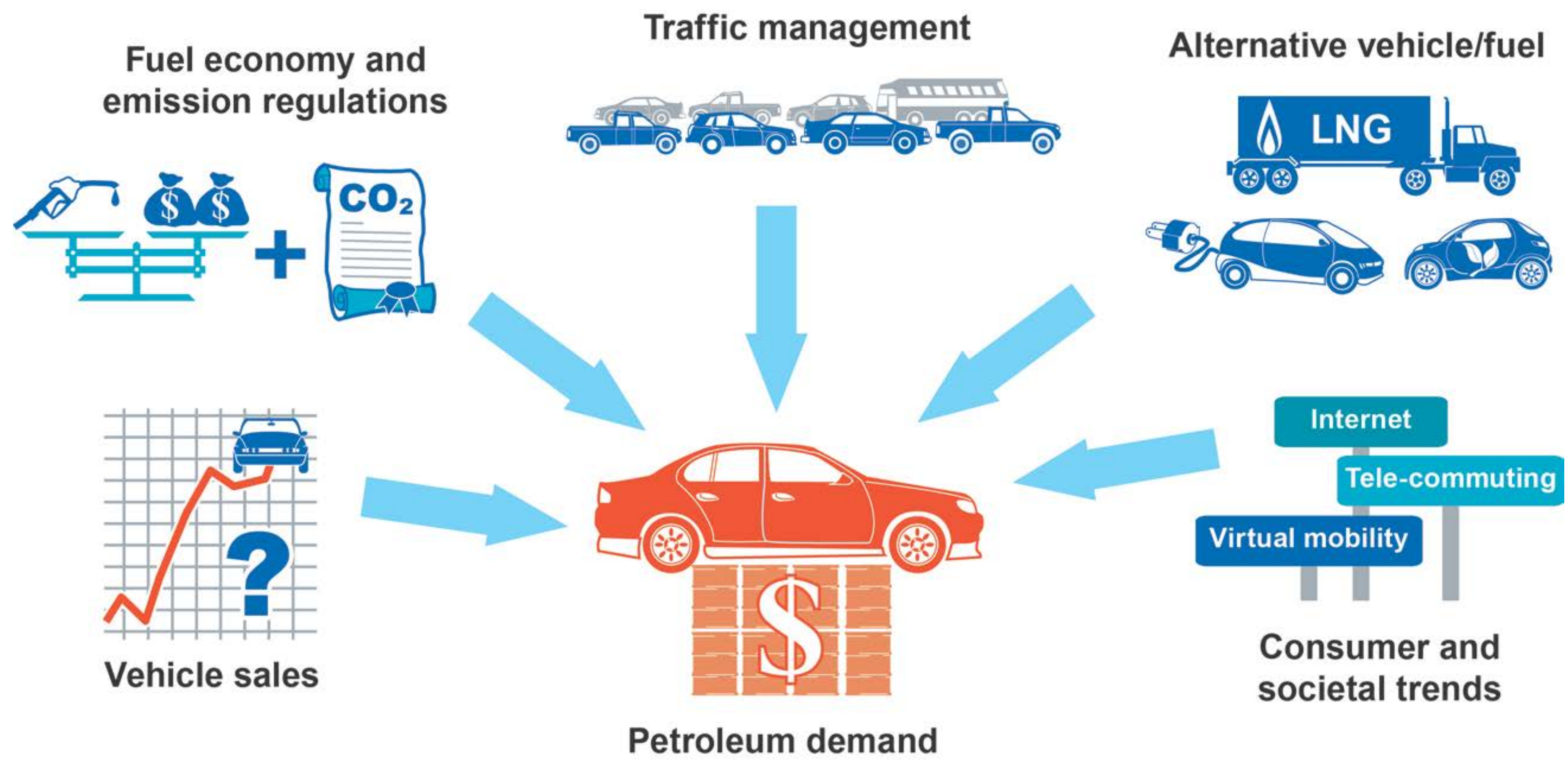
*LDV: passengers cars, light trucks, SUVs and minivans

Non-LDV includes all other ways of transport: heavy-duty, aviation, naval,…

Source: WEO (Nov. 2015), IHS, Bloomberg, NE

Key on-road fuel demand drivers that will impact future demand

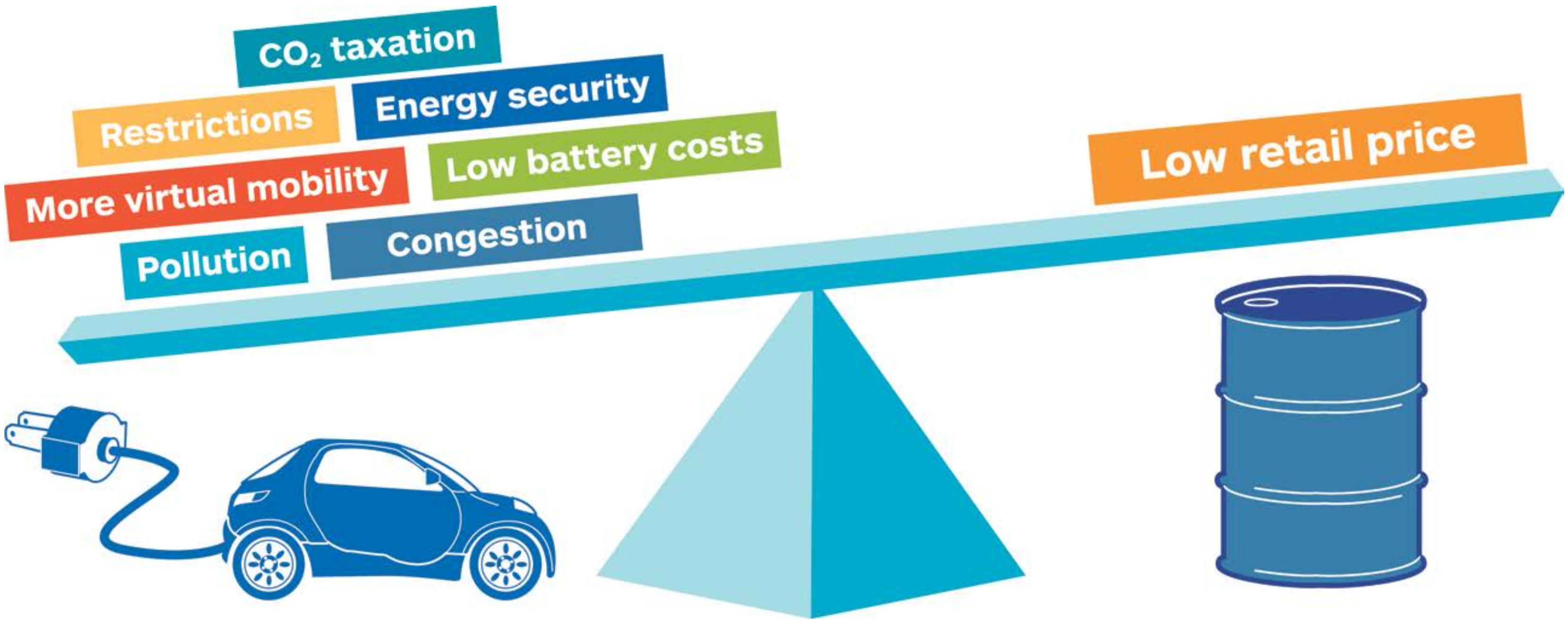
Automotive fuel demand drivers that impact future demand



Source: IHS

Even with low oil prices, other factors point toward greater electrification and new urban mobility options

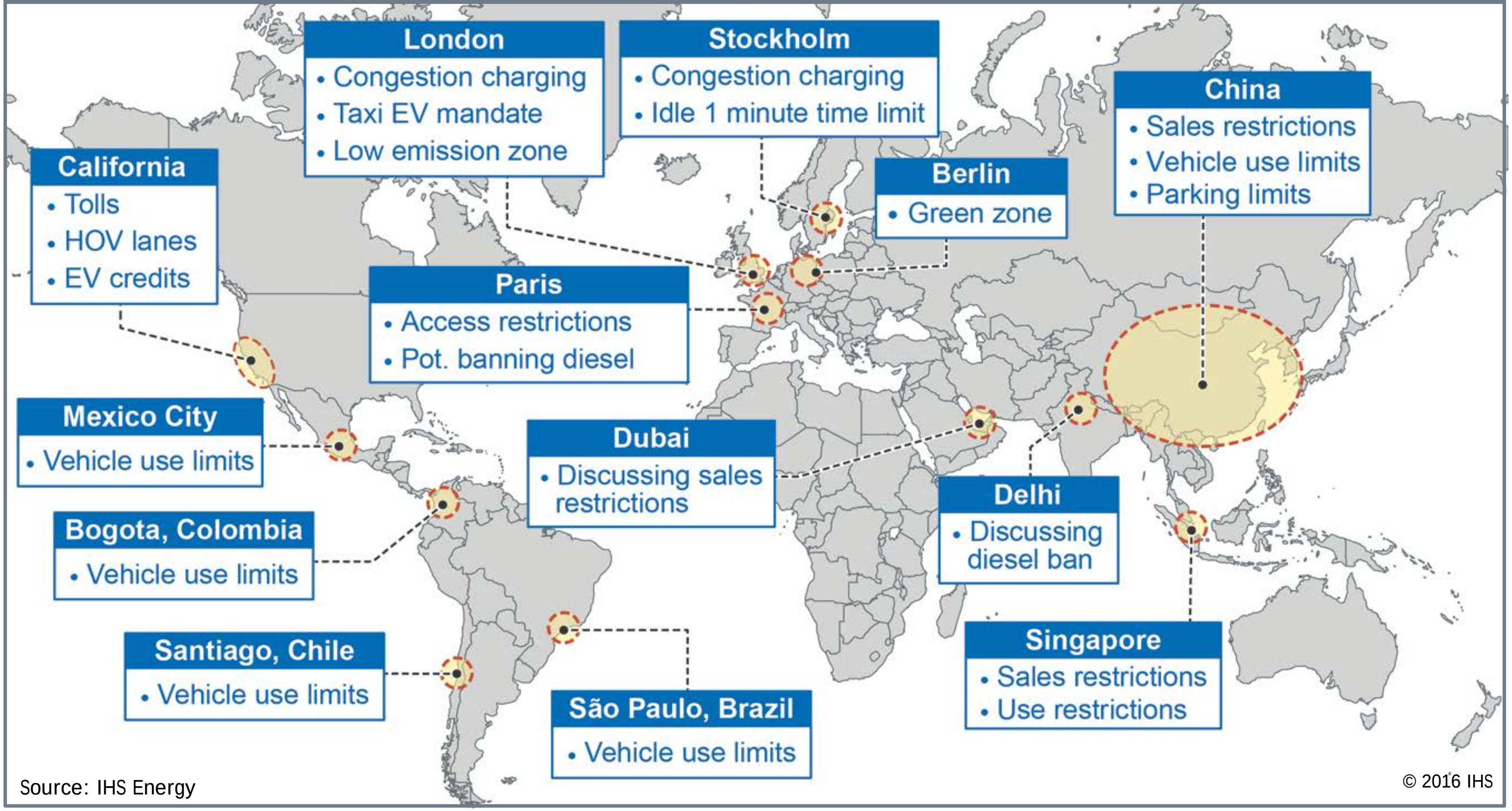
Factors moving the market toward greater electrification and new urban mobility options



Source: IHS Energy

More and more places where vehicle sales and use restrictions are in place

Vehicle sales and use restrictions



Source: IHS Energy

Urbanization is not a new trend, but have we reached a point where it is increasingly disruptive to transport behavior?

Source: Shutterstock with permission © 2016 IHS

Urbanization rates

Country	2015	2025
United States	83%	87%
Europe	77%	82%
China	52%	71%

Source: IHS © 2016 IHS

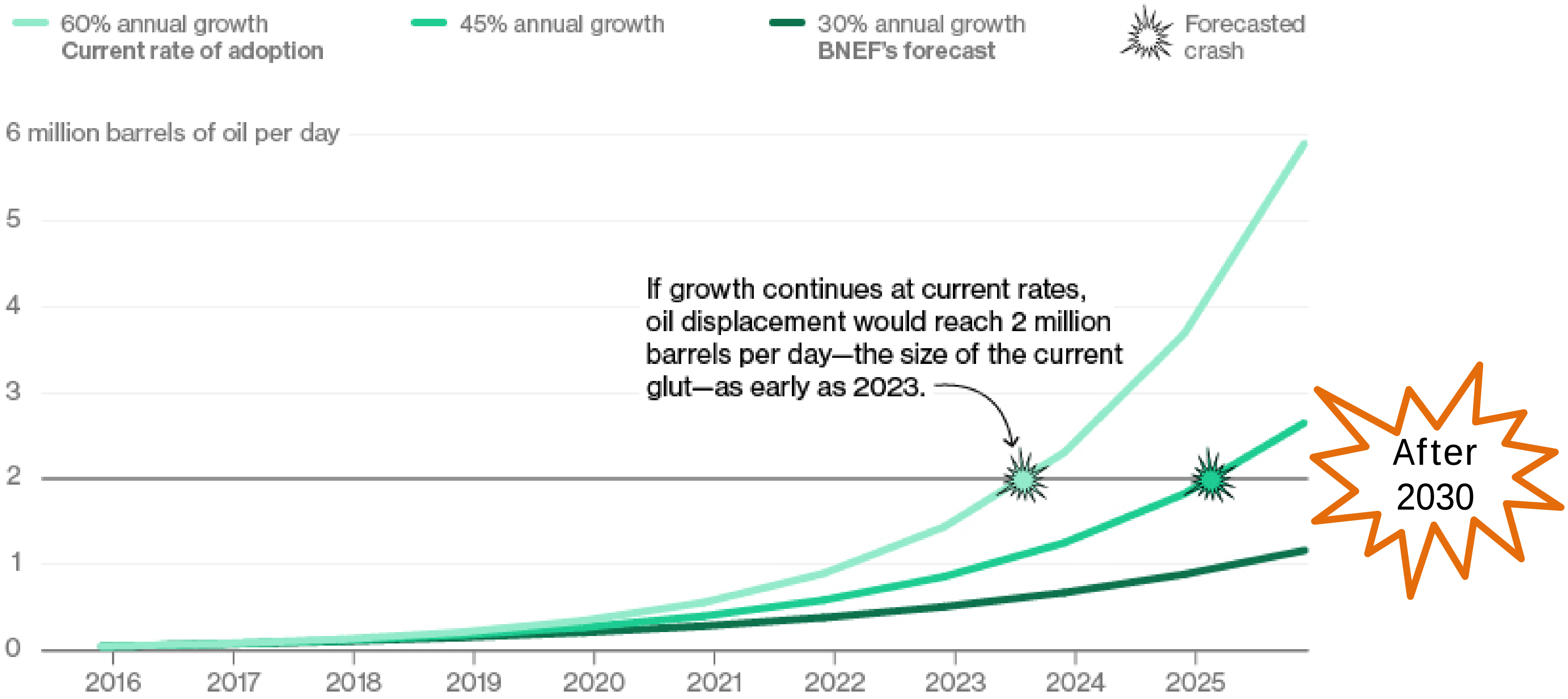
Congestion creates economic and environmental problems.

Cities today are already plagued with congestion and are exploring ways to improve mobility at the city level.

Beijing bus stop during rush hour

Source: IHS © 2016 IHS

The amount of oil displaced by electric cars will depend on when vehicles take off



Bloomberg

6. Impacts on O&G Industry – Role of Technology Innovation

Reasoning on long term impacts

What could change in O&G Industry…

UP STREAM

- Changes in consumer behaviour could force oil companies to decide whether or not to enter new energy markets
- Focus could be moved from exploration to technologies to improve efficiency and to reduce emissions, if gov'ts would impose new taxes on emissions

MID STREAM

- Switch to gas may trigger large infrastructure investments, especially in Asia
- Projects could be subject to significant headwinds and working to gain support and trust from stakeholders (gov'ts, communities, media) may become crucial

DOWN STREAM

- Uncertainty due to evolving trends in mobility and non-oil fuels
- More and more stringent compliance requirements should require flexibility and innovation
- Uptick for biofuels and lubricant promising energy efficiency

Reasoning on long term impacts

… and what in Oilfield Service Companies

OILFIELD SERVICES

BUSINESS MODEL AND STRATEGIES

- Following traditional clients potential revolutions, OFS companies may consider changing their business mode
- Potential reuse in new energy markets of traditional strength of OFS players (manage risks in complex projects)
- Opportunity for innovating OFS to drive standardisation and innovation across the sector

TECHNOLOGIES AND MARKETS

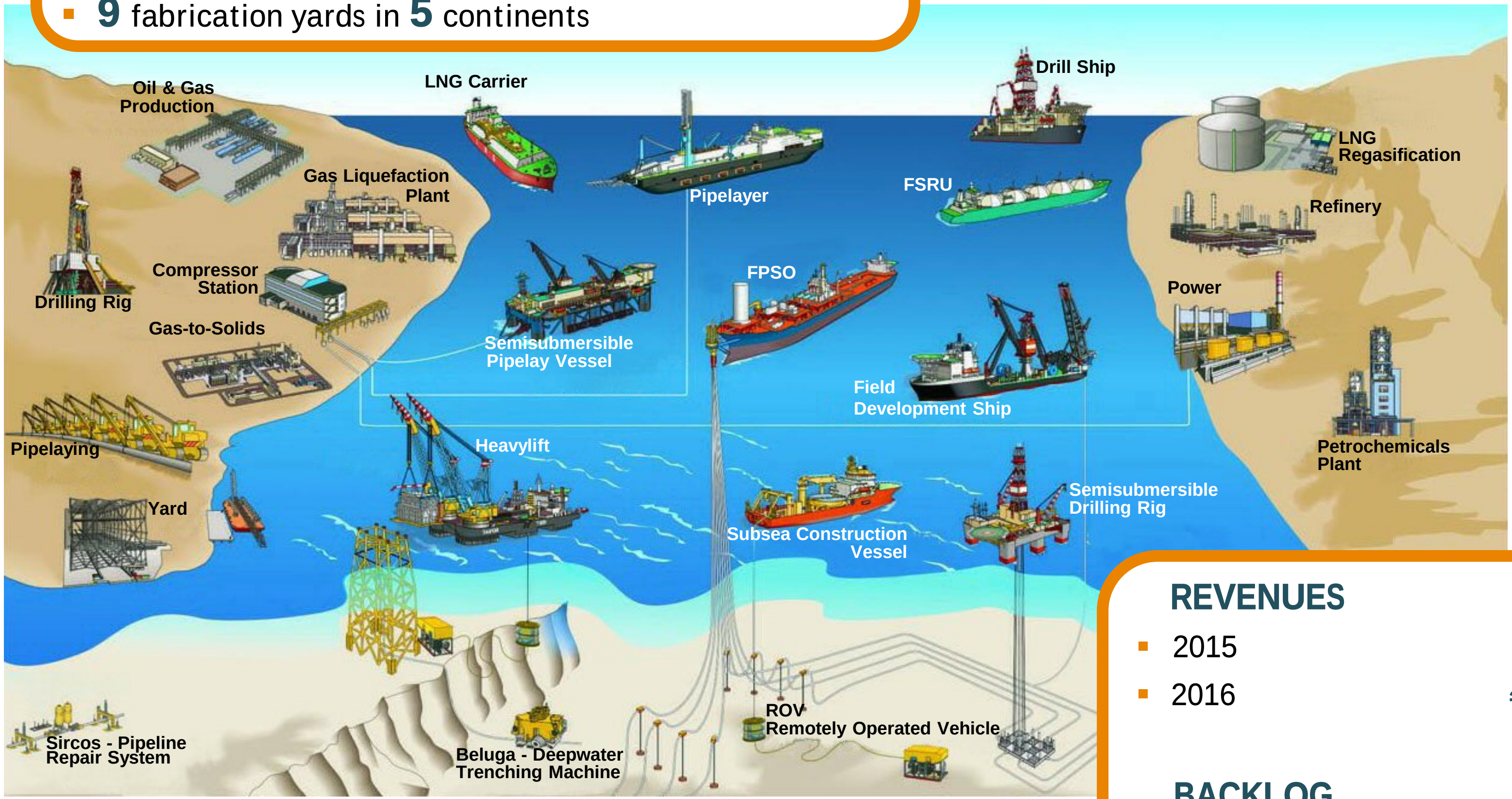
- Traditional technologies and relevant assets could be made obsolete or useless in the long term by new materials (e.g. composite pipes) or new concepts (subsea factory) or by saturation of deployed infrastructures

- Carbon constraining regulation should provide impetus to newer technologies

7. A few examples of technology innovations in Saipem

Saipem is a global leader in the field of O&G services, by realizing complex projects of Engineering & Construction

- Operating in more than **60** countries
- **~ 37,000** employees from **>120** nationalities
- More than **20** engineering and project execution centers worldwide
- **9** fabrication yards in **5** continents



(*) Source: 1Q 2017 Results Presentation

REVENUES

- 2015 **11.5** B€
- 2016 ≃**10.0** B€

BACKLOG

- March 31, 2017 **12.5** B€

SAIPEM

Technology Development

- Corporate Technology Innovation
- Technology Innovation Centers
- Technology Application Execution
- ROVs/Subsea Engineered Systems
- Technology Lab

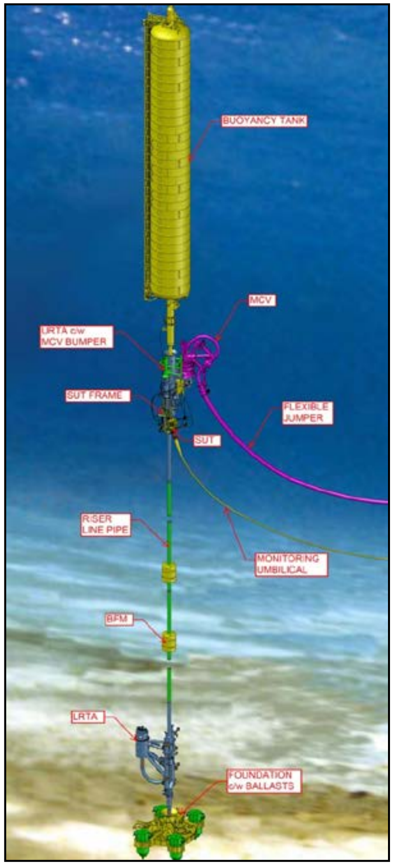
150+

full time equivalent

Saipem's history based on a strong propensity to innovate

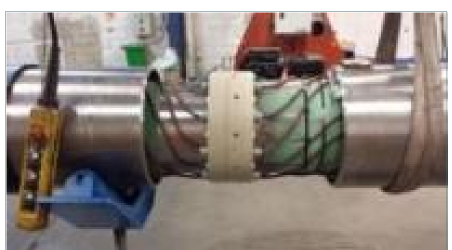
A few very recent achievements

Installed the largest, deepest & heaviest Free-Standing Hybrid Riser, with the longest and heaviest Buoyancy Tank ever built.

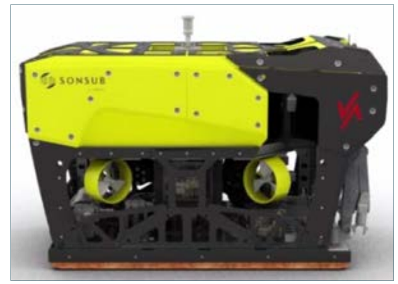


Progressing the development and industrialization of Hydrone, the subsea platform composed by an advanced AUV, a resident hybrid ROV/AUV and a work class, temporary resident ROV, now fully defined and proposed to Clients.

Qualified the Electrical Heat Traced Pipe-in-Pipe technology for rigid J-Lay installation, that extends the application of the most efficient active heating method to larger diameter risers and flowlines, for even longer tie-back lines.



Delivered the first prototypes of the Innovator 2.0 the new generation high power, work class ROV developed and manufactured by Sonsub.



SPRINGS® technology is moving forward, thanks to the cooperation with Total and Veolia, aimed to the industrialization of a subsea water treatment plant capable to remove the sulphates from seawater, before being injected in the reservoir.

Internal Plasma Welding technology successfully used on Kashagan field, to enhance productivity and reduce the cost of quality in welding clad and carbon steel sealines.

Snamprogetti™ SuperCups technology qualified in a long-run demo test in an Urea plant in Pakistan, increasing production yield, lowering steam's specific consumption and emission of greenhouse gases.

SAIPEM