INSTITUT VEOLIA

3 rd june 2017

OIL AND NATURAL GAS FUTURE

QUANTITIES, PRICES AND GHG EMISSIONS

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Former head of strategy and planning of TOTAL

PRESENTATION SUMMARY

PART ONE:

- Shale oil and shale gas: two major game changers

PART TWO

- Oil and gas reserves: the climate change dilemma

PART ONE

SHALE OIL AND SHALE GAS: TWO MAJOR GAME CHANGERS

A FEW SIMPLIFIED FIGURES TO ILLUSTRATE HOW SHALE OIL IS « DIFFERENT » FROM CONVENTIONNAL OIL (1)

	2010	2014
USA total oil production	7,5 mb/d	12 mb/d
From which shale oil/LTO	0,5 mb/d	4,5 mb/d
Us oil production as % consump	40%	60%
US oil import as % consump	60%	40%

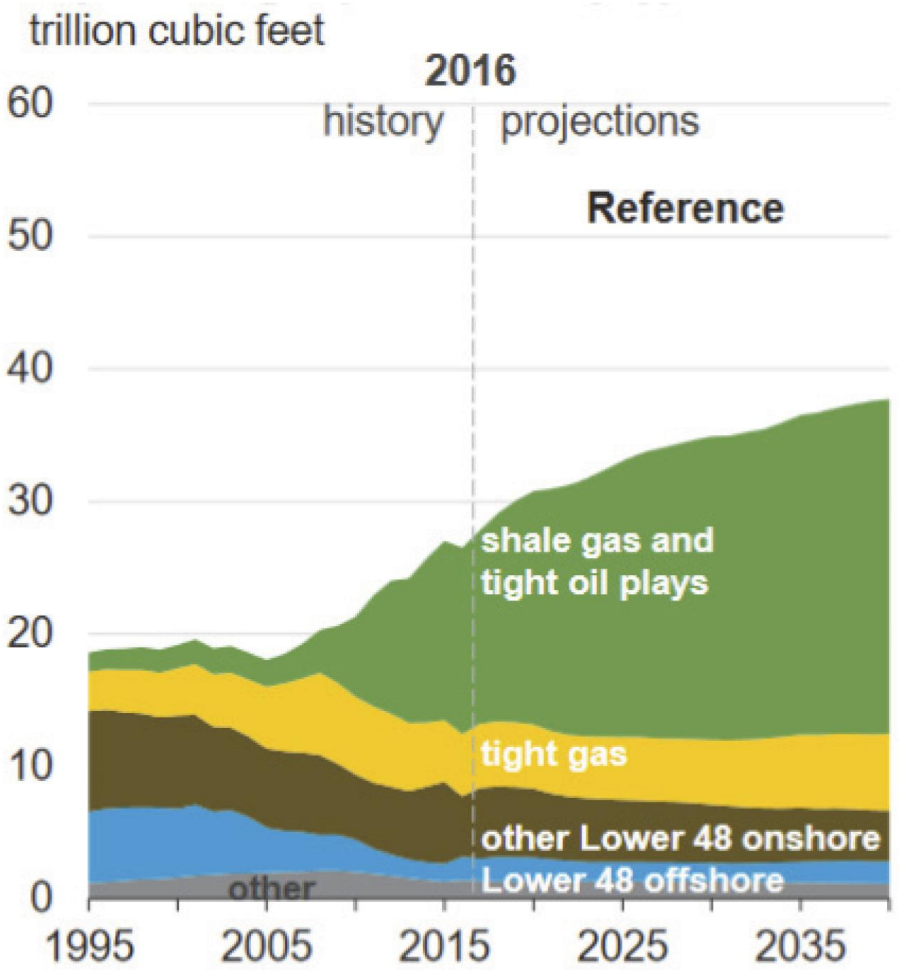
Source: PR Bauquis – 25 Avril 2015

A FEW SIMPLIFIED FIGURES TO ILLUSTRATE HOW SHALE OIL IS « DIFFERENT » FROM CONVENTIONNAL OIL 2

	Annual decline rates	Recovery rates
US conventionnal onshore	**5% / Y (after plateau)**	**50% (asymptotic rate)**
US shale oil / LTO	**50% / Y (years 1 and 2)**	**5% (increasing to 10-15%)**

Source: PR Bauquis – 25 Avril 2015

NATURAL GAS PRODUCTION IN THE US: SHALE GAS AND TIGHT GAS ALREADY REPRESENT 2/3 OF THE PRODUCTION



Source : EIA, Annual Energy Outlook 2017

A WORLD RESERVE ESTIMATE OF SHALE OIL

TO BE PRESENTED ON 15 JUNE 2017 AT THE EAGE CONGRESS BY MARC BLAIZOT

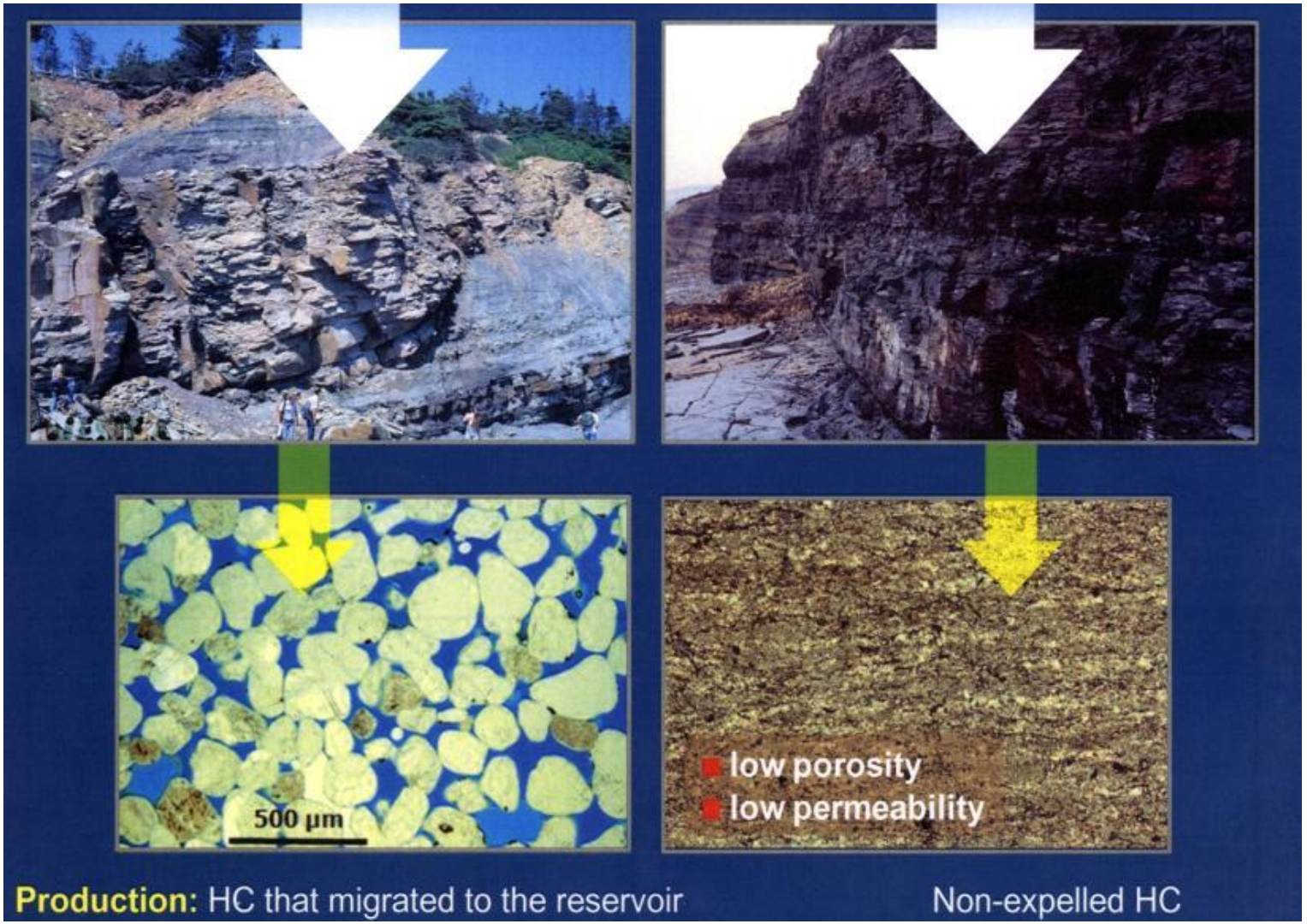
- **Methodology used: PSY (Petroleum System Yield)**
- **Retained accumulation in source rocks estimate: 75. 000 Gbo**
- **Unrisked oil reserves estimate: 10% of « in place » ie: 7.500 Gbo**
- **Reserves estimate (producible oil): 20% of « in place » ie: 1.500 Gbo (economically and environmentally producible)**

SHALE OIL/LTO COULD DOUBLE THE REMAINING WORLD RESERVES

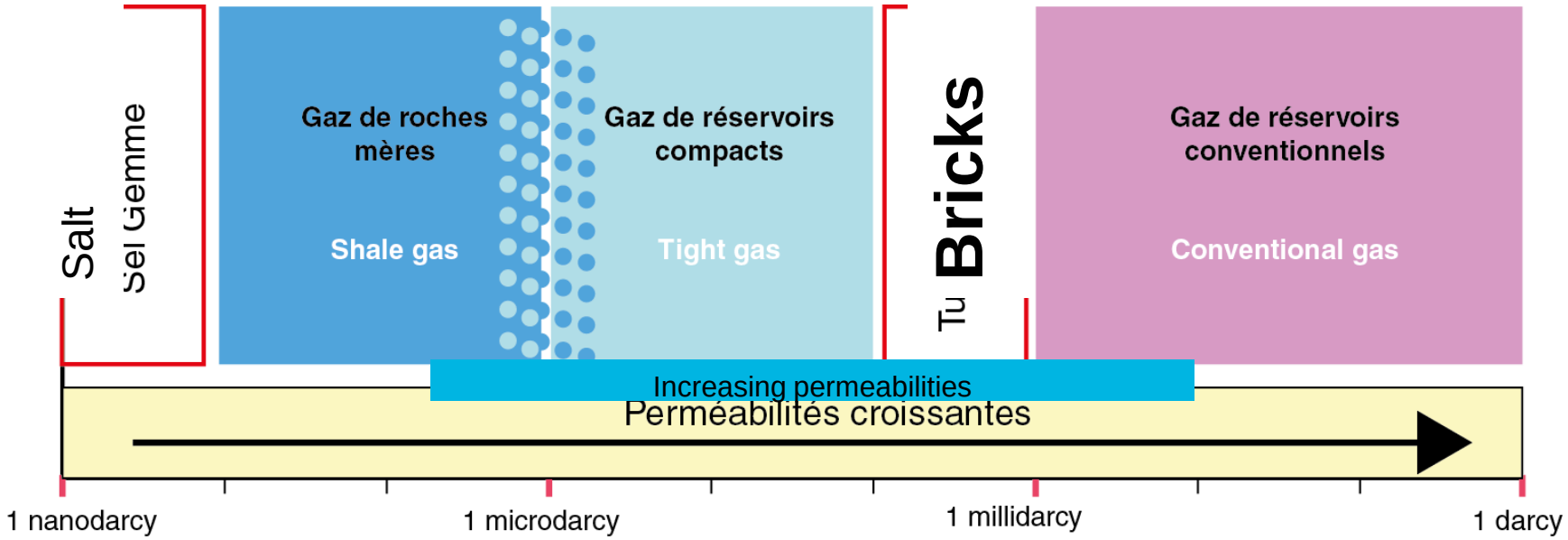
Source : Marc BLAIZOT – Former Exploration Manager of Total
Proceeding EAGE Congress Paris – 15 june 2017

CONVENTIONAL

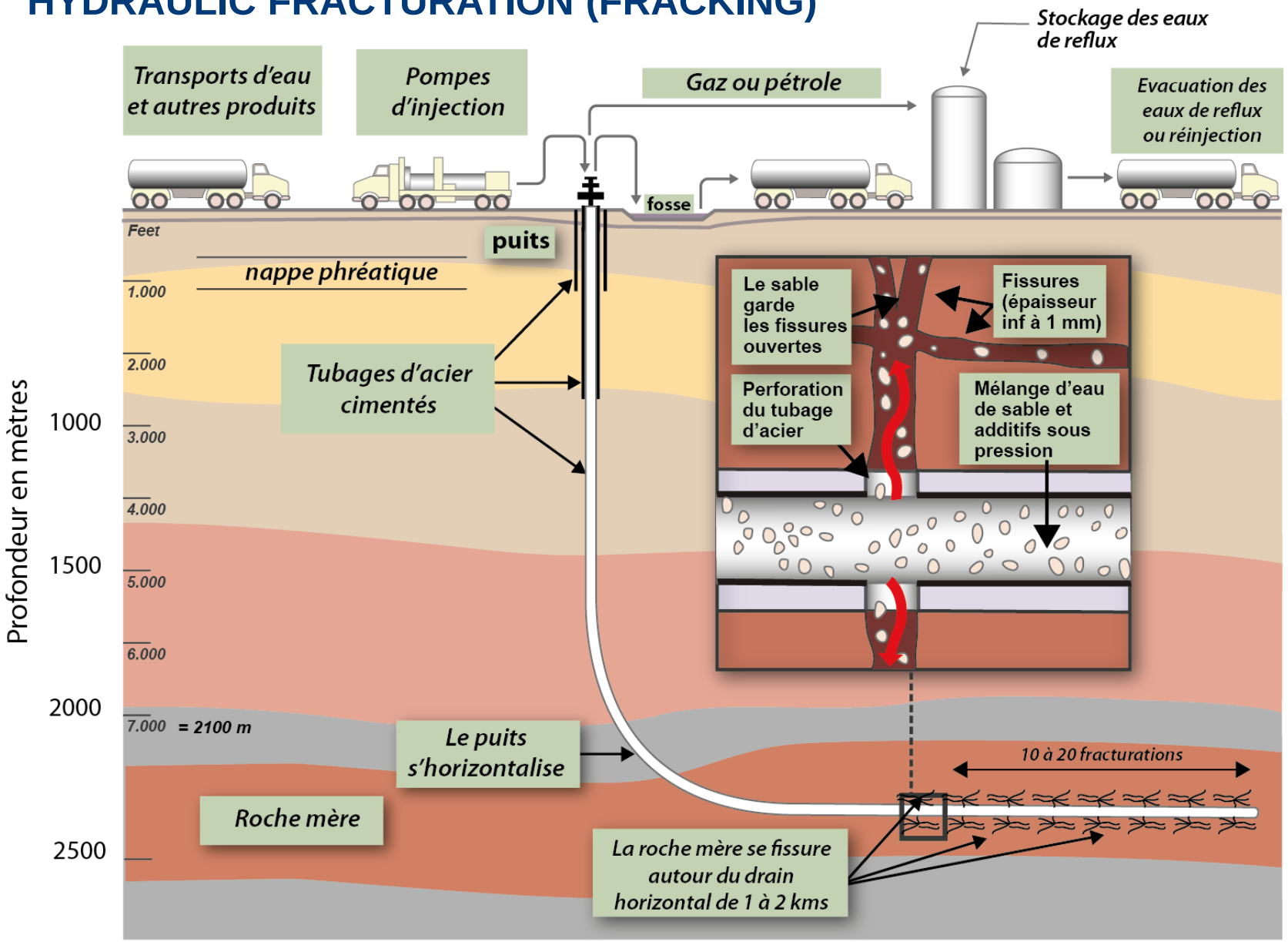
NON CONVENTIONAL



CONVENTIONAL AND NON-CONVENTIONAL RESERVOIRS

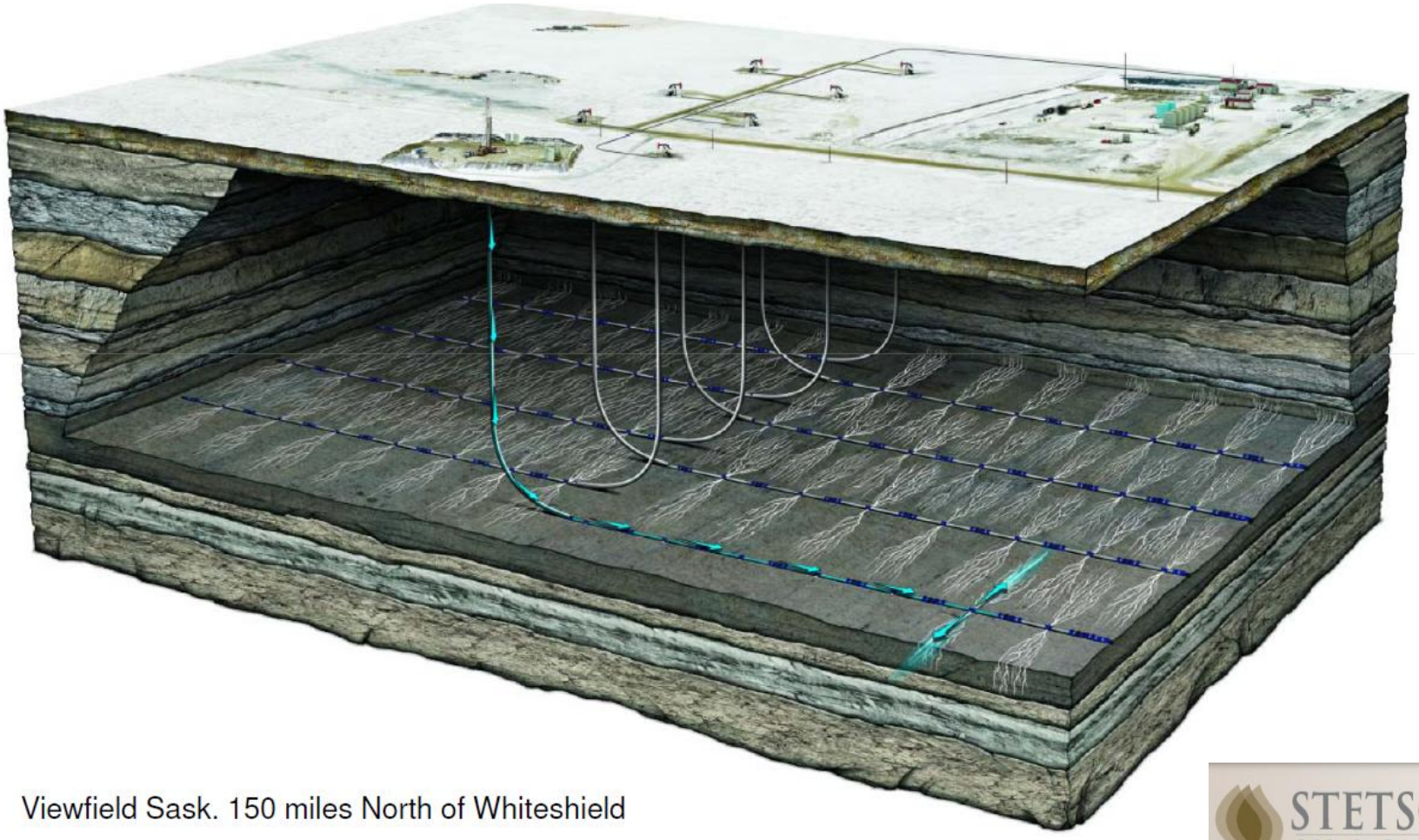


HYDRAULIC FRACTURATION (FRACKING)



source : PR Bauquis - 15 janvier 2014

SHALE GAS OR SHALE OIL TYPICAL DEVELOPMENT (USA)

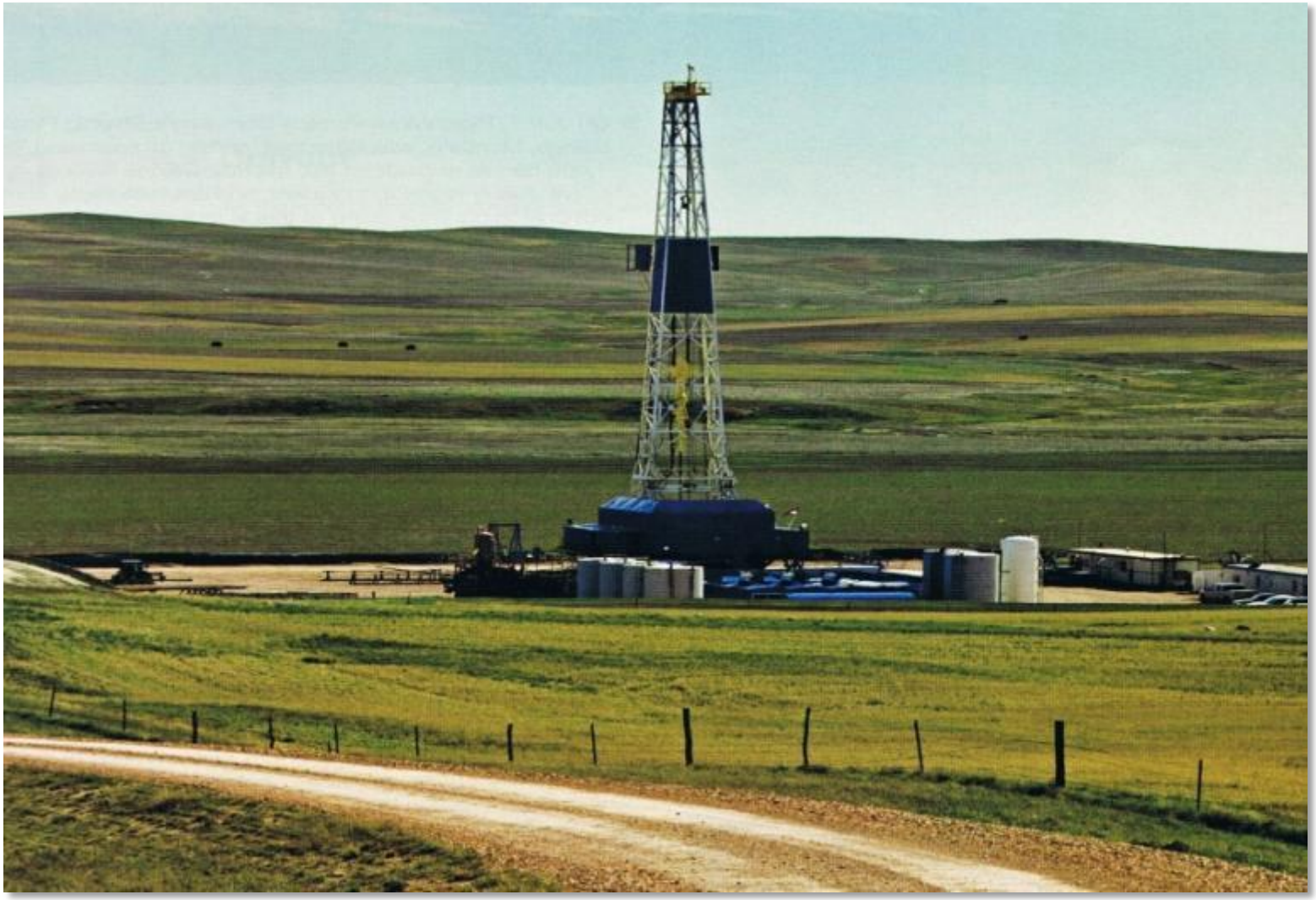


Viewfield Sask. 150 miles North of Whiteshield

STETSON OIL & GAS LTD

HOW PICTURES CAN « MANIPULATE » REALITIES

A ROSY VIEW



HOW PICTURES CAN « MANIPULATE » REALITIES

A DARK VIEW

GAS SHALE EXPLOITATION AT DALLAS AIRPORT (DFW)

- 55 pads
- 8 wells per pad
- 300-325 wells

Dallas-Forth Worth airport

GAS PRODUCTION CLUSTERS AT DALLAS AIRPORT (DFW)

Drilling Info

Spud Date: 12/25/2010
TMD: 11,680'
TVD: 7,232'
Lateral Length: 4,026'
Drilling Days: 10
Shale Thickness: 320'

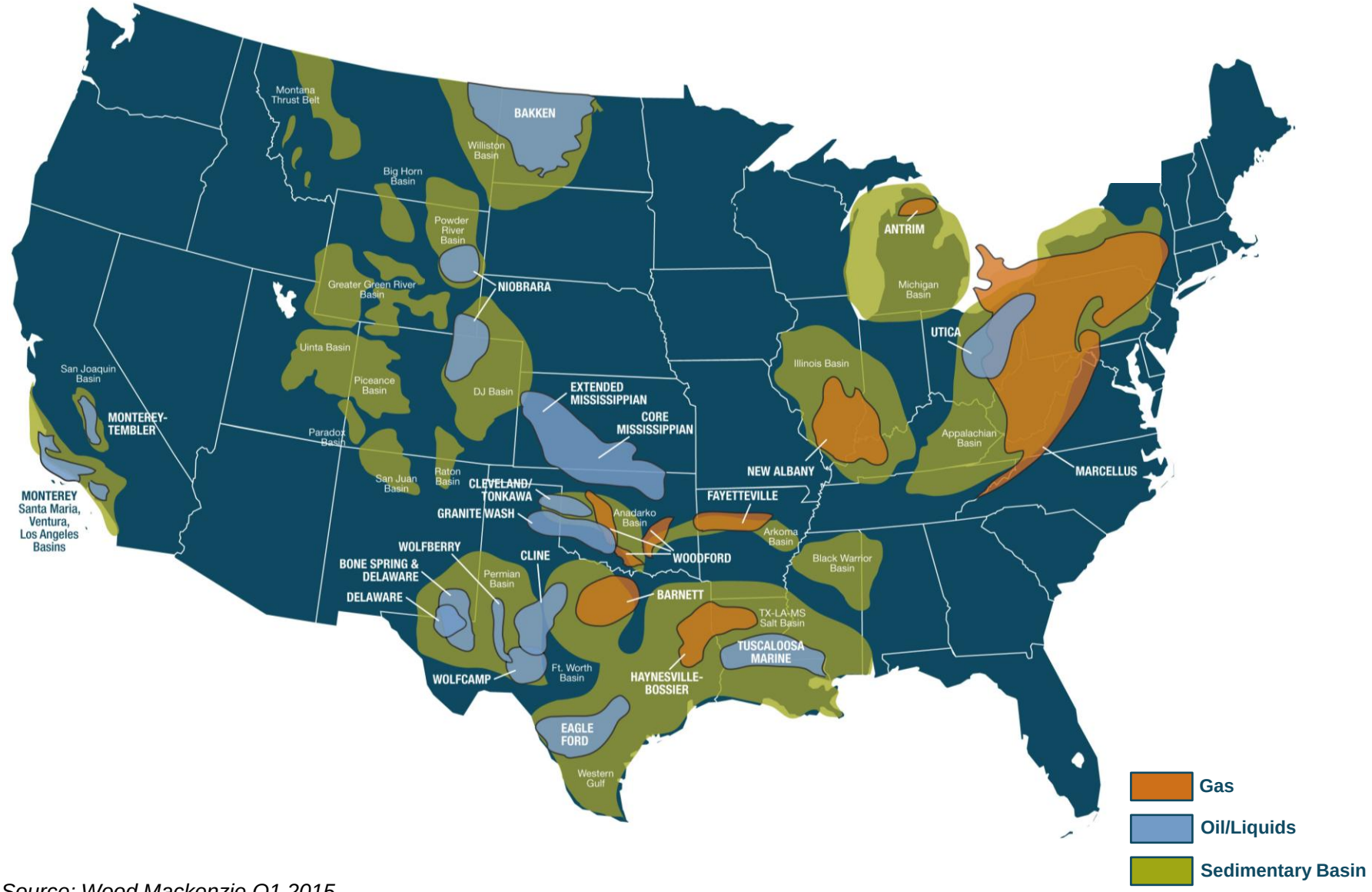
Completion Info

6 Stages
900,000 lbs of Proppant used
21,536 bbl of Fluid
3.6 Hours of Pump Time

Puits McCullar 4H

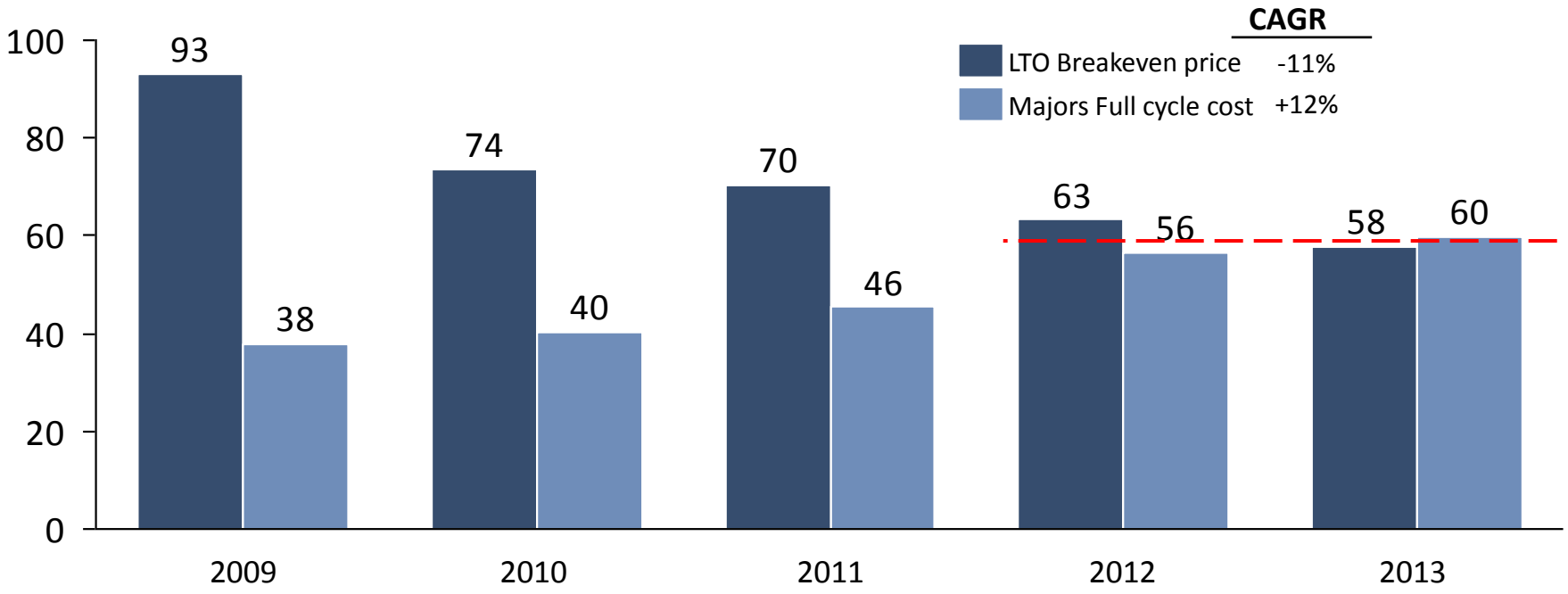
Sources: Chesapeake energy

U.S. SHALE/TIGHT GAS & LIQUIDS PRODUCTION REGIONS



Source: Wood Mackenzie Q1 2015

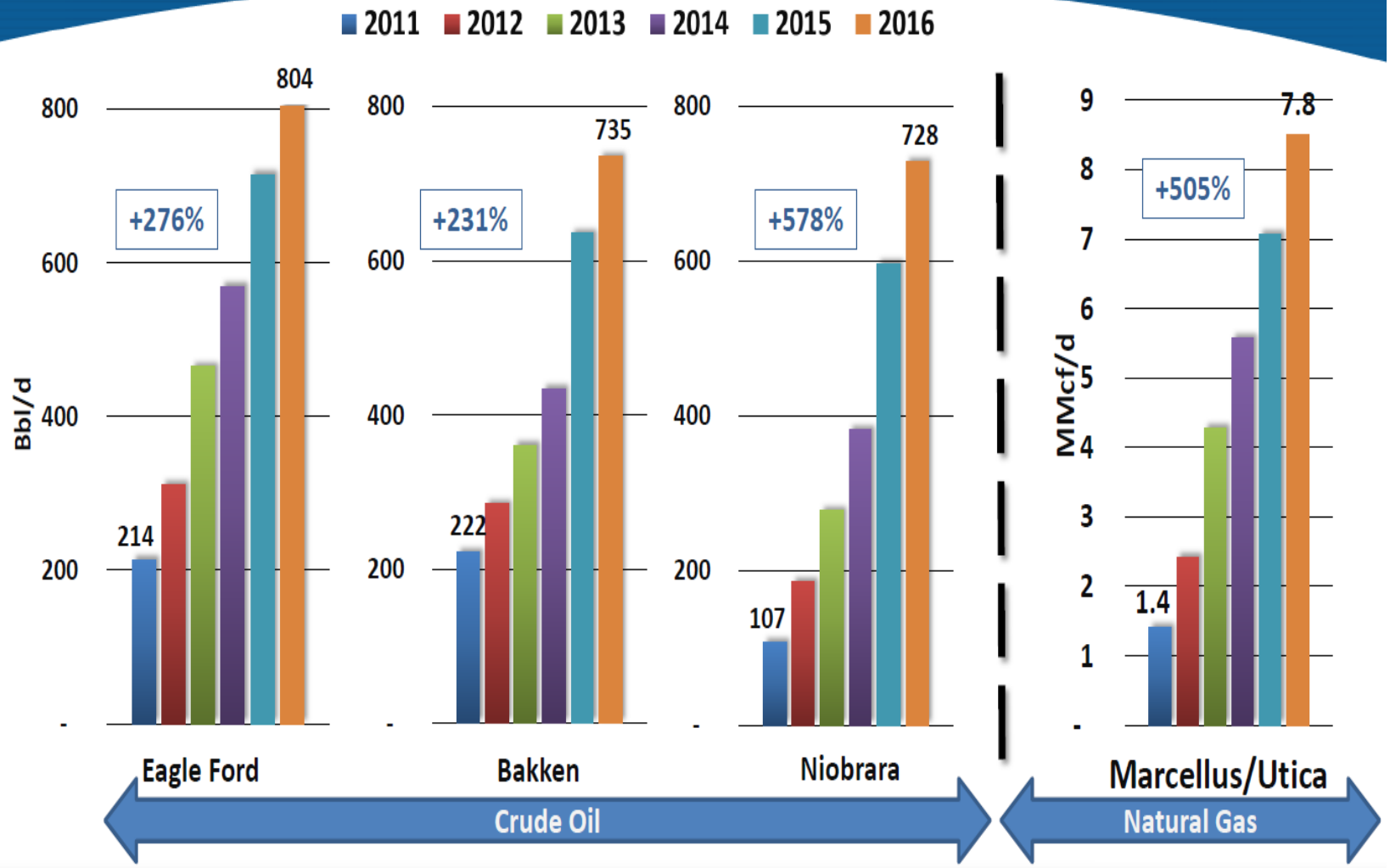
SOURCE ROCK OIL AND OTHER LTO: THEIR PRODUCTION COST ARE NOW SIMILAR TO CONVENTIONAL OIL.
HOWEVER COST STRUCTURES ARE TOTALLY DIFFERENT



Source: ***Schlumberger (A. ROSTAND)***
Conférence Oil & Money
Londres 29-30 Octobre 2014

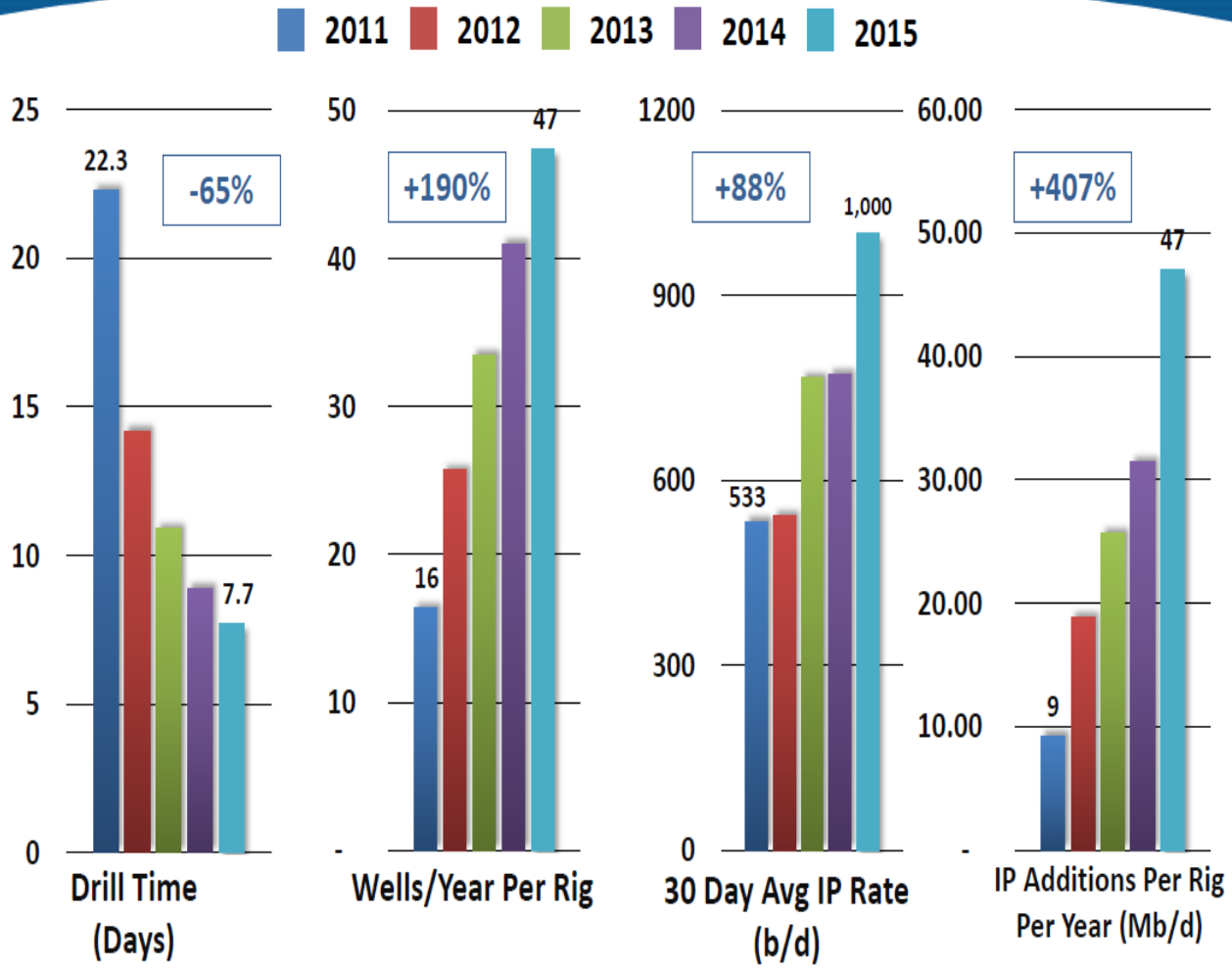
1: ***F&D + Lifting costs****. Pure unconventional NAM players*
2*: S&GA + F&D + Total Production + WACC. Majors*
Source*: 1) Rystad, IHS; 2) Evaluate Energy; Goldman Sachs*

Oil and Gas Production Added Per Rig



Source: EIA

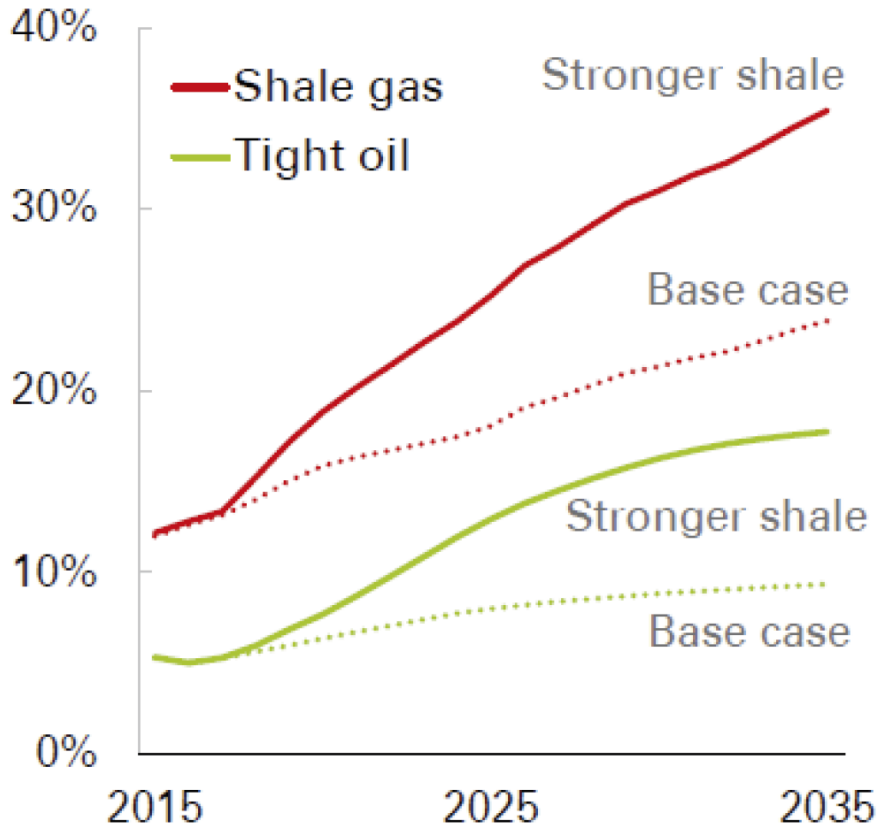
EOG Eagle Ford Productivity Gains



RBN Energy LLC

Source: EOG

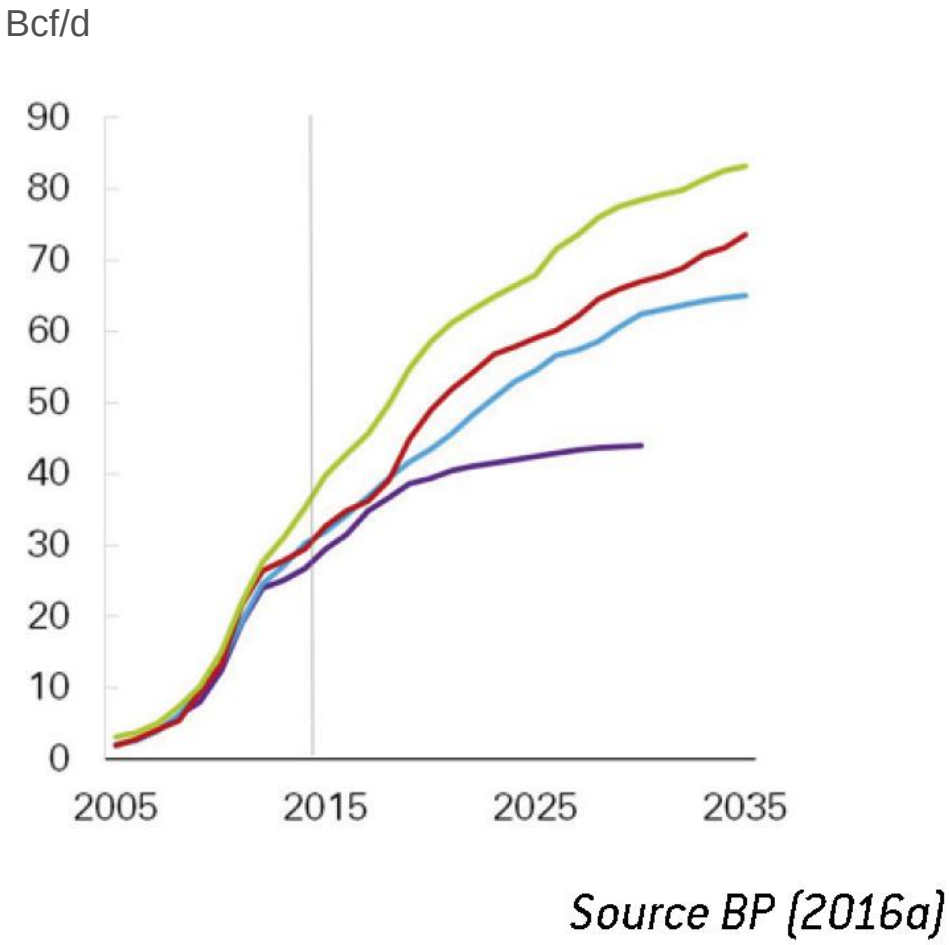
SHALE OIL AND SHALE GAS POSSIBLE SHARES OF WORLD OIL AND GAS PRODUCTIONS (2015 - 2035)



Source : BP (2016a)

SHALE GAS AND TIGHT GAS DOMINATE THE US GAS PRODUCTION AND WILL CONTINUE TO INCREASE IN THE NEXT 20 YEARS

A 100% UNCERTAINTY MARGING AT A 2035 HORIZON !



Source BP (2016a)

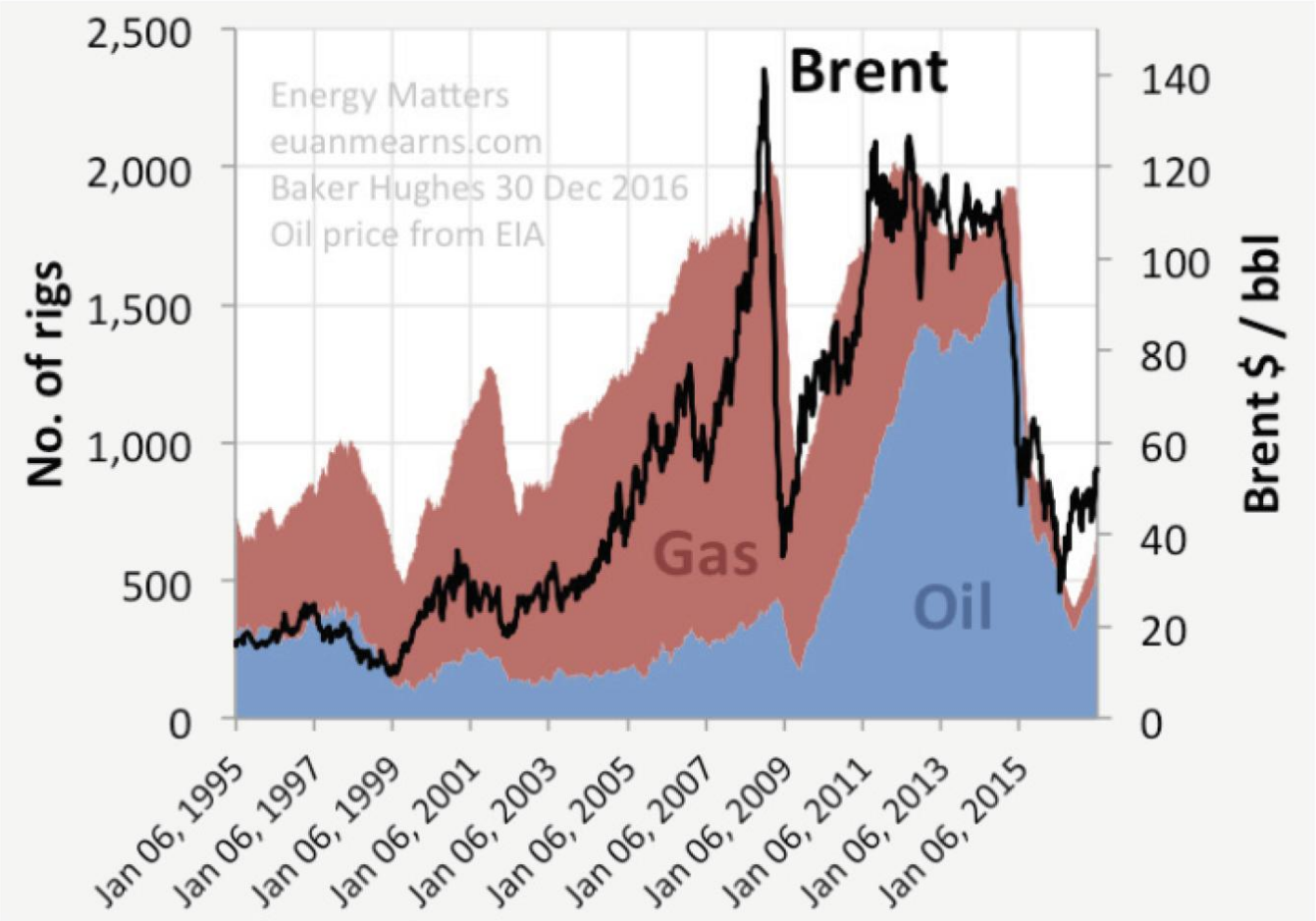
US SHALE OIL AND THE 2014 OIL PRICE COLLAPSE

DECEMBER 2014: A POLITICAL VIEW OF OIL PRICE COLLAPSE AS ILLUSTRATED BY MEDIAS

PRODUCING COUNTRIES FIRST LEAGUE (10 TO 12 MBD)

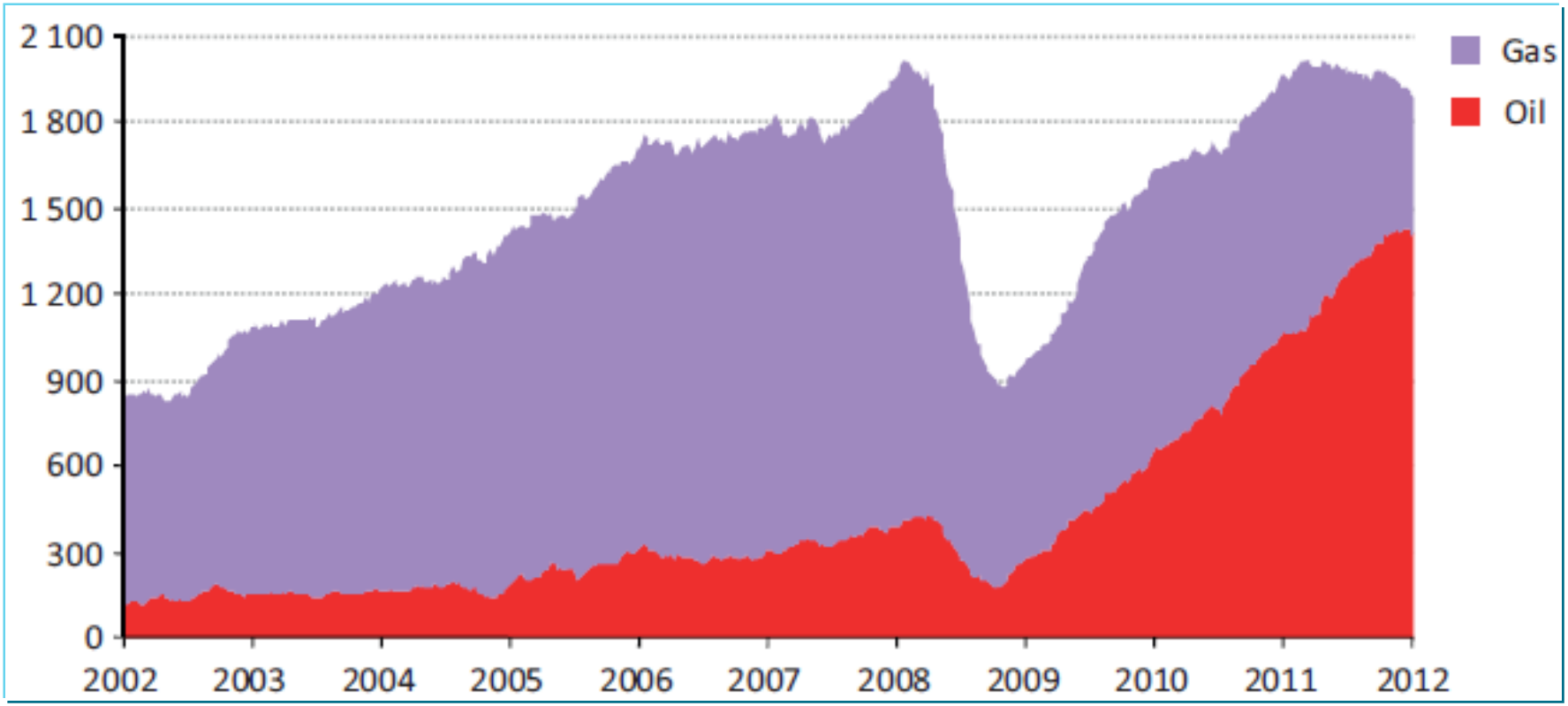
(*) US Shale Ressouces

80% OF LAND RIGS DRILLING FOR OIL (EARLY 2017) VERSUS 20% FOR GAS…VERSUS 80% FOR GAS AND 20% FOR OIL EARLY 2008



Source : Euan Mearns

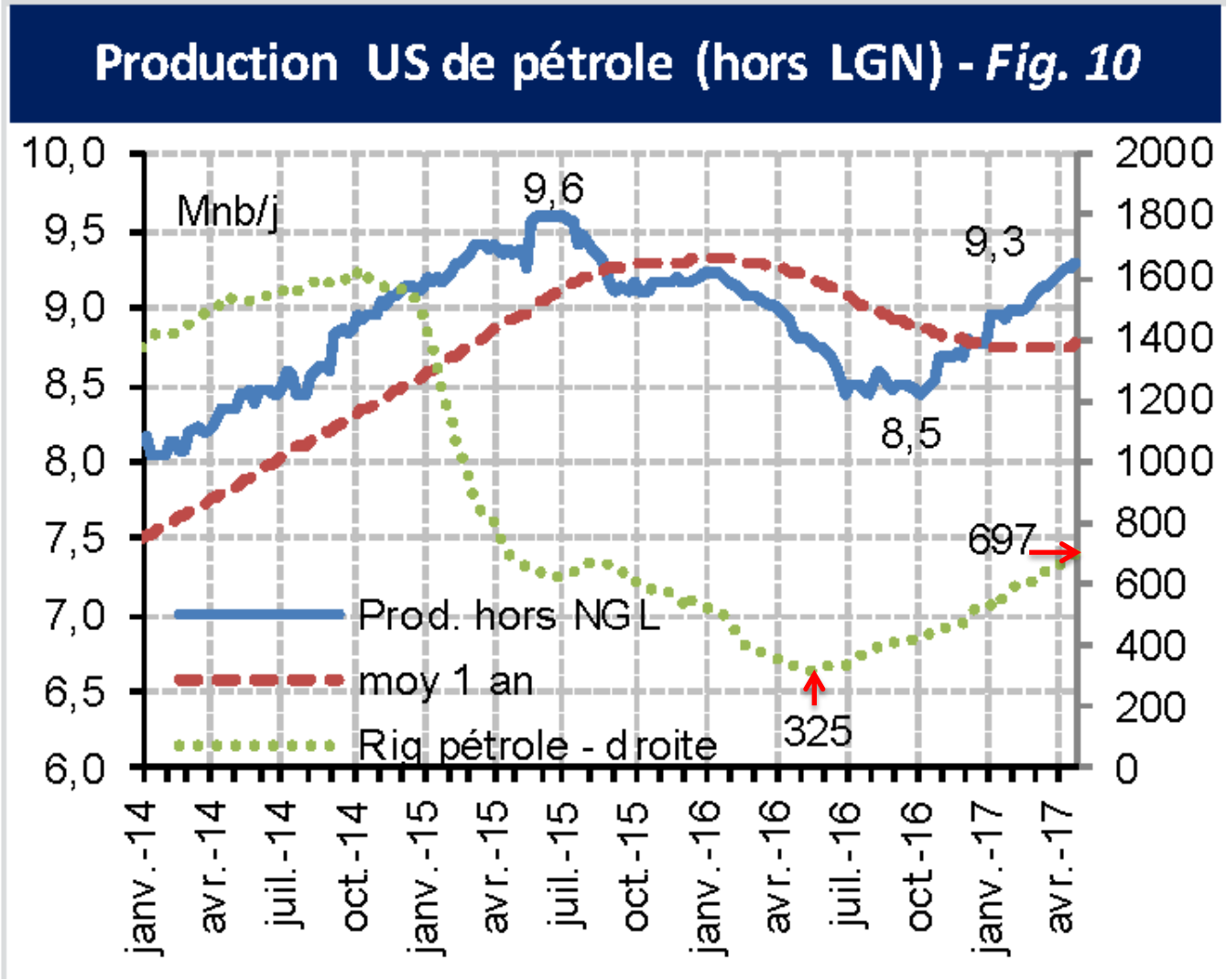
ACTIVE DRILLING RIGS IN THE US 2002 – 2012 … (SEE NEXT SLIDE FOR 2013-2015)



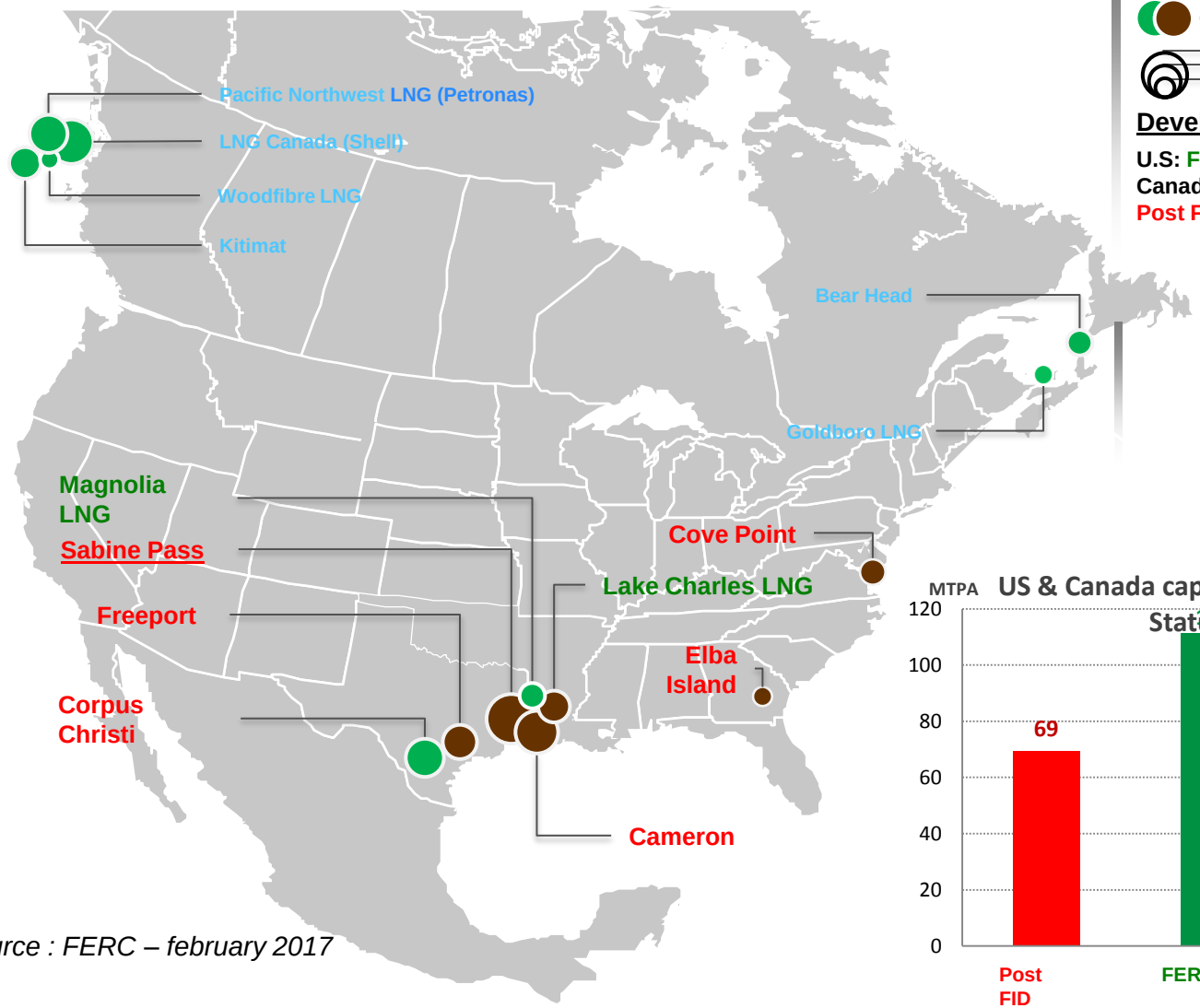
- **Decrease of shale gas wells in 2012 due to the plunge in gas price, while oil wells increased significantly thanks to robust oil price.**

Source: IEA WEO 2012

TOTAL US OIL RIG COUNT VERSUS US CRUDE OIL PRODUCTION (JANUARY 2014 TO APRIL 2017)

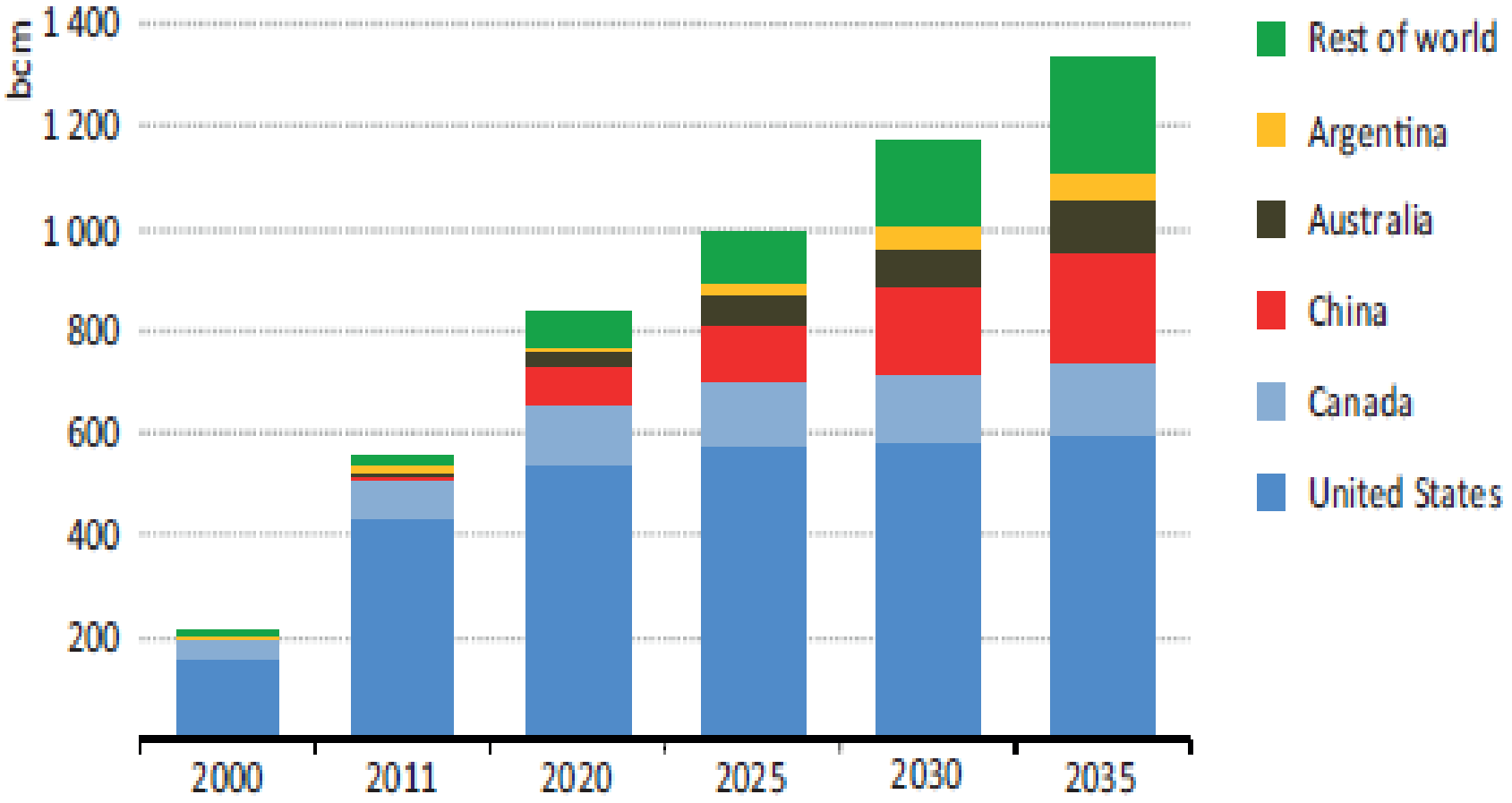


NORTH AMERICA LNG INDUSTRY WILL PLAY A MAJOR ROLE, NOT ONLY BECAUSE OF IT'S POTENTIAL CAPACITIES BUT ALSO AS A « PRICE MAKER » FOR THE WORLD LNG INDUSTRY



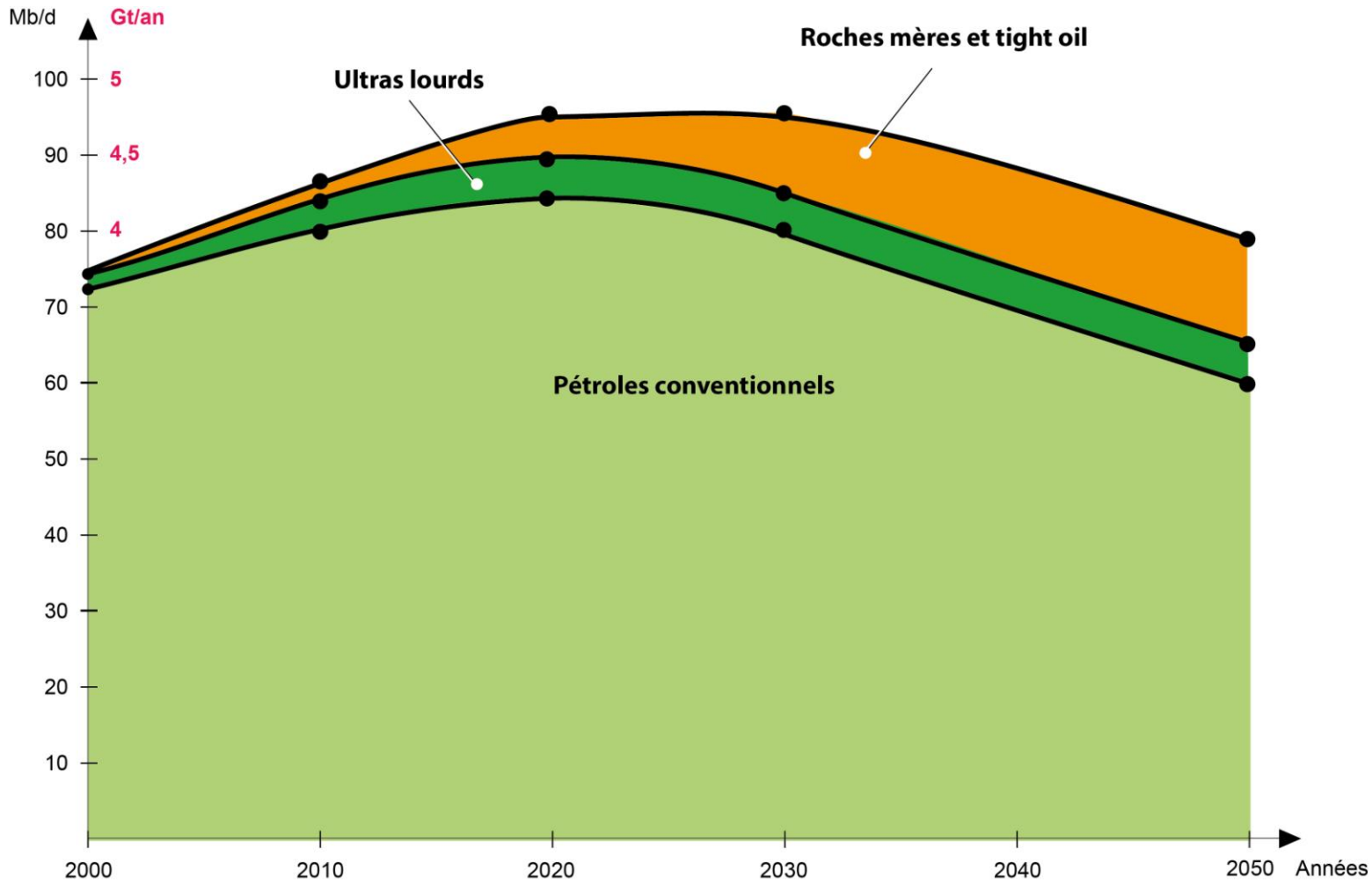
Source : FERC – february 2017

UNCONVENTIONAL GAS PRODUCTION BY SELECTED COUNTRIES (TIGHT GAS + SHALE GAS + CBM)



Source: IEA WEO 2013

A VISION FROM THE AUTHORS (PR BAUQUIS – A PERRODON) OF WORLD NATURAL HYDROCARBON LIQUIDS 2015 - 2050

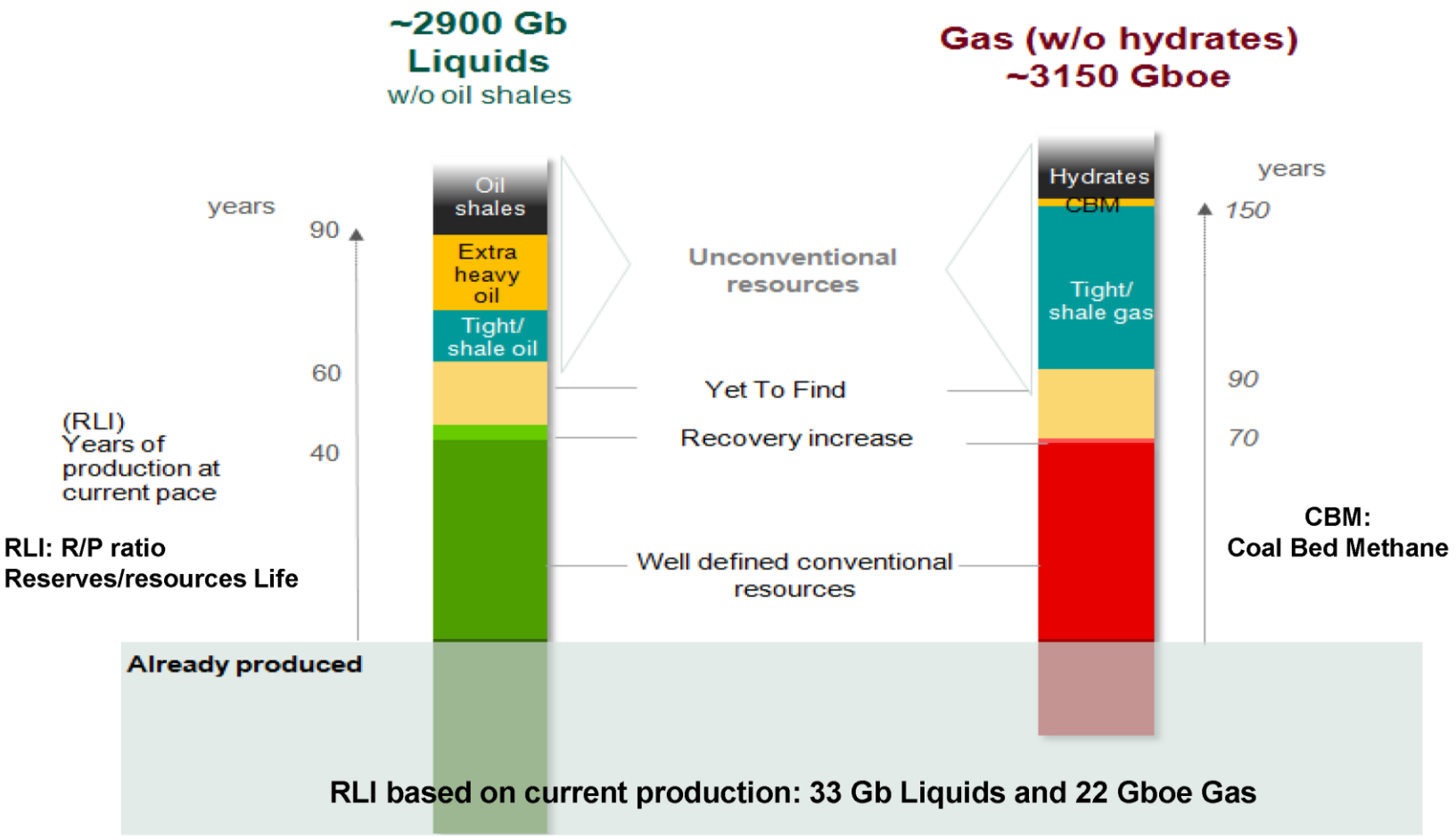


Source Alain PERRODON & PR BAUQUIS – 20 Novembre 2015

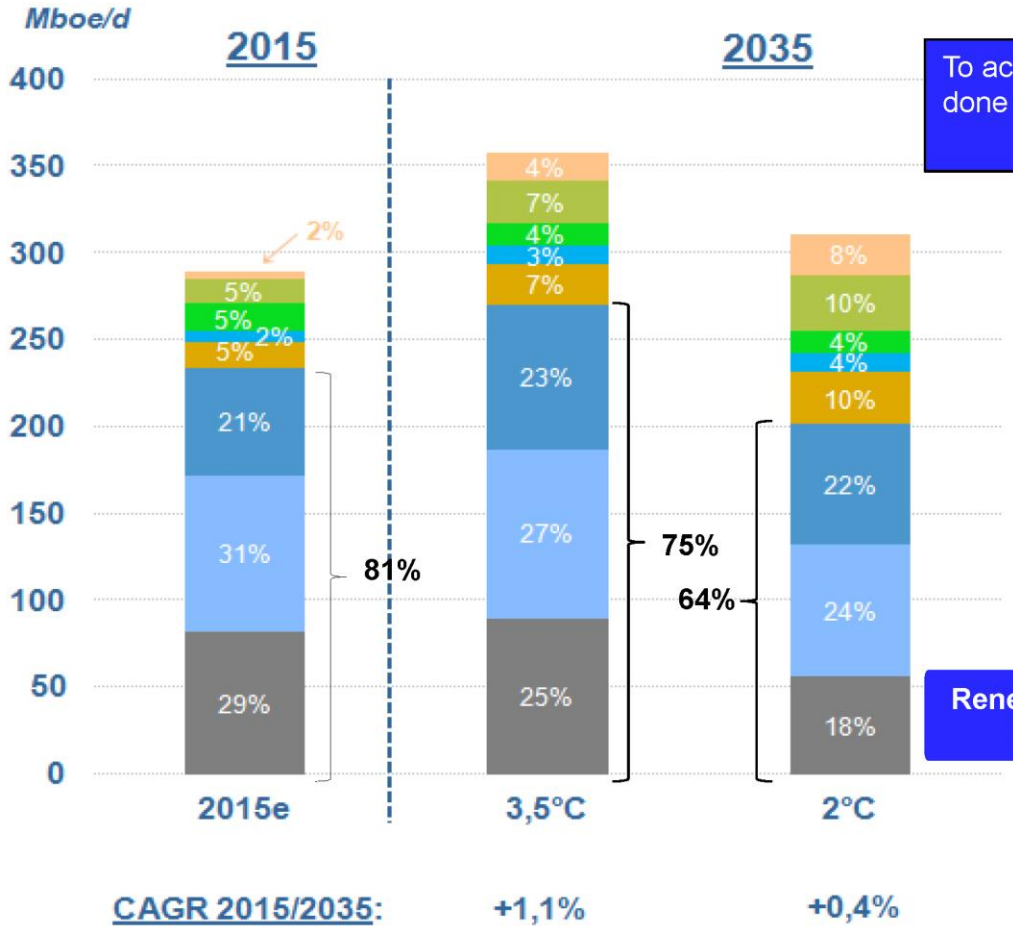
PART TWO

OIL AND GAS RESERVES: THE CLIMATE CHANGE DILEMMA

WORLD OIL & GAS RESOURCES AT 01/01/2016



FOSSIL ENERGIES WILL CONTINUE TO PLAY AN IMPORTANT ROLE IN THE ENERGY MIX BY 2035



To achieve the 2°C target, substantial efforts must be done on energy efficiency and energy intensity.

- Solar, wind and other renewables
- Modern biomass
- Traditional biomass
- Hydropower
- Nuclear
- Gas
- Oil
- Coal

Renewable energies are promised to a bright future but substitution of fossil fuels will be slow

Mboe/d	2015e	2035	
		3,5°C	2°C
Oil	89	97	76
Gas	62	83	70

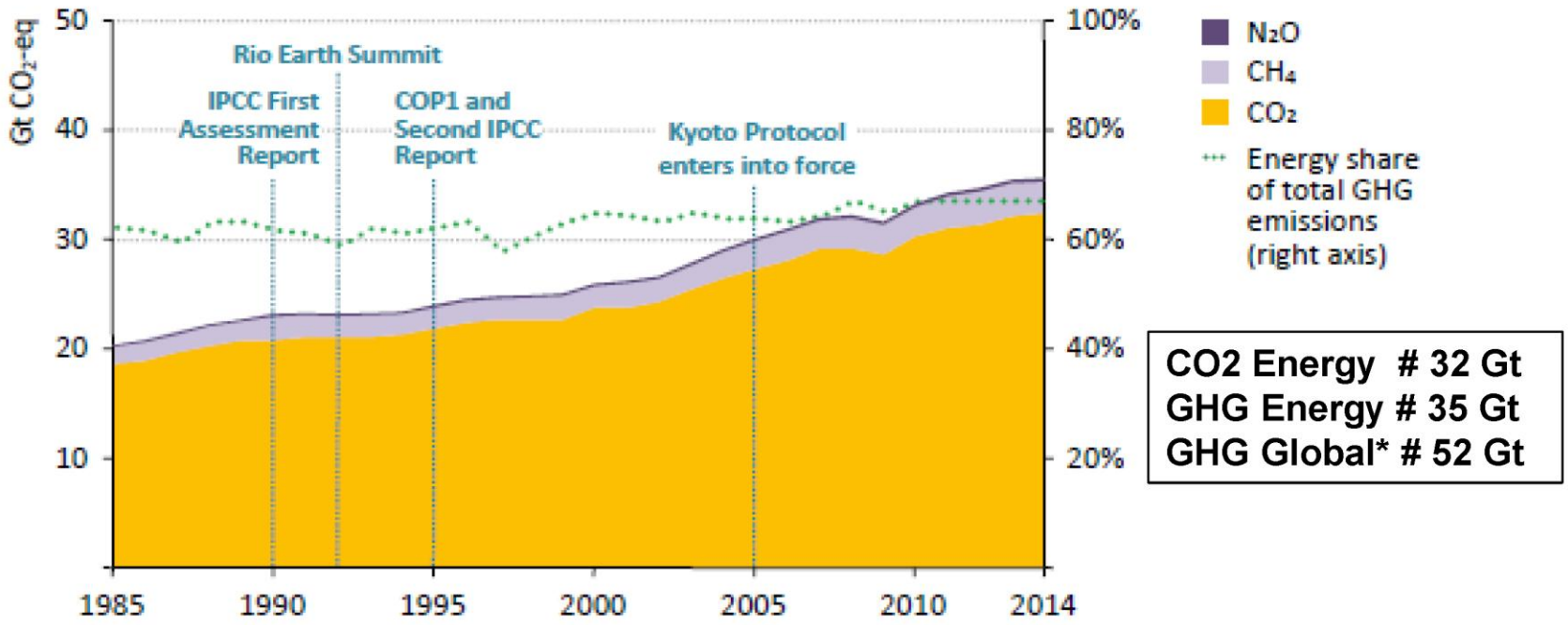
Source: Total 2016

Year 2014

Fossil Energy Demand/Production = 11 Gtoe
Hydrocarbons Demand/Production = 7 Gtoe
CO2 Emissions = 32 GtCO2

 # 2,9 tCO2/toe Fossil

GLOBAL ANTHROPOGENIC ENERGY-RELATED GHG CO2 ENERGY IS THE MOSTE IMPORTANT CONTRIBUTOR



CO2 Energy # 32 Gt
GHG Energy # 35 Gt
GHG Global* # 52 Gt

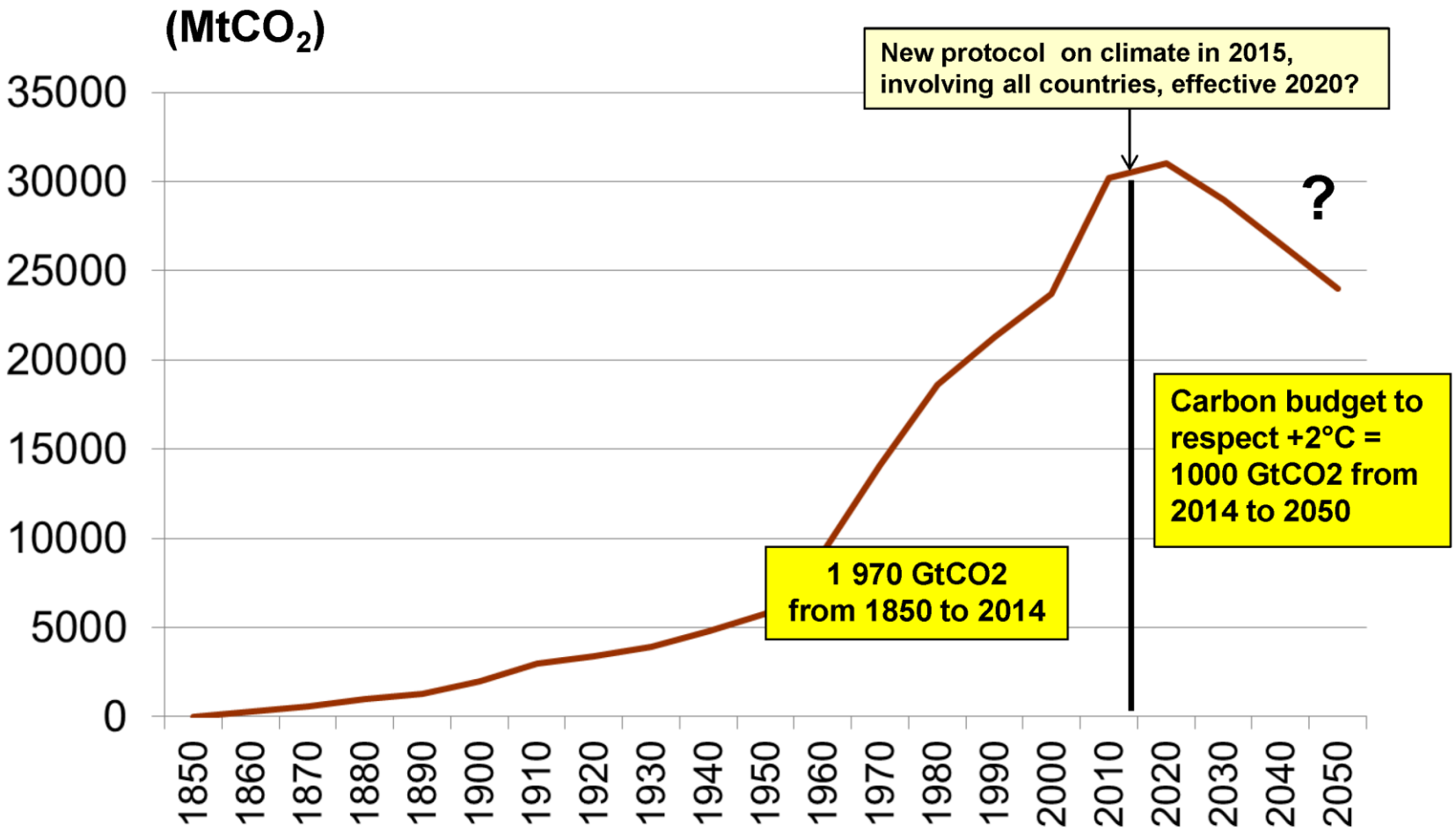
Notes: CO_2 = carbon dioxide, CH_4 = methane, N_2O = nitrous oxide. CH_4 has a global warming potential of 28 to 30 times that of CO_2, while the global warming potential of N_2O is 265 higher than that of CO_2.

Sources: IEA and EC/PBL (2014).

Source: IEA 2015 Energy & Climate Change
*** Including CH4 non energy and FOLU (Forest and Other Land Use**

Consistency with the 2° C objective Carbon Budget?

CO_2 ENERGY BUDGET: NEED TO REVERSE THE TREND

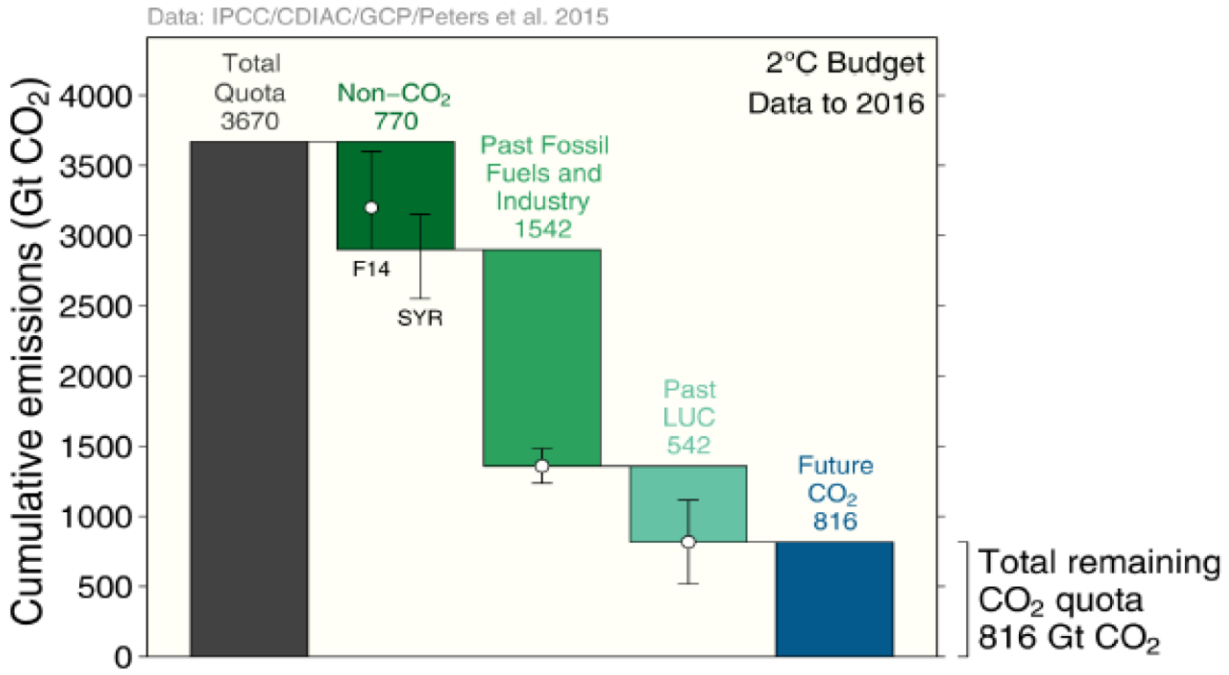


REMAINING CARBON BUDGET AS FROM 2017: # 820 GtCO2

GLOBAL CARBON PROJECT

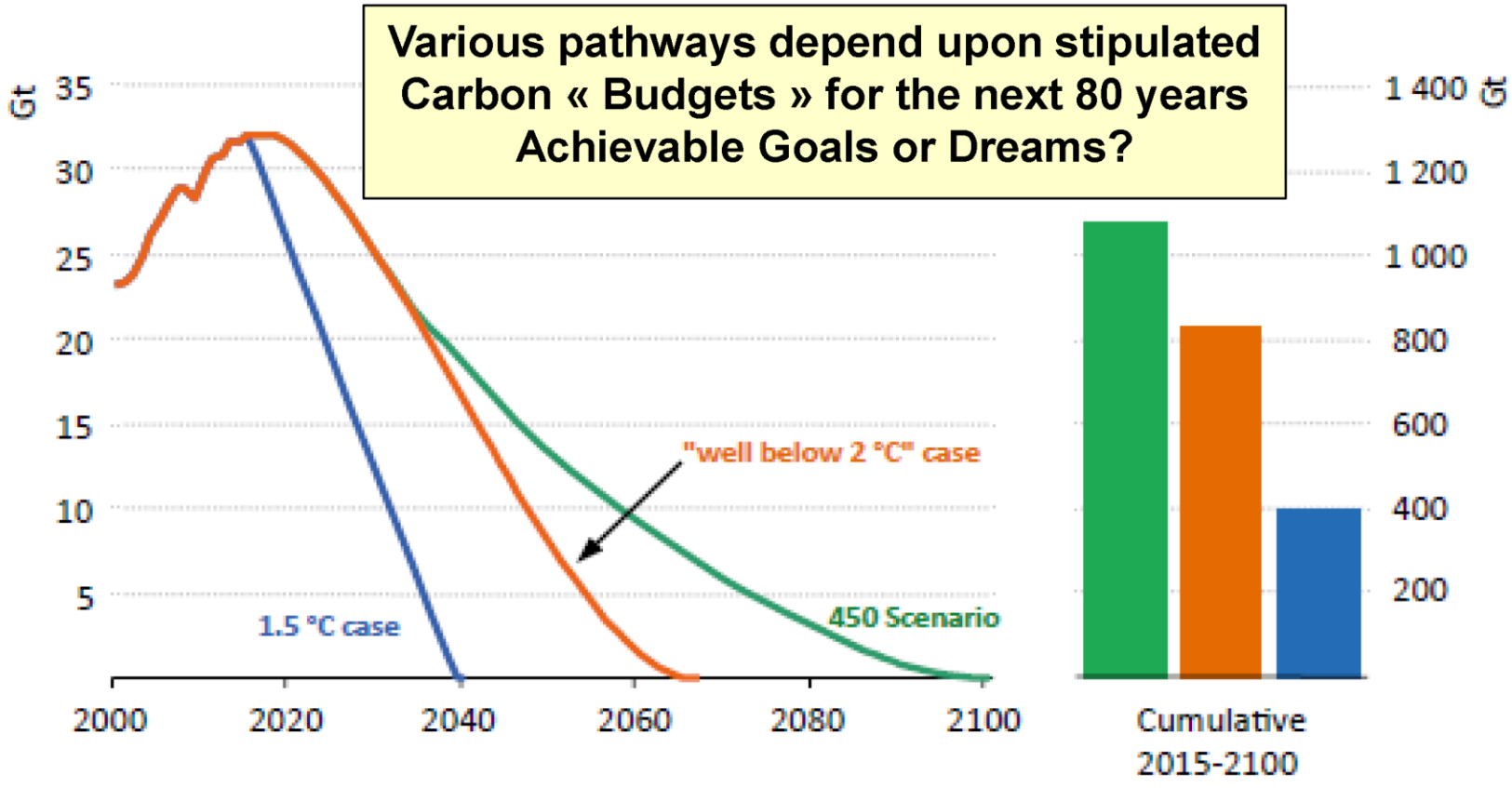
Carbon quota for a 66% chance to keep below 2°C

The total remaining emissions from 2017 to keep global average temperature below 2°C ($800GtCO_2$) will be used in around 20 years at current emission rates



Source: Global Carbon Project 2016

PATHWAY TO GET 1.5°C INSTEAD OF 2.0°C (IEA WEO 2016)



Without net-negative emissions, energy sector CO_2 emissions fall to zero by 2040 for a 50% chance of 1.5 °C and around 2060 for a 66% chance of 2 °C

Source: IEA WEO 2016

→ « Budget » Fossil Energy Production:

1 000 GtCO2 / 2,9 toe = 345 Gtoe

→

345 Gtoe/11 Gtoe = 31 years of production Fossil

« Budget » Hydrocarbons Production, assuming Coal is completely stopped as from to-morrow and fully replaced by Natural Gas:

1 000 GtCO2 / 2,6 toe = 385 Gtoe

385 Gtoe/11 Gtoe = 35 years of production HC

INTERPOLATION OF THE 2°C SCENARIO FOR 2035 UNTIL YEAR 2100: UNDER THIS ASSUMPTION, CARBON BUDGET OF 1000 GtCO2 CAN'T BE MATCHED! (UNLESS CCS WOULD BE MASSIVELY DEVELOPPED!

Energy	Production	Production	Production	Production	Production	Production	CO2 Emissions	Net CO2 Emiss.
	2015	2035	2055	2075	2095	2015-2095	2015-2095	2015-2095
	(Gtoe)	(Gtoe)	(Gtoe)	(Gtoe)	(Gtoe)	(Gtoe)	(GtCO2)	(GtCO2)
Oil	4,3	3,6	2,9	2,2	1,5	229	644	322
Gas	2,9	3,3	3,7	4,1	4,5	521	1305	652
Coal	4,1	2,7	1,3	0,0	0,0	121	404	202
Total	11,3	9,6	7,9	6,3	6,0	871	2353	1176

Nota: Net emissions assume 50% Absorption by oceans and biosphere

CONCLUSION 1: IS THERE A CHANCE TO FACE THE CLIMATE CHANGE DILEMMA?

- **Only if political leaders become convinced that GHG emissions must be drastically reduced…**
- **COP21 was a major breakthrough but President Trump was a major « breakdown » not just for the USA but for the world.**
- **All countries should enforce their COP21 « committments » and agree by early 2020's,even more drastic GHG emissions reductions.**
- **Coal consumption must be reduced as fast as possible and totally replaced for electrical power generation (renewables, nuclear and gas).**
- **Oil and gas consumptions reductions will require a world wide agreement on CO2 emission pricing at a high level (50 to 100 $/tonne).**

CONCLUSION 2: IS THERE A CHANCE TO FACE THE CLIMATE CHANGE DILEMMA?

- After 30 years of « procrastination » it is necessary to clarify wether CCS could be massively developped or not. Most actors pretend that the answer is positive (because they consider that a massive use of CCS is necessary).

- However massive development of CCS is probably unrealistic for three categories of factors: availibility of storage volumes, risk of storage leaks after one or two centuries, and economics.

- Without massive CCS, the only remaining possibility is a combination of energy consumptions reductions with the massive development of renewable energies (and associated power storage) and of nuclear.

- It will be necessary to accept nuclear risks (which can be reduced but not totally eliminated) which are a lesser danger for mankind than climate change above 2°C.

CONCLUSION 3: IS THERE A CHANCE TO FACE THE CLIMATE CHANGE DILEMMA?

- **Consequences for oil and gas exploration and production are not yet clear. Simple « reserves maths » conclude that we already have too much reserves and should therefore stop exploring for more.**

- **These calculations are basically wrong: we have too much high cost or high GHG emissions type of reserves (or even political reserves) but not enough low cost / low emission reserves.**

- **However a « tipping point » could occur around 2050 for oil exploration and around 2080 for gas exploration. This could constitute a revolution for the oil&gas industry.**

- **Oil and gas companies have the financing, technological ressources, and human ressources to become major actors of an energy transition towards a non carbon electricity world. Only a few of them will succeed.**


(သင့်ကို) ကျေးဇူးတင်ပါတယ
Bedankt
Terima Kasih
gracias
Thank you
谢 谢
Cám ơn
شکرا
спасибо
merci
grazie
Obrigado
ขอบคุณมาก
Tusen takk