Global balance sheet of the

Resources Shale Gas in the world

18-21 February 2013

The Windstor Atlantica Hotel

S, chelbeb
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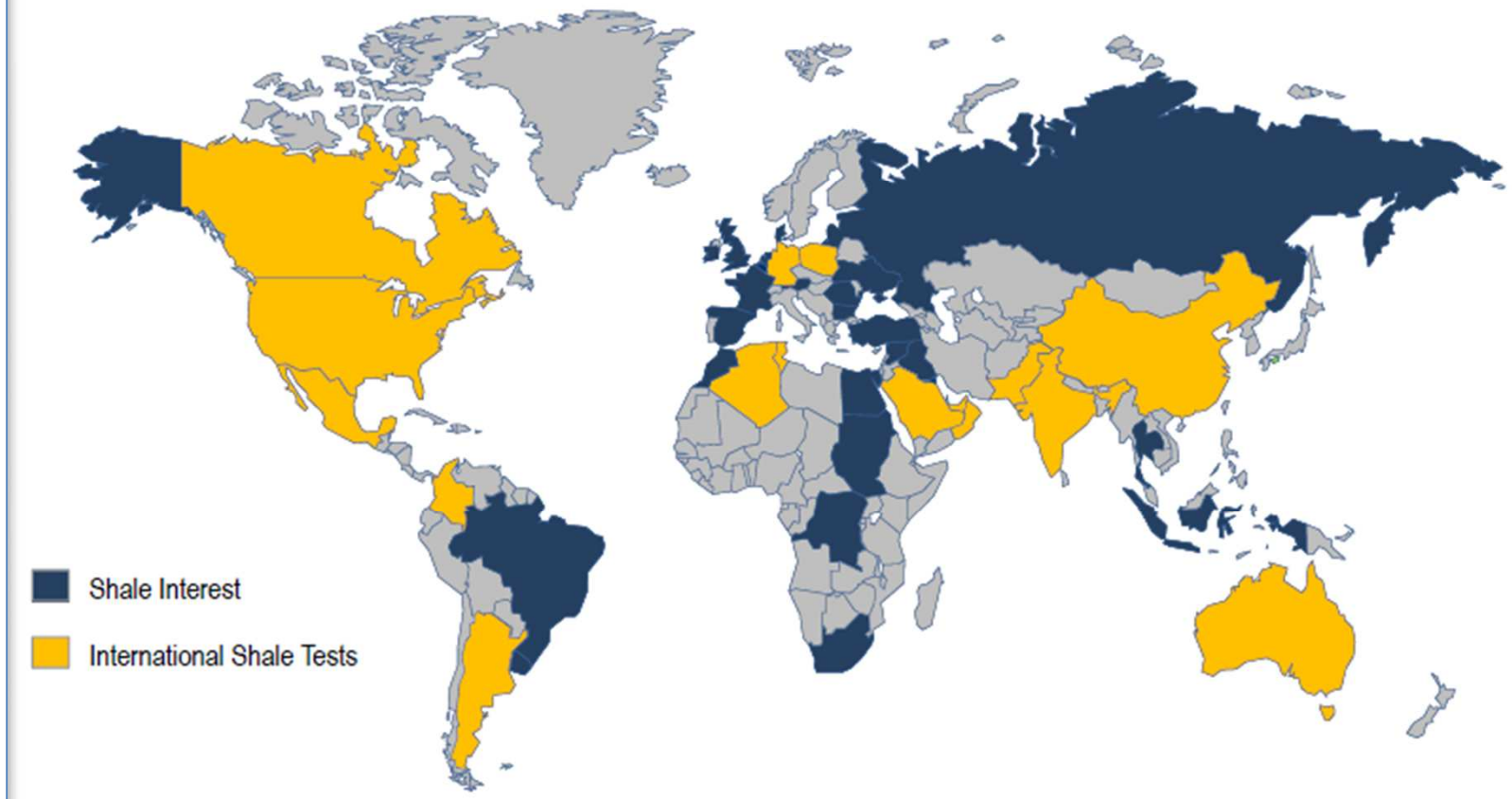
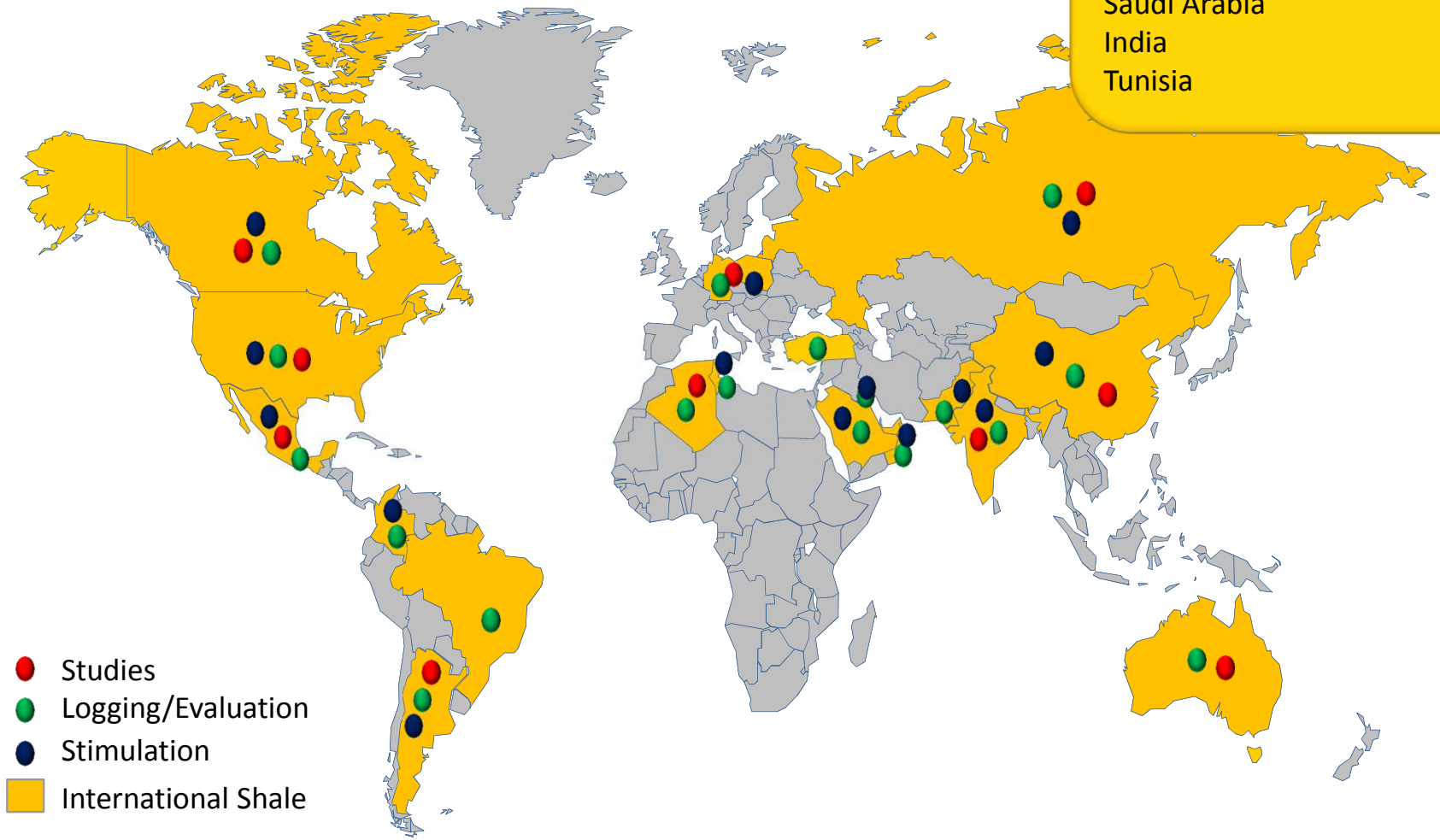
Introduction

Interest Is Increasing Daily



Shale Gas World Interest

Fracture Stimulation
Argentina
Mexico
Poland
China
Saudi Arabia
India
Tunisia



Slb,2012

Definition

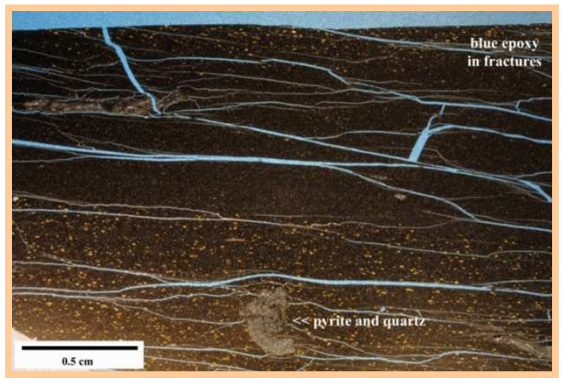
Shale gas refers to natural gas (mainly methane) found in fine-grained, organic-rich rocks (Gas Shales).
http://www.ags.gov.ab.ca/energy/shale-gas/index.html

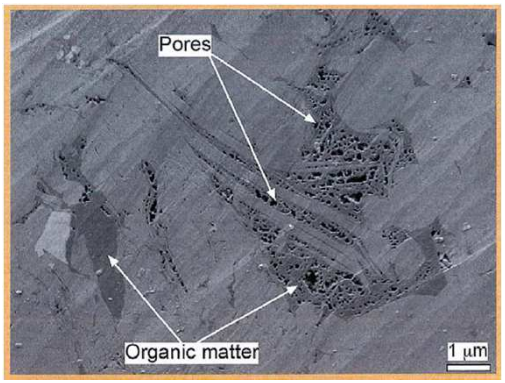
Shale gas refers to natural gas that is trapped within shale formations. Shales are fine-grained sedimentary rocks that can be rich sources of petroleum and natural gas.
http://www.eia.gov/energy_in_brief/article/about_shale_gas.cfm

Shale gas is produced from organic-rich mudrocks, which serve as a source, trap, and reservoir for the gas Guidelines for Application of the Petroleum Resources Management System, (SPE, AAPG, WPC, SPEE & SEG, September 2011.

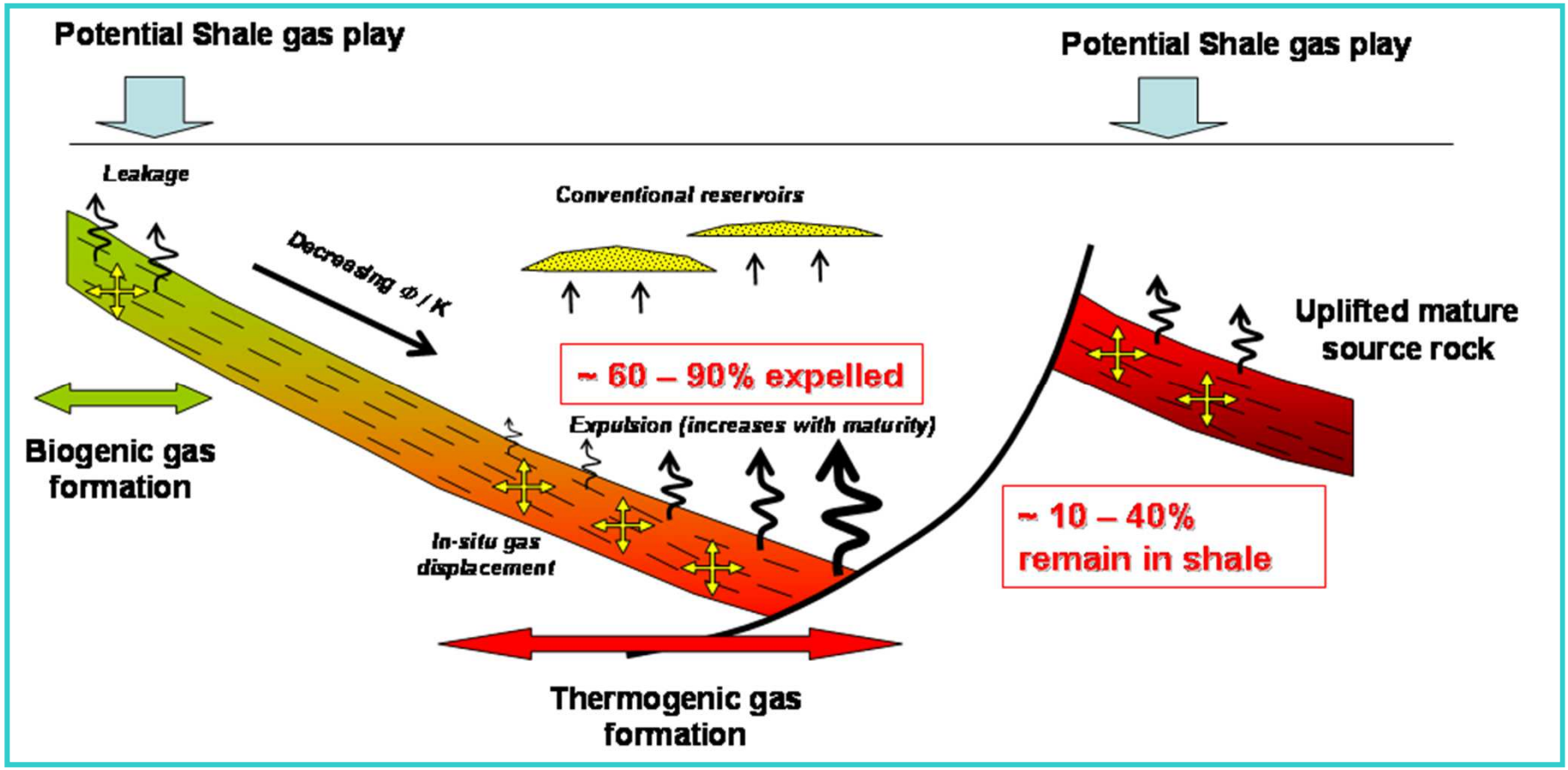
Shale gas – is gas trapped in fine grained sedimentary rock called shale which has a characteristic 'flaky' quality.
Christopher McGlade & all, A review of regional and global estimates of unconventional gas resources, A report to the Energy Security Unit of the Joint Research Centre of the European commission, September 2012

Shale gas refers to natural gas (mainly methane) found in fine-grained sedimentary rocks, organic-rich rocks (Gas Shales) which serve as a source, trap, and reservoir for the gas and has a characteristic 'flaky' quality





Plays de Shale gas =
Gaz résiduel restant dans les roches mères



Main characteristics

Critical Parameters to be commercial (example: U.S. shale Gas):

Source: Halliburton, 6november 2012, developing Algeria's Shale Gas

Gas content:	>100scf/ton (2.8m3/ton)
Thermal Maturity (Ro) :	0.7 to 2.5+range ; 1.2 typical
Permeability :	greater than 100 nanodarcies
Oil saturation:	less than 5%
Porosity:	>4%
TOC:	>2%
Water Saturation :	<45%
Thick zone :	>100ft (30m)
Moderate Clay content :	<40%
Well bounded :	i.e. good frac barriers
Brittle Shale (fracability):	i.e. low poisson's & high YM

Volume uncertainties

There are multiple and substantial uncertainties in assessing the recoverable volumes of shale gas, So current resource estimates should be treated with considerable caution

- For several regions of the world there are no estimates at all
- A variety of sources
- Studies use different methodologies for the resource estimates
- Missed Countries

Source:
Unconventional Gas: Potential Energy Market Impacts in the European Union, A REPORT BY THE ENERGY SECURITY UNIT OF THE EUROPEAN COMMISSION'S JOINT RESEARCH CENTRE, 2012

Eia, avril 2011, World Shale Gas Resources:, An Initial Assessment of 14 Regions, Outside the United States

For several regions of the world there are no estimates at all

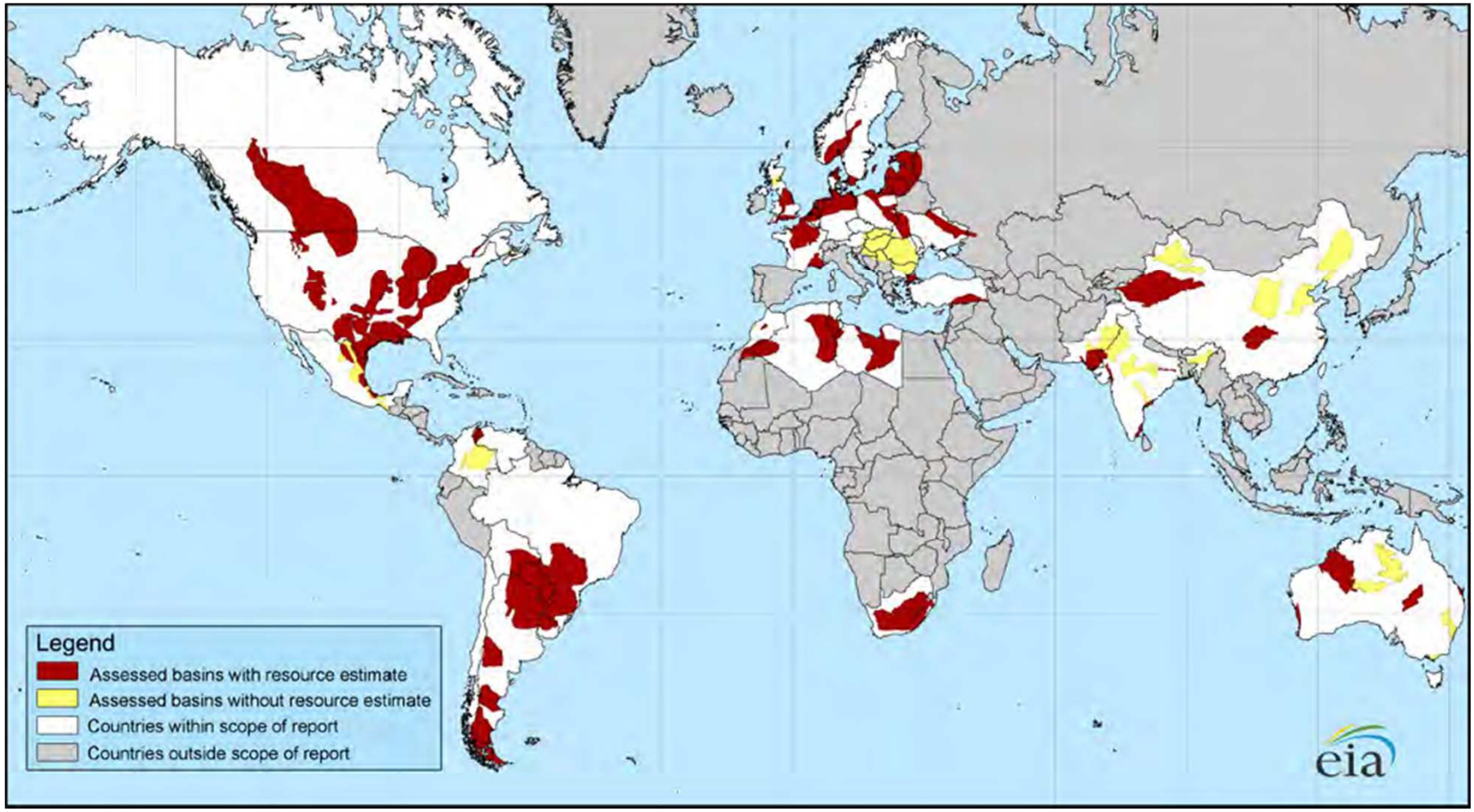


Figure 1. Map of 48 major shale gas basins in 32 countries

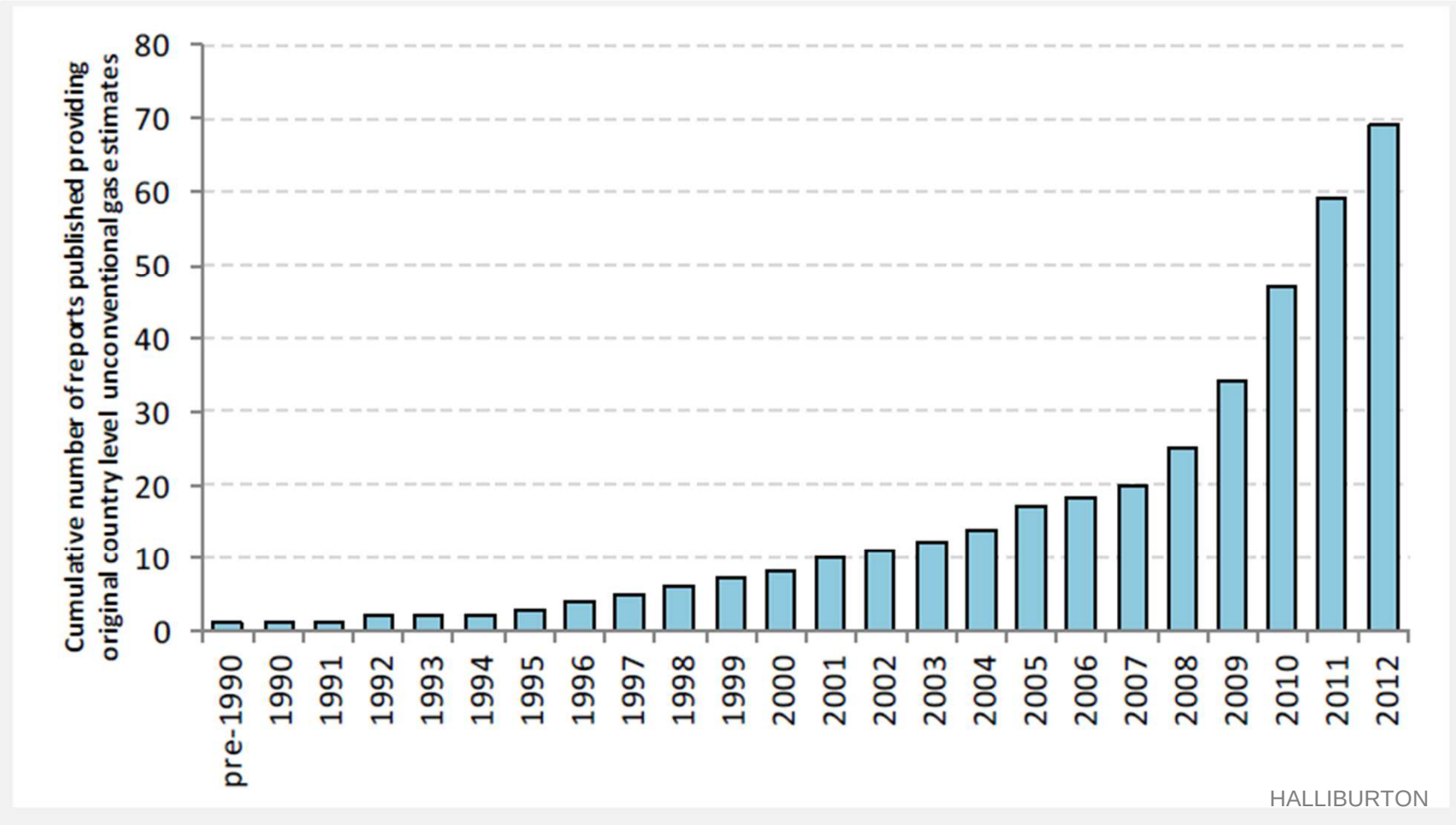
A variety of sources

Around 40 sources provide original country or regional-level estimates of shale gas resources

Author/organisation	Date of report	Countries/regions covered	Resource estimate
Mohr & Evans [27]	Sep-11	Continental regions	URR
USGS[1]	Aug-11	United States	'Potential additions to reserves'
Medlock *et al.* [28]	Jul-11	9 North American, European and Pacific countries	TRR[2]
INTEK (for EIA) [18]	Jul-11	United States	'Unproved, discovered TRR'[3]
ICF (Petak) [29]	May-11	United States. Canada	ERR[4]
ARI (Kuuskraa) [30]	May-11	United States	TRR
EIA (AEO) [25]	Various[5]	United States	TRR (2010 – 1999) ERR (1998 & 1997)
Potential Gas Committee [31]	Apr-11	United States	TRR
ARI (for EIA) [32]	Apr-11	32 individual countries	OGIP and TRR
ICF (Henning) [33]	Mar-11	United States, Canada	ERR[4]
ARI (Kuuskraa) [34]	Jan-11	United States	TRR
Caineng *et al.* [35]	Dec-10	China	OGIP
Medlock & Hartley [36]	Oct-10	United States, Canada	TRR
ARI (Kuuskraa) [37]	Oct-10	United States	TRR
World Energy Council[38]	Sep-10	Nine continental regions	OGIP
Mohr & Evans [39]	Jul-10	United States, Canada	URR
MIT (Moniz) [40]	Jun-10	United States	TRR
Dawson [41]	May-10	Canada	ERR
Skipper [42]	Mar-10	United States, Canada	TRR
Hennings [43]	Mar-10	United States	OGIP and TRR
ARI (Kuuskraa) [44]	Mar-10	United States, Canada	TRR
Petrel Robertson Consulting [45]	Mar-10	Canada	OGIP
IHS CERA (Downey) [46]	Jan-10	United States, Canada	TRR
DECC (Harvey and Gray) [47]	Jan-10	UK	TRR
ARI (Kuuskraa) [48]	Dec-09	United States, Canada, Poland, Sweden, Austria, South Africa	'Recoverable resources'
Potential Gas Committee [49]	Jun-09	United States	TRR
Theal [50]	May-09	United States, Canada	OGIP and TRR
ICF (reported by [8])	Mar-09	United States	ERR[4]
IHS CERA [51]	Feb-09	Europe	TRR
Wood Mackenzie [52]	Jan-09	Europe	TRR
ICF (Vidas & Hugman) [53]	Nov-08	United States, Canada	OGIP and TRR
Navigant Consulting [54]	Jul-08	United States	TRR
ARI (Kuuskraa) [55]	Jul-07	United States	URR
Sandrea [56]	Dec-05	United States, Global	'Recoverable reserves'
Laherrere [57]	Jun-04	Global	URR
Kuuskraa [58]	Jan-04	United States	TRR and URR
Rogner [59]	Jan-97	Continental regions	OGIP
Kuuskraa & Meyers [60]	Jan-83	United States, Canada, ROW	TRR

Table 2-2: Shale gas reports providing original country level estimates by date, countries or regions covered and type of resource estimate, UK ERC, 2012

Unconventional Gas Estimation Reports



Studies use different methodologies for the resource estimates

- use of the terms '**discovered**' and '**undiscovere**d'.

- URR: The ultimately recoverable resource of a field or region is the sum of all gas that is expected to be recovered from that field or region over all time.

- EUR: is the 'Estimated Ultimate Recovery' (EUR) from an individual well. EUR is essentially identical to URR,

- TRR: technically recoverable resources is the fraction of the gas in place that is estimated to be recoverable only with current technology.

- RTRR: remaining technically recoverable resources

however ambiguity remains over whether sources include undiscovered volumes of gas from their definitions, and what they mean by the term 'undiscovered' when its included

Confusion can occur over whether these recoverable resources should be interpreted as the ultimately recoverable or the technically recoverable.

Others examples of ressources incertainties

Example: Even in areas where production is currently taking place

In the USA, the high/best/low TRR estimates are 47/20/13 Tcm:
the high and low estimates are 230% and 64% of the best
In China the high/best/low TRR estimates are 40/21/1.6 Tcm,
the high and low estimates are 190% and 7% of the best

Others concern: Measurement of natural gas volumes

It is also important to know the temperature and pressure at which natural gas volumes are reported. The EIA and API (the American Petroleum Institute) indicate that volumes of gas in the United States are measured at 60oF (15.56^{o}C) and 14.73 psi (1 atmosphere or 101.325kPa) . The UK's Department of Energy and Climate Change ('DECC') on the other hand indicates that European natural gas data is generally reported again at atmospheric pressure but at a slightly lower temperature of 15^{o}C. These different definitions correspond to a volumetric difference of around 4%.

Missed Countries

Natural gas — BP, 2012

Proved reserves

	At end 2011: Trillion cubic feet	Trillion cubic metres	Share of total
US	299.8	8.5	4.1%
Canada	70.0	2.0	1.0%
Mexico	12.5	0.4	0.2%
Total North America	382.3	10.8	5.2%
Argentina	12.0	0.3	0.2%
Bolivia	9.9	0.3	0.1%
Brazil	16.0	0.5	0.2%
Colombia	5.8	0.2	0.1%
√ Peru	12.5	0.4	0.2%
√ Trinidad & Tobago	14.2	0.4	0.2%
Venezuela	195.2	5.5	2.7%
Other S. & Cent. America	2.2	0.1	•
Total S. & Cent. America	267.7	7.6	3.6%
√ Azerbaijan	44.9	1.3	0.6%
Denmark	1.6	†	•
Germany	2.2	0.1	•
√ Italy	3.1	0.1	•
√ Kazakhstan	66.4	1.9	0.9%
Netherlands	38.9	1.1	0.5%
Norway	73.1	2.1	1.0%
Poland	4.3	0.1	0.1%
√ Romania	3.8	0.1	0.1%
√ Russian Federation	1575.0	44.6	21.4%
√ Turkmenistan	858.8	24.3	11.7%
Ukraine	33.0	0.9	0.4%
United Kingdom	7.1	0.2	0.1%
√ Uzbekistan	56.6	1.6	0.8%
Other Europe & Eurasia	10.0	0.3	0.1%
Total Europ			8%
Bahrain			2%
Iran			9%
Iraq			7%
Kuwait			9%
Oman			5%
Qatar			0%
Saudi Arabia			9%
Syria			1%
United Arab			9%
Yemen			2%
Other Middl			1%
Total Middle			4%
Algeria			2%
Egypt			1%
Libya			7%
Nigeria			5%
Other Africa			6%
Total Africa			0%
Australia			8%
√ Bangladesh	12.5	0.4	0.2%
√ Brunei	10.2	0.3	0.1%
China	107.7	3.1	1.5%
India	43.8	1.2	0.6%
√ Indonesia	104.7	3.0	1.4%
√ Malaysia	86.0	2.4	1.2%
√ Myanmar	7.8	0.2	0.1%
√ Pakistan	27.5	0.8	0.4%
√ Papua New Guinea	15.6	0.4	0.2%
√ Thailand	9.9	0.3	0.1%
√ Vietnam	21.8	0.6	0.3%
Other Asia Pacific	12.1	0.3	0.2%
Total Asia Pacific	592.5	16.8	8.0%
Total World	7360.9	208.4	100.0%
of which: OECD	660.2	18.7	9.0%
Non-OECD	6700.7	189.7	91.0%
European Union	64.4	1.8	0.9%
Former Soviet Union	2638.5	74.7	35.8%

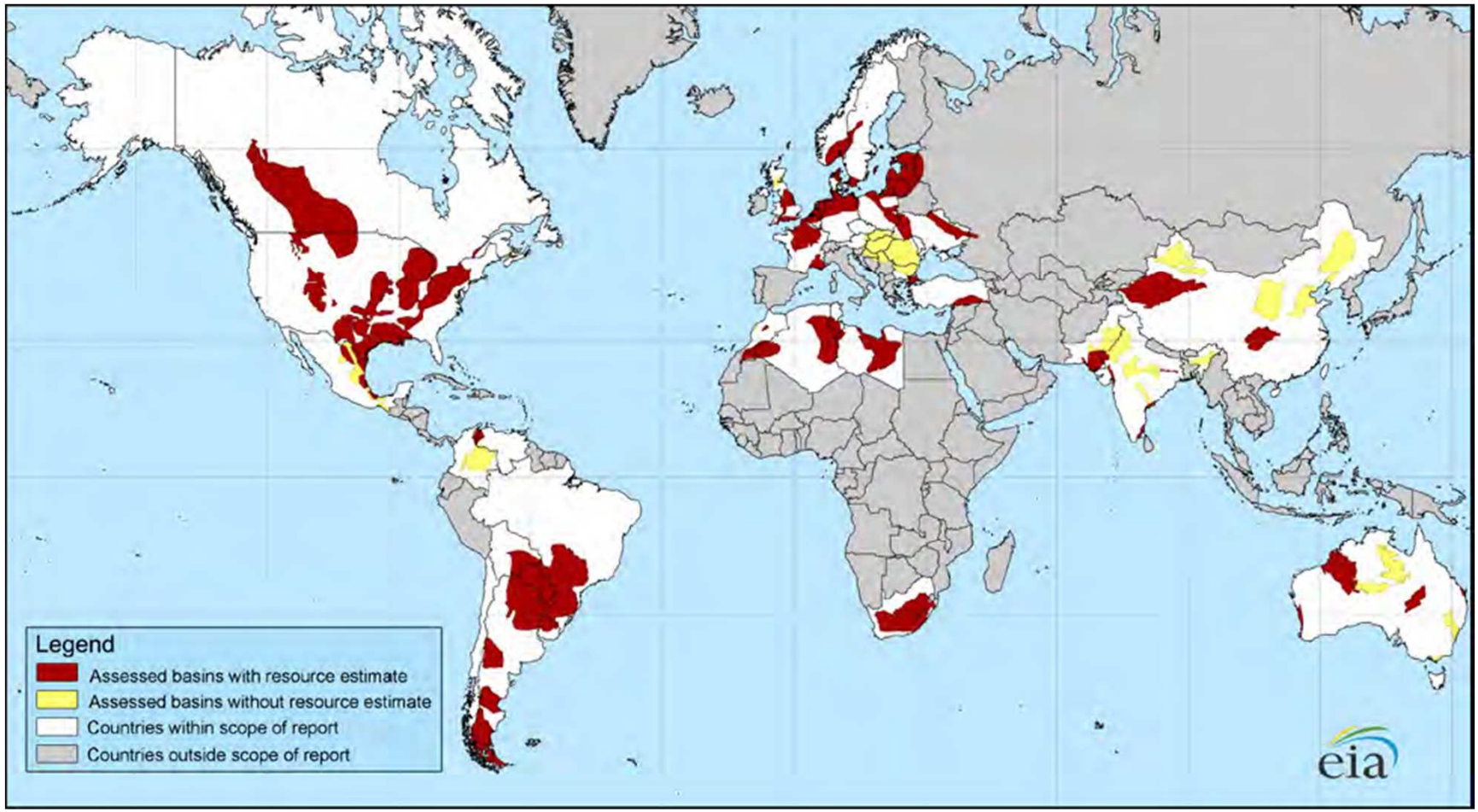
- Ignorance of regions where there are large quantities of conventional gas reserves (Russia and the Middle East)
- assess the shale gas potential in limited countries and limited shale plays

Eia, avril 2011

	2009 Natural Gas Market[1] (trillion cubic feet, dry basis): Production	Consump-tion	Imports (Exports)	Gas Reserves[2] (trillion cubic feet)	Technically Recoverable Resources (trillion cubic feet)
Europe					
√ France	0.03	1.73	98%	0.2	180
Germany	0.51	3.27	84%	6.2	8
Netherlands	2.79	1.72	(62%)	49.0	17
Norway	3.65	0.16	(2,156%)	72.0	83
U.K.	2.09	3.11	33%	9.0	20
Denmark	0.30	0.16	(91%)	2.1	23
√ Sweden	-	0.04	100%		41
Poland	0.21	0.58	64%	5.8	187
√ Turkey	0.03	1.24	98%	0.2	15
Ukraine	0.72	1.56	54%	39.0	42
√ Lithuania	-	0.10	100%		4
Others[3]	0.48	0.95	50%	2.71	19
North America					
United States[4]	20.6	22.8	10%	272.5	862
Canada	5.63	3.01	(87%)	62.0	388
Mexico	1.77	2.15	18%	12.0	681
Asia					
China	2.93	3.08	5%	107.0	1,275
India	1.43	1.87	24%	37.9	63
Pakistan	1.36	1.36	-	29.7	51
Australia	1.67	1.09	(52%)	110.0	396
Africa					
√ South Africa	0.07	0.19	63%	-	485
Libya	0.56	0.21	(165%)	54.7	290
√ Tunisia	0.13	0.17	26%	2.3	18
Algeria	2.88	1.02	(183%)	159.0	231
√ Morocco	0.00	0.02	90%	0.1	11
√ Western Sahara	-	-		-	7
√ Mauritania	-	-		1.0	0
South America					
Venezuela	0.65	0.71	9%	178.9	11
Colombia	0.37	0.31	(21%)	4.0	19
Argentina	1.46	1.52	4%	13.4	774
Brazil	0.38	0.66	45%	12.9	226
√ Chile	0.05	0.10	52%	3.5	64
√ Uruguay	-	0.00	100%		21
Paraguay	-	-			62
Bolivia	0.45	0.10	(346%)	26.5	48
Total of above areas	53.1	55.0	(3%)	1,274	6,622
Total world	106.5	106.7	0%	6,609	

World shale gas resources and reserves

. The initial estimate of technically recoverable shale gas resources in the 32 countries examined is 5,760 trillion cubic feet, as shown in Table 1. Adding the U.S. estimate of the shale gas technically recoverable resources of 862 trillion cubic feet results in a total shale resource base estimate of **6,622 trillion cubic feet** for the United States and the other 32 countries assessed.



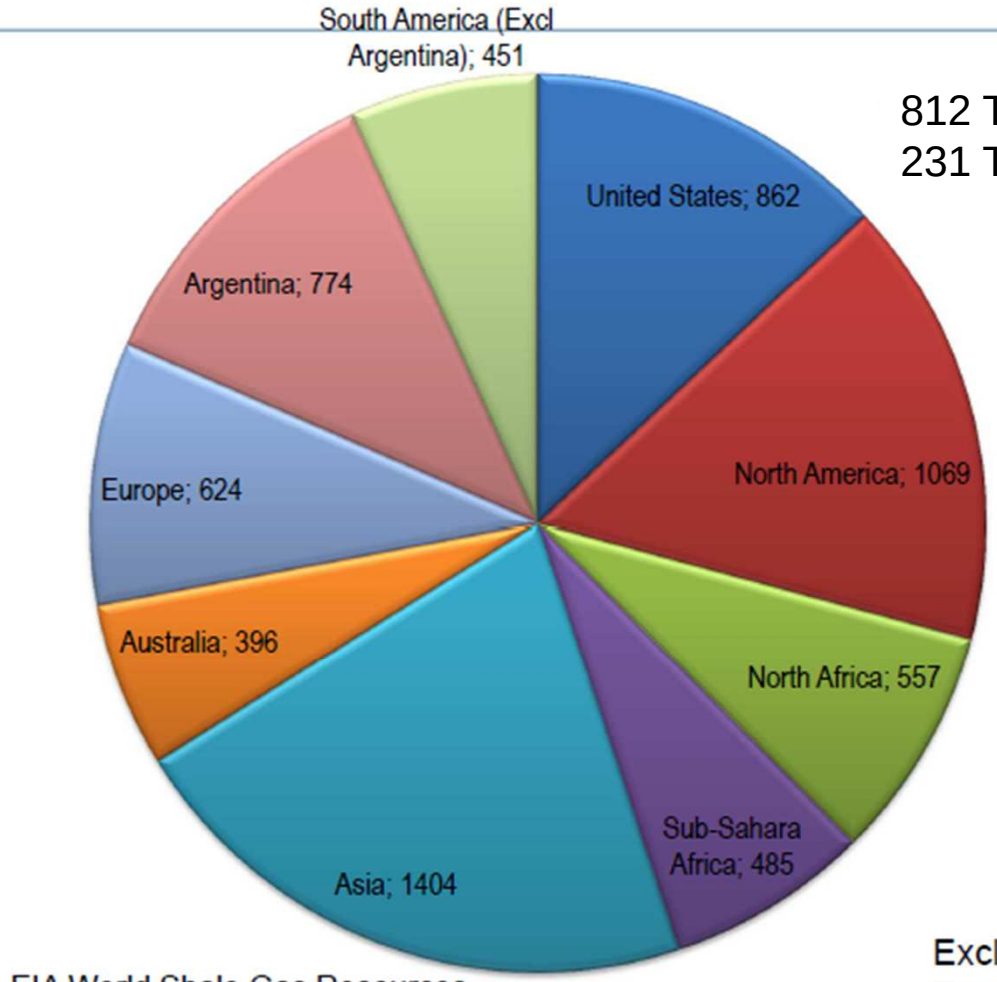
Technically Recoverable Shale Resource Estimates (TCF)

40% of world's technically recoverable gas!

Continent		Technically overable (Tcf)
North America (non U.S.)	Canada, Mexico	1,069
	U.S.	862
Total North America		1931
Africa	Morocco, Algeria, Tunisia, Libya, Mauritania, Western Sahara, South Africa	1,042
Asia	China, India, Pakistan	1,404
Australia		396
Europe	France, Germany, Netherlands, Sweden, Norway, Denmark, U.K., Poland, Lithuania, Ukraine, Turkey	624
South America	Colombia, Venezuela, Argentina, Bolivia, Brazil, Chile, Uruguay, Paraguay	1,225
Total		6,622
Total without U.S.		5,760

EIA World Shale Gas Resources

Shale Gas Technically Recoverable Resources (BCF)



EIA World Shale Gas Resources

812 TCF risked gas reserves
231 TCF TRR: 22% Africa, 3,5% total

Excludes Russia, Central Asia, Middle East, SE Asia, and Central Africa

Algeria Shale Gas

Wood McKenzie (2009) : Over 529 Tcf of gas in place (GIIP) in the hot shale of the Silurian

DeGolyer & MacNaughton (2010) : 3400 Tcf of gas in place in the hot shale of the Silurian across the whole Saharan platform from which over 600 Tcf would be technically recoverable

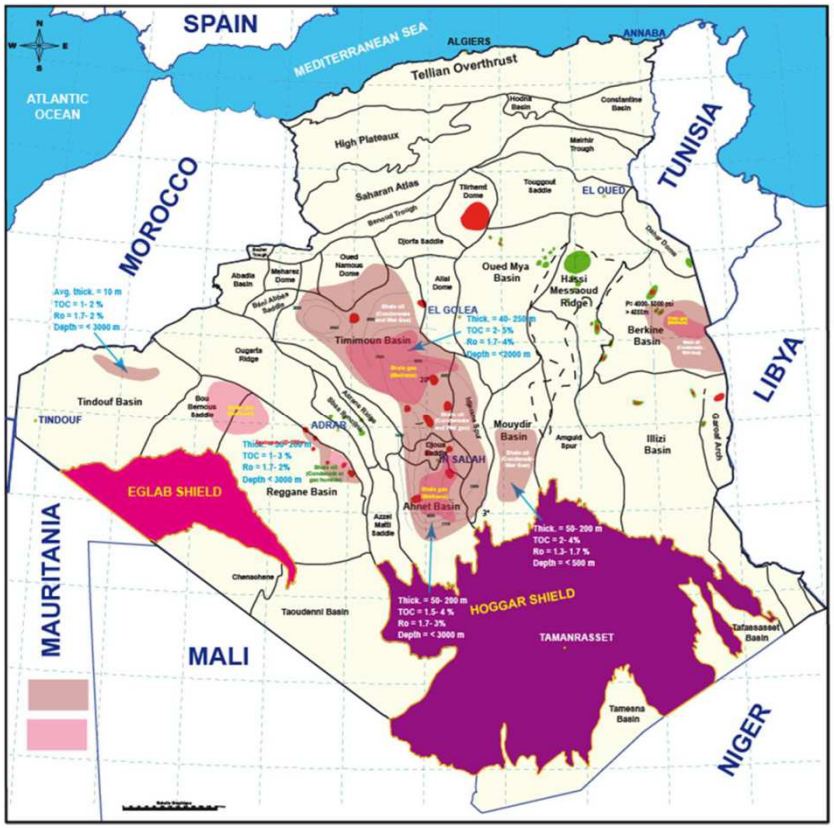
PETRENEL (2010) : 3954 Tcf of unrisked shale gas in place in the hot shale of the Silurian and Frasnian.

EIA (2011) annual report :
231 Tcf of technically recoverable gas in the hot shale of Berkine, Illizi and Tindouf basins.
(the most prospective basins such as Ahnet and Gourara are not included)

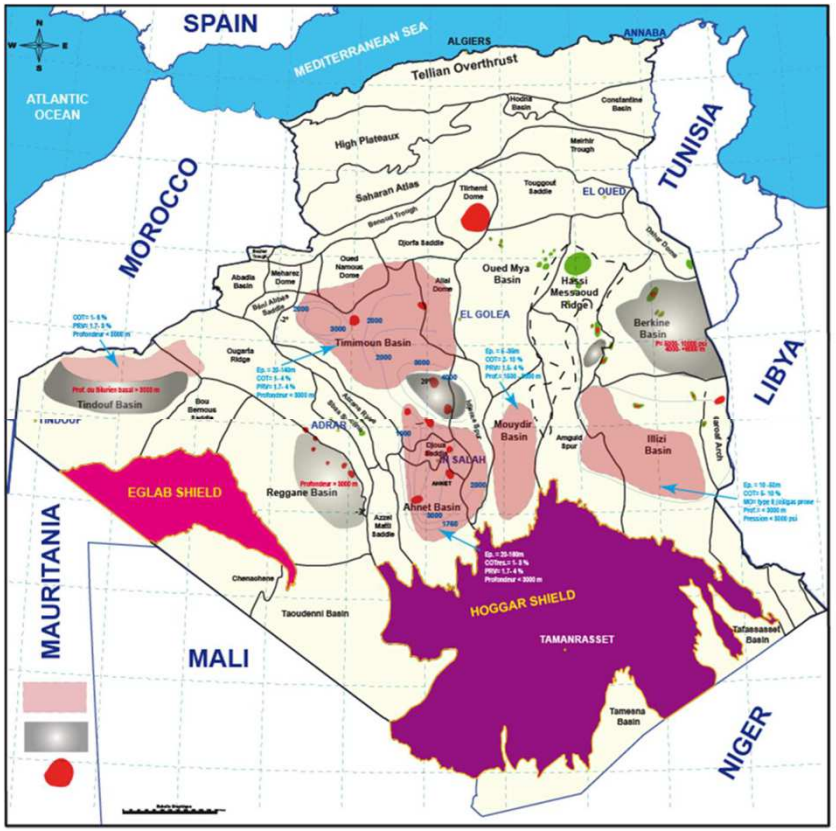
SONATRACH (2011) : 2650 Tcf de residual Gas in the source rock which represente 10% of the

Prospectivity Map of Frasnian Shale gas

Frasnian



Silurian



SELECTION PARAMETERS :

Thickness = >20m

TOC = >1%, Prefer > 3.5%

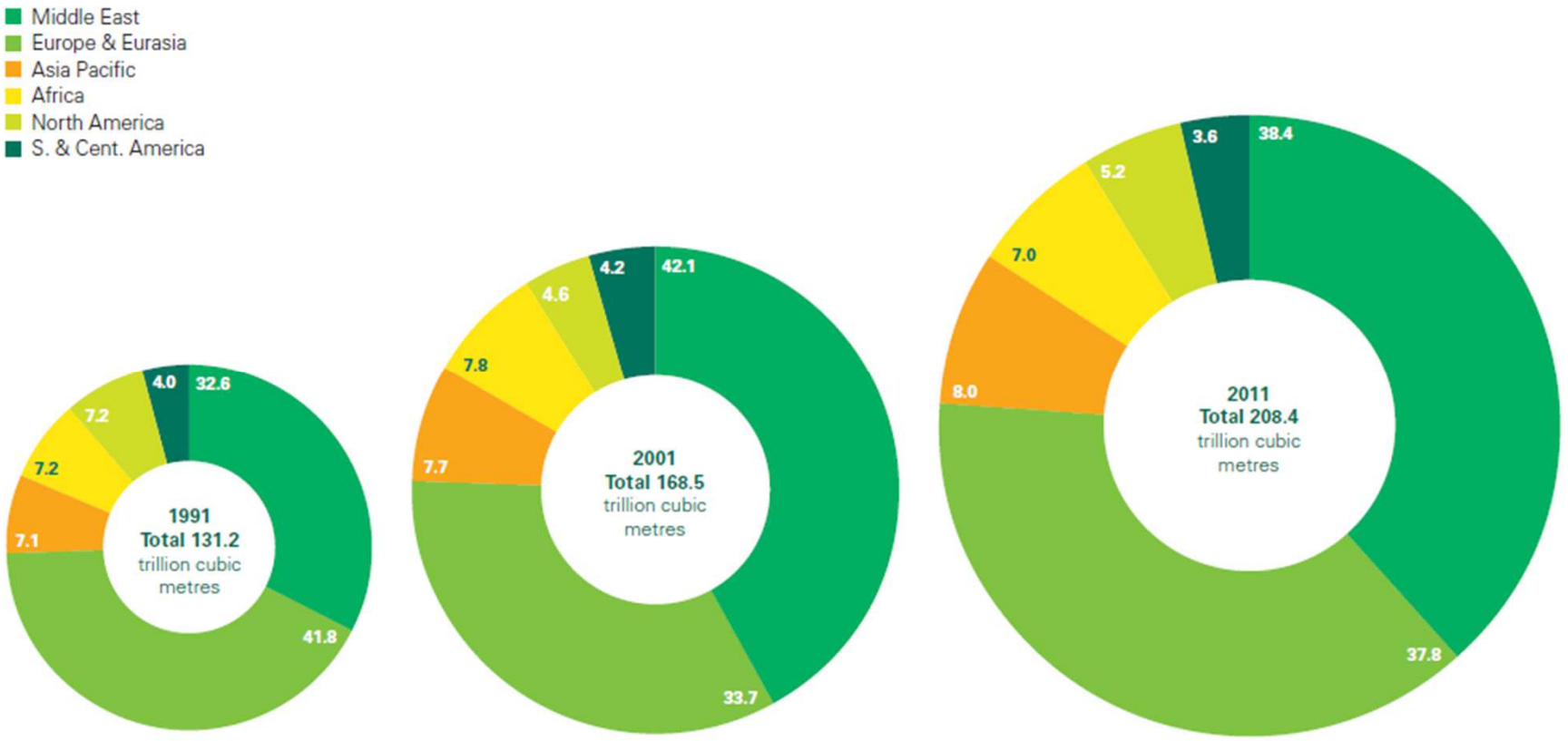
Maturity (VR) = 1.7 – 3%

Depth = < 3000 m

THANK YOU FOR YOUR ATTENTION

Back up

Distribution of proved reserves in 1991, 2001 and 2011 percentage

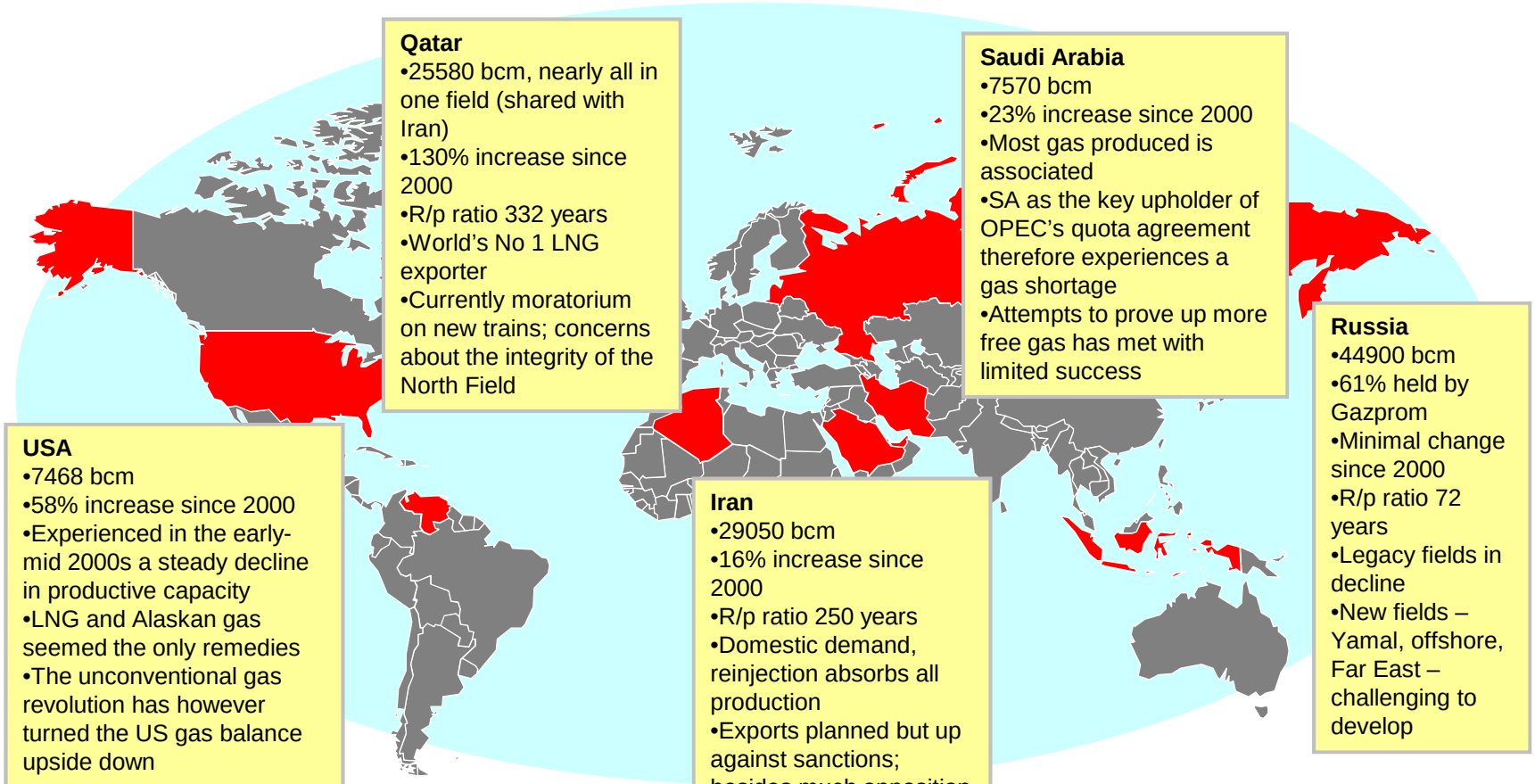


Disclaimer

The data series for proved oil and gas reserves in *BP Statistical Review of World Energy June 2012 does not necessarily meet the defi nitions*

BP Statistical Review of World Energy June 2012 (bp.com/statisticalreview)

Proven gas reserves majors



Qatar
•25580 bcm, nearly all in one field (shared with Iran)
•130% increase since 2000
•R/p ratio 332 years
•World's No 1 LNG exporter
•Currently moratorium on new trains; concerns about the integrity of the North Field

Saudi Arabia
•7570 bcm
•23% increase since 2000
•Most gas produced is associated
•SA as the key upholder of OPEC's quota agreement therefore experiences a gas shortage
•Attempts to prove up more free gas has met with limited success

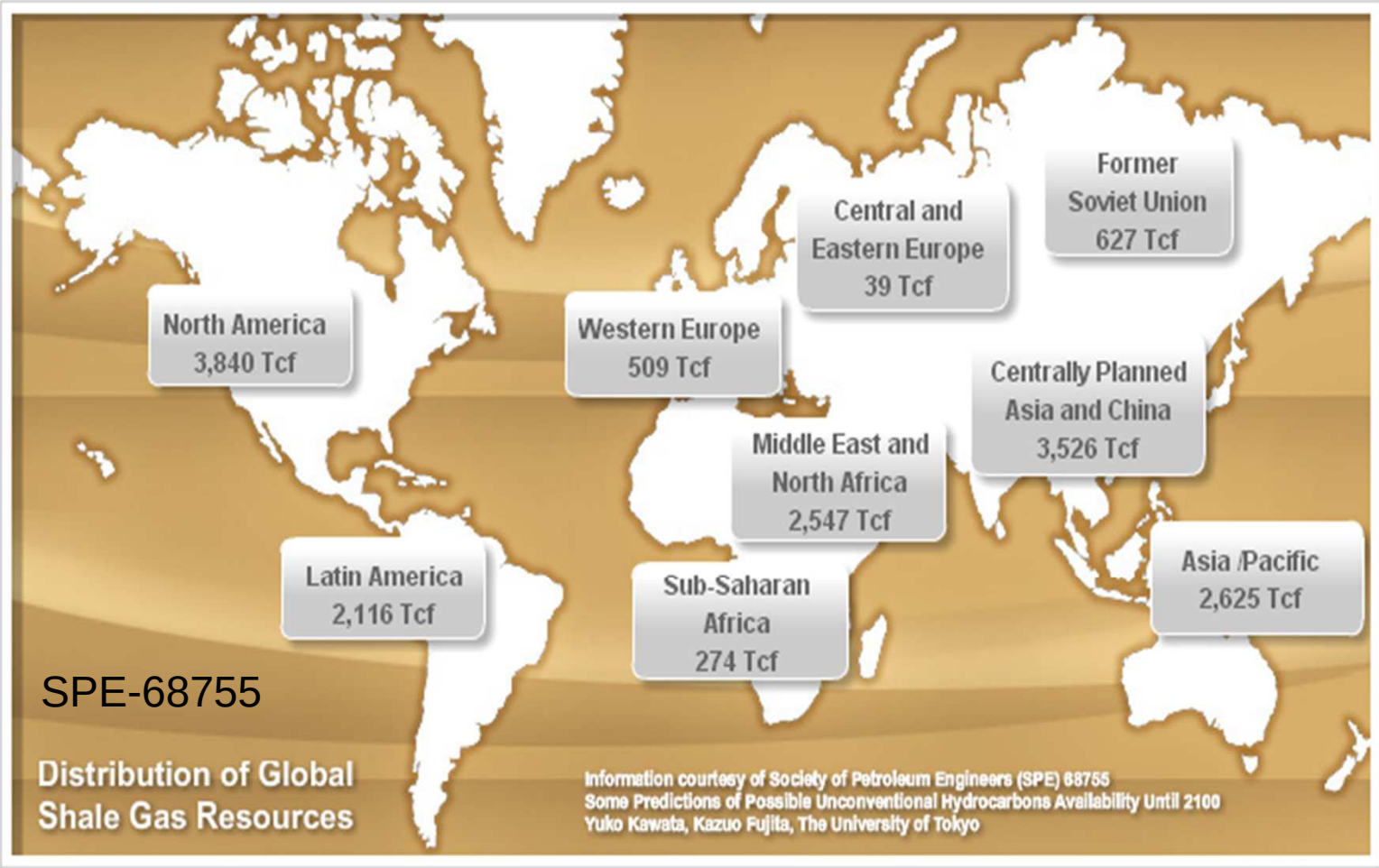
USA
•7468 bcm
•58% increase since 2000
•Experienced in the early-mid 2000s a steady decline in productive capacity
•LNG and Alaskan gas seemed the only remedies
•The unconventional gas revolution has however turned the US gas balance upside down

Iran
•29050 bcm
•16% increase since 2000
•R/p ratio 250 years
•Domestic demand, reinjection absorbs all production
•Exports planned but up against sanctions; besides much opposition to the idea

Russia
•44900 bcm
•61% held by Gazprom
•Minimal change since 2000
•R/p ratio 72 years
•Legacy fields in decline
•New fields – Yamal, offshore, Far East – challenging to develop

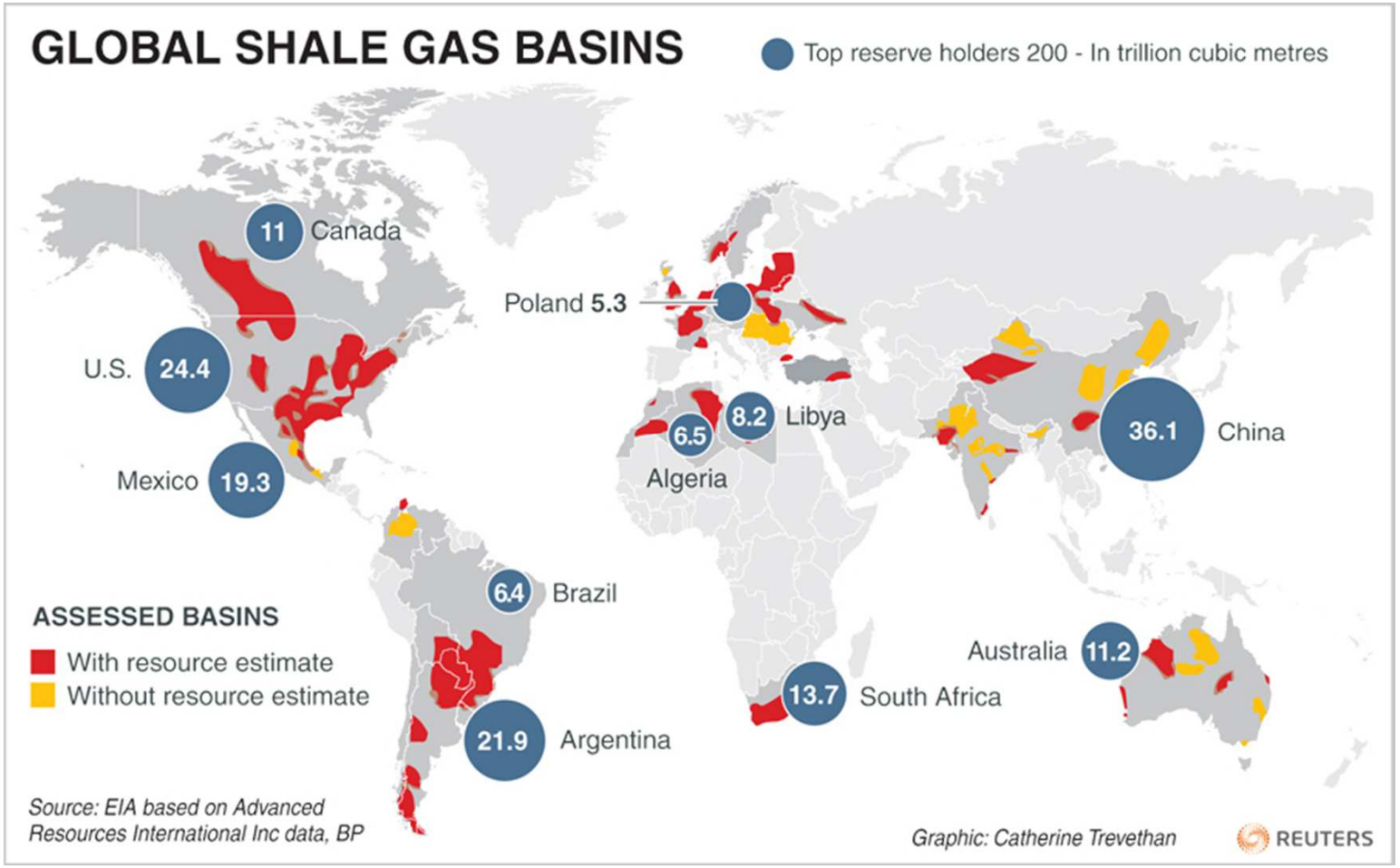
Challenge: Shale Plays Estimates

Total : 16103tcf



HALLIBURTON

Global Shale Gas Basin



HALLIBURTON

Challenge: Minimum Characteristics Needed

Lithology and Rock Fabric	A combination that enhances gas producibility
Zone Thickness	>100ft (30.5 m)
Clay Content	Moderate (<40%) with very low mixed-layer component
Brittleness	Brittle composition (low ductility), as indicated by a low Poisson's ratio and High Young's modulus. This is an indication of the fracture potential
Bounded Above and Below	Adjacent formations contain the hydraulic fracture energy within the shale
Total Organic Content (TOC)	High >3%
Thermal Maturation	In the gas window Ro = 1.1 to 1.4
Hydrogen Content	Low
Gas Content	>100 scf/ton

HALLIBURTON