UNCONVENTIONAL FOSSIL RESOURCES

Alessandro Clerici

Chairman 2010-2013 of WEC Study Group

World Energy Resources

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Introduction

Given the slow pace of change and long lead-times typical to the energy sector, it is amazing to note how the shale gas development in US is a real revolution compared to the other energy sources.

A global gas market revolution has not yet happened however outside of US and the rising star of shale gas remains for the time being confined to US.

In the United States the 35% of their gas consumption(that is 680 billion cm per year,12 times the Italian consumption) comes now from "shale gas".

US are now independent from the previous high level of imports of the expensive LNG and in some years from now they are programming to become exporter of LNG.

On the other hand also

-extra heavy oils

-shale oils

-tar sands/bitumen

are becoming more and more of interest for their huge amount of reserves which are becoming attractive in a period of high oil prices now constanly above 100 $/barrel

Global Trends in Fossil Fuels (2011)

Source: World Energy Council, 2013

	COAL				OIL				NATURAL GAS			
	Reserves (R) = 891 Gt Consumption (C) = 7.51 Gt Production (P) = 7.52 Gt R/P = 118 years				R = 223 Gt C = 4.15 Gt P = 3.98 Gt R/P = 56 years				R = 210 Tcm C = 3.37 Tcm P = 3.51 Tcm R/P = 60 years			
	R (%)	R/P (years)	P (%)	C (%)	R (%)	R/P (years)	P (%)	C (%)	R (%)	R/P (years)	P (%)	C (%)
Latin America & The Caribbean	2	134	2	0.5	20	116	9	6	3.5	36	6	4
North America (US, Canada)	27	209	16	13	13	44	16	26	5	11	26	26
Europe (including Siberia)	31	250	14	17	6	20	17	21	25	55	28	33
South & Central Asia	11	155	9	11	2	27	5	6	15	44	10	7
East Asia (China, Japan, S.Korea, Taiwan)	13	34	45	52	1	12	5	22	2	28	3	10
Southeast Asia & Pacific	12	130	11	4	1	20	3	6	4	33	7	5
Middle East & North Africa	-	-	-	-	50	79	36	10	41	143	17	13
Africa	4	121	3	2.5	7	47	9	3	4.5	79	4	2

R (%) = % of the total global reserves
C (%) = % of the total global consumption

P (%) = % of the total global production
R/P (years) = reserves to production ratio

Extractable unconventional gas 500tcm

Extractable unconventional oil 350 Gt

Some definitions

Oil shales are fine-grained sedimentary rocks containing relatively large quantities of organic matter (known as 'kerogen') **from which significant volumes of shale oil and combustible gas can be produced**.

The use of oil shale can be traced back to ancient times.

In oil shales the ratio between organic material (OM) and mineral material(MM) varies between 1/7 and 1/3;the organic material at around 500 °C is decomposed in shale oil and gas

Coal has a OM/MM ratio close to 1

The use of oil shale dates back to 1600 and in the eighties there was an yearly production of 45 milion tons mainly in Estonia and in part in Russia, China and Brazil.

Up to 1935, Scotland has been practically the largest and unique producer

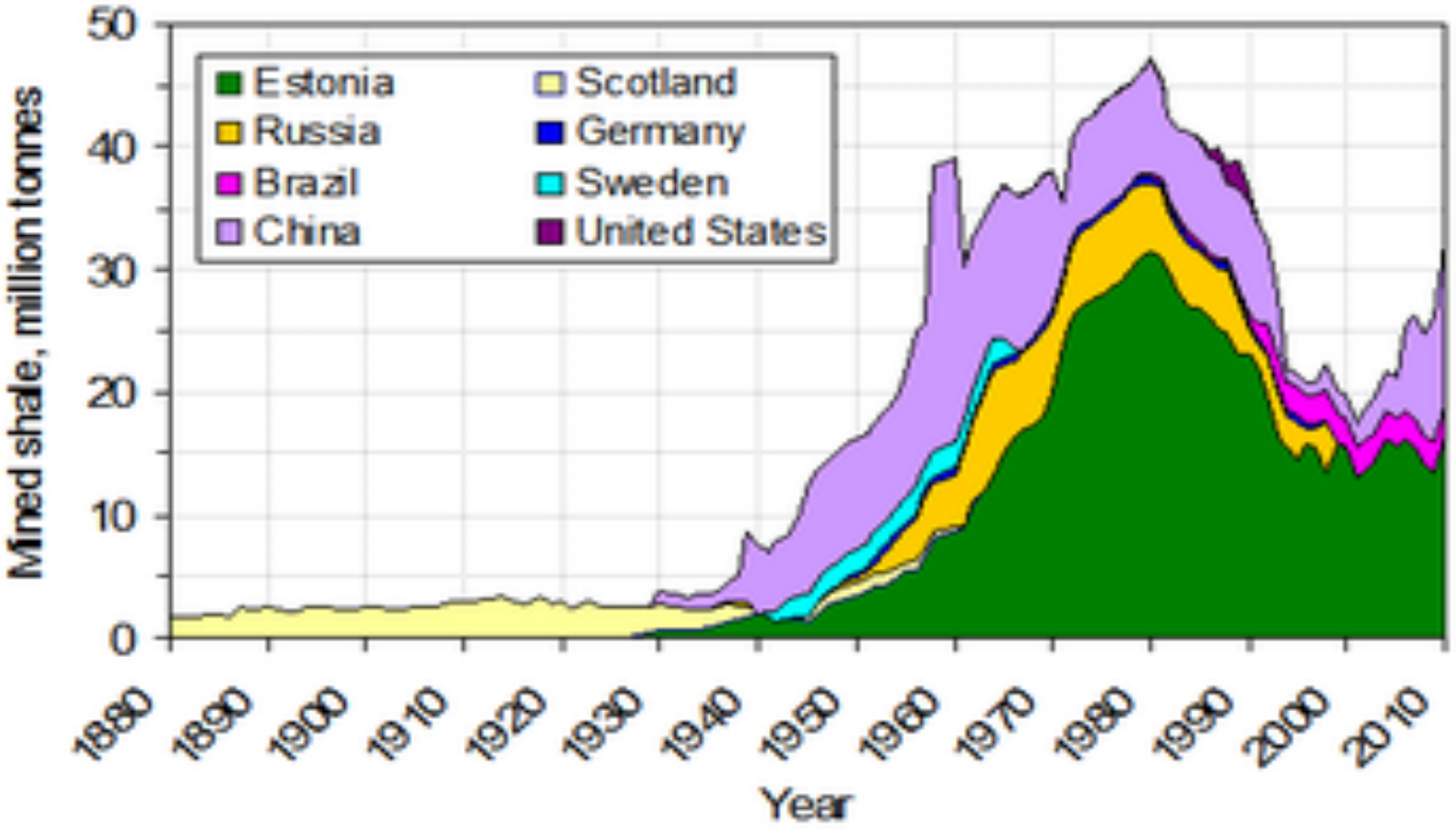

FIG. 1 World production of oil shale in mililioni tons. Source: Pierre Allix, Alan K. Burnha

Common products made from oil shale were kerosene/lamp oil, paraffin wax, fuel oil, lubricating oil and grease, naphtha, illuminating gas, and the fertiliser chemical, ammonium sulphate.

Oil shale can be used in various ways from electricity generation via direct combustion to production of a wide range of petrochemical goods, including shale oil and other liquid fuels

Taking care the **shale oil content is about 100 l/ton of oil shale**

The reduced use of oil shale to get oil for transport derived from its high price with respect to conventional oil.

Clearly the situation may change with stable high oil prices

Extra heavy oils and bitumen, are present in oil fields which have got a degradetion due to microbiological effects and have a density higher than that of conventional oil (1.02-1.04 versus 0.83) and a **very high viscosity** (1000 times that of oil in case of the extra heavy oils and 30.000 times for bitumen).

They have a rather high content of **nickel, vanadium,sulpur and nitrogen**

Extra heavy oils are in fields from hundreds of meters depth (China, Poland, Indonesia) to **1500 meters** (Venezuela, Russia, UK, Israel) to **3.000 meters in** Perù.

Bitumen is in rocks called **"tar sands"** or "oil sands" and has been used since ancient times; the **depth** of relevant fields varies from few **meters (China and Madagascar) to 350 meters (Canada**).

The extraction and upgrading of extra-heavy oils and bitumen for their transport and transformation into final products foresees various technologies involving water,heat and special processes to increase the ratio hydrogen/carbon ("carbon rejection" or "hydrogen addition");this as a function of the type of primary source and of the desired final products

The **“shale gas”,is** natural gas trapped **in mircroporosities of clay sediments** (FIG 2)which are between **2000 and 5000 meters depth.** The **extraction is got through** vertical and then horizontal perforations (Fig 3) using **high pressure water (“hydraulic fracturing”) containing special chemical additives.**

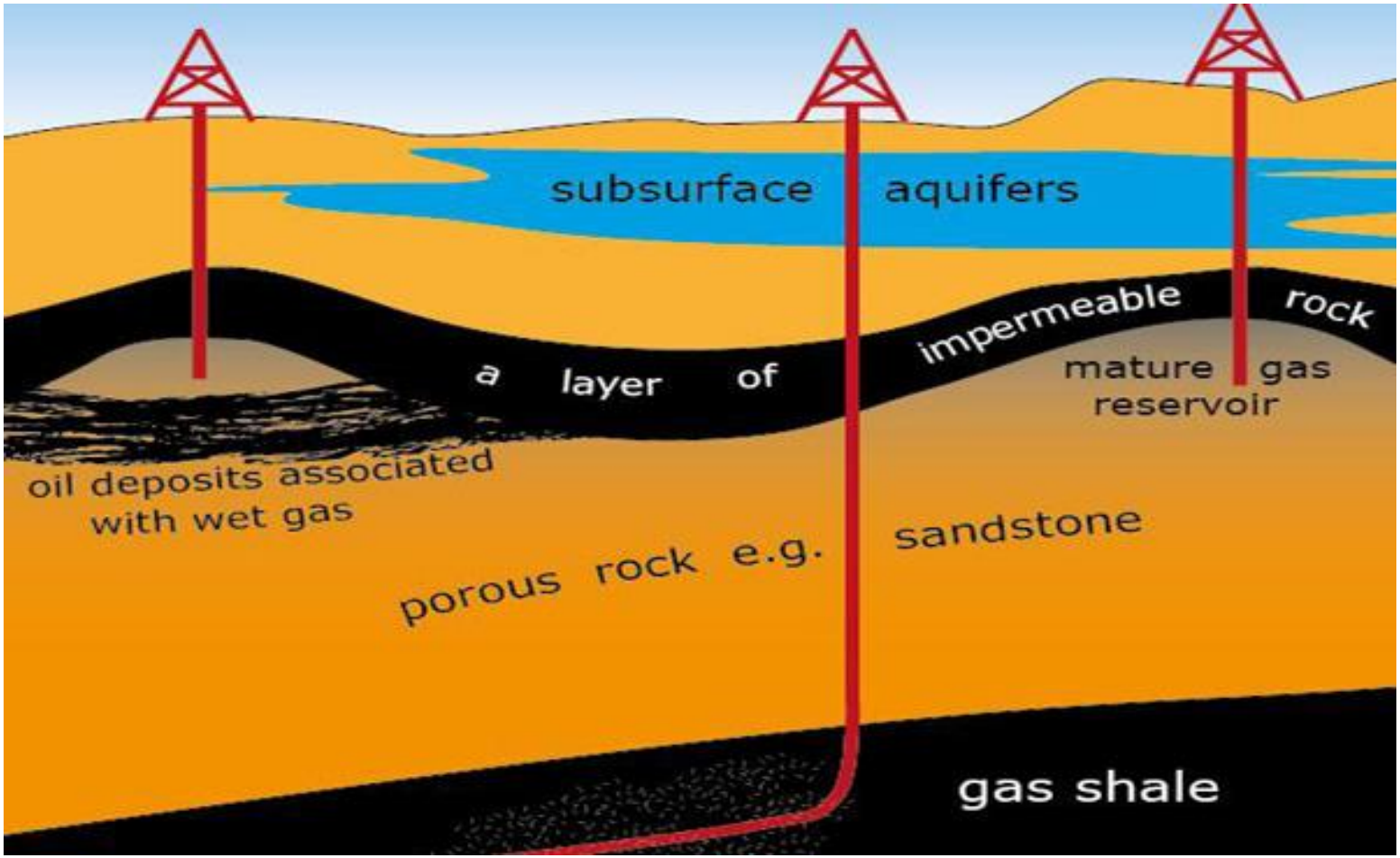

FIG. 2 Deposits of shale gas

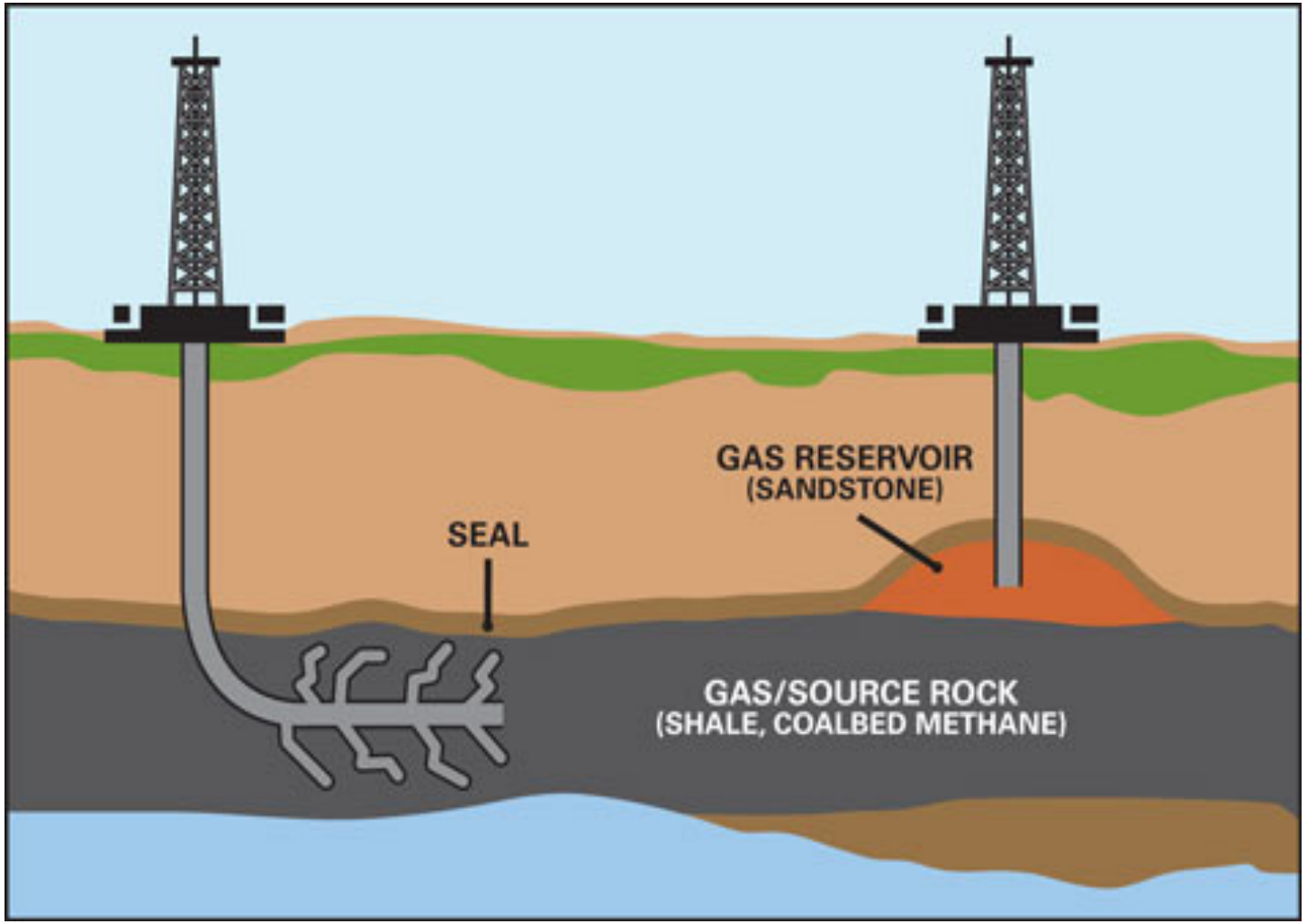

FIG. 3 Technology for shale gas extraction

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Only 25% of injected water is recuprated and treated before reinjection.

A technology under study foresees the“ fracturing” with liquid propane:less water and less dangers of contamination.

Only 30% of the gas of one deposit is recuperated with present technologies

Necessity of perforation of many wells to get an economic production but extended land occupation, traffic of trucks etc

Non conventional hydrocarbon resources

The world reserves of **oil shale** are around **660 billion TEP of possible shale oil content**;
30% of possible technical extraction and therefore close to the 220 billion TEP of conventional oil reserves

2/3 of reserves in US, followed by Russia and Brazil which together have a share of 20% .

Present production of shale oil from oil shales is only around 1 million TEP/year versus the 4 billion of conventional oil.

The reserves of **bitumen up to now known have a possible extracted oil of 35 billion of TEP:**

600 deposits in 23 nations

70% of reserves in Canada, followed by Kazakhstan and Russia.

The present world oil production from tar sands/ bitumen comes practically 100% from Canada and is around 65 million TEP/year (45% of total oil production of Canada)

The reseves of **extra-heavy oil identified in 30 countries have a possible extraction of oil equivalent to around 75 billion TEP (70 billion in Venezuela)**.

The oil **production** is around **50 million tons/year,pratically 100% from Venezuela.**

The world **shale gas "risked" resourses are around 200 trillion m^3 suddivided in 48 deposits in 32** nations,without considering the countries of Central Africa, Russia and ME which have not provided data.

The evaluations are changing frequently.
A subdivision by continents is reported in the following table

North America	29%
Asia (no ME)	~ 22%
South America	~ 19%
North Africa + South Africa	15%
Europe (no Russia)	~ 9%
Australia	~ 6%

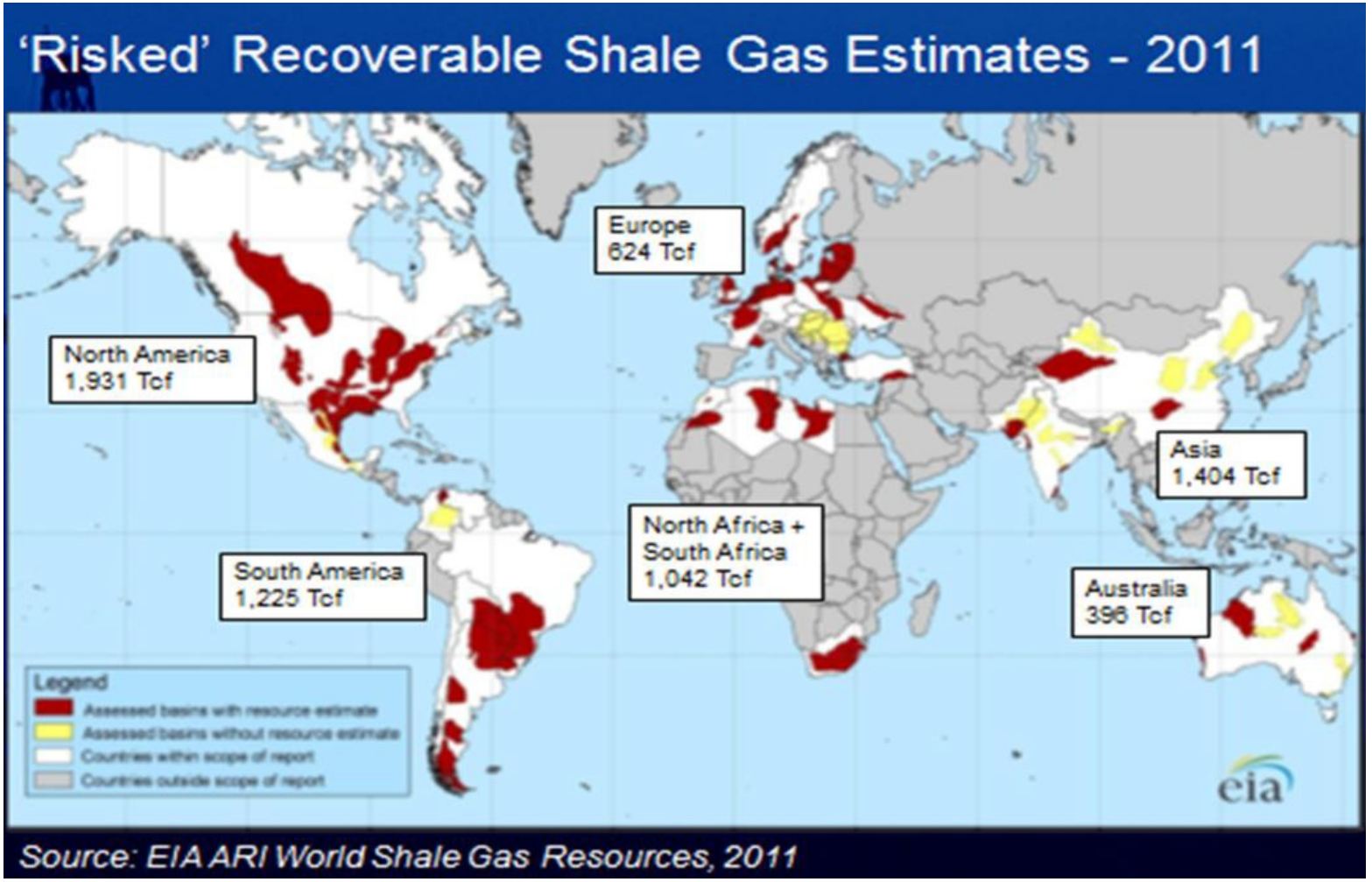


FIG. Shale gas deposits in billion of cubic feets

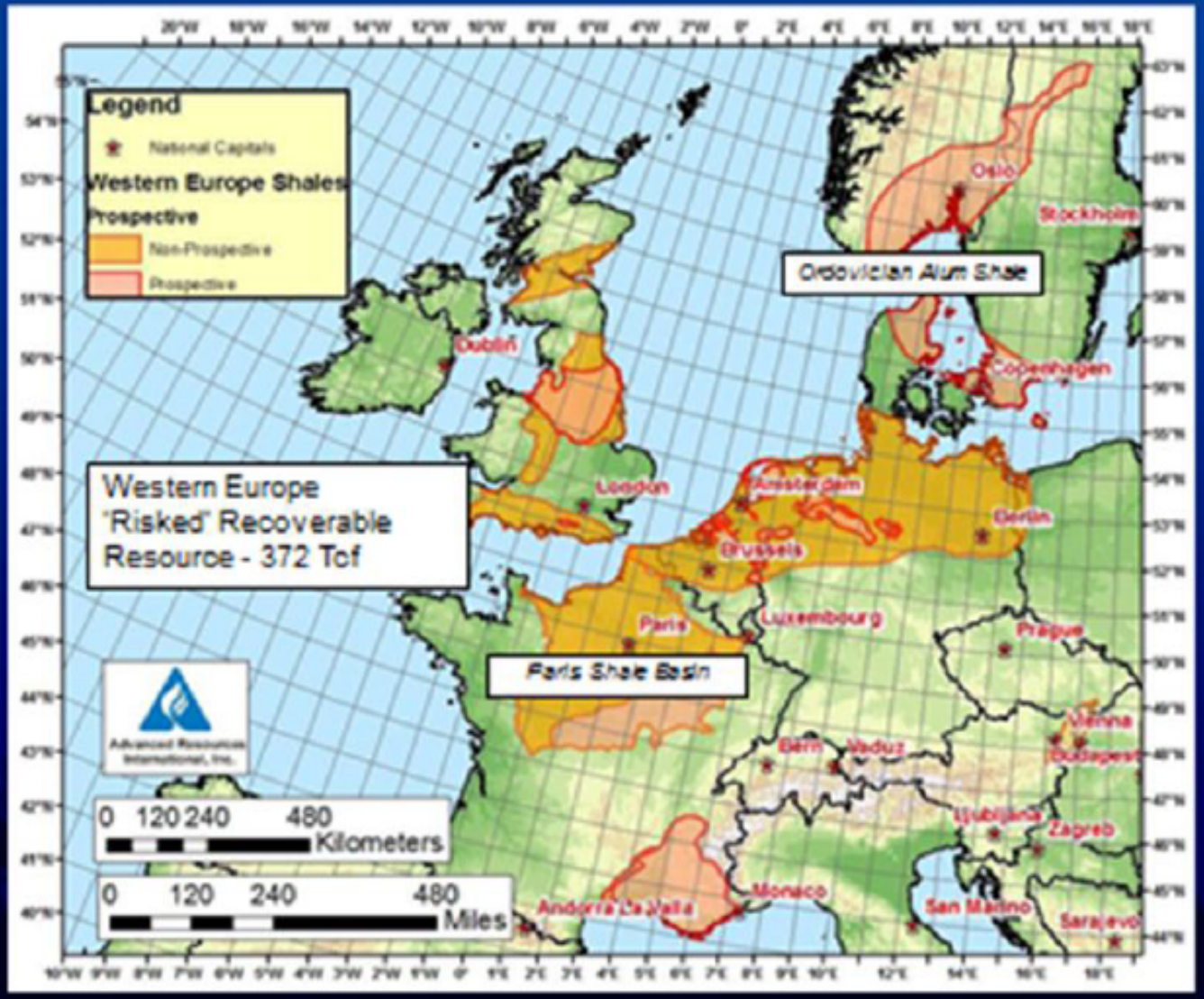
China first country with 18% followed by US, Argentina and Mexico.

In Europe, Poland is first with "risked recovery resources" around 5 billion m^3 ,close to those of **France;** Norway, Ucraina, Sveden, Denmark, UK, Germany and Netherlands follow in order of resources.

Shale Gas Plays, Lower 48 States

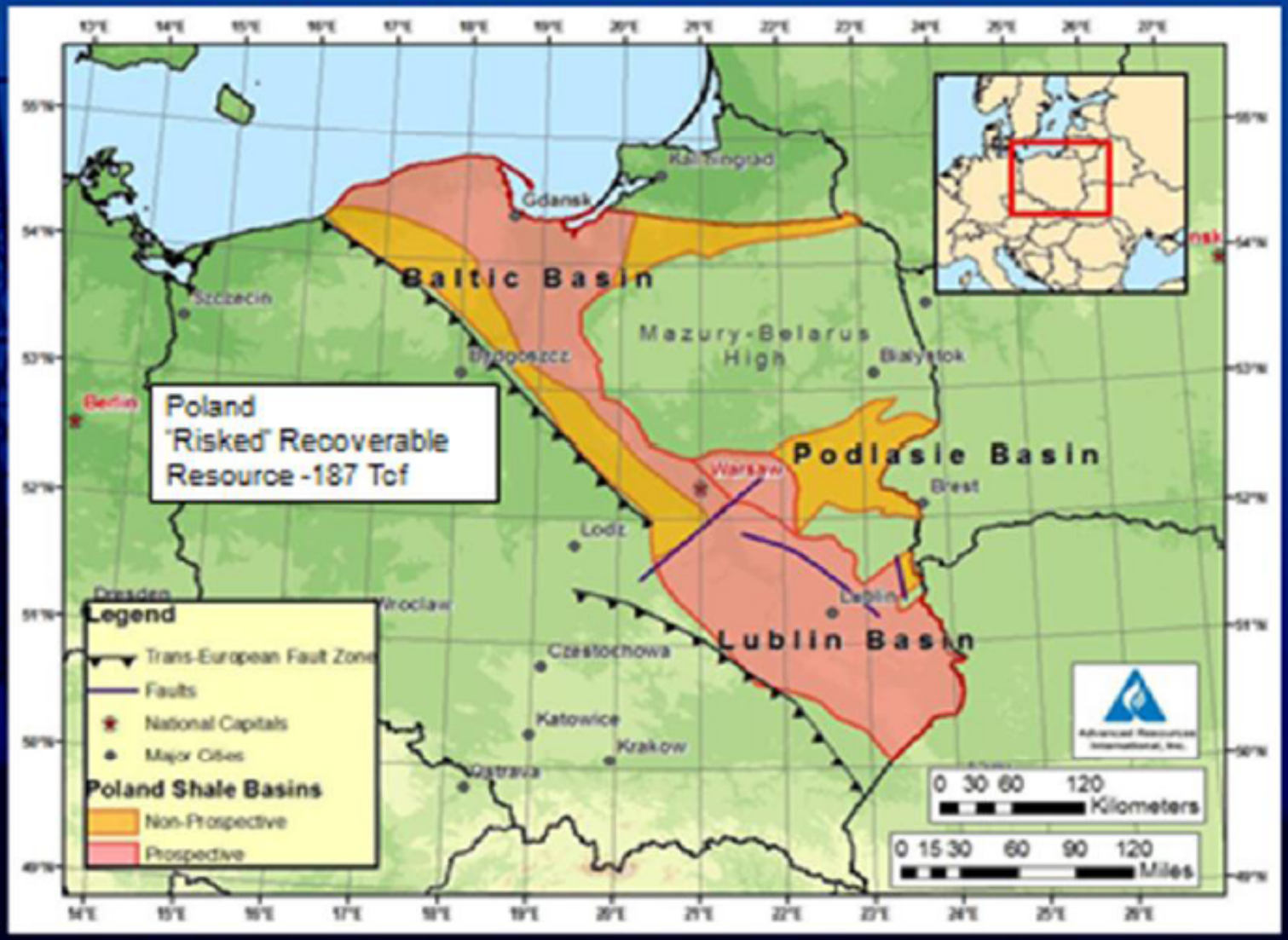
Source: Energy Information Administration based on data from various published studies
Updated: May 28, 2009

Western Europe's Shale Gas Resources & Basins



Source: EIA ARI World Shale Gas Resources, 2011

Poland's Shale Gas Resources and Basins



Source: EIA ARI World Shale Gas Resources, 2011

World reserves of shale gas are estimated 2.5 times the reserves of natural gas.

The world production of shale gas is practically 100% in US :in 2012 more than 250 billion m^3 (4 times the present Italian consumption of gas per year).

Shale gas: opportunities,risks and geopolitical aspects

A. Clerici

In US *59 billion m^3 of shale gas in 2008 and 250 in 2012 with 30000 wells in operation and a share of* 36% of global national production.

The market price of gas collapsed to about 3 $/MBTU,(1/3 of gas price in Europe and 1/5 of gas price in Japan.

In US elecricity production from gas jumped from 16% in 2000 to 31% in 2012 versus coal 52% in 2000 to 36% in 2012;but in 2013 coal up to 39% and gas down to 28%.

US strong export of coal due to local reduced consumption has caused a strong reduction of coal price in the world market

Low gas prices in US have caused collapse of cost of electricity from gas (around 30 $/MWh), «killing» nuclear and posing problems to RES

Possible gas export from US cannot be immediate and it is not clear "how much", taking care of costs of liquefaction,transport and regassification and internal debate pros and cons.

US foresees not only export of gas but also/ mainly of the associated liquids extracted with shale gas

Present shale gas price in US is considered «artificial» taking care of the high market prices of associated liquids

The investments in developments of new gas fields are concentrated on those having the maximum content of associated liquids to the extracted gas

The shale gas revolution in US:
-has created around 1 million jobs
-a revamping of petrochemical industry
-low price of energy (and also of electricity)
-initiatives to utilize gas for transports
-reduction of CO_2 emission from electricity production(less coal)

but it is posing a series of political,economic and environmental problems

Potential risks probably overemphasized by «green people» and connected to shale gas extraction are;

- possibile micro-earthquakes
-emission of methane in the atmosphere
-pollution of aquifers
-great cosumption of water
-injection of dangerous chemical additives
-large and mobile land occupation with heavy transit of trucks etc

The companies involved in shale gas extraction have demonstrated that in their opinion no one of the above mentioned concerns is supported by scientific proves

In addition they are saying that land occupation and transits are in full agreement with the owners of the lands (who in US are the owner of underground resources and get therefore royalties)

A better transparency on technologies adopted and chemical additives seem indispensable to arrive at an agreed acceptability

Emotive reactions could create problems for shale gas developments leading to negative laws as already defined in some nations (France,Bulgaria,Quebec) or affect cost of extraction

Final considerations

The potential unconventional reserves of oil and gas are huge but actual developments (apart from shale gas in US) have been poor due to the lower costs of conventional oil and gas.

With oil prices at around 100 $ /barrel the situation is changing ; the US shale gas has created a revolution in gas prices up to now in US only and on coal prices worldwide

Considering the availability of conventional resources, at present consumption rate (coal for 120 years,oil for 56 and gas for 60) and huge unconventional resources,there is a great abundance of fossil fuels and the peack oil theory is of no concern now.

The concern is:

-how to burn fossil fuels(environment)

-concentration of some fossil fuels(oil and gas) in critical areas

Thank you for your attention

alessandro.clerici@cesi.it