



WORLD ENERGY COUNCIL

CONSEIL MONDIAL DE L'ÉNERGIE

For sustainable energy.

Survey of Energy Resources: Shale Gas – What's New

World Energy Council 2011



Survey of Energy Resources: Shale Gas – What's New

Officers of the World Energy Council

Pierre Gadonneix

Chair

Kevin Meyers

Vice Chair, North America

José Antonio Vargas Lleras

Vice Chair, Latin America/Caribbean

Heon Cheol Shin

Vice Chair, Daegu Congress 2013

Brian Statham

Chair, Studies Committee

Younghoon David Kim

Vice Chair, Asia Pacific & South Asia

Norberto de Franco Medeiros

Interim Chair, Programme Committee

Marie-José Nadeau

Vice Chair, Communications & Outreach Committee

Abubakar Sambo

Vice Chair, Africa

Johannes Teysen

Vice Chair, Europe

Abbas Ali Naqi

Vice Chair, Special Responsibility for Middle East & Gulf States

Graham Ward, CBE

Vice Chair, Finance

Zhang Guobao

Vice Chair, Asia

Christoph Frei

Secretary General

Survey of Energy Resources: Shale Gas – What's New

World Energy Council 2011

Copyright © 2011 World Energy Council

All rights reserved. All or part of this publication may be used or reproduced as long as the following citation is included on each copy or transmission: 'Used by permission of the World Energy Council, London, www.worldenergy.org'

Published 2011 by:

World Energy Council

Regency House 1-4 Warwick Street

London W1B 5LT United Kingdom

ISBN: 978 0 946121 05 2

SUMMARY

One year on: is shale gas a real global game changer?

What's new

In mid-2010, the World Energy Council published a comprehensive report on shale gas. Given the slow pace of change and long lead-times typical to the energy sector, it is amazing to note how different the global outlook for shale gas is today compared to last year.

A widely anticipated global gas market revolution has not happened outside of the United States. Moreover, a number of important issues which need to be addressed sooner rather than later have emerged and obscured the rising star of shale gas.

One year on, the following key findings are emerging:

- ▶ In general, the new estimates of shale gas resources are more conservative than those reported in 2010, mainly due to the differences in the methodology used by the data publishers.
- ▶ Shale gas development can have a significant impact on the dynamics and prices on the natural gas market, and on gas-fired power generation.

- ▶ Implications of increased use of shale gas will not be the same in all regions. In the short to medium term, however, no other region is likely to be able to emulate the success of shale gas in North America supported by its large and well-developed gas transport infra-structure and gas market structures.
- ▶ Regulatory uncertainties slow down shale gas development in many countries.
- ▶ Notwithstanding the environmental moratoriums in some countries, use of shale gas will continue to grow, keeping pressure on natural gas prices and the LNG market.
- ▶ Development of shale gas in Europe can help diversify its gas supply sources moving away from the current heavy dependence on Russian gas.
- ▶ Lower natural gas prices may lead to a significant shift toward the increasing use of gas in power generation and transport.
- ▶ The policy discussion around the Energy-Water Nexus and Security and Sustainability is crucial for the future of shale gas.

Contents

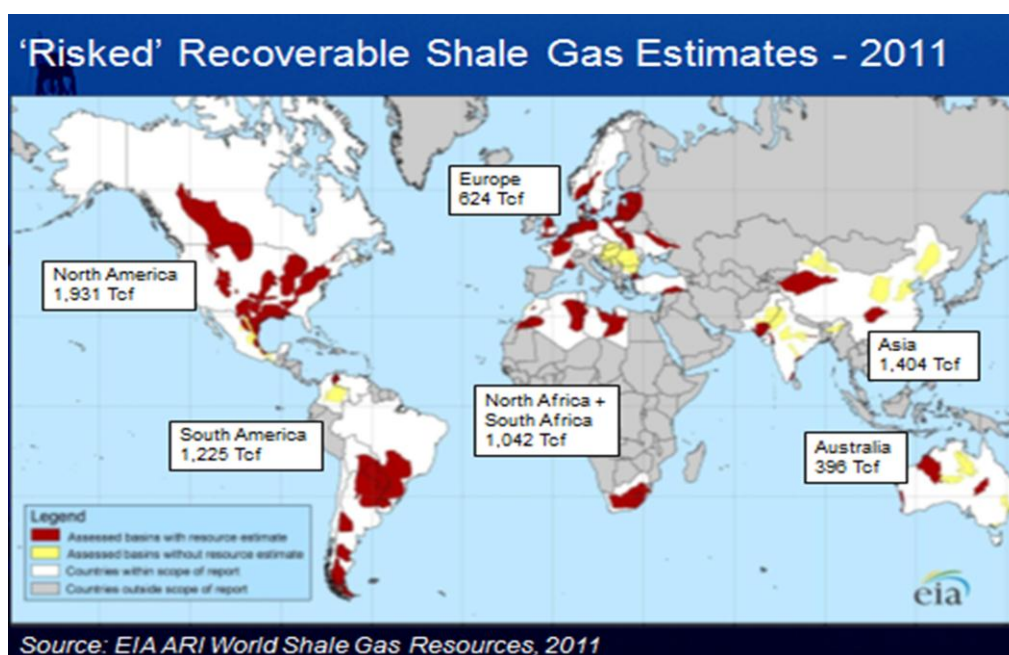
1.	Shale Gas report Updated	3
1.1	New resource data	3
1.2	The emerging economics of shale gas	4
1.3	Shale liquids	5
1.4	The market framework in Europe	6
1.5	The environmental context	7
1.6	Public policy issues	8
2.	Conclusions	10
3.	Shale Gas in France: A Political Issue	11
4.	Acknowledgements	12

1.1 New Resource Data¹

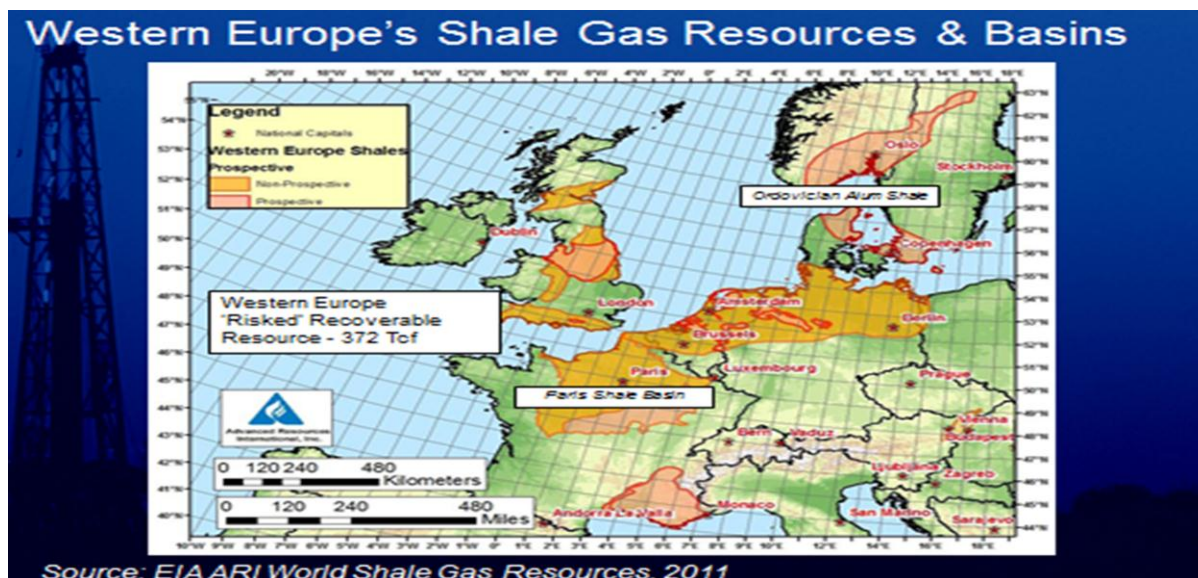
Although a number of public and private sector entities have produced shale gas resource estimates since 2010, the figures quoted in this report rely solely on global supply data published in 2011 by the United States Department of Energy, Energy Information Administration/EIA.

The USDOE conducted preliminary geologic reservoir surveys of 48 major shale basins in 32 countries.

Countries and regions with large conventional gas reserves, like Russia and the Middle East, were left out of the study. According to the USDOE, their new estimates should be considered ‘risky’, which means that the methodology employed ‘recognised the sparseness and uncertainty of data and included conservative discounting of the potential resource.’ In other words, exploration activity has been sparse in much of the shale basins, which means that reliable seismic data is not yet available.



¹ USDOE EIA World Shale Gas Resources, June 2011.
http://www.eia.gov/pressroom/presentations/newell_06212011.pdf.



In general, the new estimates are more conservative than those reported in 2010, the main reason being differences in the methodology used by the data publishers. The World Energy Council maintains that the current recoverable reserve estimates of shale gas are likely to increase in the coming years as more exploration data becomes available.

The EIA report does provide more detailed information on Western Europe and Poland, in particular. The Western European data now includes figures from the Scandinavian and Paris Basins. Poland's data partially comes from industry players who have been engaged in shale gas exploration in partnership with the Polish government. The recent decision by the French government to outlaw hydro-fracking will certainly impact further exploration of the Paris Basin (see France case study, page 11)

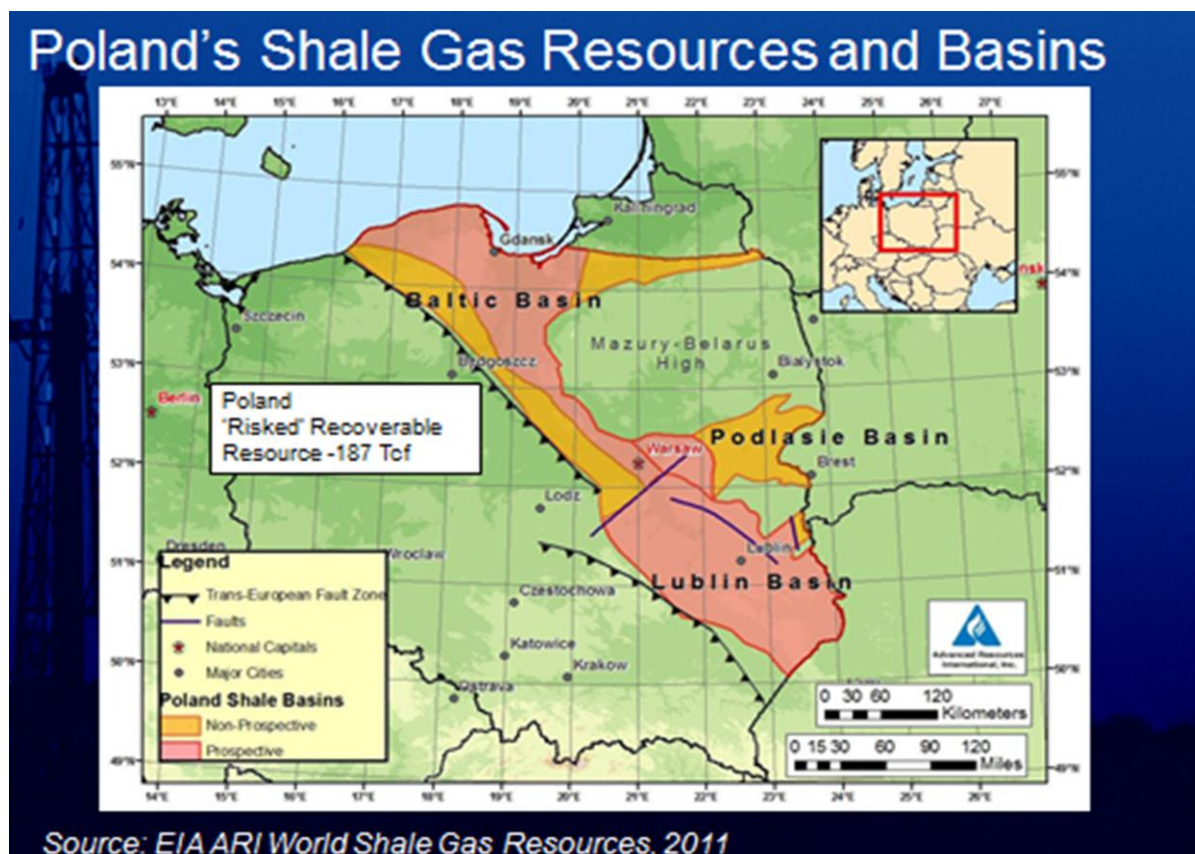
1.2 The Emerging Economics of Shale Gas

Large international oil companies (IOCs) seem to believe in the long-term economics of shale gas. Exxon, Total, Shell, CNP, Reliance Industries and others have bought significant stakes in shale gas resources in North America.

These acquisitions, which will require further investments over a period of several years demonstrate the value the oil industry places on the future of shale gas.

The increasing participation of oil majors in North American shale gas exploitation has also positive implications for the use of best practices and technologies in drilling and processing. Furthermore, the IOCs will most likely lead exploration activities worldwide.

Continued development of shale gas in North America and other countries with significant resources will have an impact on the global gas markets, however this impact is expected to remain moderate in the short to medium term, nothing comparable to what happened in the United States. In mid-2011, natural gas prices in North America (Henry Hub) hovered around US\$3.70/Mbtu, which is about 72% less than at the heights of 2008. Furthermore, in 2010-2011 the volume of natural gas in storage reached historical heights in North America. These high volumes and low prices can be directly attributed to the real impact shale gas has had on the American market. This impact will be extremely difficult to emulate elsewhere. Given that the US no longer requires LNG imports, gas prices, in general have fallen across the world.



The increasing use of shale gas will primarily impact power generation, transport fuels and the petrochemical industry.

1.3 Shale Liquids

Shale liquids are either oil found in shale, such as in the Bakken, or liquids found in association with shale gas. The latter have fundamentally changed the economics of shale gas and the petrochemical industry. In 2010, approximately 17%² of US shale exploration was driven by the search for shale liquids.

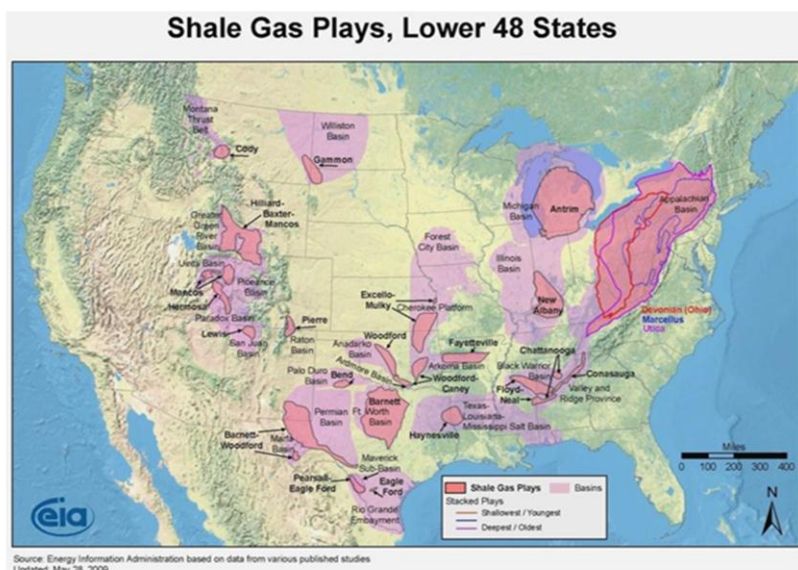
Shale basins like the western portion of the Marcellus, Utica and Eagle Ford, represent 'wet' shale gas deposits that contain significant amounts of molecules larger than methane, such as ethane, propane and butane.

The economic significance lies in the spread between natural gas and oil prices. Gas on the basis of energy content today is at about a quarter of US\$100 oil in North America. In Europe with higher gas prices, the gap is narrower. Natural gas liquids, the "wet" part of wet gas, are priced in relationship to the price of oil. Butane is higher than oil because it is essentially a drop-in replacement for gasoline. Propane and ethane are at a discount to oil. Ethane is at about half the price of oil. But all have higher value than methane

² ICIS Chemical.

<http://www.icis.com/Articles/2011/02/28/9438195/propylene-solution-goes-beyond-the-cracker.html>.

US HAS ESTABLISHED EARLY LEADERSHIP IN SHALE GAS



- The development of shale gas plays has become a “game changer” for the U.S. natural gas market.
- The proliferation of activity into new shale plays has increased dry shale gas production in the United States from 0.39 trillion cubic feet in 2000 to 4.80 trillion cubic feet in 2010, or 23 percent of U.S. dry gas production.
- Shale gas is the largest contributor to the projected growth in production, and by 2035 shale gas production accounts for 46 percent of U.S. natural gas production

Source: FIA Report on Shale Gas April 2011 Interviews and Team Analysis

Typical Marcellus wet gas prices are about 70% over dry gas. Range Resources reports that wet gas at a flat US\$4 per million Btu (MBTU) delivers a return of 60%. This is more profitable than most conventional gas projects. Expect wet gas projects to be implemented first. The price of methane will rise steadily because of demand. In a recent publication, a computer model forecast gas prices as having a ceiling at about US\$8. This stability will also contribute to switching from oil to gas. The switches will include methane propulsion of vehicles and gas-to-liquids derived diesel and gasoline.

The large oil to gas price differential has also prompted research in processing methane and ethane into high value chemicals such as ethylene and hexene. The latter is also a feed for polyethylene manufacture and can be processed to be essentially a drop in replacement for gasoline. Currently most feed stock for polyethylene production is an oil refinery bi-product. At least one company is preparing to offer a small footprint methane processor potentially suited to shale gas field implementation. This would improve the profitability of shale gas dramatically.

1.4 The Market Framework in Europe

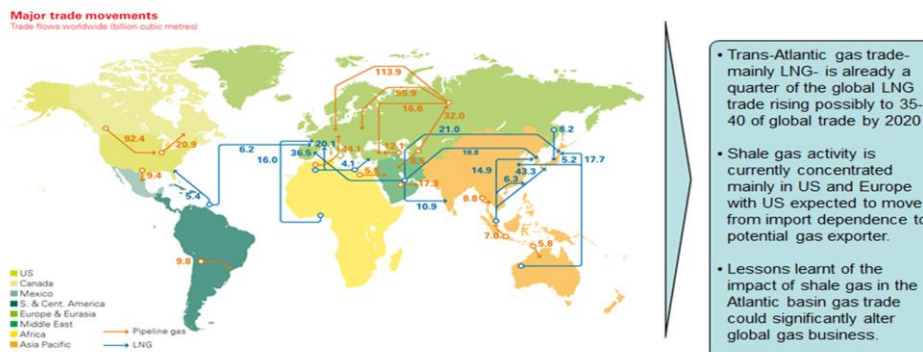
The rate of “shale gas globalisation” and its impact on the market in the near future will depend above all on policies at local and national levels as many countries seem to be concerned with the use of hydro-fracking and its impact on important natural resources like water.

There are a variety of shale gas issues facing policy and business leaders across the European continent. Europe remains highly dependent on Russian and Middle Eastern gas for heating transfer and petrochemicals.

This dependency is viewed differently in different European countries. Great Britain for example has issued a number of shale gas exploration permits, while France has banned hydro-fracking. Poland has issued 101 exploration permits to 25 companies and Hungary has refused to explore their shale basin on water contamination fears.

IMPACT ON GEOPOLITICS

Trans-Atlantic Gas Trade Will Experience The First Shock Of Shale Gas Developments In The US



1.5 The Environmental Context

Environmental concerns about shale gas exploitation have received significant attention in the media, in major newspapers like the New York Times, Le Monde, and the International Herald Tribune, to name a few. The issues raised are fresh water usage in competition with other uses such as farming, improper disposal of produced water and contamination of fresh water aquifers.

Although shale gas wells use up to 6 million gallons of water per well, the water volume used per unit of energy produced is small compared to a number of alternatives. A report in the journal Science (23 OCTOBER 2009 VOL 326 SCIENCE) paints a particularly bleak picture for alternatives, with biofuels needing several orders of magnitude more water to produce than fossil fuels.

A paper by Chesapeake Energy (2009 GWPC Water/Energy Sustainability Symposium, Salt Lake City, Utah, USA, 13-16 September 2009) reports usage of about 3 gallons per million BTU (MBTU) as compared to seven times more for nuclear and more than 3,000 gallons per MBTU for corn ethanol and even more for soy bean derived diesel.

Although this usage is relatively low compared to alternatives, any usage of water may appear to be in competition with other uses, especially in draught years.

To address this situation, salt water might be used in place of fresh water. Recent advances in fracturing permit this with small modifications to the needed chemicals. Currently 40,000 ppm can be tolerated and soon that limit will rise to 80,000 and more. To appreciate the significance of these numbers, the reject brine from sea water reverse osmosis plants is around 75,000, and could be used. Therefore, not only will fresh water not be needed, some reject waters could be used.

Improper discharge of produced water is an issue. It is best addressed by simply recycling. However, since the produced water has salinity from 6,000 to 300,000 ppm, this can be costly. The ability to tolerate salinity mentioned above can be a huge cost saving. Technology to clean up the other constituents exists and can be expected to be affordable.

There are two potential ways in which shale gas operations could contaminate aquifers. One is through leakage of the chemicals used in fracturing. These then would be liquid contaminants. The second is the infiltration of aquifers by produced methane. It is a gaseous contaminant, albeit it gets dissolved in the water.

If methane is present, a portion may be released as a gas. Natural occurrences such as the Eternal Flame Waterfall in the Shale Creek Preserve in New York, shown in the picture below, demonstrate methane intrusion into a fresh water source.

The distinction between potential liquid and gaseous contamination is important because the hazards are different, as are the remedies and safeguards. Also, because well water could not naturally have the liquid contaminants, their presence is evidence of a man made source.



Therefore, simple testing of wells proximal to drilling operations is sufficient, with the only possible complication being the influence from some source other than drilling, such as agricultural runoff, for example. This is easily resolved because of the specificity in the chemicals used for fracturing.

Methane leakage can happen because of possible combination of not locating cement in the right places and of a poor cement job. Many wells will have intervals above the producing zone that are charged with gas, usually small quantities in coal bodies and the like. If these are not sealed off with cement some gas will intrude into the well bore. This will still be contained unless the cement up near the fresh water aquifers has poor integrity. In that case the gas will leak. Wells constructed to specification will not leak.

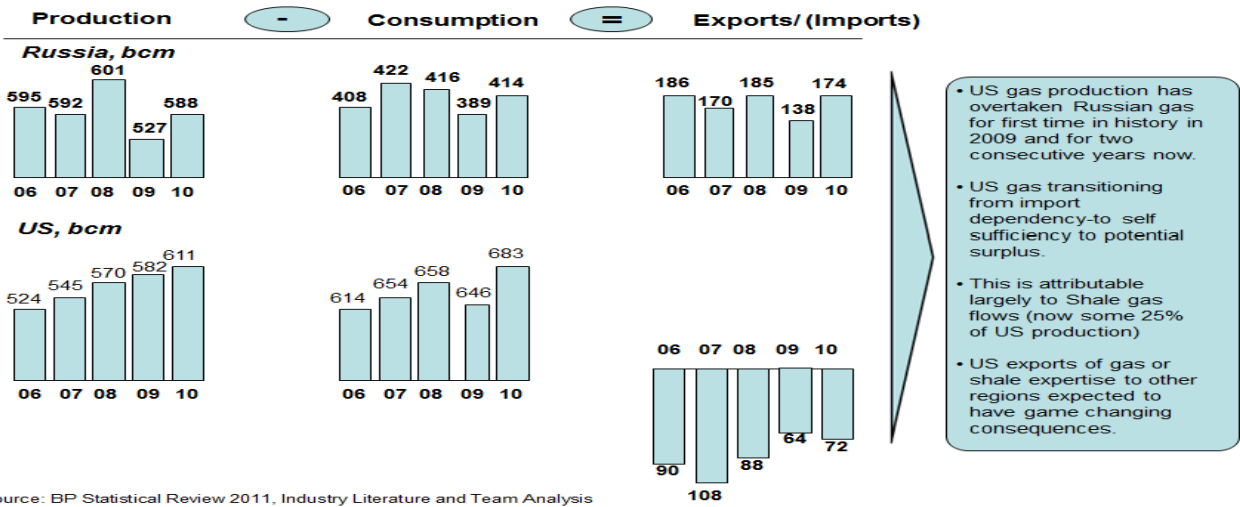
There are half a million active gas wells in the US today, many of which penetrated aquifers. Industry standards are designed to ensure integrity of the aquifers. Another environmental debate related to shale gas is its carbon footprint. Environmental groups have suggested that demand shifting to natural gas from coal will reduce carbon emission from existing fossil fuel sources. The state of California for example enacted a carbon reducing regulatory framework requiring new power generation to be provided by natural gas power plants only.

1.6 Public Policy Issues

A technological revolution in drilling and gas production technologies has greatly increased the world's reserves of natural gas and changed the outlook for fossil fired electricity generation over the next decade and possibly longer. Shale gas has already begun to flow in the US gas markets and has been at the forefront of this new revolution creating a discontinuity that is leading to great uncertainty in energy policy making. Natural gas has long been known as the cleanest of fossil fuels with emissions intensity nearly a third of that for coal and the emergence of shale gas has been viewed by many as a major contributor to mitigating environmental impacts. In North America and Europe, environmental implications are still the headline concern. Although many communities have embraced the exploitation of shale gas for job creation and energy security reasons, for example, New York State and France have outlawed hydro-fracking. For France, this means that the Paris Basin (see case study, page 11) will not be exploited.

In general, the Europeans consider energy security to be a great concern, but they have yet to accept shale gas as a possible solution to reducing that dependency.

GEOPOLITICAL IMPLICATIONS TOO ARE BECOMING PALPABLE



Although Poland has always been apprehensive about its dependence on Russian gas, it has issued nearly 25% of the shale gas exploration permits to Russian companies. Given that Poland has a bifurcated permitting process (exploration and exploitation), it is yet to be seen how much of their shale gas resources will end up in the hands of Russian companies.

Despite the availability of proven production technologies, environmental impacts are still being queried; in particular the impact on ground water resources and the possible methane releases associated with current production techniques. These issues are the subject of intense scrutiny at the moment. The supply and use of shale gas is already “changing the game” and the fossil fuels sector’s impact is not restricted to the global natural gas pricing outlook but its development has become entwined with the global energy mix and emerging nexus in energy-climate-water and its impact on the global energy supplies environment.

Finally, property and mineral rights differ across the world. In the United States, individuals can own the mineral rights for land they own. In many parts of Asia, Europe and South America this is not the case.

Therefore, unresolved legal issues remain obstacles for shale gas exploitation in many countries across the globe. Given the investment requirements needed to develop shale basins that presently have little to no infrastructure, the legal issues are important to attract the investment needed for exploration and exploitation

2. Conclusions

Shale Gas Developments can have implications for:

- Natural Gas market dynamics and prices
- The unexpected expansion of gas fired power generation
- Carbon Emissions and Management Strategies and Abatement Technologies (e.g. CCS)
- The policy debate about benefits of natural gas and renewable energy
- The policy discussions around Energy-Climate, Water, Security and Sustainability.
-

Uncertainties related to Shale Gas Developments include:

- Regulatory uncertainties (e.g. EPA role in Shale developments, FRAC Act 2009 etc.)
- Technology (e.g. use of chemicals in hydraulic fracking, assessment and evaluation of fractures, Liquefaction and Handling etc.)
- Market integration (integration with LNG, pipeline transport, gas balancing etc.)

Strategic Implications

- Estimates of proven reserves of shale gas are increasing globally and will continue to do so as exploration continues.
- Exploitation of the shale gas is keeping natural gas prices low, particularly in North America.
- Shale gas liquids are having a significant impact on the petrochemical industry in North America, which has spillover effects in Europe, the Middle East and Asia. Further, the liquids are making shale gas more profitable than traditional dry gas reservoirs.
- Development of shale in Western Europe, Scandinavia and Poland has the potential to cut Europe's heavy dependence on Russian gas, unless, of course, Russian gas companies gain control of these resources;
- Shale gas discoveries in South America have the potential of realigning the energy relationships on the continent. Argentina, Brazil and Chile are likely beneficiaries decreasing their dependence on Bolivian gas;
- Notwithstanding the environmental moratoriums in some countries, shale gas will be used in many parts of the world. This will place downward pressure on prices of natural gas and will continue to impact the LNG market for the foreseeable future;
- Lower natural gas prices may lead to significant shifting in power generation and transport fuels.

Shale Gas in France: A Political Issue

(Country Case Study by Marc Florette, GDF Suez)

In a pre-electoral climate context and following the 20th National Assembly vote earlier on 11th May 2011, the Senate adopted law 2011-835 on 30th June. This law stipulates that exploration and exploitation of liquid or gaseous hydrocarbon mines by drilling followed by hydraulic fracturing of the rock is banned on French territory.

Within two months after the implementation of the law, companies that have already obtained exploration permits will have to explain their exploration techniques and, if they engage in hydraulic fracturing (so far the only economically viable technique), the permits will be revoked. In France three exploration permits have been granted : Montélimar (Total E&P and Devon Energy), Villeneuve de Berg and Nant (Schuepbach). Whereas politicians who are particularly sensitive to environmental issues want to ban exploitation, by banning a technology and not a product, other politicians do not wish to close the door to non-conventional hydrocarbons. In addition, under the law, a national monitoring and evaluation committee will be set up, which includes industry, government agencies and scientists, in order to provide a platform for continued debate.

Strong environmental concerns arose in recent months regarding the risk of aquifer contamination, the management and disposal of waste water from the fracking process, as well as the potential strain imposed on local water resources by fracking. Industry claims that fracking itself does not pose a risk to surface water or water aquifers. It is the integrity of the well and the well casing which is paramount in preventing any leakage of fracking fluids and gas into the water supply. However, a US study revealed that, on average, methane concentrations were 17 times higher in wells near active fracking sites than those in non-active sites. As for the large amounts of water used, Industry is putting a lot of effort into increasing water recycling and alternate sourcing to reduce use of the potable water. Lastly, operators will have to declare the

type, concentration and volume of the chemicals that they are using in fracking fluids. There are still so many unresolved questions about the environmental impact of shale gas, and non-conventional hydrocarbons in general, that it will take time to have a clear and objective view on this highly sensitive issue. Research will be essential to addressing alternative fracking technologies; developing greener fracking fluids and better monitoring techniques for fracking operations.

France has become the first country in Europe to explicitly outlaw hydraulic fracturing, in the name of "precautionary principles". In the meantime, the UK Parliament's Energy and Climate Change Select Committee (the UKPSC) published a report on shale gas and suggested that there was no need (as yet) to impose a moratorium on drilling in the UK. While Germany and Sweden have also seen public opposition to shale gas exploration, it does not appear, at the moment that they are going to introduce bans. In this case, it appears to reflect the relatively low reserves, and consequently environmental impact. Poland, on the contrary, is estimated to have the largest reserves in Europe and is strongly supporting the development of the unconventional gas sector, as a unique opportunity to reduce its energy dependence on Russia. In this respect, and in the wake of the French government's decision, Poland has warned the European Commission against imposing restrictions on unconventional extraction technologies.

It is therefore clear that European countries have not reached a consensus on the issue of Shale gas development. Although it is probably too early to draw conclusions, at this stage of the debate, France's decision to ban hydraulic fracturing is unlikely to spread throughout Europe. The French case underlines the need for the industry to organize a strong and proactive communication with the local and national authorities on the one hand and with the general public on the other hand to avoid such a situation.

ACKNOWLEDGEMENTS

This is the first update of the WEC report on Shale gas published in 2010. It has been drafted and reviewed by a small ad-hoc group of experts, who participated in the work on the first report.

While I still retained the overall control over the project, major contributions came from Vikram Rao of RTEC (former Chief Technology Officer of Halliburton), Marc Florette of GDF-Suez and Elena Nekhaev, WEC Director of Programmes.

The global Shale gas market has not been created yet, but the developments indicate that despite a few setbacks, the interest in this somewhat exotic energy carrier is growing all over the world.

WEC has decided to monitor these developments and report them to its members, to provide first-hand and up to date information about short and long-term trends and events in the Shale gas market. WEC is convinced that Shale gas is here to stay and in addition to the regular updates of the Shale gas information WEC will also look into the Oil shale sector. Unconventional sources of energy will be playing an increasingly important role in future energy supply and energy professionals need to understand this role.



Rich Davis, Artis Research, USA

Member committees of the World Energy Council

Albania	India	Poland
Algeria	Indonesia	Portugal
Argentina	Iran (Islamic Republic)	Qatar
Austria	Ireland	Romania
Belgium	Israel	Russian Federation
Bolivia	Italy	Saudi Arabia
Botswana	Japan	Senegal
Brazil	Jordan	Serbia
Bulgaria	Kazakhstan	Slovakia
Cameroon	Kenya	Slovenia
Canada	Korea (Rep.)	South Africa
Chad	Kuwait	Spain
China	Latvia	Sri Lanka
Colombia	Lebanon	Swaziland
Congo (Democratic Republic)	Libya/GSPLAJ	Sweden
Côte d'Ivoire	Lithuania	Switzerland
Croatia	Luxembourg	Syria (Arab Republic)
Cyprus	Macedonia (Republic)	Taiwan, China
Czech Republic	Mexico	Tajikistan
Denmark	Monaco	Tanzania
Egypt (Arab Republic)	Mongolia	Thailand
Estonia	Morocco	Trinidad & Tobago
Ethiopia	Namibia	Tunisia
Finland	Nepal	Turkey
France	Netherlands	Ukraine
Gabon	New Zealand	United Arab Emirates
Germany	Niger	United Kingdom
Ghana	Nigeria	United States
Greece	Pakistan	Uruguay
Hong Kong, China	Paraguay	
Hungary	Peru	
Iceland	Philippines	

World Energy Council

Regency House 1-4 Warwick Street

London W1B 5LT United Kingdom

T (+44) 20 7734 5996

F (+44) 20 7734 5926

E info@worldenergy.org

www.worldenergy.org

Promoting sustainable energy for the greatest benefit of
all

ISBN: 978 0 946121 05 2