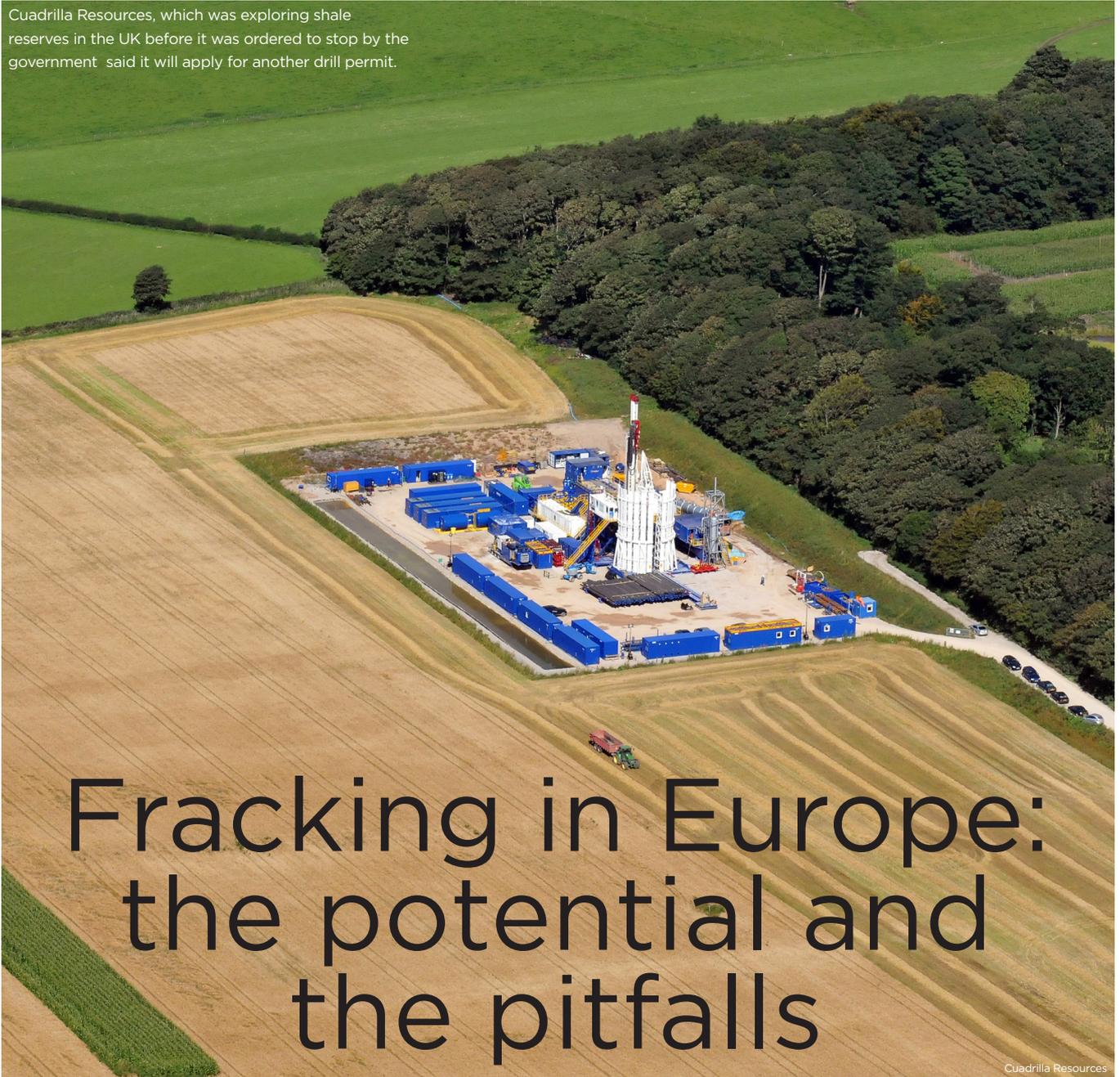


Cuadrilla Resources, which was exploring shale reserves in the UK before it was ordered to stop by the government said it will apply for another drill permit.



Fracking in Europe: the potential and the pitfalls

Cuadrilla Resources

Shale gas, a natural gas trapped in rocks, could eventually greatly expand global supplies of energy. It is increasingly adopted in the US and reports show vast untapped resources in Europe. But hydraulic fracturing, or 'fracking', the method of extraction which involves pumping pressurised water, chemicals and sand underground, is criticised by many environmentalists, who believe it can pollute water supplies. Any widespread adoption of the process will have to overcome many political and policy hurdles to gain universal acceptance.

Fracking has revolutionised the potential of the global oil and gas sector, most notably in the US. This is a well-stimulation process

Could shale gas provide the answer to global energy concerns? There are vast untapped resources in Europe, but fracking, the controversial method of extraction, could prove to be the stumbling block as *Vasili Nicoletopoulos** explains

which, together with horizontal drilling, is used to maximise the extraction of underground resources, including oil, natural gas, geothermal energy, and even water. The oil and gas industry uses fracking to enhance subsurface fracture systems to allow oil or natural gas to move more freely from the rock pores to the production wells that bring the oil or gas to the surface.

The stages are defined as: pre-production, which includes site preparation; drilling,

hydraulic fracturing, well completion, waste and wastewater treatment; production and processing; transport and distribution and well plugging and abandonment.

Shale gas - or 'unconventional' or 'new' gas - along with new finds of conventional gas, will allow many more countries to produce their own gas and make it available for export from many more places, many of which are less difficult to deal with than some traditional oil-producing countries.

Techniques and developments

Fracking may be a controversial process, but it is also a very dynamic and developing process. In addition to the classic route with water, promising new techniques include:

- Slickwater fracks, which adds chemicals known as “friction reducers” to water to allow for more efficient gas extraction
- Non-hydraulic extraction (or waterless fracking), which is a cheaper and more effective extraction method and does not affect groundwater, and includes LPG gel and foam fracking, with the latter replacing water with CO₂ foam
- ‘Green’ fracking fluids, which are moving away from using diesel or harmful chemicals to more polymer-based fracturing chemicals.

Potential for fracking in Europe

According to the US Energy Information Administration (EIA), Europe has up to 480 trillion cubic feet [tcf] of “technically recoverable shale gas resources”, compared with 862 tcf in the US, but getting the gas out of the earth’s crust is a heavily industrial process and will be more tightly regulated in the EU than in the US.

Despite this, EU nations have barely scratched the surface on shale gas: there are just two dozen test drills around Europe, compared with an estimated 35,000 fracturing sites in the US.

Shale reserves in Europe

(see table 1)

Austria

Reserves: Geological studies have shown the potential for large shale gas reserves in the lower part of Austria, which could cover the country’s domestic requirements for 30 years.

Legislation: Erwin Pröll, the governor of Lower Austria, has recently called for legislative changes to be introduced to preclude the drilling for shale gas due to concerns over the potential impact of hydraulic fracturing. This September saw oil and gas group OMV abandon Austrian shale gas plans, stating that the introduction of the law obliging companies to have a detailed environmental inspection before each planned project meant its own projects were not economically viable.

Bulgaria

Reserves: Shale-gas reserves are estimated to be at least 300 bcm, according to its Economy and Energy Ministry and are several thousands of meters deep.

Legislation: Bulgaria has joined France to become the second European country to ban exploratory drilling for shale gas using fracking. On 17 May 2012, an *ad hoc* parliamentary committee scrapped some of the

texts of a recently-adopted decision to impose a moratorium on shale gas exploration and extraction as they also hinder the production of conventional gas.

Article 1 of the moratorium bans the underground injection of fluids at a pressure of more than 20 atmospheres, which hinders the exploration and storage of conventional gas as well, state-run *Bulgarian News Agency* (BTA) quoted the committee chairman Dian Chervenkov as saying.

Bulgaria adopted the shale gas ban in January 2012 under pressure from environmental organisations and the public.

Czech Republic

Reserves: The biggest potential area of reserves is in the south near Austria, where Czech mining company MND hopes to extract gas as soon as 2014.

Legislation: The Czech government has proposed a temporary ban on shale gas exploration until a new law is passed that would address extracting the new energy source. Environment minister Tomas Chalupa said in September 2012 that the current law is insufficient and a moratorium until the middle of 2014 would give authorities time to propose legislation that would “take into account the current technologies and their environmental impact”.

France

Reserves: France could be close to Poland in holding the biggest reserves in western Europe, although it remains to be seen what fraction of this resource base is likely to prove commercial and be produced.

Legislation: 2011 saw France become the first

country to outlaw the use of fracking to tap into shale gas reserves following fears over environmental consequences. French president Francois Hollande adopted a publicly tough tone against fracking in September 2012, confirming previous president Sarkozy’s ban by declaring it too early to rule out any environmental damage and ordering his energy minister to withdraw seven exploration permits

Hollande’s move to leave French shale gas untapped in order to maintain a frayed alliance with Green parties may come back to haunt him as the domestic economy stalls.

Moreover, the government remains split, as industry minister Arnaud Montebourg has been quick to point out that Hollande has only rejected hydro-fracking, not shale gas itself, leaving open the door to production if other techniques emerge.

Germany

Reserves: The country has large unconventional gas reserves which can be safely exploited if the right regulations are in place, according to the first findings of a continuing long-term study by federal authorities.

The Federal Institute for Geosciences and Natural Resources said between 0.7-2.3 tcm of the gas could be technically extracted. This is calculated at a 10% extraction rate it believes is achievable from the 6.8-22.6 tcm of shale gas located.

Two studies by experts into the environmental impact of hydraulic fracturing have been commissioned by the Federal Ministry for the Environment and the State of North Rhine-Westphalia and these studies are likely to inform Germany’s approach to regulation.

Legislation: Germany is considering tighter regulation of a technique to unlock natural gas from impermeable rocks because of concerns it is harmful to the environment.

According to a report commissioned by the German Environment Ministry, Chancellor Angela Merkel’s government “should ban hydraulic fracturing, or fracking, near drinking water reservoirs and mineral springs and require developers to conduct environmental impact studies”.

Hungary

Reserves: Hungary saw the first major milestone of shale gas development in 2007 with a joint venture between Hungarian gas and oil company MOL and ExxonMobil to evaluate the unconventional potential of the Makó and Békés basins.

According to the EIA, the joint reserves for Romanian, Bulgarian and Hungarian shale gas in the Carpathian-Balkan basin is around 538bcm. The most promising exploration area

Table 1: Proved natural gas reserves and technically recoverable SG resources in Europe

Country	Proved natural gas reserves [tcf]	Technically recoverable shale gas resources [tcf]
Denmark	2.1	23
France	0.2	180
Germany	6.2	8
Lithuania		4
Netherlands	49	17
Norway	72	83
Poland	5.8	187
Sweden		41
Turkey	0.2	15
UK	9	20
Ukraine	39	42
Others	2.71	19

Source: EIA

is thought to be Makó, in the southern part of Hungary. A number of other companies are involved in shale gas exploration in Hungary, including RAG Hungary Kft. and Cuadrilla Resources Ltd.

Lithuania

Reserves: The EIA estimated in April 2011 that Lithuania may hold approximately 120bcm of shale gas reserves in the south-west of the country, not far from the Polish border. Earlier estimates have even put potential amounts of reserves at 480 bcm, but these were only theoretical and not based on geological data.

The Netherlands

Reserves: The country saw the first evaluation from independent research organisation TNO in 2009, commissioned by Energie Beheer Nederland, which confirmed high potential for shale gas, although with uncertainties over the gas-in-place estimates. Opinion on the potential for shale gas in the region is divided. TNO is currently working on refining shale gas estimates based on additional data collection and an integrated multidisciplinary approach. Investigations are focusing on the Jurassic Posidonia shale formation and the deeper Namurian shales.

Poland

Reserves: Recoverable shale gas reserves are thought to be as much as 187 tcf. According to a new Polish geological report, there are indications of large shale oil deposits near Warsaw, Radom and Elblag near the Baltic coast.

Poland is keen to pursue its shale gas opportunities on a commercial scale, with more concessions for exploration granted than in any other EU country. While ExxonMobil ended exploration “after tests failed to find gas in commercial quantities”, five Polish state-controlled companies joined forces this July to invest up to 1.72bn zlotys (\$515m) in the project.

PGNiG, copper group KGHM and power groups Tauron, PGE and Enea signed a cooperation agreement on shale gas exploration and extraction within PGNiG's Wejherowo licence on the Baltic coast. Other companies active in Poland include Chevron and ConocoPhillips, as well as smaller specialised groups.

Legislation: The potential for shale gas and oil in Poland is seen as a promising alternative to Russian energy imports.

A new tax is proposed on hydrocarbon production to ensure that there is a fair return for Poland but without discouraging investment from foreign companies who have the means and knowledge to help take projects forward.

Finally, Finance Minister Mikolaj Budzianowski said on 13 October that Poland



Fracking in the US: shale gas now accounts for around a quarter of domestic natural gas production.

will invest 50bn zlotys (\$16bn) in the exploration of shale gas by 2020.

Romania

Reserves: Romania has unconventional resources, such as shale gas and tight gas, in the Carpathian-Balkanian Basin, and in the Pannonian-Transylvanian Basin.

Legislation: NGOs and local groups in Romania have begun to organise in the Bârlad area and are co-ordinating with their counterparts in Bulgaria because of the large shale gas reservoir that straddles the border between the two countries. Romanian parliamentary opposition has recently proposed a ban on hydraulic fracturing, while local protests have been supported by members from both the governing and opposition parties.

Slovenia

Reserves: Slovenia has seen some activity from Ascent Resources PLC, which completed a fracture stimulation in November 2011 on a well at Petišovci where tight gas was found. As of February 2012, tight gas reserves have been estimated to amount to 14.3bcm at the Petišovci Project, which could significantly change the state of the Slovenian gas market and render it less dependent on imports.

UK

Reserves: offshore reserves of shale gas could exceed 1,000 tcf, although energy company Cuadrilla suspended test drilling for shale gas

last year after a study linked it to earth tremors.

Legislation: Cuadrilla Resources has said that it plans to apply for a permit to drill a horizontal well at its Anna's Road, Lancashire site. UK exploration was halted after earth tremors, which were possibly a result of hydraulic drilling operations in Lancashire's Bowland Basin. Cuadrilla has discovered a rich and thick geological formation that could make the UK, like the US, self-sufficient in natural gas. The results of a government consultation on fracking are expected shortly.

Norway

Reserves: Norway has approximately 83 tcf of technically recoverable shale gas reserves, according to the EIA, predominantly in the Alum Shale. It produced approximately 3.76tcf of natural gas in 2010, of which 3.6tcf was exported, accounting for nearly 94% of total gas production.

The Norwegian Petroleum Directorate forecasts that this will increase to 3.96tcf in 2015. As a result, Norway is not dependent on developing any shale gas reserves, and it is deemed that any extraction of shale gas will not be economically viable in the foreseeable future.

Russia

Reserves: There is no shale production and no published estimate for unconventional reserves in Russia. However, it is the largest natural gas supplier in Europe.

Russia's economy ministry sees “serious” risks posed by shale gas to the revenue of Gazprom beginning in 2014, as higher supply from the non-traditional hydrocarbons may hurt prices and demand for Russia's pipeline gas.

Legislation: The government hopes to unlock what may be the world's richest shale plays in western Siberia by using tax incentives to coax international companies to invest in the new energy.

Moscow is actively implementing a number of large projects along the whole gas supply chain, from exploiting the gas resources of the Yamal Peninsula, eastern Siberia and the far east to building LNG plants, export pipelines and underground gas storage facilities.

Serbia

Reserves: Domestic shale prospects may be expected to advance as its regulatory approach to unconventional resources progresses. The country so far has focused primarily on its shale oil basins. However, energy company NIS invited bids last year for the exploration of unconventional gas in the northern part of the country, at the southern edge of the Pannonian Basin. Drilling was proposed to extend to a maximum depth of 4,500m and extend over five phases, the last of which was expected to terminate in early 2012, over a total area of 532km².

Ukraine

Reserves: estimates by the EIA are around 42tcf of shale gas reserves. The Skifska field has a potential yield of 3-4bcm of hydrocarbons, and the Foroska field 2-3 bcm, according to press reports.

A quarter of all gas consumed in the EU goes from Russia through Ukrainian territory, making it the largest transit state on the continent. In addition, one-third of all inter-seasonal gas supplies in Europe are located in underground storage facilities in Ukraine. Ukraine is eager to collaborate with the EU to modernise its pipeline system for energy to travel through the country.

Ukraine has previously kept international energy majors at a distance, but last June invited bids for potential partners for the two offshore fields, picking Shell and Chevron to lead large-scale onshore exploration to help unlock offshore oil and gas using fracking and other non-conventional means. Production sharing agreements for both the onshore and Black Sea projects are expected to be signed within a year.

Turkey

Reserves: Has shown interest in exploring its large shale gas resources. State-run Turkish Petroleum Corp. recently announced that there are shale gas basins in the regions of Diyarbakır, Erzurum and Eastern Thrace, with 20 tcm of natural gas and 500bn barrels in reserves.

On 16 August, Anatolia Energy spudded its first exploratory well at the Dadas Shale, the most promising formation in southeast Turkey, estimated to contain about 159m barrels of unrisks reserves, mostly shale oil.

Together with Besni, Sinan, and Bismil, all in southeast Turkey, the total unconventional asset base is 206.1m barrels of oil equivalent, with conventional reserves estimated at 233.2m barrels.

TransAtlantic Petroleum, a pioneering junior in Turkey, has focused on the Dadas Shale alongside the Thrace Basin in the northwest. Valeura Energy of Canada is also dividing its operations between Thrace and the southeast, while Shell is exploring around Diyarbakir in the southeast.

Environmental and health issues

An unavoidable impact of shale gas and tight oil extraction is a high land occupation due to drilling pads, parking and manoeuvring areas for trucks, equipment, gas processing and transporting facilities as well as access roads.

There is also the problem of air emissions of pollutants, groundwater contamination due to uncontrolled gas or fluid flows from blowouts or spills, leaking fracturing fluid, and uncontrolled waste water discharge.

Water issues and environmental concerns

have sparked objections to shale gas development in the US and Europe, where environmental bodies claim that shale wells have contaminated groundwater supplies and drinking water. Measures to mitigate the environmental impact of shale drilling, perhaps in anticipation of the types of protests that have occurred worldwide, are being studied.

Economics

The US

The price of gas has been an important factor in the rapid increase in shale gas production in the US and will be an equally important driver of future gas demand in Europe. US natural gas prices were around \$3/mmBtu in September 2012, the level regarded by analysts at which utilities switch power generation from natural gas to coal. The price of gas in the US is now disconnected from the price of oil.

However, the shale-gas boom in the US, and the potential for similar successes around the world, is turning the sector into a buyer's market, promising deep and liquid markets with a growing diversity of supplies that improves security for buyers. The danger is that new large consumers, such as China and India, will make bilateral arrangements for large supplies of gas with big producers, which could set back the development of a global market.

At the same time, due to plunging prices, US natural gas companies are faced with the collateral damages of lower profits and large write-downs in their reported reserves. The companies involved in US shale gas production are recognising that their investments are 'in trouble' at current gas prices.

Prices of crucial shale gas by-products, such as ethane and propane, have tumbled to 10-year lows due to booming output, further hurting the profitability of energy already battling with very low natural gas prices.

Water is integral to shale-gas drilling and there is a growing market, estimated to be worth up to \$100 bn in the US, for wastewater treatment. There is no question that shale gas has been a 'game-changer' in the US. From virtually nothing ten years ago, shale gas now accounts for around a quarter of domestic natural gas production.

Geopolitics

As with most energy issues, shale has significant geopolitical ramifications.

Although fracking has seen US natural gas prices to fall to below \$3/mmBtu, the price in Europe is well over \$10/mmBtu. EU bans and moratoria could delay by at least a decade the replacement of much of the high-priced Russian and North African gas with cheaper

domestic production, although the EU could benefit from cheap imports from the US. European countries may soon have to import shale gas from Russia and the US if there is no domestic European shale development.

The prospect of even deeper reliance on Russian gas, together with a new rush to coal burning, may be the unintended yet inevitable consequences. Just as the German phase-out of nuclear energy production has resulted in Germany's increased imports of French and Czech nuclear energy, Europe's blockage of shale exploration is providing Russia with a good reason to intensify its own shale extraction.

The coal industry is greatly affected. For example, US coal miners are cutting jobs as increased use of natural gas for power generation hits demand. As shale-derived natural gas has become cheaper in recent few years, many US power companies are opting to use it, rather than thermal coal, to generate electricity. If this shift is extended outside the US, it will benefit shale-energy producing countries, but will hamper those whose economy depends on coal.

A more dramatic scenario is presented by Dr Aviezer Tucker, assistant director of the Energy Institute at the University of Texas, who wrote an article in the *Washington Times* on 13 July, which described shale gas as the "New Cold War".

In a subsequent interview, Dr Tucker claimed that "Russia was inflaming environmental fears of shale gas development in Europe in order to dominate energy markets."

"The Russian/Gazprom methods for stirring and financing local environmentalist opposition to shale gas exploitation resemble their method for encouraging and supporting the anti-nuclear movements during the 1980s," Tucker said.

"There is obviously a conflict between the US and Russia. The US is interested in promoting energy security and independence for the nations of Europe. Russia wishes to maintain its virtual monopoly over the supply of gas to eastern and central Europe and the economic dependence it implies. It also has an interest in maintaining a high price for gas in Europe in general since it is the largest single supplier," he added.

In considering the status of various European countries and their stance on shale gas, Tucker drew the following conclusions:

"We lost Bulgaria. We are likely soon to lose the Czech Republic. We gained Ukraine. Poland has always stood with us. Germany hedges its bets. France definitely is not with us. The UK probably will side with us. The Baltic States would love to join us if they have the resources. A fierce battle rages over Romania," he said.

National public policies

The established natural gas supplying countries will have to be very aware of the new situation created by the revolution in shale oil and shale gas, and design their policies accordingly. In a bid to gain energy independence from Russia and Gazprom, central and eastern European countries appear more determined to develop hydraulic fracturing than those of western Europe.

The main relevant policy issues include:

- Environmental and licensing;
- Protection of public health and safety in general;
- Enhancing and protecting natural resources;
- Price volatility;
- Investment uncertainty;
- Tax policy.

Although shale gas activities are underway in Germany, Spain, the UK and Ukraine, commercial production will not begin immediately.

European countries are also subject to legislation beyond granting authorisation and permits for hydrocarbon exploration and production. This will obviously delay operations further.

France, Germany, Poland and Sweden all have, or had, shale gas projects in their territories, although the number of projects, and the stage they are at, differ.

In Sweden, for example, the areas licensed for shale gas prospection activities are small in comparison to other member states, while Poland has granted the highest number of authorisations of all scrutinised states.

Exploration projects for shale gas are largely only in an initial phase throughout the EU, with only Poland, and to a more limited extent, Germany, seeing actual drilling activity. A ban on hydraulic fracturing has put all shale gas activities in France on hold, while Sweden is the only member state where an exploitation concession has been granted and then, only for small-scale operations. However, this has not led to the actual launch of any exploitation activities.

EU policies

Acknowledging that evidence indicates that shale gas is the form of unconventional gas with the most promising growth potential in the EU, DG Energy, the Directorate-General for Energy, European Commission, has invited proposals by public authorities in EU member states in relation to organising public debates and information campaigns on shale gas in the region.

EU policies will have to deal with issues related to land access; higher production costs than in the North American market; heightened environmental concerns; the

Other impacts on the environment could be:

- Earthquakes induced by the hydraulic fracturing process or waste water injection;
- Air and noise pollution;
- The mobilisation of radioactive particles from the underground;
- Fugitive methane emissions from hydraulic fracturing processes can have a large impact on the greenhouse gas balance; and
- The chemically laden water affecting livestock, with deaths occurring in major US fracking areas such as Louisiana and Pennsylvania as a direct result of hydraulic fracturing.

difference between EU and US in property rights; and the fact that shale gas fields in the US occur far away from populated areas, whereas in Europe shale gas operations would be nearer to inhabited communities.

On 30 March 2012, the European Parliament [Committee on Industry, Research & Energy, Rapporteur: Ms Niki Tzavela] issued a 'Draft Report On Industrial, Energy And Other Aspects Of Shale Gas And Oil'. This is a 'Motion for a European Parliament Resolution' on industrial, energy and other aspects of shale gas and oil.

The motion "believes that expectations about the pace of shale gas development in the EU should be realistic" and "calls on the Commission, in line with the EU Energy Roadmap 2050 strategy, to evaluate the impact of and prospects for unconventional gas in the EU, whilst recognising that the extent of unconventional gas use in the EU will ultimately be decided by the market".

The report also "calls on the Member States to ensure they put in place the necessary administrative and monitoring resources for the development of shale gas activities; encourages cooperation between relevant EU and US companies with a view to reducing costs (...) without delay to check and, if necessary, improve regulatory frameworks in order to ensure their adequacy for shale gas projects, especially with a view to being prepared for possible future commercial-scale production in Europe (...) adopt a one-stop-shop approach to authorisation and licensing and the examination of compliance with environmental regulations, which is the usual practice in certain Member States for all energy projects (...)" and calls on the Member States "to evaluate their legislation to see whether proper account is taken of this aspect".

Furthermore, the report "stresses the importance of fully consulting the public, particularly in the context of the introduction of a new approach in gas exploration; points out that, in certain Member States, there is a lack of public consultation in the authorisation phase".

A similar attitude is expressed in a European Commission presentation early in 2012, which stated that the Commission's role is:

- Neither to open nor to close the door to shale gas operations in Europe;
- To obtain a clear picture on potential risks/impacts; and
- To ensure that hydrocarbons operations comply with all applicable EU legislation and offer a high level of safety for the environment and for humans'.

Lastly, a study has been undertaken in September 2012 by the Joint Research Centre, the European Commission's in-house science service, titled 'Unconventional Gas: Potential Energy Market Impacts in the European Union', JRC Scientific and Policy Reports, European Commission'. The report emphasises "aiming at zero harmful emissions and the lowest possible environmental footprint; aiming at 50% cost reductions for large-scale drilling campaigns; investing in research and development, as well as human resource capacity and establishing and building the required technology in Europe; supporting large-scale field developments with several hundreds of rigs operating in Europe for many decades, and developing and building the required infrastructure".

The concluding comment is that, "The development of shale gas will only be successful in Europe if the environmental and economic boundary conditions can be fulfilled".

Clearly the potential for shale gas is there, with a will for its successful adoption. But many hurdles still remain before it becomes a reality.

*Vasilis Nicoletopoulos owns Natural Resources GP, a consulting and brokerage firm www.naturalresources.gr. Maria Kalaitzaki, environmental engineer, contributed to this article.

Relevant Work by Natural Resources GP:
Rare Earths and Shale Oil & Gas: Technology, Environment and Politics, presented at Sustainable Mining Development in Europe, International Fair Plovdiv, Plovdiv, Bulgaria, September 24-25, 2012
Fracking for Shale Gas & Shale Oil Worldwide, presented at 2nd Tunisia Oil & Gas Summit, Hammamet, Tunisia, September 22, 2012
Hydraulic Fracturing, IENE, September 26, 2012
Hydraulic Fracturing and the Growth of Shale Gas and Shale Oil Internationally, comprehensive study by Natural Resources GP, July 2012