The "Unconventional Oil Revolution" is a challenging topic that has profound consequences at both economic, technological and geopolitical levels. In particular, the rise of US tight oil production could dramatically impact on US domestic and international energy policy strategies, driving a global spin in the world energy scenario. The expectations on unconventional oil growth and the possibility of a shift in the balance of energy exchange could deeply change the US presence and intervention in some critical areas of the world. It could also lead to the rise of new players and different approaches in managing complex relations. This volume addresses the complex consequences related to the unconventional hydrocarbons revolution, focusing primarily on US foreign policy, the driving forces leading towards a new world energy balance, the role of new players in a renewed energy scenario and the related political, sociological and geostrategic dynamics.

John M. Deutch

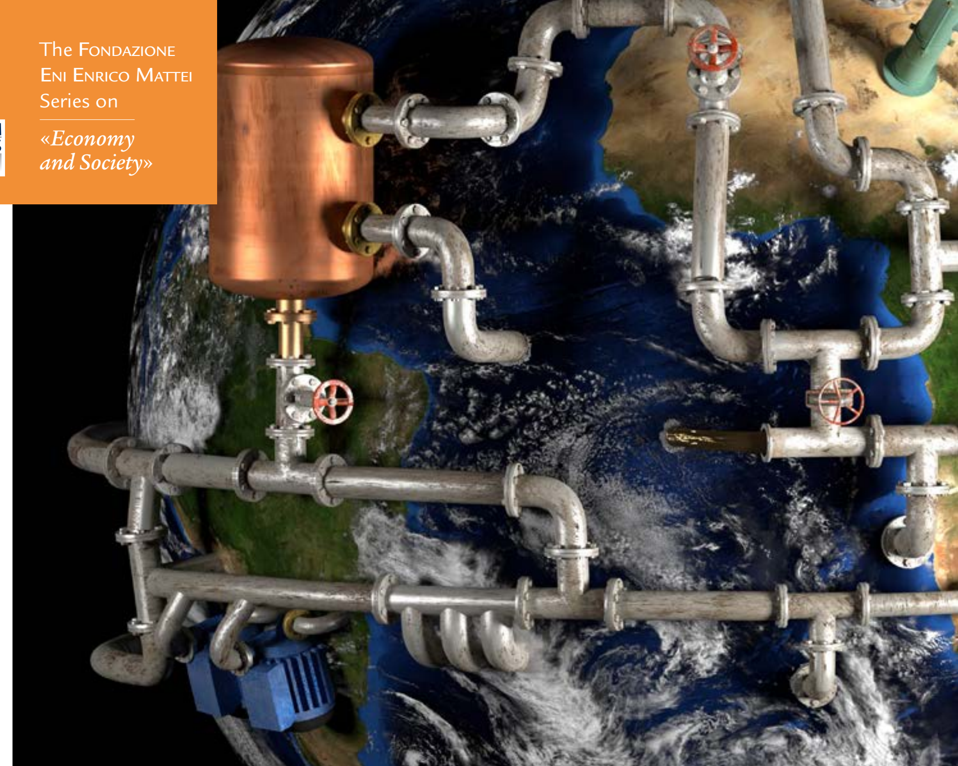
Emeritus Institute Professor at the Massachusetts Institute of Technology, has been a member of the MIT faculty since 1970 and has served as Chairman of the Department of Chemistry, Dean of Science and Provost. John Deutch was Director of Central Intelligence, and served as DCI from May 1995 until December 1996. In this position, he was head of the U.S. Intelligence Community and directed the Central Intelligence Agency (CIA). From March 1994 to May 1995, he served as the Deputy Secretary of Defense, and from March 1993 to March 1994 he served as Under Secretary of Defense for Acquisitions and Technology. From 1977 to 1980, John Deutch served in a number of positions for the U.S. Department of Energy. He has published over 140 technical publications in physical chemistry, technology, energy, international security, and public policy issues.

The Global Revolution of Unconventional Oil | *by John M. Deutch*

1/2014

The Fondazione Eni Enrico Mattei Series on *«Economy and Society»*

FEEM PRESS



by John M. Deutch

The Global Revolution of Unconventional Oil

New Markets, New Governances, New Policies

FEEM PRESS

ENGLISH/ITALIAN

The **Fondazione Eni Enrico Mattei (FEEM)** Series on

«Economy and Society»

Fondazione Eni
Enrico Mattei

Foreword

Globalisation involves complex shifts in the world's social, political and economic paradigms destined to unhinge consolidated transnational relations and to lay the groundwork for future governance scenarios. A multidisciplinary approach, including the sociological, economic, anthropological, political and technological dimensions, is needed to fully comprehend the complexity and interdependence of these changes. FEEM's "Economy and Society" Series aims at stimulating and disseminating novel perspectives to interpret the multiple cultural, economic and geostrategic challenges ahead. Capitalising on the international lectures of the Research Programme "Economy and Society", each volume will propose a different topic, opening the debate to a variety of interpretations and providing the scientific community, decision makers and civil society with the latest theoretical insights in view of a new planetary governance.

Premessa

La globalizzazione è caratterizzata da un complesso e diffuso sommovimento dello scenario sociopolitico ed economico mondiale, in grado di scardinare relazioni transnazionali consolidate e promuovere nuovi equilibri di potere. Per comprendere alla radice la complessità e l'interdipendenza dei fenomeni in atto è necessario promuovere un approccio multidisciplinare, comprensivo dell'analisi sociologica, economica, antropologica, politica e tecnologica. Con la nuova collana editoriale "Economia e Società" la Fondazione Eni Enrico Mattei si propone come catalizzatore e divulgatore delle più acute riflessioni teoriche per interpretare le molteplici sfide culturali, economiche e geostrategiche che ci attendono. Ogni volume - dedicato a una lecture *del Programma di Ricerca "Economy and Society" - proporrà un differente argomento di dibattito, aperto alle più eterogenee chiavi interpretative per restituire al mondo scientifico, ai decisori e alla società civile i risultati più avanzati della riflessione teorica internazionale e tratteggiare i primi contorni di una nuova* governance *planetaria.*

The **Fondazione Eni Enrico Mattei (FEEM)** is a non-profit, nonpartisan research institution devoted to the study of sustainable development and global governance. FEEM's mission is to improve through research the rigour, credibility and quality of decision making in public and private spheres.

Fondazione Eni Enrico Mattei
Corso Magenta 63, Milano – Italy
Ph. +39 02.520.36934
Fax. +39.02.520.36946
E-mail: letter@feem.it
www.feem.it

ISBN 9788890991806

Translation and text elaboration by Marco Soggetto.

Printed in Milan in May 2014 by Roberto Cremonesi.Co Srl

The **Fondazione Eni Enrico Mattei (FEEM)** Series on

«Economy and Society»

The Global Revolution of Unconventional Oil

New Markets, New Governances, New Policies

by John M. Deutch

ENGLISH

FEEM PRESS

Table of contents

Introduction

An ever-changing world, characterized by fluctuating market trends and unstable political relations. Driven by the urgent requests of modern manufacturing systems, the challenge for accessible, enduring energy supply transcends its merely functional essence - to provide power and support human life - to become the focal point of international relations, diplomacies and even armed conflicts.

During the last years we have frequently seen how sudden changes in politics and alliances could disrupt long-time established fuel supply routes, leaving stakeholders and policymakers adrift. Domestic tensions in producing countries and key areas of the world, regime collapse, unexpected change of interlocutors: worldwide companies and governments share the constant fear of power supply cuts. From this perspective, and without the availability of brand new energy sources, stakeholders have focused their interest on already known energy provisions: a different perception of well-known hydrocarbon sources, based on new technologies and able to overcome the dilemma of increasing reserve scarcity.

In this vague and uncertain scenario, the Economy and Society Programme's lecture delivered by Professor John Deutch offered a sharp, enlightening point of view on unconventional resources - their story and evolution, the pros and cons of their application, a glimpse of their possible future.

1. Unconventional Oil and Gas. The rise of a new technique

Great expectations have been placed on unconventional resources, due to the afore-mentioned threats to reliable supply lines, as well as to the growing energy demand. Already thirteen years ago, the IEA's 2001 report World Energy Outlook, aimed at a time horizon up to 2020, stated for instance "(…) *Unconventional oil is likely to play a growing role*", as well as "(…) *Unconventional oil may well exceed current projections and account for a much greater share of total oil resources and supply by 2020*".[1]

Unfortunately, the deployment of these extractive techniques could not be easily compared with the customary infrastructures, broadly used in the last decades for conventional onshore and offshore drilling operations. Movies and press accustomed us to the "traditional" rig concept, based on single wells in which oil is expected to flow almost naturally thanks to the difference of pressure between the underground and the surface, or with the use of artificial lift mechanisms, mainly pumps.

A typical unconventional oil and gas producing system is far more complicated, requiring more sophisticated recovery technologies and, above all, implying a completely different production scale. Such a facility is not limited to a chain of single wells, scattered on the reservoir's surface like waypoints on a map: an unconventional recovery operation would require lateral spots, pooled out from the main well which can reach a depth of 2 or 3 km. Moreover, the distance reached by these lateral spots could be very large, up to 5 km from the main well.

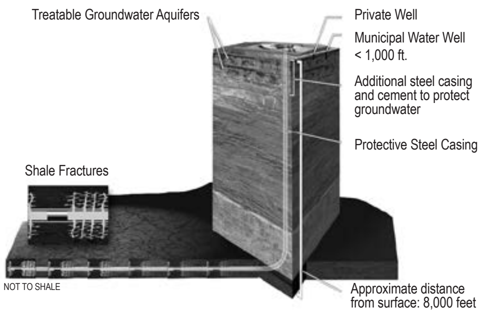
1 *World Energy Outlook 2001: Assessing Today's Supplies to Fuel Tomorrow's Growth*, International Energy Agency, OECD/IEA, Paris 2001.

Along this wide area, the underground formation is perforated by the lowering of lateral wells. Once ready, the system starts injecting an enormous amount of fluid at very high pressure, in order to force the release of oil, gas or their mixture. Through this process the injected fluid (usually water with sand and chemicals) breaks the rock creating microscopic fractures, to be held open by injecting small grains of "*proppant*" after the removal of hydraulic pressure from the main well. These particles provide stability to the fractures, thus allowing oil and gas to flow towards the well. According to the characteristics of the reservoir and of its rocky formations, it may request multiple hydraulic fracturing: a procedure commercially applied since 1949, but never conceived on this scale and complexity.

Even if highly productive, this technique has forced a rethink of the whole concept of oil recovery on a larger scale, also requiring better understanding of the shape and contours of the underground. Moreover, it has triggered the development of high-precision drilling over large distances, because of the need to reach very definite points within very few meters of accuracy - on a kilometric scale.

Figure 1.

Cross-section diagram of an unconventional well.



Source: John M. Deutch, Geopolitics of Unconventional Oil & Gas: New Markets, New Risks, New Policies,
Outline Presentation, 1.20.2013.

Box 1.

The Dawn of Hydraulic Fracturing. George Mitchell's Dream

The current hydraulic fracturing technology owes everything to the genius and the force of will of an American businessman and philanthropist, George Phydias Mitchell (1919-2013). Defined by The Economist as "the embodiment of the American dream" *for his poor Greek origins and* "the embodiment of the entrepreneurial spirit"[2]*, this semi-legendary figure provided the link between shale gas and oil, already described and mapped by geologists, and their successful commercial exploitation. A former Army Corps Engineer during the Second World War, Mitchell grew up in Galveston and attended the Texas A&M University, earning a degree in Petroleum Engineering. With great perseverance, he found a convenient way to extract natural gas from the Barnett Shale sedimentary formation, thus starting the new "unconventional boom" in North America. A very tight gas reservoir, Barnett Shale was not commercially useful before the lucky advent of two innovative technologies,* hydraulic fracturing *and* horizontal drilling*; according to an US Energy Information Administration report, this is the third most productive reservoir in the country.*[3]

Discovered in 1981 after the first drillings near Newark by the Mitchell Energy and Development Corp., the reservoir offered very low production rates for years. In 1986 the company abandoned the previous foam fracking and turned to hydraulic fracturing: this decision marked a real breakthrough. In 1997 George Mitchell adopted a "slickwater" fracturing in Barnett, lowering the completing wells' costs and increasing gas recovery, thus paving the way for large-scale extraction. It was the crowning achievement of a long struggle against technical difficulties and geological resistance, a battle fought by George Mitchell for long years in spite of the constant, impressive economic loss. Mitchell didn't limit himself to this revolutionary combination of technology and intuition. He also had an important role in the long development of a new technology, called horizontal drilling, *which could*

2 *The father of fracking. Few businesspeople have done as much to change the world as George Mitchell*, The Economist, August 2013.

3 United States Energy Information Administration, *What is shale gas and why is it important?*, December 2012.

be briefly described as sideways drilling offering an increased yield, unlocking more gas. This technique was applied to the Barnett Shale since large part of this reservoir lies under Fort Worth and would have not been easily exploitable with common, vertical rigs. After the first technical failure in 1991 and two other attempts in 1998, technically successful but economically unsuitable, horizontal wells became more economical and technologically improved. At the end of his long and successful life, George Mitchell supported the campaign for a strict, government-regulated law on fracturing, in order to ensure the protection of the environment.

Figure 2.
Trucks and machinery surrounding an unconventional well.

Source: John M. Deutch, Geopolitics of Unconventional Oil & Gas: New Markets, New Risks, New Policies,
Outline Presentation, 1.20.2013.

Unconventional oil and gas operations have to be supported by a huge amount of industrial capacity on the surface area: each drilled site will show large crowds of trucks and trailers, tankers for diesel fuels etc., all surrounding the main well.

Box 2.

Unconventional Oil and Gas. A new concept of already-known resources

Notwithstanding the impression of difference given by its definition, the term "unconventional" *should not be associated with the final product of this process, oil and natural gas. It does not refer to a "special kind" of oil, underlining instead the very different way to extract it from the ground.*

Mankind has long known these hydrocarbon sources and, above all, started their industrial use after the discovery of kerosene distillation process by the Scottish chemist James Young, in 1847. Unfortunately, a whole century of intensive extraction caused a general depletion of the most accessible resources, while other large and promising reservoirs lay out of reach - in deep oceanic waters or exposed to extreme climatic conditions, like in the Arctic, or even in war-zones. Under the pressure of an ever-increasing global demand, brand new technologies were developed and thrown in the field, focusing on very different ways of extraction: an innovative conception of the "old" crude oil and natural gas, to be reached outside the proven, comforting wells-drilling environment. In low permeability strata, where rocks have poorly connected pores, oil and gas are not expected to flow naturally; previously rejected as not exploitable, such sources were suddenly reconsidered as a powerful asset after the introduction of various extractive technologies.

A general definition of unconventional oil should mention, first of all, that this oil does not come from underground basins through the usual production wells. When referring to unconventional oil and gas, we may think of "tight oil and gas"*, to be found and extracted from shales, carbonates and sandstones - all low-permeability rocks. We may also hear about* "coal bed methane"*, a kind of natural gas to be extracted from coal beds, or about* "shale oil"*, usually addressing the unconventional oil derived by thermal dissolution, hydrogenation or pyrolysis of an insoluble organic solid, the kerogen mixture, included in sedimentary rocks.*

Current unconventional sources also include oil sands-based synthetic crudes and their derivative products, extra-heavy oil, gas-to-liquid, coal-based liquid supplies, biomass-based liquid supplies.

2. Environmental Concerns and Policy. The United States Case

The injection of high-pressure fluids on vast underground areas, aimed at forcing the resistance of rocks, necessarily implies large-scale dynamics with considerable environmental issues.

A privileged view of the problem may be provided by the United States where, with the prospect of 100.000 new wells being drilled over the next decades, a significant debate has arisen in the last years concerning the environmental and health impact of this new technique. Mainly focused on contamination risks by fracturing fluid, this debate obtained great attention and concern from the public, in the United States as well as in other countries planning to adopt unconventional oil and gas production activities. Despite their environmental impact, unconventional sources are anyway supposed to offer a clear advantage to European countries - noticing for instance how Germany, after its aggressive support to wind and solar energy, was recently forced to import and burn more coal than ever.

Since their already advanced application of such activities, the United States of America may also provide an overview of various related issues, transcending a mere environmental discussion. Together with the mentioned debate, the almost unique American landownership condition has triggered a wide approval of unconventional oil and gas exploitation: in a country where resources belong to the direct landowners, the current race to unconventional production has granted a tremendous economic incentive to the population.

4 This know-how prevalence in investors-owned companies also appears in the unconventional field.

This phenomenon, strictly linked to an American peculiarity, could not be expected to exist elsewhere in the world. Other countries do not share this broad landownership concept and, taking into consideration the vastly different ways governments may relate to their respective citizens, public acceptability of this technology would be really expected to be different from the United States.

A further element has eased the widespread diffusion of unconventional oil and gas exploitation in North America: the greater intensity of drill rigs, pumping equipment and related stimulation technology, already present on the field and socially accepted after decades of use. This presence, directly connected to the United States' long-period exploitation history, leads also to a second advantage: the prevailing technical know-how of investor-owned companies, if compared with other countries' national oil companies .

Public opinion and policymakers abroad have closely followed all these issues and considerations from the United States market, especially in Europe, where various countries own large unconventional reserves.[5] When talking about energy policy, the American case provides a powerful view on how much the world has changed in the last four or five years, since the implications of unconventional oil and gas became clear and known by a broader community. Around 2009 and during the first term of Barack Obama's administration, a widely accepted opinion saw the most part of global oil and gas resources concentrated in the Middle East, an area frequently unfriendly and unstable for United States interests. This of course implied the unavoidable dependency of large industrialized economies on oil and gas imports from the Middle East, with an equally inevitable increase of oil and gas real price. Natural gas markets - essential for European and American

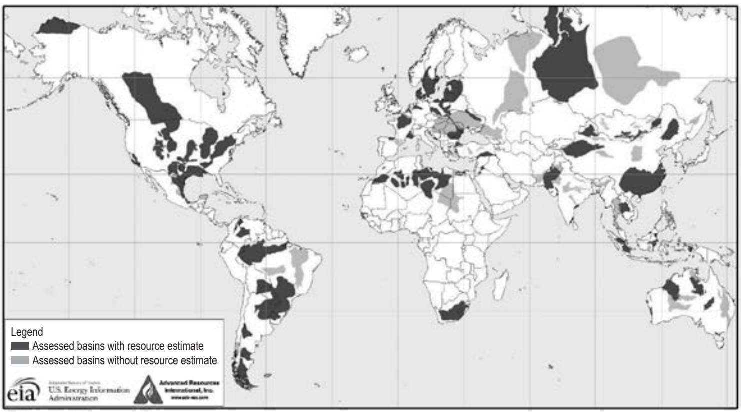
---

5 Countries like the United Kingdom, France and Poland will probably explore the unconventional production, provided that they will be able to manage the key issues of public acceptance and environmental impact. If so, gas importers will be able to renegotiate more favorable contracts, less indexed to oil.

home heating, electricity production and chemical feedstock - were perceived as inevitably fragmented, with increasing gas prices. In this static landscape, a real revolution was then started by the new exploitation technologies, paving the way for the largest change ever to have occurred in the whole future of energy in the last forty years.

Gaining knowledge of the tremendous potential represented by unconventional resources, a brand new view has replaced the previous one. According to this new concept, unconventional oil and gas resources are widely placed all around the world, instead than in a relatively narrow and potentially unfriendly area, such as the Persian Gulf, the Middle East and the Russian Federation. What matters most is that these resources are available at technically and economically recoverable rates, even if this does not necessarily mean that they will be equally rapidly exploited and produced.

Figure 3.
Shale gas resources by allocation



Source: John M. Deutch, Geopolitics of Unconventional Oil & Gas: New Markets, New Risks, New Policies,
Outline Presentation, 1.20.2013.

Various countries, such as for instance Colombia and Brazil (this latter is said to have technically recoverable shale gas resources) are not yet included in official reporting lists, even if their underground may hide unconventional reservoirs.

Consequently, the largest economies will break their long-period dependence from the Middle East's imports[6] and, from an economic point of view, this plurality of sources and allocations will grant lower real prices for decades, with obvious benefits for all the stakeholders - people, companies and policymakers. Finally, the currently regional natural gas market may become a global one.

This global variation of perception has led to implications of paramount importance. Energy will remain one of the key points in international relations and geopolitical changes, and inside this topic, unconventional sources will increase their strategic relevance. At the same time, the expected lower prices will trigger a virtuous circle, with increasing demands for unconventional oil and gas combined with economic and political interaction. Lower prices will also grant sensible benefits to the final consumer, allowing for instance cheaper home heating for poor people – as has already happened with natural gas prices in Boston, currently half of those of five years ago.

More broadly, worldwide markets will experience a progressive shift in energy use, due to the ever more competitive price of unconventional sources. Natural gas, currently the less expensive, is expected to replace other traditional sources (coal, nuclear power and renewables as well) as the most convenient electricity generator. This substitution will of course result in a global change in the balance of power, with a consequent winner-loser process among the traditional resource holders and, above all, with further geopolitical strains.

---

6 In spite of this predicted decrease in United States dependence on Middle East reserves, the unconventional revolution is unlikely to reduce their military presence and control in the area. The Middle East will remain strategic from various points of view, besides oil, like for instance nuclear proliferation and terrorism. Moreover, the United States will pursue their stability-enforcing process of Iraqi and Afghanistan's governments, also continuing to play a role in the Arab-Israeli war.

Box 3.

Unconventional Oil and Gas. Extraction and Environment

As happened with traditional mining and drilling activities, various environmental concerns have been underlined by unconventional oil and gas extractive operations. Along with a strong increase in noise pollution*, the main risks concern* underground contamination *and* water quality*: the injection of large volumes of fluid on large areas may affect ground waters and freshwaters aquifers, while the flowback requires a careful, industrial-scale wastewater management - not to be left in the hand of common wastewaters plants on municipal scale.*

Another related topic concerns water consumptio*n, posing a potential threat to water supplies for domestic uses and power generation, as well as to river and lacustrine environments: a recent study on the Marcellus Shale reservoir implied a use from 4 to 8 million gallons of water in a week, with a possible need to hydro fracture again and again the same wells.*[7]

Moreover, the potential hazard represented by the injected chemicals has raised questions about the danger of pollution of deep aquifers, as well as for human safety these are once back again on the surface; an analysis of this fluid revealed that it is composed of water and sand (99.51%) and chemicals (0.49%)[8]*. Of course, it is on this latter minority that the main concerns about drinking water supplies and potential human health damage rest.*

Hydraulic fracturing may also be related to micro-seismic events and tremors. Air quality *could be affected by the increase of diesel fumes by trucks and compressors in the very concentrated space around the wells, as well as by methane (a greenhouse gas) released during fracturing. Unconventional oil and gas recovery implies also a huge* land-use *and* community impact*, due to the extended area of operation and to the burden represented by up to 100 trucks required for every production site.*

---

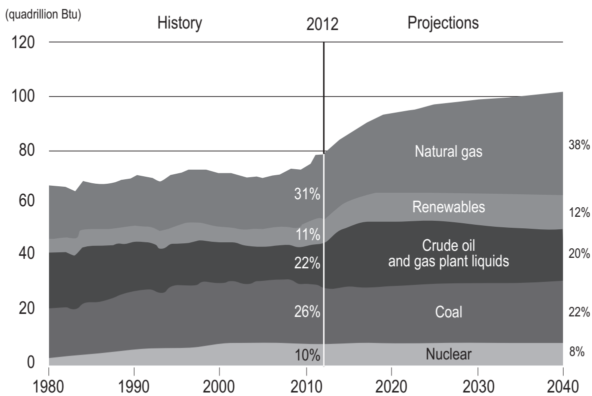
7 Charles W. Abdalla, Joy R. Drohan, *Water Withdrawals for Development of Marcellus Shale Gas in Pennsylvania, in Marcellus Education Fact Sheet*, Pennsylvania State University, 2010.

8 This percentage includes surfactants, gelling agents, scale inhibitors, pH adjusting agents, breakers and crosslinkers, iron controls, corrosion inhibitors, biocides, acids, friction reducers.

3. Unconventional Oil and Gas Revolution. Its impact on global markets

The United States has seen a rapid and continuous increase in oil and gas production, over the last five or six years. If calculated since 1980, their natural gas production has experienced a 31% increase in 2012, followed by coal (26%), crude oil and natural gas plant liquids (22%), renewable energies (11%) and nuclear power (10%).

Figure 4.
United States energy production by fuel (1980-2040)



Source: United Nations Energy Information Administration, www.eia.gov.

Even though the case of the United States offers an interesting point of view, the presence of huge unconventional oil and gas resources in Canada and Mexico, should accustom us to addressing the question over the whole North American continent. The revolution in unconventional resources has also brought about closer ties between these countries, leading North America to forge closer political cooperation and far greater economic opportunities: Mexican policymakers are considering a wider liberalization of their oil and gas market, and this country will probably contribute to the gas supply. Meanwhile, Canadian authorities have asked for an improvement of the Keystone and Keystone XL (eXport Limited) Pipeline System.[9]

Leaving the North American continent, we may immediately realize that unconventional resources of oil and gas are available almost everywhere in the world with a huge production potential. Differently from the most part of conventional sources, unconventional oil and gas basins seem to present a large variety of typologies from "dry" (only gas resources) and "wet" (only oil), or even mixtures of oil and gas, or tight oil. This is not only a technical issue, since this great variability will always reflect on unconventional production costs and require a careful case by case analysis of the various environmental impacts.

From an economic point of view there remains a tremendous uncertainty between the ratio of the oil and gas prices, both in local economy and globally. The latter's price shows a huge difference: 1000 cubic feet of gas could be paid $ 4 in North America[10], rising to $ 12 in Milan and even to $ 16-17 in Shanghai and Tokyo. Instead, oil prices remain almost the same (around $ 100 a barrel) everywhere in the world, and the equivalent energy price of this same oil is much higher than gas prices in North

9 The Keystone Oil Pipeline connects the Western Canadian Sedimentary Basin (Alberta) to Nebraska and Illinois refineries, continuing to the Gulf Coast (Texas).

10 This $ 4 price reflects the overpayment made by United States companies for reserve acquisition, also because of the enormous amount of flared gas.

America. Moreover, gas production costs in North America will probably continue to decrease, probably for at least 20 years: dry natural gas production is currently flattening out in the United States, but only because the local market is already overstocked.

Following this first economic reasoning, stakeholders should also focus on an apparently secondary and exquisitely technical issue, the future of LNG tankers. According to the evolution of these giant ships, unconventional gas costs may increase or decrease, thus finding new ways to reach markets with still very high gas prices. Anyway, the intrinsic nature of unconventional resources poses two important bottlenecks to their successful exploitation. The first problem concerns the enormous infrastructure costs implied by unconventional exploitation: the large extension of unconventional operations, the amount of machinery required and the volume of fluids to be injected, the transportation costs will oblige stakeholders to take on a great challenge. Consequently, the commercial development of unconventional resources will probably be slow.

More geographically and nationally related, the second issue relates to the concentration of unconventional resource exploitation technology, mainly available in North America. It has been estimated that 60% of unconventional able drilling rigs and related pressure machinery is currently located in North America, while 25% is said to be in China, even if this is probably not as sophisticated and reliable as the former. This underlines the curious difference between the conventional resource market, increasingly controlled by national oil companies, and the rising unconventional market, mainly in the hands of investor-owned companies.[11]

Even if more related to domestic policy, a third issue should be underlined: running parallel to the environmental debate,

11 Even if mainly concentrated in the United States and North America, other companies, such as Total, BP and other Norwegian and Italian companies, share valuable knowledge.

various countries with potential unconventional resources will face a difficult and expensive national debate concerning their eventual use - for export or turned into the national productive system, or grid.

In the wake of this recently christened unconventional revolution, various implications for global oil and gas markets have arisen. First, even if remarkable, the North America supply shock will not affect the global oil price; at the same time, oil price could potentially decrease to a range of $ 70 - $ 90 per barrel. This because of a combination of multiple factors, such as the above mentioned North American oil and gas productive capability expansion, the high levels of global spare production capacity in the major producing countries, the slower growth in oil and gas global demand. This same spare capacity has shown to be large enough to positively overcome the frequent, minor supply disruptions mainly due to local conditions, like for instance the daily 30,000/40,000 barrels seized by the state of war in Syria or sporadic Nigerian problems, or even the past Yemen and Libya disruptions. Simultaneously, major resource holders such as Iran, Russia and Venezuela have suffered a negative wealth effect because of the decrease of their conventional oil and gas resources. Today, various expensive conventional exploitation projects point to underwater basins, like Australian coal-bed methane, or for instance to the deep Gulf of Mexico as well as in the Artic.

This multiform, multifaceted landscape poses several interesting questions for the future. A first dilemma concerns natural gas prices' current regional difference: with a natural gas price of $ 4 per 1000 cubic feet in North America, of $ 12 in Europe and of $ 16 in Asia, all the stakeholders involved will have a huge opportunity to reduce differences in price.

A second question should be raised concerning the future of the current energy equivalent difference between oil and gas: as for the previous point, a terrific technological and economical opportunity awaits the technologists and investors who will be able to narrow this difference. A technology challenge is also required for a possible implementation of natural gas in power generation systems: this would allow the displacement of nuclear and renewable energies, as well as coal, in favor of a cheaper resource, also suggesting a progressive introduction of natural gas in the transportation sector - at least in North America's long distance truck fleet.[12] Obviously, all these possible future evolutions will result in an increase in natural gas demand.

12 Natural gas could be used in transportation systems with compressed natural gas or bi-fuel vehicles, or converting gas to liquids (GTL) or to other chemicals, like methane or methanol.

4. Geopolitical Energy and Foreign Policy Implications

Unconventional resources will certainly affect the United States energy policy, since their first and most intuitive effect - to be extended to the whole of North America - will be an increased export of crude oil and natural gas. At the same time, North America will become effectively independent of oil imports, but still not energy independent: this apparent contradiction may be easily explained by considering that North American economies will anyway remain vulnerable to possible disruptions somewhere in the world, since North American prices will continue to reflect global price trends.

Moreover, from a strategic point of view, United States closest allies (like Germany, Italy and Japan) will remain dependent on imports; and for this reason, Congress has introduced new bills aimed at facilitating access to United States' LNG to NATO members. The reduction of North American oil and gas imports has already "freed" a large amount of resources, now available for European consumers, starting therefore to decrease their dependency on Russia.[13] Moreover, well aware of the risks implied by its energy dependency, the European Union voted the ambitious Horizon 2020 Program, aimed at meeting with renewable resources 20% of its overall energy need by the year 2020.

Anyway, this greater flexibility of the United States together with a diversity of lower cost supplies for their allies will force a reduction of the constraints that energy has placed in United

13 Moisés Naím, *Will shale gas have a role in foreign policy?*, in *Oil Magazine*, December 2013.

States' foreign policy. Geopolitically, this significant change in the United States' energy policy will increase their leverage abroad, with positive consequences for their allies; of course these geopolitical effects may not be always foreseen and may be seen in bilateral or multilateral ways as well.

In the broad and complex foreign policy arena, energy will always play a key role. It should be remembered that, in spite of their media preeminence, oil and gas represent only an aspect of the wider international energy relationships. While increased supplies will surely favor consumers, sudden disruptions or local tensions may lead to escalations: the first priority is to carefully avoid getting involved in armed conflicts as a result of such pressures. And this point, which we may define as obvious, will be considered under a new light in the case of an extended oil price drop: countries like Iran, Iraq, Libya and Venezuela need a price of at least $ 100 a barrel to maintain their fiscal balance. Their worst-case scenarios would surely trigger social consequences with possible military escalations, on a scale hitherto never experienced.[14]

Starting from these concepts, it is possible to propose several closer profiles of single nations.

4.1 Iran

Western countries' relations with the Islamic Republic of Iran have known a seesawing trend, since the aftermath of the 1979 revolution. In the past decades, this country has been able to exert a strong influence on the world oil market, being OPEC's second producer and, therefore, placing an implicit limit on Western responses and proposals for a mutual coexistence regime.

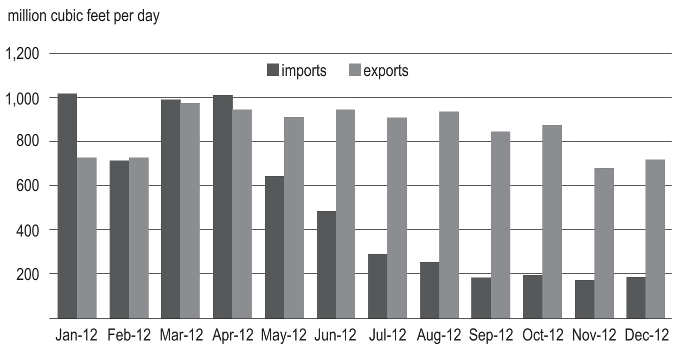
Today, Western-Iranian relations are strained by four main problems: the very controversial Iranian nuclear plan, firmly opposed by Western diplomacies as a probable nuclear weapons-

14 Moisés Naím, *Will shale gas have a role in foreign policy*, ibid.

building hidden program. Second, Iranian support for terrorist organizations like Hamas, Hezbollah and the Palestinian Islamic Jihad, as well as the long-term Iranian shadows cast on the Israeli-Palestinian conflict; finally, Iranian supplies to the world oil market, corresponding to 3 million barrels per day.

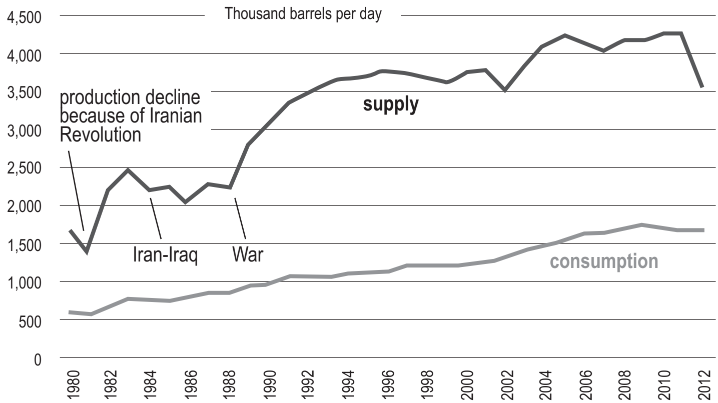
A first consequence of the impending energy revolution would surely have geopolitical repercussions on the problems mentioned above: the international community may be encouraged to a greater firmness in opposing Tehran's nuclear program, thanks to the already explained lower cost supplies. At the same time, unconventional oil and gas contribution would impose a severe wealth loss on Iranian gas market, through the oil and gas price drop. In any case, the unconventional revolution's overall effect on Iran may not be so huge, since the country is already facing severe economic problems and, above all, an already impressive economic pressure. This complex situation led to the famous interim deal, signed in Geneva on November 24th, 2013 between Iran and the five United Nations Security Council members plus Germany, aimed at decreasing international sanctions in return for Iranian concessions on their nuclear plan.

Figure 5.
Iran's natural gas imports and exports, January-December 2012



Source: United Nations Energy Information Administration, www.eia.gov.

Figure 6.
Iranian total supply and consumption of oil, 1980-2012



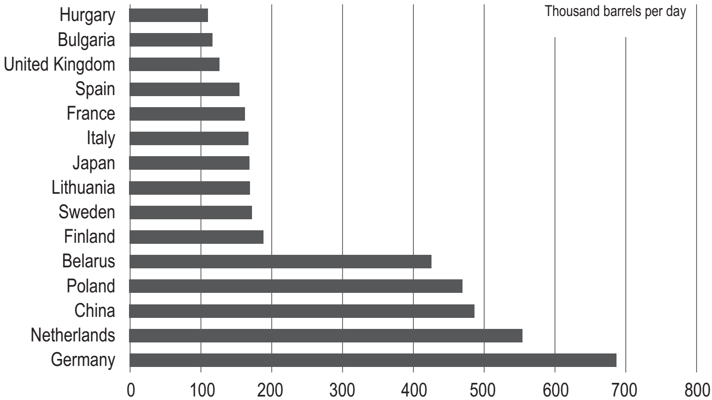
Source: United Nations Energy Information Administration, www.eia.gov.

4.2 The Russian Federation

As often underlined since the outbreak of the Crimean crisis in February and March 2014, various Central and Eastern European countries depend on Russian's energy supplies, with obvious political and diplomatic consequences. Germany depends on Russian natural gas exports, with prices indexed to oil.

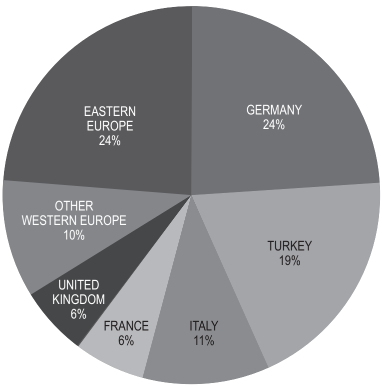
At the same time, this commercial bond has a strategic relevance also for the Russian economy, mainly depending on oil and gas exports to Europe. A progressive increase in diversity and quantity of energy supplies would weaken this mutual dependence, thus boosting European bargaining options and posing fewer restraints to its joint foreign policy. In comparison with three years ago, Russia is expected to obtain much less favorable prices of its gas exports to Europe, as well as lower revenues from oil exports and consequently, lower investments in the oil and gas sector. These short-term changes would affect Russian internal economy, probably placing a significant burden on its political instability.

Figure 7.
Russia's crude oil and condensate main export destinations, 2012



Source: United Nations Energy Information Administration, www.eia.gov.

Figure 8.
Share of Russia's natural gas exports by destination, 2012

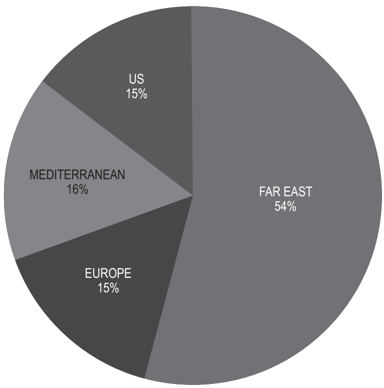


Source: United Nations Energy Information Administration, www.eia.gov.

4.3 Saudi Arabia

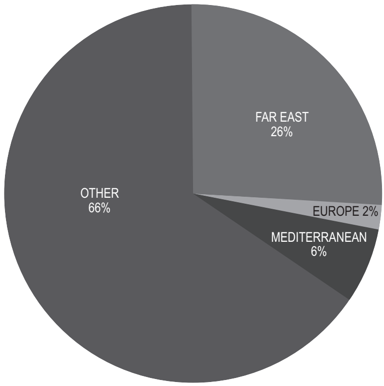
Lower oil and gas prices would surely represent a great risk for Saudi Arabia. It has been estimated by the International Monetary Fund that, due to the production cost of its own conventional oil, Saudi Arabia's fiscal balance compulsorily requires at least $ 90 per barrel from their exported oil. In years of increasing social pressure, especially expressed by the younger generations, it will be predictably difficult to maintain social security after a long-period oil price drop: this scenario would include a possible destabilization of the monarchy and the consequent rise of less Western-oriented governments, whilst continuing with current oil export activities. Similar situations may be foreseen, to a varying extent, for countries like Yemen, Libya, Iraq and Algeria.

Figure 9.
Saudi crude oil exports by destinations, 2012



Source: United Nations Energy Information Administration, www.eia.gov.

Figure 10.
Saudi NGL exports by destination, 2011



Source: United Nations Energy Information Administration, www.eia.gov.

4.4 The People's Republic of China

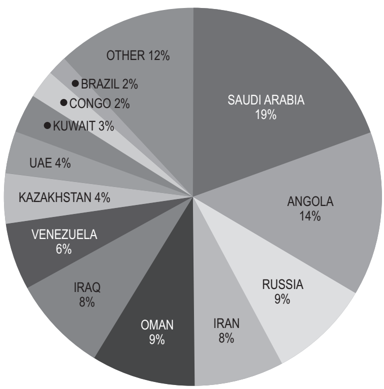
The most populous country in the world poses a fascinating and enigmatic dilemma, probably the most difficult to be resolved. It is anyway reasonable to suppose that its economic growth, as well as the needs of almost 2 billion inhabitants, will necessarily require further, increasing consumption of oil and gas.

From this perspective, and while trying to use more gas for electricity production in order to replace diesel and coal fuels, China is understandably looking for other oil and gas resources. Since the late 1950s, the People's Republic has been interlacing a careful net of bilateral arrangements with various African countries, related to trade and technical, military support. More recently, China has been esteemed to import one third of its oil from Africa, mostly from Angola and Sudan, Nigeria, Equatorial Guinea and the Republic of Congo. Moreover, these arrangements have been supported by strong political expectations, aimed at drawing these countries into a Chinese sphere of influence and providing a secure source of oil.

In order to acquire the much needed new oil and gas supplies, Chinese authorities may focus on unconventional resources, even if the country does not own the huge amount of water required for such a gigantic implementation. Alternatively, they may change course towards larger imports of unconventional oil and gas supplies from neighboring countries, like the Russian Federation and other Central Asian producers. Of course, such a change would heavily reverberate on the Chinese domestic market, requiring, therefore, a significant internal economy reorganization to introduce these new oil and gas supplies at a reasonable price. A secondary but relevant effect of the wider availability of unconventional resources would make China less inclined to pursue special relationships with Middle East countries.

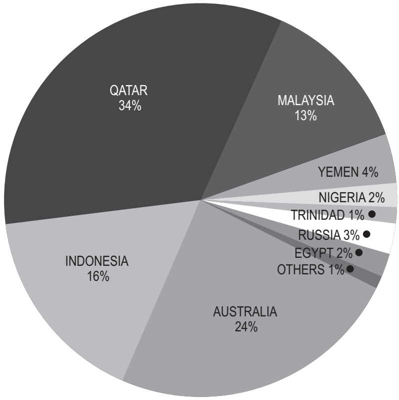
However, it should be also underlined that, withthe bulk of unconventional resources' extraction technologies being concentrated in the United States, the latter should clearly be able to use the technology transfer process in its relations with Beijing.

Figure 11.
China's crude oil imports by source, 2013



Source: United Nations Energy Information Administration, www.eia.gov.

Figure 12.
China's LNG import sources, 2012



Source: United Nations Energy Information Administration, www.eia.gov.

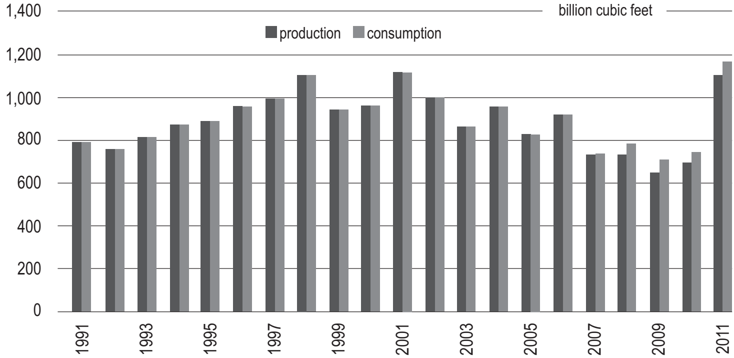
4.5 Venezuela

Defined as having long been a thorn in the United States' side, Venezuela succeeded in subsidizing the oil needs of those small Caribbean and Central American countries. According to the IEA's 2001 report, "(...) enormous volumes of unconventional oil lie in heavy and extra-heavy oil deposits in Venezuela", especially concentrated in the Orinoco Belt.[16]

In the aftermath of the unconventional revolution, the United States will be easily able to replace Venezuela in its role as energy supplier, with consequent political advantages.

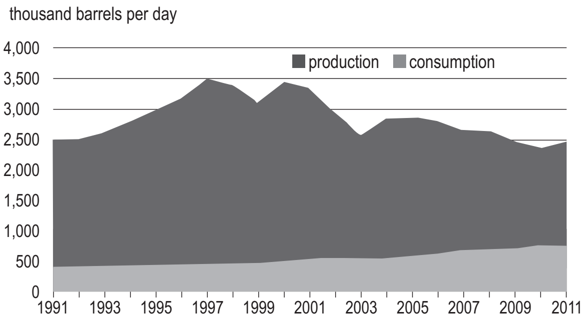
16 *World Energy Outlook 2001: Assessing Today's Supplies to Fuel Tomorrow's Growth,* ibid.

Figure 13.
Venezuela's natural gas production and consumption, 1991-2011



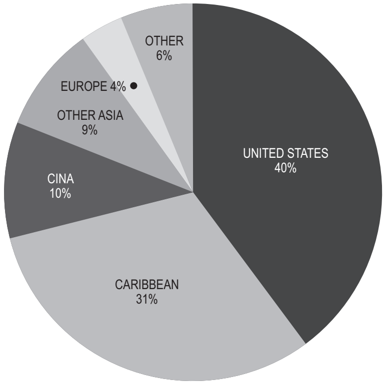
Source: United Nations Energy Information Administration, www.eia.gov.

Figure 14.
Venezuela's oil production and consumption, 1991-2011



Source: United Nations Energy Information Administration, www.eia.gov.

Figure 15.
Venezuelan crude oil exports by destinations, 2011



Source: United Nations Energy Information Administration, www.eia.gov.

4.6 Mozambique

Owning the richest natural gas reserves of Sub-Saharan Africa and among the most significant in the world, this country has seen a very sudden increase in this resource's extraction: between 2000 and 2005, natural gas production and consumption coincided in Mozambique. After 2005, with the discovery of new reserves, the country started exporting to South Africa and the production trend quickly increased.[17]

Mozambique has been considered by two large companies, eni and the American Anadarko, to be the core of a potential investment for large LNG projects. These plans were based on the assumption that LNG prices would remain indexed to oil, and more precisely, on the expectation of an Asian gas price indexed to oil prices, around $ 100 a barrel.

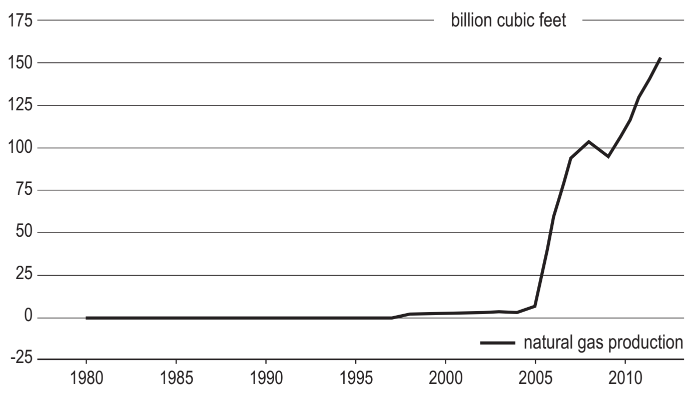
These assumptions were soon destined to collide with the current uncertainty on the oil index price; therefore most of the planned investments suddenly became potentially inconclusive.

17 Charlotte Bolask, *The Africa of growth, in Oil Magazine*, December 2013.

But Mozambique's importance on the international energy scene is also illustrated by a second factor: its large gas resources would be certainly appreciated in the role of competitor with Iran, if this country were to become a big exporter of gas. Mozambique's example underlines the strategic importance of unconventional resources, able to provide a wider differentiation as well as to create more transparent and competitive oil and gas markets, with positive outcomes on the global economy. Moreover, this example of "in being" resources explains once more how the current unconventional revolution is to be considered as a global-changing issue, not limited to North American countries.

All the national cases herewith considered also underline how equally shared the technology opportunities are, for producers and users alike. Due to the environmental and regulatory debate, as well as the economic complications to be expected in regional markets, this revolution would probably need one or two decades to be accomplished.

Figure 16.
Mozambique natural gas production, 1980-2012



Source: United Nations Energy Information Administration, www.eia.gov.

Box 5.

Hydraulic Fracturing. A Timeline

1821. *A first Devonian shale gas well was pioneered in Fredonia (New York), Chautauqua County, by the gunsmith William Hart. His first well reached 27 feet, followed by a 1.5 inch diameter well reaching 70 feet. In that same time, a similar fracturing technique was used on Mount Airy, North Carolina, in a granite pit.*

1865. *On April 25, Lieutenant Colonel Edward A. Roberts patented his revolutionary* "exploding torpedo"*, tested near Titusville and then in the whole Appalachian region, in Pennsylvania, New York, Kentucky, West Virginia, Ohio. His first patent was titled "Improvement in Exploding Torpedoes in Artesian Wells", literally meaning the aim of its author. On November 20, 1866, he received the United States Patent n. 59.936 for the* "Roberts Torpedo".

A veteran of the bloody Civil War, Roberts designed his powerful invention in the shape of an iron artillery shell, filled with 15/20 pounds of gunpowder and aimed to give a massive blow in depth, disintegrating rocks to release oil or gas. He fought with the New Jersey Regiment at the famous Fredericksburg Battle in Virginia, in 1862, and took this idea after seeing the devastating effects of Confederate shells falling on a narrow canal filled with water. Surviving this large bloodbath, Roberts applied the self-same scientific principle for oil recovery: carefully lowered down the borehole, armed with an explosive cap, the large "torpedo" was triggered releasing a weight in the well, hitting the cap. Before the detonation, the operators injected a huge amount of water in the well, in order to crack the rocks with a "superincumbent fluid tamping"*: an intelligent way of increasing the violent concussion effect around the well, exactly as seen by Roberts at Fredericksburg.*

Gunpowder was soon abandoned in favor of the even more dangerous and powerful nitroglycerin, increasing the effect of accidents - as well as the oil production, which reaped great benefits from this risky system, with a record increase of 1200%. In the beginning, nitroglycerin was used in its liquid form, then solidified: terribly hazardous to handle and easy to detonate, it gave birth to the significant term "oil well shooting" *and was widely used, legally or illegally. Roberts became a wealthy man, asking from $ 100 to $ 200 per torpedo, together with royalties on the increase in oil flow; he spent years and more than $ 250,000 defending his patents from unlicensed colleagues, illegally* *adopting his technique at night - hence the term* “moonlighting”. *After his death in 1881, his Roberts Petroleum Torpedo Company was sold and turned into the Independent Explosives Company. Otto Cupler Torpedo Company used the last amount of liquid nitroglycerin in 1990 after the devastating loss of the last production plant, in 1978.*

1939. *Ira J. McCullough was awarded with two patents on April 18, for an innovative multiple bullet-shot casing perforator, able to fire at various levels through the borehole protective casing.*

1947. *In the 1930s, horizontal wells and less dangerous, non-explosive alternatives were studied and applied in the following decade, with a focus on acid substances. In 1947, at the Hugoton natural gas field (Kansas), Stanolind Oil tested an experimental fracking based on napalm and sand, taken from the Arkansas River. Floyd Farris of Stanolind Oil and Gas Corporation then conceived the project of hydraulic fracture, after the success achieved in Hugoton.*

1949. *On March 17, Duncan, Stephens County (Oklahoma) and Holliday, Archer County (Texas) saw the first commercial hydraulic fracturing, performed by Halliburton. Patented by Stanolind, the* Hydrafrac *technology was licensed to Halliburton and, in 1953, to other companies. In its first year of employment, 332 wells were fracked, achieving a 75% increase in production.*

1997. *After years of failures and attempts, George P. Mitchell, adopted a “slickwater” hydraulic fracturing in Barnett Shale, lowering costs and greatly increasing gas recovery. After first failures in 1991 and 1997, he also improved the revolutionary horizontal drilling technique.*

2003. *United States: oil and gas companies started the exploration of shale formations on a massive scale in Texas, Pennsylvania, Wyoming, West Virginia, Maryland, Utah.*

La **Fondazione Eni Enrico Mattei (FEEM)** è un'istituzione non-profit che svolge ricerca nel campo dello sviluppo sostenibile e della governance globale. La missione della FEEM è di contribuire attraverso le ricerche al rigore, alla credibilità e alla qualità delle decisioni nella sfera pubblica e privata.

Fondazione Eni Enrico Mattei
Corso Magenta 63, Milano – Italia
Tel. +39 02.520.36934
Fax. +39.02.520.36946
E-mail: letter@feem.it
www.feem.it

ISBN 9788890991806

Traduzione ed elaborazione testo a cura di Marco Soggetto.

Finito di stampare a Milano nel mese di maggio 2014 presso Roberto Cremonesi.co Srl