Opportunities and challenges for energy players in the global shale revolution

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Fracking technology has recently enabled the large-scale exploitation of vast amounts of shale gas and oil, impacting energy equations and balances across the world. This article addresses why shale developments will be a game-changer and how energy and petrochemical industry executives and regulators should cope with the opportunities and challenges.

Predictors of peak oil have for many decades underestimated the energy industry's capacity to innovate and develop new and improved technologies to extract increasing amounts of hydrocarbons from hard-to-reach or highly complex reservoirs. Fifty years ago it was hard to imagine that the oil industry today would be producing over 7 million barrels per day from deepwater regions around the world, and that wells could be drilled in water depths reaching up to 10,000 feet. The most recent and perhaps most important breakthrough in the industry has been the emergence of two new key technologies: horizontal drilling and hydraulic fracturing, commonly known as fracking. These technologies have enabled the large-scale exploitation of vast amounts of unconventional types of hydrocarbons known as shale gas and shale oil, with dramatic consequences for the global energy markets and huge potential repercussions in many other sectors of the global economy.

While the so-called shale revolution has so far been limited to North America, the potential shale resources in many regions of the world are enormous, and many countries and industry players expect to benefit from a growing global trend in fracking activity. However, the road towards shale globalization presents significant strategic, commercial, technical and environmental challenges for energy players, particularly when considering developments in densely populated regions such as Europe, or emerging markets such as China or Argentina, where the rules of the game are still unclear.

In this article we will discuss why shale developments are becoming a game-changer for the global energy industry. We will also address some of the expected impacts in other industry sectors, the potential hurdles for the globalization of the fracking boom, and issues that need to be addressed by investors, governments and regulators around the world to succeed in this new global energy adventure.

Game change for the global energy industry

Shale fracking, i.e. the exploitation of hydrocarbons from shale rocks, is having a significant beneficial transformation impact on the global energy industry, and consequently the global economy, by providing enduring opportunities for an abundant, cheaper and relatively cleaner new source of energy supply. This trend has become a real game-changer for four reasons:

1. The shale gas bonanza has already transformed the energy equation in North America.

2. The fracking revolution is expanding into new geographies and will impact global energy balances.

3. Low-cost shale feedstocks are heralding a renaissance in basic petrochemicals and related industries.

4. Continued innovation related to shale exploitation is strengthening cost competitiveness.

Transformation of the energy equation in North America

Shale fracking, i.e. the exploitation of hydrocarbons from shale rocks, is having a significant beneficial transformation impact on the global energy industry, and consequently the global economy, by providing enduring opportunities for an abundant, cheaper and relatively cleaner new source of energy supply.

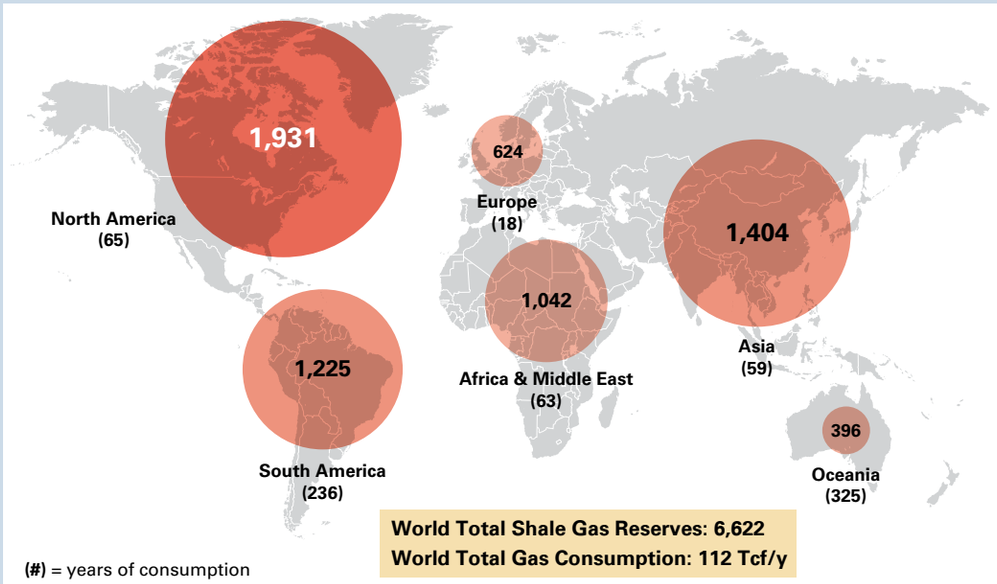
The development of shale gas in North America over the last decade has been so dramatic that it has quickly helped to transform the energy markets in the region. The proliferation of drilling in established and new shale plays helped the US to increase its dry shale gas output from only 0.39 trillion cubic feet (TCF) in 2000 to 7.2 TCF in 2011, an average increase of over 30 % per annum. Shale gas production already accounts for more than one third of total natural gas domestic output and is expected to reach 60 % by 2035. Moreover, shale drilling in the US is rapidly expanding into liquid-rich basins, and the country's domestic output of crude oil has also started to increase after decades of declining production.

A few years ago a key topic of energy discussion in the US was the country's need to add significant regasification infrastructure in order to be able to import growing volumes of liquefied natural gas (LNG). Today, with the anticipated growing supply of domestic shale gas, the US has reversed

its fortunes, and the first LNG export project in more than 40 years is already being developed by Cheniere Energy to target, among others, the gas markets of Spain, Korea and India. Several other LNG export projects are on the drawing board in the US and Canada. The shale gas boom could turn the region into one of the world's largest LNG exporters within a decade. This change of polarity in the North American LNG markets will also have significant implications for gas producers and consumers elsewhere in the world. With plentiful and cheap incremental supplies of US natural gas reaching the markets of Europe and Asia in the future, dominant gas players such as Russian Gazprom will come under mounting competitive pressure. Furthermore, several planned new LNG projects in less stable regions such as Africa will be pushed back into the "not likely" category.

Access to cheap natural gas from shale developments is also encouraging fuel substitution in the domestic transportation sector. Many fleets of school and public transit buses, trash collection trucks and tractor-trailers have been switching from diesel to compressed natural gas (CNG) technologies in recent years, thereby helping the US reduce its dependence on expensive imported crude oil.

Table 1 **Shale Gas Technically Recoverable Reserves (TCF)**



Source: World Shale Gas Resources, EIA, (2011); BP Statistics (2011); Analysis Arthur D. Little

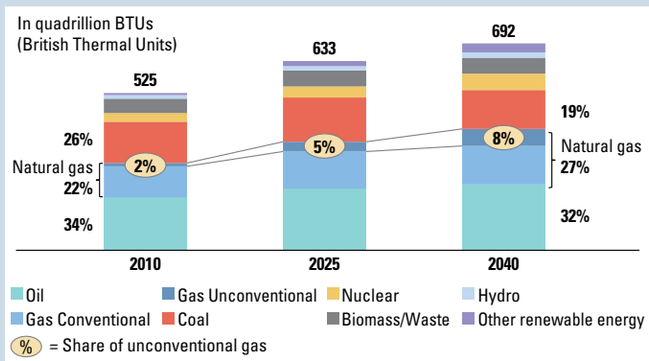
The impact on global energy balances

The shale gas revolution is only now beginning to expand into Eastern Europe, Asia and Latin America, where current production is still non-existent or very modest relative to the potential shale gas reserves.

Geological estimates of the global potential for technically recoverable shale resources are enormous in comparison to conventional reserves of oil and gas, and many basins around the world have significant shale gas resources (Table 1). The shale gas revolution is only now beginning to expand into Eastern Europe, Asia and Latin America, where current production is still non-existent or very modest relative to the potential shale gas reserves. Many players with the appetite, capital and technical know-how are already securing acreage with known shale prospects in these regions, and significant investments are expected in the next few years.

The sudden potential availability of over 6,600 TCF of recoverable shale gas has had a radical impact on the world's energy balance. At a current global gas consumption rate of 112 TCF per year, shale gas reserves represent nearly 60 years of natural gas demand. The share of unconventional gas (shale gas, tight gas and coalbed methane) in the global energy supply matrix is expected to grow by a factor of four in the next three decades, mostly due to the rapid expansion of shale gas supplies (Table 2). Global energy output from unconventional gas is already 60 % higher than that of solar and eolic energy combined, and this difference will widen as shale gas exploitation expands beyond North America. Shale gas availability will also help substitute coal in many markets, with positive effects on the reduction of greenhouse gases and other undesirable pollutants.

Table 2 **World primary energy supply matrix**



Source: Exxon Mobil 2012 ,The Outlook for Energy: A View to 2040; Arthur D. Little analysis

A renaissance in basic petrochemicals and related industries

To ensure the competitiveness of shale resources on a global basis, the energy industry needs to continue investing heavily in leading-edge technologies and process innovation in both the upstream and downstream segments.

Massive exploitation of shale gas resources is also having significant repercussions on other sectors such as the petrochemical industry. In North America, for example, the availability of low-cost ethane derived from shale gas is already causing a petrochemical renaissance, with several new olefins projects announced in recent years. The relative feedstock advantage of ethane and other derivatives from liquids-rich shale plays is making North American petrochemical projects competitive vis-à-vis naphtha-based projects in the Middle East. Dow Chemical, Shell, Chevron Phillips and Formosa Plastics are some of the leading players that have announced new large-scale cracker projects in North America. Westlake Chemical, Lyondell-Basell, INEOS and Williams are also planning expansions or debottlenecks at existing sites. Several international players such as Thailand's Indorama Ventures, Saudi Arabia's SABIC and Brazil's Braskem are also considering petrochemical ventures in the US market, while Sasol from South Africa is studying a gas-to-liquids project.

Planned expansions would add 30 % to US ethylene installed capacity by 2017. This overbuild of US capacity to crack ethane is likely to cause a major upheaval in the global petrochemical markets. While some of the incremental olefin production can be absorbed by growing North American demand, most of it will be exported in the form of intermediate petrochemicals and polymers, potentially leading to a downturn in the petrochemical cycle and capacity rationalization in higher cost supply regions such as Europe.

The industrialization trend will extend into other geographies as shale gas developments provide new opportunities for downstream integration projects. For example, shale gas is considered crucial for the expansion of Poland's state-controlled strategic industries, including copper miner KGHM and oil refiner PKN Orlen. In China, Total has signed agreements with Sinopec to explore for shale gas and build a new refinery. In the same vein, Mexico is hoping that future exploitation of shale gas resources will help the country revitalize its ailing petrochemical industry.

Innovation and cost competitiveness in the global energy sector

The ability to drive production costs down has been a critical factor for the success of the shale gas industry in North America. To ensure the competitiveness of shale resources on a global basis, the energy industry needs to continue investing heavily in leading-edge technologies and process innovation in both the upstream and downstream segments. For example, one key challenge for shale developers is the need for early identification of underground sweet spots and the creation of precise predictive models during exploration to ensure the efficient deployment of resources throughout the drilling phase. This would allow for an increasing recovery of hydrocarbons while reducing the number of fractures needed. Inter-disciplinary efforts involving seismology, geophysics, petrophysics, chemistry and IT have led to impactful innovations in areas such as ultra-high density seismic imaging needed for sweet spot detection.

Although innovation in the oil industry continues to make strides, and new technologies are transforming what yesterday was clearly "unconventional" into today's "conventional", major technical challenges still need to be overcome.

Another emerging exciting innovation around shale exploitation is a new fracturing technique using liquefied propane gas instead of water. If commercially successful, this approach would help eliminate the need for huge amounts of fresh water required in fracking while also eliminating the problem of disposal of the injected water.

Oilfield services companies are instrumental in many of these technological advances. Leading players such as Halliburton, Baker Hughes and Schlumberger are already leveraging their experience in North America to support new shale developments around the world. Other service players are developing capabilities in specific shale-related niches, such as WorleyParsons in water management and NuTech in shale interpretation.

Challenges to benefiting from the global fracking boom

Significant technical challenges are still ahead for the development of unconventional hydrocarbons. Table 3 shows a comparison of typical challenges faced by oil industry players when developing a conventional project versus an unconventional shale opportunity. Although innovation in the oil industry continues to make strides, and new technologies are transforming what yesterday was clearly "unconventional" into today's "conventional", major technical challenges still need to be overcome. In addition to the higher technological hurdles, shale developments are also subject to complications such as needing to find large sources of water supply and sand for shale fracking activities.

The industry has also been receiving a lot of bad press due to the public perception that chemical fluids used in the fracking process could contaminate underground water and represent a potential health risk for communities that are in proximity to the wells. Although many of these claims have not been scientifically proven, regulators in many countries around the world are struggling to find the right balance to manage the complexity of unconventional hydrocarbon developments.

As energy players go global in their quest for the unconventional hydrocarbons economic prize, they also need to recognize that the so-called "above-ground risks" in emerging markets can be significantly higher than those faced in the relatively safe and well-established sandbox of North America. In practice many of the typical risks faced by the industry are magnified in emerging markets due to the presence of additional challenges such as less developed gas markets, absence of pipeline infrastructure, incoherent or conflicting regulations, an undeveloped local services industry and greater environmental and community concerns.

Table 3 **Development challenges**

	Conventional drilling	Unconventional (shale fracking)	
		North America	Emerging regions
Technology readiness	◔	◑	◕
Regulatory uncertainty	◔	◕	●
Environmental impact	◑	◕	●
Water management	◔	●	●
Community acceptance	◔	◕	●
Specialized services industry	◔	◑	●

● High challenge ○ Low challenge

Source: Arthur D. Little analysis

Country case studies

China
China has the largest shale gas potential in the world, with technically recoverable resources estimated at 1,275 TCF, representing over 330 years of current natural gas consumption. The National Energy Administration is aggressively promoting opportunities and targeting 0.23 TCF of shale gas output by 2015 and up to 3.5 TCF by 2020. Key challenges include geological risks, infrastructure limitations and water availability. China will require accelerated investment in basin-specific technologies to address its unique geological conditions. China's shale gas geology remains largely untested, and accordingly there is limited understanding of the opportunities.

Argentina
Argentina is ranked third globally in terms of technically recoverable shale gas resources with 774 TCF. Royalties are relatively low and the country has been providing incentives in the form of differentiated prices for shale gas. Argentina has a well-developed gas market and extensive gas infrastructure in place. Declining production of conventional hydrocarbons and increasing energy imports have triggered a strong interest in developing domestic shale gas resources. However, the recent government measure to re-nationalize YPF has affected the investment climate, dissuading foreign investors and potentially delaying these developments.

Poland
Poland has the largest technically recoverable shale gas reserves in Europe with 187 TCF. The country is pursuing shale gas exploration to reduce its dependence on Russian imports and as a means of reducing greenhouse gas emissions. The Ministry of Environment has already awarded over 100 shale exploration licenses to both international and domestic players. Poland hopes to start shale gas production by 2014 and be able to meet its domestic gas demand by 2035. State-owned PGNiG is studying related investments in petrochemical and other industries. Key challenges are high drilling costs and uncertainty about the productivity of the shale reservoirs.

In view of these challenges, many countries are already taking a more cautious approach to shale developments. Also, regions with higher population density, such as Europe, will face more public opposition to drilling for shale gas, and this may slow down or completely stop developments, as already seen in the cases of France, the Czech Republic, Bulgaria and Hungary, where complete bans on hydraulic fracturing have been implemented. The insert discusses the current status of shale gas initiatives in three countries with significant resource potential and different development challenges.

The new rules of the game for the energy industry

In order to capitalize on the potential economic boom associated with shale gas riches around the world and ensure sustainable development, the energy industry needs to pay special attention to a series of strategic, commercial, operational and sustainability-related factors (Table 4).

Strategic considerations. Early access to acreage in promising shale basins will provide strategic advantages. However, energy players also need to avoid over-exposure to high-risk countries. A properly balanced portfolio of unconventional assets will help international companies sustain long-term growth. Key skills and technical know-how can be incorporated through acquisitions or alliances.

Table 4 **Development factors for unconventional hydrocarbons**

Strategic	Commercial
■ Access to acreage ■ Partnering and alliances ■ Access to capabilities ■ Portfolio balance	■ Access to market and infrastructure ■ Contractual and fiscal regime ■ Downstream Integration ■ Pricing structures
Operational	**Sustainability**
■ Technology selection ■ Well design and productivity ■ Operational efficiency ■ Procurement of services	■ Water management ■ Local communities ■ Environmental footprint ■ Public image

Source: Arthur D. Little analysis

Commercial considerations. Significant shale resources exist in countries where natural gas markets and infrastructure are not fully developed. Unconventional players need to take an integrated view of their projects since monetization of the hydrocarbons may convey significant challenges. Opportunities for value creation through downstream integration (e.g. petrochemicals) should be explored.

There is no unique recipe for succeeding in the global shale game. Energy players need to carefully select opportunities and build international portfolios that align well with their overall strategic interests and specific capabilities.

Operational considerations. There are many critical technical decisions that can significantly impact the economic returns of a shale development. Choice of drilling equipment, stimulation technologies and well spacing will determine the productivity of a field. Reservoir response should be carefully monitored over the life of a project to make necessary adjustments to the operational model.

Sustainability considerations. Shale developers need to proactively manage all of the environmental risks linked to these projects, including the consumption of large amounts of water and the potential for contamination of fresh water aquifers. A baseline environmental study is highly recommended before the start of drilling operations. Community concerns must be addressed with a transparent and fact-based approach.

There is no unique recipe for succeeding in the global shale game. Energy players need to carefully select opportunities and build international portfolios that align well with their overall strategic interests and specific capabilities. While the shale gas space is starting to get crowded in North America, there are still plenty of exciting although perhaps riskier opportunities to choose from around the world. The reality is that for most global energy companies unconventional hydrocarbons will represent a significant growth avenue for many years to come.

Independent Oil Companies (IOCs). The first movers in the shale gas game in North America were medium-sized independent companies such as Chesapeake Energy, Encana and Cabot Oil & Gas Corporation, which secured significant amounts of acreage and took advantage of emerging technologies to benefit from the exploitation of prolific shale basins. These early movers were able to lease promising acreage at relatively low costs before the shale boom started driving prices up. A key to the success of these players has been their ability to resell shale properties at much higher prices once the resource potential has been established. While many independents remain focused on North America, others such as Apache and EOG in Argentina or Talisman in Poland are venturing into new territories.

Major Oil Companies. With access to conventional oil and gas becoming more challenging around the world due to the prevalence of petro-nationalistic attitudes in places such as Russia and Venezuela, large global energy players have quickly embraced unconventional hydrocarbons strategies as a vital option to sustain long-term growth. Today unconventional projects, and particularly shale gas developments, represent a significant portion of the majors' investment portfolios. The easiest and quickest way for the majors to enter into established unconventional hydrocarbons plays in North America was through the acquisition of smaller niche players. This strategy provided two significant advantages: 1) rapid access to extensive acreage needed to sustain large volumes of shale gas or shale oil production, and 2) acquisition of critical skills, technical know-how and commercial capabilities to successfully exploit unconventional hydrocarbons. The majors are now aggressively pursuing global shale gas opportunities in markets with significant resource potential. For example, Total and Shell have recently partnered with Chinese companies to explore and develop shale gas opportunities in China, while Exxon Mobil has taken large shale gas exploration blocks in countries including Argentina and Poland.

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National Oil Companies (NOCs). NOCs such as China's Sinopec, which typically enjoy advantageous access to the most attractive opportunities in their home markets, are also moving fast to acquire the technologies and skills that will allow them to exploit vast amounts of shale resources in order to contribute to their countries' growing energy needs. A preferred approach for Chinese players has been to take equity stakes in established shale developments in North America so that they can get exposure to the know-how and capabilities of their Western partners in these projects.

Table 5 shows the contrasting business models being deployed by different types of energy companies in their quest to secure new growth opportunities around unconventional shale developments.

Table 5 **Contrasting business models of players active in unconventional hydrocarbons**

Chesapeake: "Acreage grabber"	Exxon Mobil: "Acquirer"	PetroChina: "Resource holder"
■ Owns assets only in US and onshore ■ Grows production and proven reserves organically ■ Identifies and develops new leasehold plays ■ Acquires leaseholds at wholesale prices and sells off minority portions at retail prices ■ Pursues a vertically integrated business model with presence in oilfield services and midstream	■ Has global portfolio with current unconventional gas opportunities in the US, Canada, Germany, Hungary, Poland, China, Indonesia, Argentina and Colombia ■ Acquired US-based niche shale gas player XTO in 2010 valued at $41 billion ■ Created new organization leveraging XTO's capabilities and staff (nearly 3,300 employees) to focus on unconventional resources	■ Owns significant share of world's largest unconventional resource bases in China ■ Has made investments in unconventional opportunities in North America to acquire key skills and technical know-how from major oil companies ■ Has partnered with Shell for shale gas exploration and production in the Sichuan Basin in China

Source: Arthur D. Little analysis

Insights for executives in the energy industry

When developing strategies to benefit from the growing opportunities in the unconventional hydrocarbons business, executives in the energy industry are advised to follow four guidelines.

First, business strategies and operational models for unconventional hydrocarbons need to be flexible. There are no two identical shale gas basins in the world. Success in one region does not guarantee that similar results can be achieved elsewhere. Entry strategies and deployment of operations need to be adapted to the technical, commercial and political realities of each market.

Second, investors need to balance economic goals with sustainability objectives. Sustainability challenges are magnified in unconventional hydrocarbon developments. It is critical that operators engage all relevant stakeholders early on with proactive, open and clear communications to ensure a collaborative working environment.

Third, regulatory risks should not be underestimated. Energy industry regulators in many countries around the world are still trying to understand the sometimes subtle distinctions between conventional and unconventional developments. This will lead to regulation changes along the way. Operators need to factor these potential risks into their assessment of opportunities and be prepared to adjust their business models to new situations.

Fourth, oil service players need to show flexibility to invest and deploy capabilities in new regions with sufficient speed. In large shale gas developments hundreds of wells must be completed quickly and at low cost, so service companies need to scale up drilling capabilities and related services to cope with increased demand in new regions. Suppliers of equipment and materials will also find market opportunities to innovate and launch new products and services for the unconventional hydrocarbons sector.

Insights for governments and regulators

In order to ensure sustainable economic development, governments and regulators are advised to follow three guidelines.

First, host countries need to strike an adequate balance between the often conflicting goals of new energy supplies and protection of the environment and local communities. Regulators need to learn as fast as industry players and be ready to understand and anticipate potential issues and complications associated with the deployment of novel unconventional techniques. It is important to be able to discern the "noise" from the science when interpreting the impacts of shale fracking and water management issues.

Second, promotion of opportunities and contractual frameworks need to reflect the different nature of unconventional developments. Governments promoting shale opportunities need to ensure that block sizes are sufficiently large to compensate for the additional geological risks, and exploration & production contract models should be customized to reflect the specific development challenges of shale projects.

Third, economic incentives may also be needed in some regions. Despite the foreseeable high energy price environment, in some markets unconventional hydrocarbons will never be developed unless some special incentives such as lower royalty rates, tax credits or differentiated price schemes are provided to compensate investors for the higher costs and additional risks. These incentives are particularly critical during the early stages of industry development.

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