Game Change?
The Many Faces of Today’s Energy Revolution

Part I: Technology and Economy, Cause and Consequence

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Introduction

Much ado has recently been made about what has been termed the ‘shale gas revolution’: the boom in US unconventional gas production driven, in large part, by technological advances. The fortuitous developments in the energy sector have been discussed at length in the media, not only because of their promising economical prospects for a nation some had labeled as in decline, but also for its potential to bring about profound changes in the geopolitical landscape.

This series of brief papers aims to be a guide to help contextualize some of the confident claims being made in the media on today’s shale gas revolution, offering a variety of factors – economic, political, security-related and environmental – to take into account in order to paint a more multidimensional view of the prospects. Both positive and negative effects stemming from the energy revolution will thus be addressed.

Part I of the series provides critical background information, offering insights on the range of energy sources involved in the revolution, the technology behind their extraction and the economical factors which have propelled the energy boom – and which could present risks of their own. Part II presents the geopolitical side of the story, with a detailed look at a number of countries and regions – United States, China, Russia and Europe – in turn, teasing out potential consequences of the energy revolution. Part III, which rounds out the series, examines the environmental effects of the energy boom on a local and global level.

The present paper is Part I of this paper series, covering essential background to today’s energy revolution – which is, importantly, not driven solely by shale gas. The paper first offers a look at the various unconventional sources used to produce energy today and the recoverable reserves in different countries and regions. Thereafter, attention is turned to the technology behind their extraction, yielding clues as to opportunities and risks of the energy revolution. The following section builds on this technical background, asking which
geological, technological, economical and regulatory elements have propelled the energy boom forward in the United States. Part I concludes with the economic benefits and hazards of the surge in American production, providing clues to the geopolitical perspectives presented in Part II.

What are the energy types behind the boom, and where are they?

The current dramatic changes in the energy panorama have been strikingly dubbed the ‘shale gas revolution’. However, this may be a misnomer. While the stark increase in energy production in North America is in large part due to an explosive growth in shale gas production, other unconventional hydrocarbon sources are also increasingly being tapped: from deepwater oil in the Gulf of Mexico to tight oil trapped in the same rock as shale gas, and from coalbed methane (CBM) to bitumen extracted from (chiefly Canadian) tar sands. Indeed, the revolution lies mainly in the proportional production increase of unconventional¹ hydrocarbon sources as opposed to conventional oil and gas, rather than in the rise of a single energy source (shale gas) alone. Several of the most prominent conventional and non-conventional sources fueling the energy boom are listed below:

<table>
<thead>
<tr>
<th>Conventional and unconventional sources contributing to today’s energy revolution</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Shale gas</strong></td>
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<tr>
<td>Natural gas trapped in the pores of layers of shale rock, generally spread over a large area. Increased application of the improved technologies of horizontal drilling and hydraulic fracturing have recently allowed a boom in extraction.</td>
</tr>
</tbody>
</table>

| **Tight gas**                  |
| Natural gas trapped in relatively impermeable or nonporous hard rock, sandstone or limestone formations. Extracted through the same technologies as shale gas (horizontal drilling and hydraulic fracturing). |

| **Coalbed methane**  |
| Methane in a near-liquid state, trapped in the matrices inside coal seams. Often held in place due to the pressure of the water in the seams; extracted by dewatering so the gas can rise to the surface for capture. Sometimes extraction is boosted by horizontal drilling and hydraulic fracturing. *Also known as: CBM, coalbed gas, sweet gas, coal seam gas (in Australia)* |

| **Tight oil**                  |
| Light crude oil trapped in the same shales as shale gas, and extracted through the same technologies (horizontal drilling and hydraulic fracturing). *Also known as: tight tight oil* |

| **Oil sands**                   |
| Loose sand or rock material saturated with bitumen (tar), a very viscous and heavy form of petroleum. Extracted through surface/strip mining or *in situ* techniques: injecting steam into the subsoil to separate bitumen from sand. *Also known as: tar sands, bituminous sands* |

| **Deepwater sources** |
| Oil and gas in deposits in - sometimes ice-filled - deep water. Previously left untapped because of difficulties in extraction such as geology, operating costs, and environmental risks. |

¹ Note that ‘unconventional’ gas is an ambiguous term, as the ‘conventionality’ of a resource is a shifting concept. The International Energy Agency (IEA) defines ‘unconventional gases’ as “part of a gas resource base which has traditionally become been considered difficult or costly to produce”.
It is important to remark that the quantities, location and distribution of the world’s nonconventional reserves are still under exploration. However, in its special report on unconventional gas published earlier this year, the International Energy Agency (IEA) estimated that the technically recoverable resources of unconventional gas worldwide approach the size of remaining conventional resources, which stand at 420 trillion cubic meters (tcm). The distribution of the unconventional side of this equation was estimated as follows:

<table>
<thead>
<tr>
<th>Type of unconventional gas</th>
<th>Shale gas</th>
<th>Coalbed methane</th>
<th>Tight gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated technically recoverable reserves, in trillion cubic meters (tcm)</td>
<td>208</td>
<td>47</td>
<td>76</td>
</tr>
</tbody>
</table>

According to the same report, at end-2011:

Half of the USA’s remaining recoverable resources of natural gas were unconventional, with the full total of gas resources representing around 110 years of production at 2011 rates. The deposits are distributed across the country, however coalbed methane resources are found mainly along the Rocky Mountains. Some of the major shale reserves are the Marcellus shale in the northeast (New York, Pennsylvania, Virginia, Ohio), the Haynesville formation in the south (Louisiana, Arkansas, Texas), and the Bakken shale, which crosses the Canadian border. The distribution among the various unconventional sources is:

<table>
<thead>
<tr>
<th>Type of unconventional gas</th>
<th>Shale gas</th>
<th>Coalbed methane</th>
<th>Tight gas</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated technically recoverable reserves, in trillion cubic meters (tcm)</td>
<td>24</td>
<td>3</td>
<td>10</td>
</tr>
</tbody>
</table>

China’s unconventional gas resources were as of yet fairly uncharted, however they are “undoubtedly large”. Remaining recoverable resources of unconventional gas (almost 50 tcm) far outstrip remaining conventional gas resources, by a factor of 13. Geographically, the non-conventional resources are concentrated mainly in the far northwest (Junggar Basin) and the center (Ordos and Sichuan Basins), with some presence in the northeast. The distribution is as follows:

<table>
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</tr>
</thead>
<tbody>
<tr>
<td>Estimated technically recoverable reserves, in trillion cubic meters (tcm)</td>
<td>36</td>
<td>9</td>
<td>3</td>
</tr>
</tbody>
</table>

In Europe, Poland and France are estimated to have the largest shale gas reserves, followed by Norway, Ukraine, Sweden, Denmark and the UK. Coalbed methane resources

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2 Note also that estimates of recoverable resources vary widely. For a detailed description of these varying estimates and the reasons for the differences, see the European Commission’s Joint Research Center report Unconventional Gas: Potential Energy Market Impacts in the European Union (2012).

3 However, note that official Chinese figures published in March indicated recoverable shale gas reserves to be at 25 tcm.
are also present, mainly in Ukraine, the UK, Germany, Poland and Turkey. For the OECD Europe countries, at end-2011, the IEA estimated the distribution of non-conventional gas reserves to be as follows:

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<th>Shale gas</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Estimated technically recoverable reserves, in trillion cubic meters (tcm)</td>
<td>16</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

How are unconventional hydrocarbons extracted?

As mentioned above, technological advances are one of the main factors behind this most recent energy revolution. Shale gas is not a newly discovered resource: its existence has been known for decades, but its extraction was not economically or technically feasible until recently. Because this ‘unconventional’ gas is trapped in dense pores spread widely throughout the layer of shale rock, the vertically drilled wells used to extract conventional hydrocarbons were only able to release a very limited proportion of the gases underground. However, the combination of horizontal drilling and hydraulic fracturing (fracking) technologies – which are not new, but have been vastly improved – has radically changed extraction volumes and prospects. Consequently, these technologies have truly taken off: whereas fewer than 10% of the US wells were horizontal in 2000; currently that proportion stands at 80%.

Modern day shale gas wells are started by drilling vertically down to the shale rock layer. The drilling then shifts to a horizontal phase, with the horizontal sections extending for up to several kilometers each. Hydraulic fracturing, the second revolutionary technology, is applied after the drilling phase is complete. A liquid known as fracturing fluid is pumped into the well at high pressure in order to ‘crack’ the rock, opening fissures or fractures which radiate out from the well bore for tens to hundreds of meters: these channels allow the gas trapped inside the rock to escape.

After the initial fracturing (which can be applied in a single or multiple stages), the well starts producing a mixture of flowback water and gas. Initially, the proportion of hydrocarbons in this output is low, but it increases rapidly as the volume of flowback water decreases. A large

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4 Each drilling pad can hold a single or multiple wells, thus increasing potential yield.
5 Fracking liquid exists in various compositions, but it is typically made up of a high proportion of water combined with a complex blend of chemicals, as well as particles (sand, ceramic beads, or others) which become lodged in the fissures to prevent them from collapsing after the initial injection. Other types of fracturing liquids include foamed fluids and hydrocarbon-based fluids.

* Graphic design: © Katrien Vandendriessche
amount of gas (mostly methane) is often vented into the atmosphere during this phase; alternatively, it is flared (i.e. the hydrocarbon content is burned off in a controlled fashion). Venting and flaring are the one of the main causes of the high levels of greenhouse gases emitted during the production of unconventional hydrocarbons. Once the flowback period (which can last for a number of days or weeks) is over, the hydrocarbon content of the output increases sharply and collection and production spikes. However, the sharp burst of valuable and highly concentrated output typically only lasts for a year or couple of years, after which there is a steep decline and very limited output for the rest of the well’s life.\(^6\)

Despite technological advances and economies of scale, the production of shale gas remains expensive when compared to conventional gas. A typical shale well\(^7\) costs some $8 million, while a conventional vertical gas well in the same geographical area would cost only $3 million. The price difference lies mainly in the well completion cost (the fracking stage(s)), which make up roughly 60% of the total cost in a horizontal shale well with a long lateral section – as opposed to 15% in a conventional gas well.

Note also that shale gas production costs vary widely depending on geological factors such as depth of the reserves and pressure. These factors are highly favorable in the case of the USA; in contrast, continents such as Europe are not as geologically fortunate. The USA presently holds a strong cost advantage due to the combination of, inter alia, geological features, economies of scale and concentration of technical know-how.

**Which factors contributed to the American boom?**

According to the US Energy Information Administration (EIA), US shale gas production was nearly non-existent in 2000 – by 2012, annual production exceeded 225 billion cubic meters. This sudden boom, baptized the ‘shale gas revolution’, was caused by a cluster of geological, technological, economical and regulatory factors, examined below.

The strong US cost advantage described in the previous section is one of the elements behind the ‘revolution’, but it did not come about in a vacuum. For instance, the technological advances that made shale gas (and tight gas and oil) production economically feasible were propelled forward by both market and geopolitical determinants, such as high global oil prices and the quest to quell dependence on outside sources.

Another factor, which has been unequivocally fundamental, is the natural geological blessings of the USA, such as the size of its recoverable reserves and the depth and

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\(^6\) Based on experience on the Barnett Shale Play Paul Stevens wrote in a 2010 Chatham House Report that shale wells might only have a life of 8–12 years, compared with 30–40 years for a conventional gas well.

\(^7\) The typical shale well here is the one taken as a reference by the IEA in its Golden Rules Report.
pressure of its wells. Maximizing these natural benefits has been possible, in part, because of such characteristics as the low population density on certain shale formations (such as North Dakota’s Bakken Shale) and the dense and developed pre-existing infrastructure of the American pipeline network.

Economical and regulatory factors are in play as well: high-risk private capital investment, for example, has arguably been instrumental in the novel exploration and development of the shale gas reserves. This high-risk capital investment is further facilitated by federal and state regulation of land rights in the US: because private land owners hold the rights to the oil and gas beneath their land, they are able to privately (and lucratively) lease it to drilling companies.

It is important to note that this cluster of factors has served to benefit more than the shale gas revolution alone. While recent media coverage has focused primarily on the shale gas ingredient, the energy boom in the entire North American continent is actually multifaceted, with strong contributions coming from the bitumen from oil sands (chiefly in Canada) and from tight oil and deepwater petroleum.

In a context of dropping natural gas prices (described further in the following section), focus has been shifting away from shale gas production alone. This has led, for example, to increased interest in shale sites with a higher proportion of liquid hydrocarbons (which retain higher market value). The necessary diversification of sources has been sped along by applying the twin technologies of horizontal drilling and hydraulic fracturing – initially used primarily for shale gas extraction – to tight oil and tight gas extraction, which have also become much more feasible. In fact, the reference case used by the EIA in its Annual Energy Outlook (AEO) 2012 sees both strong increases in natural gas production and in domestic production of petroleum and other liquids, including biofuels.

What are the economic risks and opportunities?

Such an extreme surge of comparatively cheap energy (after more than a decade of increases, real natural gas prices have been dropping steeply since 2009, and are now approaching levels of 1980) could have profound effects on US manufacturing prospects. Competitiveness of exports stands to improve considerably; the term ‘reindustrialization’ is even in circulation. A Citigroup analysis published in March asserted that the energy boom could create 2.7 to 3.6 million net new jobs and add 2 to 3% to real GDP by 2020. Activity in the petrochemical sector and related industries could be enhanced

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8 Estimated growth of 1.0% per year, allowing the US to become a net gas exporter by 2022. Shale gas will account for almost half of this production by 2035, up from 23% in 2010.
9 Set to rise by 3.1 million barrels per day from 2010 to 2035.
further by the inflow of large volumes of Foreign Direct Investment (FDI), as investors may reason that prospects are arguably more secure in North America than in the volatile Middle-East.

Nevertheless, euphoria can be blinding, and there are some caveats to be addressed. Firstly, on the production side, it is obvious that the costs of shale gas extraction cannot continue to fall indefinitely. With natural gas prices dropping vertiginously in parallel with a slowing decrease in production costs, the profit margin of shale gas – which is still much more costly in production than conventional sources – is diminishing. This may affect the commercial viability of the energy source. Changes in (environmental) regulation, which is still under revision or even construction, may cause further cost increases. Secondly, shale gas presents a number of difficulties related to consumption and export. For one, natural gas is not fully fungible. Applications in the transport sector, for example, are currently scarce. In addition, because gas cannot easily, safely and economically be transported in its gaseous state, possibilities for export depend heavily on liquefaction capacity.

Another danger pointed out by some analysts is the possibility that a shale bubble is growing. In recent years, there has been somewhat of a ‘land grab’ in energetically valuable parts of the American territory: for example, in the Eagle Ford shale play (Texas), the cost of drilling rights increased from less than $4,000 an acre at the start of 2010 to more than $20,000 an acre in November of that same year10. Investment in drilling rights and gas leases, both by domestic and foreign actors, has been massive. However the profitability of many of the purchased drilling sites is highly uncertain and sometimes under-researched. Geological idiosyncrasies, variable well recovery rates and dropping national gas prices, among other factors, lend a high level of risk to these investments. As such, the soaring prices of drilling rights may not always be justified11.

Conclusion

Part I of this paper series has sketched a technological and economic picture of the current energy revolution. Each of the factors presented holds clues as to the risks and potential of this ongoing trend. One of the main elements to consider is that, despite the oft-used label

10 according to analysis of transaction data by IHS, a research group, cited in The Financial Times
11 Moreover, legal analysts have warned of significant dangers of gas leases on mortgaged lands: not only are homeowners usually unaware of their liability in case of environmental damage caused by often underinsured and risky resource extraction on their lands; but there is also a serious risk to the secondary mortgage market and even to US economic recovery. In the November/December 2011 edition of the New York State Bar Association Journal, Elisabeth N. Radow describes in detail how potential or real damage caused by drilling could lead to mortgage defaults (even the mere act of a homeowner signing a gas lease on a mortgaged property, which usually occurs without lender consent, may provide reason for termination of the lease, and thus potential default). As drilling companies are also underinsured, the costs of such defaults could fall on the $6.7 trillion American secondary mortgage market, and possibly on taxpayers. This poses a serious risk for US economic recovery as well, because its measurement is based partly on indicators such as construction starts and new mortgage loans - which could be impacted severely by the phenomena described above.
‘shale gas revolution’, the current boom in US energy production is not driven by shale gas alone. The technologies behind shale gas exploration have opened up avenues for other unconventional hydrocarbons such as tight oil and tight gas, which may indeed prove to be more profitable than shale gas itself. Deepwater drilling for crude oil and extraction of tar from Canada’s oil sands provide further additions to the energy boom.

Reserves of the world’s unconventional hydrocarbons are still under exploration. However, the IEA estimates that technically recoverable resources of unconventional gas worldwide approach the size of remaining conventional resources, thus truly changing world energy perspectives. Reserves on the American continent have been explored most completely, revealing high volumes of shale and tight gas, while other country’s reserves are lesser known.

However, even if all resources were charted, extraction prospects are not. The revolution in energy production is currently concentrated in the USA because of a unique cluster of drivers and advantages which ensures the energy revolution will not be easily replicable, at least in the short term, in other countries and continents. Stark improvements of the twin technologies of horizontal drilling and hydraulic fracturing have been critical to the American success, but advantageous geological conditions, regulation, economic incentives and high-risk investment have also played significant roles.

All of these conditions have come together to provide immense economic benefits for the USA, including the prospects of ‘re-industrialization’ driven by cheap energy prices, a potential inflow of FDI, and a burgeoning petrochemical industry. Elation over these prospects, however, should be tempered in light of a number of looming risks, such as the shrinking profit margin and thus diminishing commercial viability of shale gas. It is also important to recall that natural gas is as of yet not a replacement for the energy-thirsty and petroleum-reliant transport sector. In addition, the much-touted export opportunities of unconventional gas are far from guaranteed, pending government approval of exports as well as improvements in liquefaction capacity and export facilities. Lastly, the high-risk investment that helped fuel the boom may also be creating a dangerous potential real estate bubble.

In part II of the paper series, the economic opportunities and risks described above will form the basis for a look at the possible geopolitical implications of the energy production revolution. The US, China, Russia and Europe will be examined in turn. Finally, the series will conclude with an examination of the environmental impact of natural gas, both on local and global levels, in order to round out this panoramic and multifaceted view of the current energy revolution.
For further information on ESADEgeo’s Position Papers, please feel free to contact:

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Game Change?
The Many Faces of Today’s Energy Revolution

Part II: Geopolitical Implications

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Introduction

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“The relative fortunes of United States, Russia, and China - and their ability to exert influence in the world - are tied in no small measure to global gas developments and vice versa.”

Following the claim above, the present paper – **Part II of this paper series** – introduces a number of possible geopolitical scenarios. For a number of years, geopolitical analysis has been set on the idea that the United States, the world’s great power, was in decline, due in no small part to its relative economic position. However, forecasts such as those made recently by the IEA in its 2012 World Energy Outlook (WEO), have turned that relativity upside-down. The IEA predicts that the US will overtake Saudi-Arabia to become the world’s largest oil exporter by 2020; by 2015, it will be producing more natural gas than gas empire Russia, and by 2020, it should be a net gas exporter. In what follows, a number of countries and continents – United States, China, Russia and Europe – are studied in turn in order to examine the possible and plausible geopolitical shifts they could experience as a result of the current energy revolution.

**The American dream of energy independence**

The USA is central in the story of the current energy revolution: it is in this country that a cluster of geological, technological, economical and regulatory factors has come together most beneficially, leading to a vast increase in unconventional hydrocarbon production. Despite also entailing a number of potential economical risks\(^2\), this revolution has reignited the American dream of ‘energy independence’, a concept desired by United States presidents since the 1973 oil crisis. The term was flung around once again in this year’s presidential election cycle, this time with the year 2020 attached. Interestingly, after years of unattainable visions, the IEA has confirmed that the domestic side of the equation is indeed pointed in the direction of energetic self-sufficiency: American oil imports are predicted to fall from 10 million to 4 million barrels per day (mb/d) (and have already dropped by 1 mb/d since 2008).

However, neither achieving ‘energy independence’ nor its supposed political and security consequences are guaranteed. There are a number of reasons why **attaining energy independence is far from sure**. For one, increased domestic production only accounts for a portion of the decline in oil imports: due to the economic crisis and to increasing fuel efficiency, American demand has fallen. Moreover, natural gas, at the heart of today’s energy boom, is not fully fungible. It is, for example, **no substitute for the petroleum required by the crucial transport sector**. Furthermore, there may be a glut of confidence in one of the main components to America’s global energy success, namely **becoming a net exporter of gas**: the ability to export natural gas will require a stark increase in liquefaction capacity, as well as the construction of export terminals and governmental consent – none are certain as of yet.

\(^2\) See Part I of the series for more detail on the economic drivers, opportunities and risks of the American energy revolution.
Despite the impediments described above, it is likely that the dream of energy independence will live on and prosper – after all, the hypothetical geopolitical rewards do shine bright. Simplistically stated, reduced reliance on oil imports could mean lower need to secure overseas production sites and to pander to oil-producing regimes, which are not always in line with American ideals. Concretely and in the present world scenario, some have suggested US ‘energy independence’ would allow newly re-elected President Obama to complete his ‘Asia pivot’: after extricating the country and its troops from messy wars in the Middle-East by 2014, the US could devote its foreign policy resources to the burgeoning Asian continent. Military resources could also be freed up, for example, from the Strait of Hormuz, the critical maritime alley which sees the passage of 20% of all world crude oil trade, 20% of world LNG trade (mainly from Qatar), and 35% of all seaborne traded oil. In addition, the competitiveness benefits brought by the energy production revolution would considerably broaden the US’ scope of action and incentives toolbox on many fronts.

But, even if energy independence is reached or approximated, it is unsure whether the mythical and much-touted benefits of energy independence will all materialize. A number of factors could tie the US down. Firstly, it is important to remark that oil prices are global - as opposed to gas prices, which vary immensely by region as there is currently no global gas market. As seen in recent years, tumultuous events such as the Libyan uprising have disturbed the oil markets profoundly, leading to increased prices despite the supposedly mitigating effects of the US energy revolution. Secondly, the United States has allies in the Middle-East which it will not abruptly abandon; humanitarian concerns may also retain US involvement in the region. But perhaps most importantly, the US is an inextricable part of a global economy: if its export or import markets were to suffer due to disruptions in oil flow from the Middle-East, America too would feel the pain.

To sum up, neither the possibility of reaching the American dream of full energy independence nor the resulting liberty for American foreign policy actions are fully assured. On the one hand, economic factors and technological developments may mar the achievement of self-sufficiency; on the other, global interdependence and global markets may severely restrict American foreign policy maneuvering room.
China’s scramble for resources and what it might require

China and Asia are in a very different situation. Energy demand in the Asian continent is hitting new highs every day. Chinese energy demand, for example, is set to grow by 60% between 2010 and 2035. At present, Asia, with its lacking pipeline infrastructure, is highly reliant on LNG (Liquefied Natural Gas) and coal. Coal is still in heavy use in China in particular, with the World Resources Institute reporting that China consumed 46% of world coal consumption in 2010 and that, together with India, the country accounts for 76% of the proposed new coal power capacities in the world. Asia is thus in search of energy sources, both conventional and new, especially with traditional LNG supply (from Indonesia and Malaysia, among others) in decline.

As described in the Part I of this series, China’s reserves of unconventional gas are still under assessment. Despite measurement being at an early stage, the IEA suggests that the size of unconventional gas resources in China is “undoubtedly large”. At this time, however, the only type of unconventional gas being explored on a significant scale is coalbed methane (production stood at 10 billion cubic meters (bcm) in 2010). Indeed, at the beginning of 2012, China had only 20 shale wells in total.

Nevertheless, the country is ambitious in its exploration goals, targeting a shale gas output of between 60 and 100 bcm by 2020 (a scenario the IEA sees as likely, if certain policy features are in place), as well as a tripling of coalbed methane output by 2015. However, shale gas development experience and technical know-how is lacking as of yet – one could speculate that this may explain in part why foreign companies are being permitted to enter into partnerships with state-owned enterprises (SOEs) for new shale exploration projects (while SOEs typically hold monopoly roles in Chinese domestic petroleum exploration).

Another highly attractive source of energy is the South China Sea. Though there is no agreement on the precise reserves of oil and gas beneath the ocean floor, these rich grounds are becoming more and more disputed between the surrounding countries. Moreover, claims of sovereignty over the seabed are far from being settled, rendering the situation even more incendiary. While energetic concerns may not be the only elements at play here (nationalisms, historic frictions and economic issues such as shipping routes and fishing grounds are certainly relevant as well), this priceless tinderbox is likely to become more contentious and dangerous as energy stakes increase.

Regardless of the success of the domestic development of the ‘new’ hydrocarbons, it appears that in the short term, China – and Asia – will become increasingly reliant on the
Middle-East for their energy supply. So, while the Gulf States will be losing an export market in the US, Asia will probably step in quickly to fill its shoes. In fact, the IEA predicts that 90% of Middle-Eastern oil exports will be destined for the Asian market by 2035. Currently, 85% of all oil going through the Strait of Hormuz is already headed eastward (mainly to Japan, India, South-Korea and China); this number only stands to increase.

The question that follows is: who will guarantee the security of these energy sources and their transport routes? Some would suggest that with the US benefiting from its newfound domestic energy resources and disengaging from Middle-Eastern battlefields, the age of free-riding on American security provision in the Middle-East is over. In this case, they suggest, China will have to step up, matching both its economic strength and more assertive foreign policy positioning. Alternatively, some posit that the US could use its security provision in the Middle-East as a carrot in Sino-American negotiations on a broad range of issues. It appears, economically at least, that China may already be taking a pro-active role to guarantee its future petroleum provision. According to The Financial Times, for example, state-owned Chinese energy companies are currently rehabilitating the giant oilfields in the south of Iraq, a country set to overtake Russia to become the second-largest global oil exporter by 2030 – with 25% of its oil output destined for China by 2035 (IEA estimates).

In sum, Asia’s energy demands paint an interesting picture, one which may require increased interaction with neighbors and global partners. Efforts to develop renewable and unconventional sources at home – whether from shales, coal seams or the seabed – will undoubtedly be expedited, but in the meantime, import from the Middle-East is almost certain to become much more central. In addition, negotiations with Russia on new pipelines may become more attractive. Finally, increasing dependence on the Middle-East may require taking up a stronger international security role, after years of riding American coattails.

Russia’s weaknesses: fiscal dependence, stagnant leadership

Russia is a country highly dependent on oil and gas revenue: these revenues accounted for a third of total federal government revenue in 2008 (IMF) and almost half (46%) of it by 2010. This fiscal position is a clear vulnerability in a world discovering and exploiting new energy sources: for example, sizeable shale gas reserves are being found in a number of European countries. At the same time, the IEA sees American production of natural gas as set to overtake Russian production in just three years, with the spread widening through to 2020.

Russia’s problem is not one of reserves: its conventional gas resources are still larger than the shale gas reserves discovered in its neighbors in West and East Europe, and as is
demonstrated in the next section, the European import market is unlikely to evaporate. However, the price fetched by Russian gas depends heavily on European demand, and it would appear that these prices are gradually decreasing. A recent report by Harvard University’s Belfer Center remarks that Russia has already had to accept lower prices for its natural gas. In what the authors call a “major paradigm shift” in pricing terms, and because of global energy trends, Russia is now allowing part of its European sales to depart from the practice of indexing gas to oil prices. Instead, these gas prices have been indexed to spot natural gas markets, or regional market hubs.

Moreover, Russia’s non-European export market is limited because of infrastructure: there are many lost gas export opportunities to Russia’s south, due to lack of pipeline connections to Asia. The combination of fiscal vulnerability, dependence on European demand and gas prices, and lack of export infrastructure to one of the world’s most promising markets could make Russia somewhat of a lame duck in the changing world energy market, unable to control its own destiny. In addition, these international developments could have domestic political repercussions. If indeed a point is reached where Russia’s static elites start to feel the pressure of dropping oil and gas revenue, this could arguably reduce the political isolation they currently enjoy – which in turn could hypothetically increase calls for domestic reform.

Europe: Many impediments for new reserves on the old continent

Nevertheless, it is clear that Europe, the world’s second largest regional gas market, will not be able to cut the energetic umbilical cord with Russia any time soon. Many factors are at a play here, including the recent pledges by many European countries to reduce their reliance on nuclear power (a movement accelerated considerably by the Fukushima disaster). As nuclear power is phased out and European production of conventional gas declines, Europe will certainly look to other resources to make up for the shortfall.

Considerable non-conventional reserves have been located in countries such as Poland, France, Sweden, the UK and Germany. However, their exploration will likely face a number of inherently European roadblocks. For one, Europe’s reserves are thought to be more difficult to extract due to geological factors such as depth and pressure. Moreover, the dense population of the continent is a strong inhibiting factor. Public opposition is quite fierce in certain countries (such as the UK and France), and can be explained in part by population density and the NIMBY (not-in-my-back-yard) phenomenon. The opposition is further driven by environmental concerns such as earthquake risks and

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3 See also Paul Stevens’ 2012 Chatham House Report for an excellent extensive examination of the feasibility of reproducing the US shale gas revolution in Europe.

4 A number of exploration operations in Poland, for example, have already turned out to be unsuccessful.
groundwater contamination. Many European governments have taken these public and environmental worries seriously; a number of governments have instated moratoria on drilling pending investigations.

In addition, crisis-mired Europe is not exactly abuzz with investment at the moment, and prospective investors could be put off by such factors as the expense of European extraction. These high costs are attributable to lack of economies of scale, as well as the geological factors mentioned above. However, risk and costs also run high in Europe due to environmental regulation and ownership of mineral rights. Environmental regulation, determined both at national and at EU level (especially environmental protection rules such as water protection and chemical disclosure), is tighter in general on the Old Continent. Struggles over regulation, dubbed as schizophrenic, are ongoing between different European institutions and between European Parliament Committees – an element inconducive to investment security.

Another crucial determinant of drilling prospects is mineral rights, which constitute a major difference between the US and Europe. Whereas private land-owners or leasers in the US hold the rights over the minerals and oils underground, mineral rights in Europe are held by the state rather than by private land-owners. That is, while American land-owners are paid off for the negative externalities they face when energy companies drill on their land, in Europe it is governments rather than local landowners who reap the advantages of drilling. Logically, this severely reduces incentives for locals to participate in the development of mineral resources.

All in all, Europe faces a great number of difficulties in the development of its unconventional gas reserves, and an immediate boom mirroring the North American one is unlikely. Nevertheless, if a number of policies are instated by government and industry, the IEA predicts that growth in unconventional supply in the EU will suffice to offset decline in conventional output by 2020. This will certainly not liberate Europe from its Russian gas ties. It is possible, though, that global market pressures may have some pricing effects in Russian-European gas trade.

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5 See Part III of this series for a more detailed discussion of these concerns.
6 In the UK, for example, fracking was temporarily halted last year after seismic events were measured near a drilling site. In France, government action has gone further, instating an all-out prohibition on hydraulic fracturing in the Southeast Basin after an initial moratorium.
8 An example set of such policies are outlined in the IEA report “Golden Rules”.
Conclusion

The so-called ‘shale gas revolution’, which has dominated headlines recently, has huge transformative potential on many fronts. However, it is imperative to avoid sweeping declarations and one-dimensional views. This revolution is not a panacea, on national or global level. As Part II of this series of papers has shown, the effects of a change in the energy-economy-geopolitics chain are far from straightforward and predictable.

While some are proclaiming the arrival of long-desired US energy independence as a premise for something near isolationism and the revival of great power status, or at the very least as a license for the US to ‘go its own way’, in fact the country is inextricably collected to the world economy. The United States may indeed experience more freedom in its foreign policy movements and will undoubtedly benefit greatly from strong economic growth, but global oil prices and dependence on petroleum as a transport fuel – along with other strategic and humanitarian concerns – will likely ensure that the US remains involved to some degree in energy-producing regions such as the Middle-East for a long time yet.

Meanwhile, the strategic importance of the abovementioned region will increase for China and the rest of Asia, with their burgeoning populations, economies and consequently, energy needs. This may force China’s hand to step up its involvement in the Middle-East, perhaps even in providing the security of its maritime oil fairways. The country is also sure to invest in development of its vast unconventional resources, whose magnitude is yet unknown. The drive for ‘native’ energy resources could potentially hold a great deal of danger, especially with sovereignty rights over maritime resources (such as those in the South China Sea) undefined.

Then there is Russia, with its high reliance on gas and oil exports. In a way, the nation has its hands tied as it watches the world’s energy landscape transform, and this without strong export options (pipelines) to the promising Asian markets. However, it would appear that in absence of very strong development of Europe’s non-conventional reserves (an unlikely scenario, at present, due to geological and regulatory factors, as well as strong public opposition), Russia’s export market is guaranteed. Nonetheless, the conditions of the Russia-Europe gas trade may experience some change, especially if the gas market becomes more globalized.

All in all, this tentative snapshot of possible geopolitical implications suggests the dream of American ‘energy independence’ will not come about miraculously and abruptly, and that its geopolitical effects may not be as quick and momentous as some might suggest. Nevertheless, the energy revolution’s effects on the domestic American market may
significantly transform geopolitical dynamics which once seemed to be on a one-way track. In order to maintain competitiveness, other regions and countries of the world are sure to attempt to follow the American ‘shale gas revolution’. However, the success of these efforts is far from assured, and will not be felt in the short term. Until then, China and Europe will remain dependent on foreign energy supply (and thus vulnerable). Furthermore, the ripple effects of the American shale gas revolution may mean China will have to step up its security role in the Middle-East, and that Russia may have to accept lower prices for its gas in Europe. It is certain that no country will be left untouched, in today’s interconnected world.

Part III, the conclusion of this series of papers, will examine an aspect of the energy revolution which is often neglected, but which is of existential importance. Environmental concerns on the local and global levels are scrutinized, revealing a structure of incentives which could have significantly adverse consequences.
For further information on ESADEgeo’s Position Papers, please feel free to contact:

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Game Change?
The Many Faces of Today’s Energy Revolution

Part III: Environmental Effects and Myopia

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Introduction

Much ado has recently been made about what has been termed the ‘shale gas revolution’: the boom in US unconventional gas production driven, in large part, by technological advances. The fortuitous developments in the energy sector have been discussed at length in the media, not only because of their promising economical prospects for a nation some had labeled as in decline, but also for its potential to bring about profound changes in the geopolitical landscape.

This series of brief papers aims to be a guide to help contextualize some of the confident claims being made in the media on today’s shale gas revolution, offering a variety of factors – economic, political, security-related and environmental – to take into account in order to paint a more multidimensional view of the prospects. Both positive and negative effects stemming from the energy revolution will thus be addressed.

Part I of the series provides critical background information, offering insights on the range of energy sources involved in the revolution, the technology behind their extraction and the economical factors which have propelled the energy boom – and which could present risks of their own. Part II presents the geopolitical side of the story, with a detailed look at a number of countries and regions – United States, China, Russia and Europe – in turn, teasing out potential consequences of the energy revolution. Part III, which rounds out the series, examines the environmental effects of the energy boom on a local and global level.

This paper is the third and final part of the paper series. Attention is brought to the environmental side of the story: while public opposition to drilling projects often brings local environmental effects such as seismic fears and groundwater pollution into media headlines, some crucial elements are underreported. One is water scarcity and the rising competition for water usage between the extractive and other industries. Another, existentially critical, contingency is climate change: while combusting natural gas may produce lower greenhouse
gas emissions than traditional hydrocarbons, the unconventional energy heyday could reduce the sense of urgency in developing renewables, the only truly clean energy source.

**Local Environmental Concerns**

The arrival of the industry of shale gas or other unconventional energy extraction activity can yield immediate benefits for local communities. Employment creation, for instance, is high on the list: the IHS has calculated that shale gas production supported more than 600,000 US jobs (direct, indirect and induced) in 2010, while the unconventional gas industry supported 1 million jobs. By 2035, these numbers are forecasted to grow to 1,660,000 and over 2.4 million, respectively. Nevertheless, perhaps the most vociferous opposition to the extraction of unconventional resources (such as shale gas, or tar from Canada’s oil sands) comes from the local population at the site of extraction, citing concerns about the environmental effects of hydraulic fracturing.

First among the worries is water. Fracking is a water-intensive technology:\(^1\): in fact, the IEA estimates that the amount of water required for energy production will increase at twice the rate of energy demand from now to 2035. This increase reflects the increased share of unconventional gas in the energy mix. In areas which already experience water stress and shortages, competition may ensue between hydrocarbon extraction and other local industries, such as agriculture. In addition, if water for fracking cannot be tapped from local aquifers or other sources, it is transported in by trucks, sometimes hundreds per well – which, of course, has local impacts of its own on roads and populations along the routes.

On the other hand, water contamination is a recurrent fear and risk. Firstly, there is the issue of produced water, drilling mud, and the fracking liquids used at the well site, which often contain polluting chemicals, high levels of salt, and some radioactive elements (the latter two resurge from the rock beneath). These liquids require posterior treatment, whether in vast evaporation pools or through advanced water treatment systems. A second major concern is that water could migrate from the wells into groundwater deposits and other aquifers, contaminating drinking water with chemicals found in the fracturing liquid and hydrocarbon in various forms.

Moreover, there is a heated debate about the abovementioned chemicals: drilling firms are reluctant to disclose the exact compositions of the chemical solutions they add to fracking liquid, claiming the formulas are trade secrets. Environmentalists, however, claim

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\(^1\) For a more detailed look at the technologies of horizontal drilling and hydraulic fracturing, see Part I of this paper series.
the right to know what is being injected into the ground in order to analyze health risks\textsuperscript{2}. Other local environmental concerns include the air pollution caused by particles from the wells, as well as disposal of waste rock, and \textit{seismic events}. While the jury is still out on whether the small earthquakes that have been experienced near some natural gas drilling sites (for example in Blackpool (UK) and in Ohio (USA))\textsuperscript{3} were caused – wholly or in part – by hydraulic fracturing, the events have led to temporary moratoria in drilling activities pending further investigation.

As described in Part II of this series, \textbf{public opposition}, whether driven by environmental concerns such as the ones described above or others, has been particularly fierce in Europe. In the US, however, particularly in the state of New York, which rests on the energy-rich Marcellus Shale, local voices are also growing louder. As much environmental regulation on gas and oil extraction is determined at state and local level in the US and at national level in Europe, the public’s worries do stand to have an impact on energy production prospects and thus, potentially and on a smaller scale, on the geopolitical outlook.

\textbf{Avoiding Myopia: The Long-Term Global Picture}

Moving up one degree on the ladder and in altitude, there is the global environmental picture: the greenhouse gas emissions which flow into the world’s shared atmosphere upon the combustion of hydrocarbons. Advocates of shale gas often emphasize the emission benefits of natural gas, citing that it produces 50\% less greenhouse gases (GHG) emissions than traditional hydrocarbons such as petroleum. While there are some doubts as to the magnitude of this stated gap (due mainly to the energy-exhaustive technologies required in the extraction of shale gas and to the short but intensive life cycle of the greenhouse gas methane – which is produced in greater quantities in the extraction and combustion of unconventional hydrocarbons), it is held fairly widely that \textbf{using natural gas instead of other ‘conventional’ hydrocarbons leads to lower levels of greenhouse gas emissions}.

Though this effect is positive for global warming prospects in the short term, it is not unconceivable that the boom of non-conventional hydrocarbons may have negative effects in the long-term. The planet’s reliance on fossil fuels may be extended far further than where it could have reached under the conditions of purported ‘peak oil’, due to the continuing subsidization of said fuels on the oil hand, and the diminishing costs of

\textsuperscript{2}In the USA, the debate on this matter centers on a clause in the 2005 Environmental Protection Agency’s (EPA) Clean Water Act, dubbed the ‘(Cheney-)Halliburton Loophole’, which provides particularly lenient environmental legislation on fracking. According to Paul Steven’s 2012 Chatham House \textit{report}, the Loophole also weakened environmental impact assessment options significantly, both ex ante and ex post (due to lack of measured baselines).

\textsuperscript{3}Tremors of around 2.0 on the Richter scale were measured in Blackpool in the UK, which were possibly linked to the Cuadrilla shale gas operations in the area. In Ohio, some tremors reaching 4.0 on the Richter scale were registered, which were possibly linked to the subterranean injection of drilling wastewater.
hydrocarbons such as natural gas on the other. And of course, these fossil fuels will keep causing GHG emissions, regardless even of best practice scenarios such as drastically improved fuel efficiency and avoidance of flaring

Within the IEA report which has made such a media stir of late, there is a clear message which has been far less publicized than the possible realization of the American dream of energy independence and its economical and geopolitical implications. The report also stated plainly that, without further policy changes and global carbon-cutting agreements, so many greenhouse gas (GHG) emissions are likely to be “locked-in” by 2017, that global temperatures will no longer be able to be contained to the 2°C maximum rise agreed to in the UNFCCC (United Nations Framework Convention on Climate Change) negotiations. Moreover, the IEA wrote that “no more than one-third of proven reserves of fossil fuels can be consumed prior to 2050 if the world is to achieve the 2°C goal, unless the carbon capture and storage (CCS) technology is widely deployed”. In the run-up to the UNFCCC’s annual meeting of the parties, COP-18 in Doha, multiple international organizations published further warnings.

At the beginning of this century, when global oil prices were soaring, consciousness of the climate change problem was growing, certain countries had pledged to decrease their dependence on nuclear sources, and ‘peak oil’ was seemingly approaching, there was an international push towards renewable energy sources. However, the rise of ‘new’ unconventional hydrocarbons such as shale gas, propelled forward by drastically reduced extraction costs, may very well collapse the urgency of developing other energy sources which produce zero emissions, rather than lower emissions.

The trends do not point in the right direction. On the one hand, subsidies for fossil fuels are still going strong. In fact, the IEA states that fossil fuels were subsidized by $523 billion in 2011, which is almost 30% more than 2010 levels, and six times more than subsidies to renewables. This growth is contrary to the pledge made at the 2009 G20 summit, when leaders promised to phase out fossil fuel subsidies over the following ten years. On the other

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4 With investment in improved separation and capture of gases during the initial flowback phase of each well, flaring (one of the main sources of the high GHG emissions during shale gas extraction) could be diminished drastically. (See also Part I of this series for further details on flaring and venting, which occur during the initial phases of shale gas extraction.)

5 The World Bank has published a study showing a 20% likelihood of average global temperatures rising by more than 4°C by 2100; the World Meteorological Organization (WMO) has written that GHG emissions reached a record high in 2011, with the United Nations Environment Programme (UNEP) showing that annual GHG emissions now 14% above where they need to be in 2020; and the European Environment Agency (EEA) has provided information on the climate change damage Europe is already sustaining.

6 This is a relatively conservative estimate: the Worldwatch Institute, for example, saw fossil fuel subsidies at over $660 billion in 2011, and estimates they will reach between $775 billion and $1 trillion in 2012.
hand, the **decreasing price of natural gas makes the naturally expensive development of renewables resources less attractive** for investors.

Collectively, the ‘cleaner’ alternatives of shale gas and its cousins may be an ominous sign for the development of renewable energy. To sum up, the combination of the decreased urgency of exploring alternative energy sources, falling hydrocarbon prices, consistently high costs of development of renewables and the continuation of fossil fuel subsidies could mix into a toxic cocktail for global warming.

**Conclusion**

Part III of this paper series has attempted to show, once more, that the current energy revolution is **not a cure-all, on national or global level**. The extraction of shale gas and other unconventional hydrocarbons can bring strong benefits to local communities, through job creation. On the other hand, however, the new technologies used by the thriving industry are hardly without risk.

A common denominator in the concerns at local level is water: both the **competition for scarce water supplies** between the extremely thirsty technology of **fracking**, and the **risk of groundwater pollution** posed by the chemicals injected while applying said technology. Seismic risks are another element of alarm, combining with the previous to strengthen the outcry in certain local communities. In a number of cases, public opinion has already led to governmental moratoria on drilling. **Local environmental concerns, therefore, are an element which cannot be ignored, and one which will certainly have to be addressed through best practices** in industry and regulation.

On the global level, the environmental perspectives are also worrying. While unconventional gas is hyped as a ‘clean’ energy source because of its lower emissions rates in comparison with fuels such as crude oil, in fact the boom in its extraction may have perverse effects on global warming. The realization that the planet’s fossil fuels reserves are much larger than previously thought and much more accessible than before (due to technological advances), could potentially remove urgency from the equation, **releasing some of the pressure to develop renewable energy sources**. **Price incentives** also come into play here: developing renewable energy is inherently expensive, and this cost is not set to fall any time soon. With natural gas prices dropping, renewable energies may simply not be economically viable. This situation is no way helped by the whopping sums of subsidies provided to fossil fuels each year, which are currently six times higher than the subsidies for renewables.

This paper series set out to hold a prism up to the current energy revolution, showing the many colors of today’s developments. Clearly, and as shown in parts I and II, the revolution
holds true transformative potential, economically and geopolitically, for the US and the rest of the world. However, it also poses many environmental risks: the planet’s future path may hang in the balance. Shale and other natural gas relatives, with their benefits of lower greenhouse gas emissions, could be a promising bridge to a greener future. However, if care is not taken amidst the euphoria, they could end up being a bridge to nowhere.
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