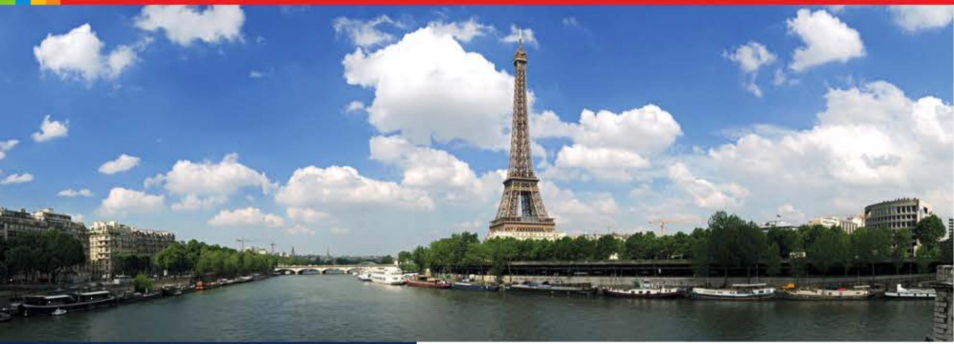
2012-2015 Triennium Work Reports



Environmental Aspects of Unconventional Gas

Seeking common ground for a key energy source

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2012-2015 Triennium Work Report
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Environmental Aspects of Unconventional Gas

Seeking Common Ground for a Key Energy Source

Executive Summary:

There is little discussion that the increasing development of unconventional resources during the past 10 years - particularly in the USA - has significantly changed the global map of the natural gas industry, and that if the trend continues we could be looking at the dawn of a renewed age in the world energy scenario, with natural gas playing a major role.

Indeed, we just need to refer to the LNG flows projected only a couple of years ago and how they have been notably revisited, especially those into the USA, who in 2013 has overtaken Russia as an oil and gas producer, thanks to the spectacular growth of shale gas production.

But behind the USA (and in a lesser degree neighboring Canada, and also China), other countries and regions across the world have uncovered very interesting potential and could be decidedly following suit, indicating that these changes could soon be developing at a global scale.

Besides the potential increase of natural gas output, the benefit of such a global development lies also in the diversity of these resources, improving the security of supply and helping to moderate the impact on future gas prices. The combination of this may well unlock a demand for natural gas, which could increase by 50% in 2035, displacing coal in the world energy matrix, according to studies conducted by the IEA[1].

But for several reasons which will be addressed at this paper, the path to this brilliant future for the natural gas industry is not free from considerable hurdles, some of which have already deterred

[1] Golden Rules for a Golden Age of Gas, IEA, 2012

unconventional gas projects.

The fact is that this expansion of unconventional gas is being now widely perceived as a game-changer and has generated the expected resistance, both from competing energy industries - some of which fuel both economic and political issues - to the public opinion and media, armed with a vast volume of information, some of it valid, some less so.

This takes us to one of the central issues of this paper: unconventional gas is still “the new kid on the block”, and as such has to conduct all the efforts needed to prove that it can also be a “friendly neighbor”. In these efforts, the fact that some opinions are arguable is of little consequence - the *new kid* must prove its worth above expectations, limiting the opposition to the inevitable disgruntling few.

Two critical areas on which these efforts must be centered are the social and the environmental impacts. Both topics are strongly related, and this paper intends to review the path to public acceptance, addressing the main environmental concerns surrounding shale gas developments. We will list a few of the best practices and success stories, as well as the challenges still to overcome.

For these efforts to be successful in achieving the “social license to operate”, the gas industry must promote the convergence (the “same page”) of the three major stakeholders: governments and their regulating bodies, the communities and related NGOs, and the industry operators.

This paper intends to establish a working platform to develop a more extensive study within the next triennium which aims to contribute on two of the International Gas Union’s responsibilities for this endeavor: nurture the global gas network with collective experience, and to provide solid information and knowledge that will support IGU’s role as spokesman for the global gas industry.

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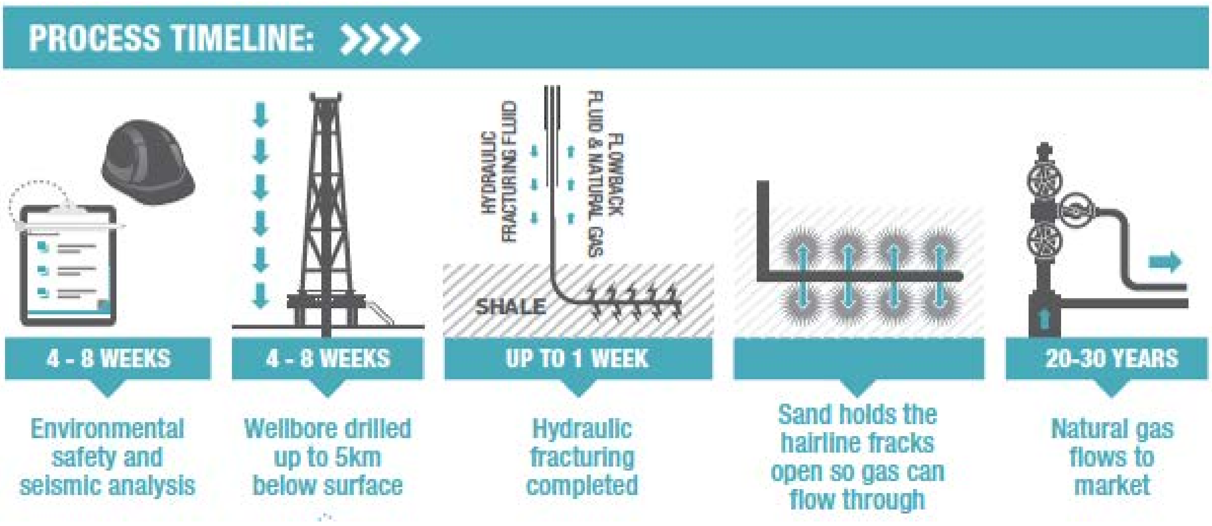
Introduction: a turning point for the global gas industry – if we do things right

Hydraulic fracturing is not a new technology in the oil and gas industry. In fact, the first tryouts were back in 1947, though it was considered commercially viable 3 years later. Even horizontal drilling is not new, as they were not uncommon in the late 1970's. Overall, the SPE estimates that in the past 60 years around 2.5 million "fracs" have been conducted around the world, of which approximately 1 million were done in the United States.

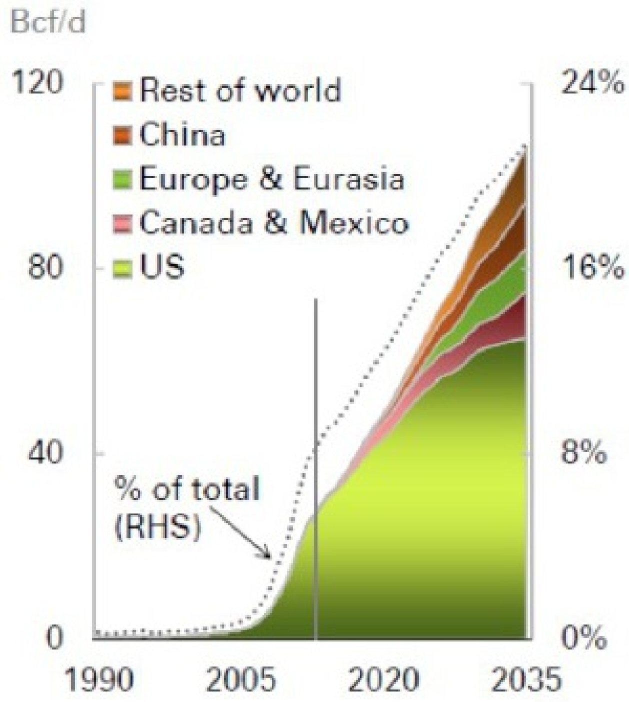
Literature is also extensive. The SPE's count until 2012 were over 3,000 papers on horizontal drilling of which 550 link them to shale gas extraction, submitted in the previous 30 years. But the diversity of sources from where these have come during the last few years (over 70 universities, a dozen or more state and international agencies, and a handful of national laboratories, besides more than 100 energy-related companies), are a strong indication of the widespread interest this activity has generated.

George P. Mitchell is regarded as the father of the shale gas industry, following his success in making the Barnett Shale commercially viable in 1998, allegedly lowering costs down to $4/million BTU. However shale gas was still widely perceived as marginal at best and shale gas provided only 1.6% of US gas production in 2000.

In a nutshell, the following figure broadly describes the shale gas extraction process:



Since then, ground-breaking developments, particularly in hydraulic fracturing and horizontal drilling, started giving way to the potential hinted at Barnett. Indeed the increase in the proportion as well as the length of horizontal wells, and the amount of fracturing stages per well impacted decidedly on the operating costs and yields per well. The share of horizontal wells present in shale gas developments jumped from 10% in the year 2000, to over 80% by 2013, while the average length increased 50% from 800 to 1200 meters. The adaptation of pad drilling from offshore to the onshore shale gas installations as from 2004 provided a further boost while lessening the surface footprint, while developments on micro seismic imaging helped to provide crucial data on geology characteristics and reserve clustering, for a more effective mapping of the extraction and injection paths.



As the success of the Barnett Shale consolidated and energy prices continued on the rise, other companies started drilling wells in this formation so that by 2005, the Barnett Shale alone was producing almost half a trillion cubic feet per year of natural gas. Coupled to the positive outcomes in Fayetteville Shale in northern Arkansas, the investors and operators began pursuing developments in other formations like Marcellus, Eagle Ford and Woodford.

As a result, US shale gas production increased by 51% per year since 2007.

In its Energy Outlook Report 2014[2], BP graphed (left) the shale gas production per country and its future projections. To date the US accounts for the vast majority of this, with Canada following suit (which is why most of the content in this paper is based on the experience of these 2 countries), and followed by China. These 3 countries are the only ones which to date are producing commercially viable volumes.

Rank	Country	Shale gas (tcf)
1	China	1,115
2	Argentina	802
3	Algeria	707
4	U.S.A.	665
5	Canada	573
6	Mexico	545
7	Australia	437
8	South Africa	390
9	Russia	285
10	Brazil	245
	World Total	**7,299**

However the U.S. Energy Information Administration (EIA)[3] has informed that “Since the release of EIA's 2011 assessment of technically recoverable natural gas resources from selected shale formations in 32 countries, the blossoming of interest in shale resources outside the United States has resulted in the publication of more and better information on the geology of many shale formations. Wells drilled in shale formations in countries such as Argentina, China, Mexico, and Poland have also helped to clarify their geologic properties and productive potential”.

The table at right provides EIA’s 2013 report on the “Top 10 countries with technically recoverable shale gas resources, clarifying that it is important to distinguish between a technically recoverable resource (the volumes of oil and natural gas that could be produced with current technology) and an economically

[2] http://www.bp.com/content/dam/bp/pdf/Energy-economics/Energy-utlook/Energy_Outlook_2035_booklet.pdf
[3] http://www.eia.gov/analysis/studies/worldshalegas/pdf/overview.pdf

recoverable resource (resources that can be profitably produced under current market conditions).

In November 2012, IEA's "Golden Rules Scenario"[1] posed the following scenario for natural gas in general and unconventional gas in particular:

1. An accelerated global expansion of gas supply from unconventional resources, with far-reaching consequences for global energy markets.
2. Greater availability of gas supply has a strong moderating impact on gas prices
3. As a result, demand for gas grows by more than 50% to 2035 and the share of gas in the global energy mix rises to 25% in 2035, overtaking that of coal.
4. Production of unconventional gas, primarily shale gas, more than triples to 1.6 tcm in 2035.
5. The share of unconventional gas in total gas output rises from 14% today to 32% in 2035.
6. Whereas unconventional gas supply is currently concentrated in North America, in the Golden Rules Case it is developed in many other countries around the world, notably in China, Australia, India, Canada, Indonesia and Poland (to which we would add Argentina).
7. The Golden Rules Case sees a more diverse mix of sources of gas in most markets suggesting an environment of growing confidence in the adequacy, reliability and affordability of natural gas supplies.
8. An increased volume of gas, particularly LNG, looking for markets in the period after 2020 stimulates the development of more liquid and competitive international markets.
9. The projected levels of output in the Golden Rules Case would require more than one million new unconventional gas wells to be drilled worldwide between now and 2035.

In June 2014 BP's report[2] still provides a promising picture with the following predictions:

1. Shale gas is the fastest growing source of supply at 6.5% per annum, providing nearly half of the growth in global gas.
2. Shale gas supply is dominated by North America, which is expected to account for 99% of shale gas supply until 2016 and for 70% by 2035.
3. However, shale gas production growth outside North America is expected to accelerate and overtake North American growth by 2027.
4. China is the most promising country for shale production growth outside North America, accounting for 13% of world shale gas growth.
5. Together, China and North America will account for 81% of shale gas by 2035.

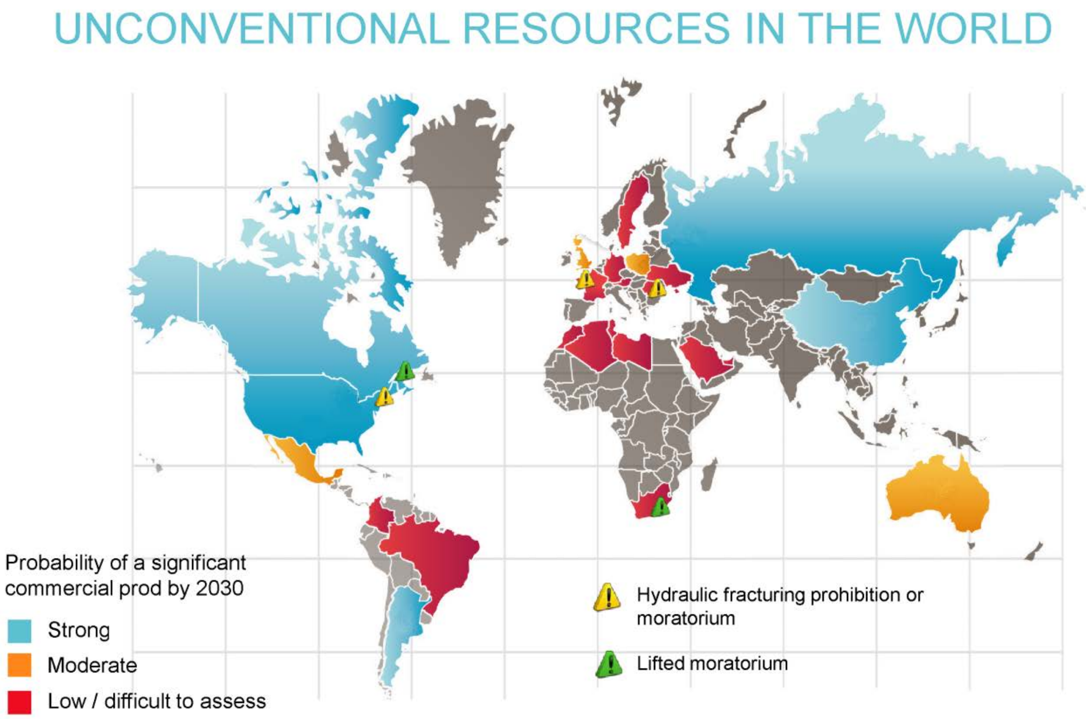
But the development setbacks, delays and moratorium registered worldwide, including in the USA, are an eloquent indicator that this bright future is far from assured.

Indeed, for reasons which will be mentioned throughout this work, several issues – in particular those related to social and environmental concerns – have forced the operators to focus on ways to significantly mitigate these concerns in the most assertive and conclusive ways possible.

As stated by the IEA[1]: "Producing unconventional gas is an intensive industrial process, generally imposing a larger environmental footprint than conventional gas development. More wells are often needed and techniques such as hydraulic fracturing are usually required to boost the flow of gas from the well. The scale of development can have major implications for local communities, land use and water resources. Serious hazards, including the potential for air pollution and for contamination of surface and groundwater, must be successfully addressed. Greenhouse-gas emissions must be minimized both at the point of production and throughout the entire natural gas supply chain".

The map below[4] displays the global shale gas potential according to the latest data available.

[4]Environmental issues of shale gas, Total Austral, Argentina



Besides the technical feasibility (to which the economical feasibility must be compounded), the figure indicates where the shale gas industries has been more severely restricted because of these concerns.

To the technology breakthroughs that enabled the shale gas to be economically viable, there has followed a number of developments to meet these challenges. However, this will remain an ongoing process whereby the gas industry, policy-makers and regulating bodies must establish the setting to ensure a continuing performance improvement, to gain or maintain public confidence. As recommended by the IEA[1]: “The industry needs to commit to apply the highest practicable environmental and social standards at all stages of the development process. Governments need to devise appropriate regulatory regimes, based on sound science and high-quality data, with sufficient compliance staff and guaranteed public access to information”.

Basically it means getting all stakeholders on the same page, at least if they cannot be of the same opinion altogether, after which the industry must consistently prove that it remains on this page, by means of a comprehensive engagement program throughout the entire board of stakeholders.

Acknowledgements

We would like to thank Mel Ydreos and Terrence Thorn, incoming Coordination Committee Chairman and Secretary respectively, and also Total Austral of Argentina, for their input in this paper.

Addressing stakeholders’ concerns: finding the elusive “same page”

Someone once defined natural gas as the *Rorschach test of energy policy*, whereby depending on the point of view it can either be the energy of choice, or a fossil fuel which in the overall balance does not provide an adequate solution. The problem with shale gas developments is that due to their nature – both in terms of location as well as procedures – the scope of people looking at these particular Rorschach inkblots has widened dramatically.

In December 2014 the governor of the state of New York, Mr. Andrew Cuomo, banned the use of hydraulic fracturing, following the report from the New York Department of Health which found "*significant uncertainties about the adverse health outcomes"* from the use of this technology.

Barely one month before that, the governor of Maryland, Mr. Martin O'Mall, gave the green light to hydraulic fracturing developments in the west of the state, based on the report from Maryland's Department of Environment and Natural Resources which stated that *"…the risks of Marcellus Shale development can be managed to an acceptable level*."

Considering that the reports were developed by two professional agencies, and at practically the same time, it is safe to assume that they were based on very similar science and data.

So if science didn't divide the decision, what did?

Besides the possible political implications for each administration and other specific state issues (like size, Maryland's area is much smaller than New York's, who therefore faces more risks – albeit also benefits), there are two significant differences, which might also explain the outcome of similar decision processes around the world.

One of the aspects is the *focus* of these reports.

Maryland's report was conducted by an agency involved in environment and resources, which besides analyzing the impact on health and environment, will typically have a broader view including economic and development considerations.

New York's report is specifically focused on health.

The other aspect is *risk assessment and management*, which are reflected in the terms "significant uncertainties" and "acceptable levels" mentioned above in the reports' extracts.

Mr. Cuomo's decision would be based on the *precautionary principle,* which is basically a risk-aversion position when facing uncertainties. So though not totally divorced from a scientific perspective, the decision is primarily driven by the perception and reaction to risk, based on the data available.

Policy and regulatory differences have also have driven the investors of this industry for a fuller disclosure on environmental hazards and corporate risk management policies, such as the adoption of precautionary best management practices, as informed by the Investor Environmental Health Network (IEHN) [5].

An eloquent indicator of the divorce between stakeholders of shale gas developments is the sharp increase of lawsuits against shale gas operators. On the "Analysis of Litigation Involving Shale & Hydraulic Fracturing[6]" issued by Fullbright and Jarowsky, a study was conducted on over 70 litigations between in the states of Arkansas, Colorado, Louisiana, New York, Ohio, Pennsylvania, Texas and West Virginia. As expected, most of these has happened between landowners and shale gas operators, but a few have also confronted other organizations, both public (regulating bodies, municipalities and other official entities), and private (namely NGOs with environmental or other protection interests).

Not surprisingly, most of the landowners' claims are related to alleged groundwater contamination. However air quality, soil degradation, noise, and even earthquakes also compose the list of conflicting issues.

[5] www.iehn.org.overview.naturalgashydraulicfracturing.php
[6] http://www.nortonrosefulbright.com/files/20140101-analysis-of-litigation-involving-shale-hydraulic-fracturing-104256.pdf

This situation has triggered actions from regulatory bodies which are not strictly tied to energy policy in the USA. Such is the case of the Securities and Exchange Commission (SEC) which in 2012 started requesting shale gas operators to submit information regarding their procedures, particularly in regards to the chemicals being used in the hydraulic fracturing. These actions opened the vast and complex litigation front related to the intellectual property of the gas operators.

But the recent settlement of such a case in Wyoming could shed some light on how the stakeholders could meet at the “same page”, even on this delicate issue.

In 2010, Wyoming became the first state to require oil and gas companies to disclose the chemicals used in hydraulic fracturing, an action contended by operators like Halliburton Energy Services, Inc. under the trade secret exemptions legislation. This situation gave way to the case of the Powder River Basin Resource Counsel vs. and the Wyoming Oil and Gas Conservation Commission (WOGCC) and Halliburton.

The Powder River Basin Resource Counsel is an NGO whose mission is *“The preservation and enrichment of Wyoming's agricultural heritage and rural lifestyle”*[7] who in the litigation was joined by other environmental groups like the Wyoming Outdoor Council, and Earthworks, as well as the Center for Effective Government.

The case reached the Wyoming Supreme Court and in January 2015 a groundbreaking legal settlement was reached whereby:

1. The WOGCC is to implement new procedures by adopting a form and applying certain guidelines concerning applications for the provision of confidentiality protection
2. Following the adoption of the above, the WOGCC is required to notify the operators to resubmit their requests for confidentiality protection to conform to the new form and guidelines

In light of this settlement, Wyoming’s governor expressed that his administration will continue to pursue the balance between environmental protection and energy development, in his words: “Wyoming will implement these guidelines and it will allow public access to important information and, where appropriate, will protect trade secrets”[8].

Engagement – albeit a forced one like the case described above – paved the way to agreement. This topic will be specifically addressed in one of the final chapters of this work.

But corporate reporting should not be the only information flow supporting this quest. These should be “complemented by other corporate environmental, social and governance reporting mechanisms” as stated by the IEHN report[9]. Again, these are not always on the same page, but some progress is being made.

Such is the case of The Global Reporting Initiative (GRI) which has developed reporting guidelines for multiple sectors and has recently linked with IPIECA, the global oil and gas industry association for environmental and social issues, to align the industry’s own guidelines.

A final word on “bridging the language barrier” as mentioned on the report issued by the Society of Petroleum Engineers (SPE)[10], possibly the first cornerstone needed for a productive dialogue between stakeholders. As mentioned in the report “Environmentalist critics insist that some “fracs” have contaminated ground and surface waters while engineers insist than not one frac has ever

[7] www.powderriverbasin.org
[8] http://energylawtoday.foxrothschild.com/2015/01/articles/fracking/groundbreaking-settlement-regarding-fracking-disclosure-procedures/
[9] Extracting the Facts: An Investor Guide to Disclosing Risks from Hydraulic Fracturing Operations
[10] Hydraulic Fracturing 101: What Every Representative, Environmentalist, Regulator, Reporter, Investor, University Researcher, Neighbour and Engineer Should Know About Estimating Frac Risk and Improving Frac Performance in Unconventional Gas and Oil Wells

contaminated ground waters…Surprisingly, both sides have valid arguments – just a mismatch of definitions”. The point lies on what each side understands (or encompasses) under the term of fracking (for short of hydraulic fracturing).

Indeed, while engineers limit this term to the specific stimulation activity whereby the fluid initiates and/or extends fissures, for the regular neighbor and environmentalist, the term represents practically all the stages of shale gas production.

The SPE states that the science behind well development activities – including shale gas – is based upon about 60,000 presented papers from over a dozen engineering and geosciences societies which represent around 100,000 engineers and scientists of the oil and gas industry across the world, and – as confirmed by the mentioned IEHN report, “the largest known risks from natural gas operations are from surface operations and improperly performed near-surface well construction, not from the literal breaking apart (fracturing) of shale formations thousands of feet below the surface and drinking water aquifers”.

The following chapter will address the main conflicting issues of the surface operations mentioned above.

Environmental issues: reviewing the roadmap to social license to operate

Though this chapter will mention some technical references, the objective is basically to review the list of key conflicting issues related to shale gas operations, the impact on other stakeholders (namely local communities), and in some cases the trends, improvements and success stories that could signal the way to move ahead.

Deployment: geology, land use, well-planning and drilling

As in all projects, the preliminary studies and evaluations – both below and above ground – will be the first (and sometimes only) activities responsible for the success (measured in terms of deriving conflicts) of a shale gas development.

A site will be chosen not only on the geological evaluation and climate impositions, but also on a number of other considerations that have a more direct impact on local communities like proximity to populated areas, water availability, local infrastructure (particularly roads and waste disposal treatment), and other highly sensitive concerns including environmental and heritage.

These are the critical topics which would be included in the engagement agenda.

The IEA[1] includes this issue in their second “golden rule” (“Watch where you drill”), while the IEHN[9] does so in their “Recommended Core Management Goals”.

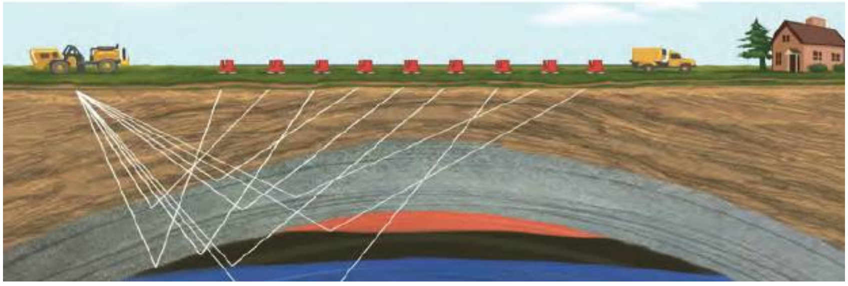
While conventional wells (excluding the more mature) could on average require 10km^2, a shale gas operation’s needs could be 10 times that figure (an eloquent example of this can be found in some counties in Texas, where the Barnett shale production requires over 30 wells in areas less than 20km^2).

But shale gas surface footprint derives not only from the number of wells, but mostly of the associated surface operations, as the storing of fluids and other waste matter, equipment, etc. which can on average occupy a surface of one hectare around each well.

A productive geological study will render 2 critical inputs:

1. Reservoir's layout and potential "sweet spots", which is of particular relevance to the surface footprint issue as it will enable to identify the best locations of the drilling pads to optimize operations
2. The presence of possible deep-faults that could potentially allow the migration of hydrocarbons or fracking fluids into underground or surface water

As mentioned in the previous chapter, the occurrence of migration is highly improbable given that the reservoirs are several thousand meters below usable aquifers (which are all within the 350mt depth range), and that between these two locations there are usually several layers of impermeable rock formations. However it is theoretically possible if such layers do not exist (even though the migration could take several decades), or in the case of deep faults that could act as conduit of the undesirable fluids. Considering that there is known natural methane seepage or presence in aquifers due to geological or biological events, a sound geological evaluation is an important instrument to appease the concerns related to water contamination; particularly for the less deep reservoirs (the SPE uses a 2,000ft reference).



Seismic imaging has been one of the successful developments. In Europe, Eurasia and Middle East, Chevron [11] has developed the use of 4 to 5 trucks that place vibrating plates spaced out by 25meters, which send sound waves that are reflected to create seismic imaging that enables to minimize the number of wells to be drilled and allow for fault lines to be mapped. Another example (and technology) is the case of Royal Dutch Shell which has recently started to test a laser device that can detect, map and measure the size of underground reserves[12].

While still on the geological survey topic, a couple of paragraphs should be included regarding the alleged link between shale gas operations and seismic activity.

Originally discarded by most stakeholders (including public opinion which ranked this event at the bottom of their concerns, if at all), recent events have placed this issue under a renewed spotlight.

Indeed minor tremors (between 2.0 – 3.9 in the Richter scale, as classified by the United States Geological Survey – USGS[13]) have been recorded close to some hydraulic fracturing operations. The most renown cases include the "Cuadrilla Cases" in Lancashire, UK, in April and May of 2011 (2.3 and 1.5 respectively, in the Richter scale). In the USA similar cases were registered in Arkansas, Oklahoma, Ohio and West Virginia. In Alberta, Canada, the original concerns due to the increase in 2013-2014 of tremors ranging between 2.5-3.5 have recently been heightened by the 4.4 mark registered in January 23, 2015, at Fox Creek., the highest mark registered to date.

Seismic activities below 3.9 (of which the USGS estimates that occur close to 1.5 million times per year around the world) are rarely (and in most cases barely) felt. However they are recorded and in some occasions have been enough to pause some of the operations and triggered moratoriums on new developments until further scientific evaluation was conducted, and preventive measures put in place.

Unfortunately the studies conducted after such events have never rendered conclusive results. Such is the case of the Oklahoma Geological Survey (OGS) regarding the incident at the Eola Field[14]: "Determining whether or not earthquakes have been induced is problematic because of our poor knowledge of historical earthquakes, earthquake processes and the long recurrence intervals in the stable continent. In addition, understanding fluid flow and pressure diffusion in the unique

[11] http://www.chevron.com/stories/#/allstories/seismic/
[12] http://www.niobraranews.net/drilling/shell-testing-laser-based-sensor-find-shale-gas/
[13] www.usgs.gov
[14] http://www.ogs.ou.edu/pubsscanned/openfile/OF1_2011.pdf

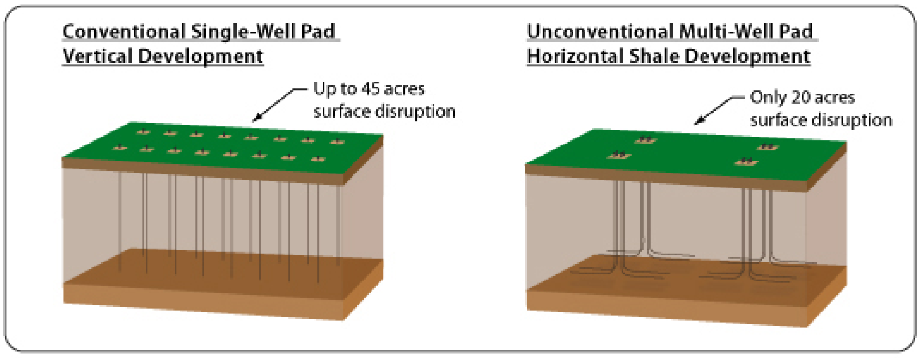
geology and structures of an area poses real and significant challenges". Adding to this uncertainty is the USGS report of April 2012 following the increase of tremors as from 2009: "…a naturally-occurring rate change of this magnitude is unprecedented outside volcanic settings…While the seismic rate changes described here are almost certainly manmade, it remains to be determined how they are related to either changes in extracting methodologies of the rate of oil and gas production". Similar conclusions were reached by the West Virginia Department of Environmental Protection (WNDEP) following the activity registered close to the Chesapeake Energy operations.

These uncertainties do not favor the shale gas industry. Even though other anthropogenic processes (mining, constructions of dams and other large structures, geothermal wells, etc.) have proved to trigger seismic activity, shale gas still carries the "new kid on the block" stigma, so the continuing involvement of third parties highly qualified in this specific field remains as a key strategy to raise the comfort level of the public opinion. Here follow a few examples:

- Cuadrilla worked with Keele University and the British Geological Survey (BGS) to set optimally placed seismometers to monitor ground movements around the active well sites as well as the surrounding area.
- In British Columbia the industry, government and regulators founded the Induced Seismic Network Consortium, and who recently signed a 2-year for seismologist studies related to shale gas
- In the meantime the Canadian Association of Petroleum Producers (CAPP) are taking part is assessing anomalous seismic activity
- With information provided by the operators in seven different locations where tremors were registered following fracking activity, the USGS has developed a model for calculating the magnitude of hydraulic fracturing, having uncovered a link between it and the volume of injected fluid

Some progress has been in done in regulation; while on the technical front scientists seem to agree that the problem could be narrowed down to the flow-back discharge, rather than the actual fracturing. In the words of Brian Baptie, head of Seismology at the BGS: "Weak rocks like shale break easily so they do not allow enough tension to build to generate big tremors[15]". But concerns still remain on the pace at which conclusive information is being gathered. While referring to the coal seam gas activity in that country, the Center for Coastal Biogeochemistry Research of the Southern Cross University in Australia posed the question if the industry was moving fast as a hare while public policy and science was doing so at the pace of a tortoise[16]. The shale gas industry's stakeholders across the board should ensure that it is not facing a similar race.

On drilling, a positive move to reducing surface footprint has been the development of pad (or multiple) drilling, which together with horizontal drilling have been technology breakthroughs that have been determinant for the shale gas industry. Essentially, pad drilling is the practice of drilling multiple entry points into wells from a single surface location. Prior to the discovery of pad drilling, an operator would drill a single well, disassemble the drilling rig, move it to a new location, and then repeat the process. Pad drilling allows up to twenty or more wells to be drilled from a single drilling location.



[15] http://www.cuadrillaresources.com/protecting-our-environment/seismicity/
[16] http://scu.edu.au/coastal-biogeochemistry/index.php/69

This innovative technique reduces drilling cycle time and the overall cost of operating wells (with reductions which can vary from 15% to 30%), while leaving a smaller footprint on the surface of the well. Also, fewer access roads need to be constructed and fewer trucks to carry the materials, further reducing the environmental impact and community disruption.

Fully-assembled rig moving between pads

Pad drilling originates from offshore production but started gaining momentum onshore as from 2004. In 2014 it accounted for nearly 60% of the unconventional gas developments in the USA and Canada, and has long been used in Russia.

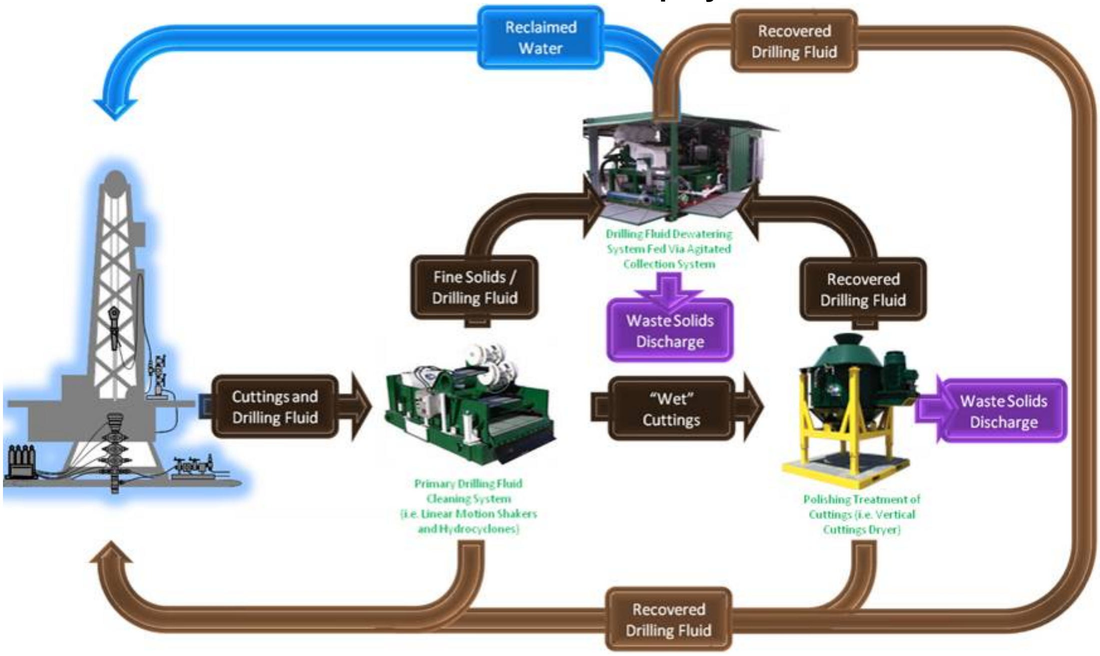
With drilling come the solid waste and sludge residuals, which impact both at surface footprint (containment) and logistics (trucking) to move it to licensed disposal facilities.

Open containment pits – once commonplace in conventional oil and gas rigs – were particularly resisted in shale gas developments due to the higher drilling activity. The main concerns included faulty or ripped lining, overflow, and air contamination due to fumes and vapors.

Closed containment systems (tanks) have provided a first containment solution, which has proved to be adequate and sufficient for some production sites.

However, the developments of "closed loop" systems, like the ones being used by Anadarko[17] and ExxonMobil at the Marcellus region have provided an alternative which has proved to be beneficial for both producers and public.

Closed Loop System



The main advantages are:

- Eliminates unsightly and hazardous pits
- Reduces the surface disturbance

[17] http://www.anadarko.com/Responsibility/Sustainable-Development/HSE/Water-Management/

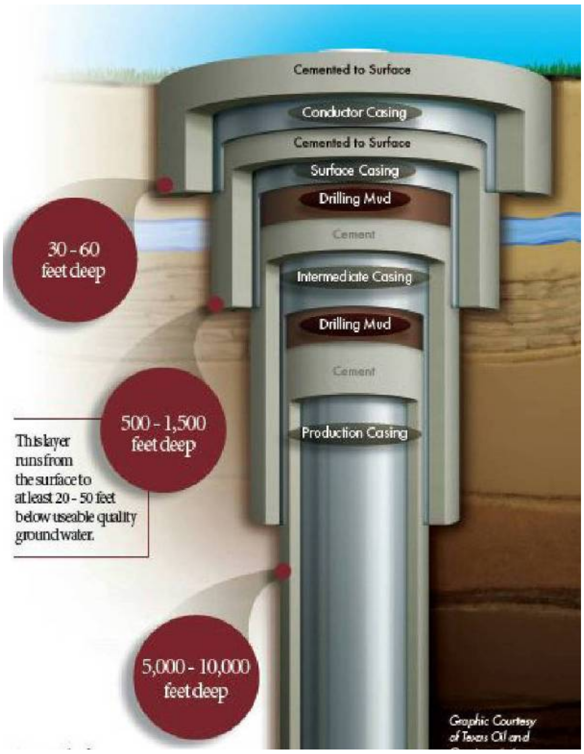
- Avoids possible interference with pipelines, etc
- Eliminates contamination to wildlife
- Virtually eliminates drilling waste
- Reduces water usage (potentially as much as 80%)
- Reduces truck traffic associated with transporting drilling wastes by as much as 75%
- Non contaminated drill cuttings may be put to beneficial use

Another interesting development has been the introduction of high-performance water-based fluid formulations to replace conventional oil based mud alternatives (OBM) which allow engineers to provide comparable or even better performance than OBM, while mitigating the need for drill cutting disposal.

Drill cuttings produced with conventional OBM must be disposed of via off-site land farming methods, as owners of the properties on which drilling has taken place typically forbid operators from burying the drilling waste on their land. This process results in land farming costs of $5-$10 per barrel plus associated transportation and bioremediation expense. With high-performance water-based fluids, disposal options are far more flexible, whereby landowners are often willing to allow the operator to simply deposit the drilling cuttings at the well site.

This chapter cannot conclude without a few short lines on well construction, a highly sensitive issue for 3 basic reasons:

1. *Extensive*: shale gas requires much more wells than conventional extraction
2. *Intensive*: the liquid injected into shale gas wells for hydraulic fracturing contain additives which are of particular concern to environmentalists and public opinion, due to the risk of contamination into underground water reserves in case of leakage or rupturing
3. *Perception*: the wells are the only part of a rig which cannot be seen, which adds to the public uncertainty and forces it to extend the benefit of the doubt



Well construction problems are reasonably rare (1%-5% according to the SPE[10]), but this could well be above the tolerable limit for a shale gas rig's neighbor.

The IEHN[9] has this item under one of the top Core Management Goals (Goal #3) and the IEA[1] includes this item in their Golden Rule #4: "Put in place robust rules on well design, construction, cementing and integrity testing as part of the general performance standard that gas bearing formations must be completely isolated from other strata penetrated by the well, in particular freshwater aquifers… Multiple measures need to be in place to prevent leaks, with an over-reaching performance standard".

Extending on the technical issues behind well construction exceeds the purpose of this chapter, particularly considering that on this topic there is no one-size-fits-all, as explained by the SPE[10] (which is why the SPE specifically excludes this topic from their risk analysis[4], considering well construction a separate risk entity). However cementing does seem to be one of the more critical issues, where cementing practices are a technology in itself, with vast data and research extending back to 1930. "The importance of cement seals cannot be over-estimated. Cement is a strong, durable, very long-lasting barrier as long as it is mixed and placed properly", as stated by the SPE[10].

Measuring and monitoring is a key instrument to “making visible the invisible”, positively impacting the public’s perception and appeasing the concerns mentioned. These would include pressure tests (in 2012 Pioneer installed pressure gauges for monitoring and testing space between inner and outer well casing in 100% of their wells, throughout the well completion process), advanced acoustic methods (like those described by El Paso Corporation in their sustainability report[18]), and routinely run cement to surface to assure isolation are some of the actions proposed by the IEHN[9], in their proposal to “…surpassing applicable regulatory standards…”, which together with IEA’s terms[1] of “robust rules on well design” and “over-reaching performance” should be the central concepts when engaging a community on this stage of shale gas development.

Water usage and care: being crystal clear

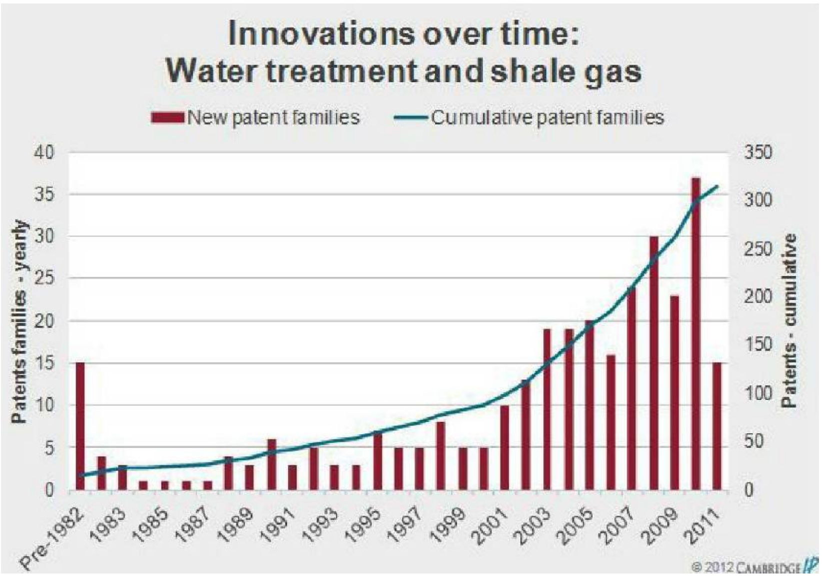
Water demand of Shale gas wells could range right up to 30,000 m^3, and the expected flow-back between 20%-50% of this volume depending on the geology, so it is not only the challenge of the demand of a sensitive resource, but also that of the final disposal of its return.

This section will address this topic, including the contamination risks posed by the use of additives in the “fracking water”. As stated by the IEA[1]: “Sound management of water resources is at the heart of the Golden Rules”.

The gas industry has used valid arguments defending its water management, including:

- Shale gas will typically use 1% of the available water resources, leaving more than enough for human consumption and agricultural uses (5%), and over 90% available for other destinations.
- Shale gas water utilization is one of the most water-efficient energy sources, only surpassed by conventional gas (coal uses 10 times this amount, while renewables could use up to 1,000 times)
- “Fracking fluid” contains nearly 95% water, around 5% sand and less than 0.5% of additives
- Additives are chemical components commonly found in households, medical disinfectants and even in the food industry

However these arguments have started to run short and the industry has had to speed up on projects that address this topic.



This could explain why there has been the over 600 patents in 2011 related to shale gas and wastewater, produced water, recycled water, and fracturing fluid, where more than 300 patents were filed in 2011 alone, according to Cambridge IP[19].

Top of the list on these developments are the ones relative to reusing/recycling, a term which in itself will condition favorably a community engagement process.

Indeed recycling (either for reusing into the fracking process

[18] www.elpaso.com/csr/2010CSR_FULL.pdf
[19] www.cambridgeip.com/custom_includes/PR_CambridgeIP_NEFFrackingTechnology.pdf

or to dispatch for agricultural use or even human consumption) simultaneously attacks both the usage as well as the disposal problems, impacting favorably on other conflicting activities like trucking.

This comes in a time when powerful environmentalist voices like that of the National Resources Defense Council (NRDC) are putting pressure against disposal methods which have been common in the past (like containment in both open and closed receptacles), declaring that only recycling and deep well injection are currently the only ones acceptable[20] (the second one now under pressure given the possible correlation is some geologies between this alternative and seismic occurrences).

In Eagle Ford play in west Texas the water usage per well was reduced from 18.5 to 13.6 thousand of m^3, primarily through increased recycling.

Other examples of this trend include:

- Royal Dutch Shell: at Groundbirch, Canada[21] under an agreement with the City of Dawson Creek they have supported the construction of a water recycling plant for the city which will treat sewage and other waste water to then be piped for reuse by Shell, avoiding the need to draw on fresh water and, without the need to ship water in, cuts truck journeys by 3,000 km a year. The local government also uses some of the water to, for example, clean roads and water sports fields, as well as selling some to other industries.
- A similar agreement was reached between Encana and the authorities of the Town of Rimbey[22] for the use of municipal wastewater effluent, with priority access to up to 180,000 m^3/year. Encana has also expanded its recycling facilities at the Piceance Basin which allows them to reuse 90% of produced water during nearly all stages of gas exploration (drilling, completion, and production).
- Noble Energy[23]: As part of an 18-month research program in the DJ Basin, the company worked with contractors and water treatment providers to develop new fracturing fluids and treatment processes, aimed at expanding the use of recycled flowback water in the hydraulic fracturing process. The result was a proprietary technology that treats water for gels, metals, bacteria and other impurities, returning it to a condition suitable for continued use in hydraulic fracturing operations.

While new technologies continue to expand, the potential for disposal cost reduction increases, as reported by the SPE[24], following the recent electrocoagulation technology applications conducted by Halliburton and XTO Energy in Eddy County, New Mexico. Electrocoagulation is the use of e to prompt organic material to coagulate, facilitating its filtration. A seven-well recycling program substituted over 8 million gallons of produced water for fresh water, saving between $70,000-$100,000 per well in water management costs, according to the report.

A market research contracted by Origin Oil (the developers of electrocoagulation) predicts that in the USA the frac water clean-up market will grow nine-fold, to $9 billion, in 2020.

Goal #6 of the IEHN's proposal[9] recommends also the use of other non-potable water sources like saline aquifers. Such is the case of Encana's operations in BC, Canada, who supplements the use of surface water with saline water from aquifers at approximately 1,000 m below ground. The centralized facility created for this purpose is expected to meet 50% to 75% of their water needs in the area[22].

For severe water-stressed areas developments are being done with the goal of replacing water altogether. In foamed fluids, where water is foamed with nitrogen or CO_2 with the help of surfactants, 90% of the fluid can be gas which has very good proppant-carrying properties.

[20] www.nrdc.org
[21] http://www.shell.ca/en/aboutshell/our-business-tpkg/upstream/e-and-p-canada/groundbirch.html
[22] http://www.encana.com/sustainability/corporate/reports/
[23] http://www.nobleenergyinc.com/2012sr/hydraulic-fracturing.html
[24] http://www.ftwatersolutions.com/pdfs/ProducedWaterPaper.pdf

Hydrocarbon-based fracturing fluids such as propane or gelled Hydrocarbons could replace 100% but for now their flammability makes them more difficult to handle safely at the well.

We will close this section with a short reference to the "disclosure issue" behind the chemicals used in the fracturing fluid, which the IEA includes in their first Golden Rule: *Measure, Disclose and Engage*[1]. In Chapter 3 we mentioned a case where litigation on this issue gave way to a solution for all stakeholders involved, and how the increasing concerns of the investors (and external organizations like the SEC) have been forcing the industry to open up to the public's concerns. This theme has possibly been one of the more conflicting issues as from the early development stages with the so-called "Halliburton loophole", named after the company that patented an early version of hydraulic fracturing. Passed during the Bush-Cheney administration, the loophole exempted the oil and gas companies from the requirements of the Safe Drinking Water Act.

This situation has changed dramatically but the industry has still some serious image-improving work ahead, and transparency seems to be the foremost term being used in this regard. The development of alternative materials with low-impact and biodegradable chemicals is providing some help in that direction.

For better or for worse, the gas industry forcibly does not stand alone on the major topic involving water, as this critical resource if practically always governed by municipal, state or national regulating bodies (quite often all three at the same time). Indeed, when a different political agenda or other considerations do not block the engagement process prior to a shale gas development, these bodies provide both a technical capability which could be conducive to finding a scientific common ground, while at the same time offering a direct interface with the local communities. It is up to the operator to find the way to optimize the workings of this relationship.

Emissions: aiming for a good atmosphere

Shale gas faces two emission-related challenges:

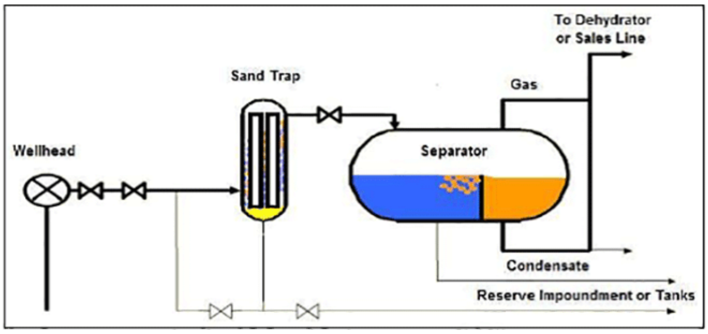
1. Methane emissions from well completion and production
2. Emissions from equipment (trucks, compressors, etc.), which include CO_2 and VOCs, among others

The case of methane emissions from shale gas is more complex than that of conventional due to the number of wells needed (always a recurring issue), and to the well completion process where the flow-back contains a certain percentage of hydrocarbons.

To this we should add the "conventional" emissions related to fugitive emissions, ruptures or intentional venting due to safety or maintenance operations.

The IEHN[9] recommends the following steps in their Goal #8 (Minimize and Disclose Air Emissions):

1. Monitor, measure and report publicly on air emissions, volatile organic compounds, BETX and other toxic chemicals from natural gas operations in shales. Same regarding results from specific emission reduction measures.
2. Reduce emissions from well sites by using natural gas or alternative methods in lieu of diesel fuel for powering site operations
3. Reduce transportation emissions by substituting pipelines for truck transport, transporting chemicals in dry rather than liquid form, and converting vehicle fleets to natural gas
4. Reduce emissions from well sites by using "green completion" practices
5. Establish ambient air quality monitoring network, funded by the company or collaboratively with local communities and regulators, to provide routine data on ambient conditions, including tracking of specific chemicals of concern (such as hydrogen sulfide and BETX).

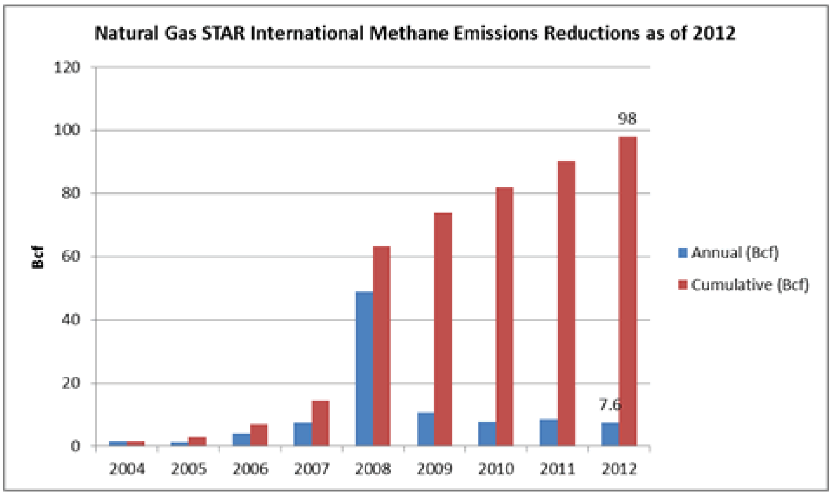


Green completion is an alternate practice that captures the produced gas during well completions and well work-over following hydraulic fracturing, separating the gas from the liquids and solids in the flowback stream.

Green completion systems present a significant opportunity for cost savings.

By using portable equipment (right) to process gas and condensate, the recovered gas can be directed to a pipeline and sold. These truck or trailer mounted systems can typically recover more than half of the total gas produced and industry results have shown that investment in portable three phase separators, sand traps and tanks can be recovered in 2 years or less.

Natural Gas STAR Program[25], sponsored by the EPA is a "…flexible, voluntary partnership that encourages oil and natural gas companies – both domestically and abroad – to adopt cost-effective technologies and practices that improve operational efficiency and reduce emissions of methane, a potent greenhouse gas and clean energy source".



The program provides technical documents on over "80 cost-effective technologies and practices," free technology transfer workshops, and technical guidance. After a successful domestic STAR program, the international Natural Gas STAR program has worked to reduce emissions across the globe. Companies in Argentina, Brazil, Canada, Chile, Colombia, Equatorial Guinea, India, Indonesia, Nigeria, Oman, Poland and Qatar have reported reducing emissions through implementing more than ten different technologies and practices.

The Reduced Emissions Completions (RECs) performance standards set by the Center for Sustainable Shale Development (CSSD)[26] require all pipeline-quality gas resulting from well completion of development wells, re-completion, or work-over of a well must be fed into a pipeline for sales. Furthermore:

- Gas not captured cannot be vented, and must be flared.
- Gas may be sent to flare if it is a low-flammability gas, or for safety reasons.
- Raised flares or an engineered combustion device containing continuous ignition are the only acceptable flaring methods, and must have a minimum of a 98% destruction efficiency of methane.
- Gas may not be sent to flare because of lack of pipeline connection, inadequate water disposal capacity, or inadequate flow back equipment.

[25] http://www.epa.gov/gasstar/
[26] https://www.sustainableshale.org/about/

In Canada, Encana has utilized funding from the Environmental Innovation Fund and Climate Change and Emissions Management Corporation (CCEMC) to start a two-year program for the installation of vent gas capture at 52 natural gas compressors in Southern Alberta. Each installation will capture gas that previously vented to the atmosphere. The new systems will take gas produced during normal operations and redirect it into the compressors' engine air intake as fuel. When completed, the project is forecasted to reduce greenhouse gas emissions by over 67,000 tons of CDE annually, with the simultaneous recovery of 180 million scf of sales gas per year. Since November 2012, Encana has utilized a portable flare unit in northern Louisiana. This voluntary device allows for the reduction of emissions produced from the removal of fluids through the wellbore and forecasts a reduction of 2,592 tons of CDE annually due to this implementation[22].

The EPA has reported that methane emissions from petroleum and natural gas systems sector in the USA have decreased by 12 percent since 2011, with the largest reductions coming from hydraulically fractured natural gas wells, which have decreased by 73 percent during that period[27].

No man is an island: the need to engage, and involve

Global shale gas industry entered a "perfect storm" following the dramatic growth registered in the USA as from 2007.

Drilling and hydraulic technology break-throughs, combined with an energy-strived market that boosted prices to unprecedented levels, and a regulation that supported this development, even by means of "unfriendly" rulings like the so-called "Halliburton Loophole" we referred to before, gave way to an unbridled (and in some aspects uncontrolled) growth of the shale gas industry.

To worsen matters, most of the developments were conducted in regions without a tradition or history with the oil and gas industry, and where several of the early developments were conducted by small and mid-sized companies with limited or no communication skills at all.

Incidents related to water, air, soil, wildlife and community disruptions, gave way to claims from both private and public bodies, fortified by media (both biased and un-biased), some of which have induced productions pauses or stoppages, and development moratoriums across the world.

While some vessels keep struggling in these stormy conditions, they recognize that a renewed sailing strategy must urgently be put in place.

Public acceptance has taken center stage, with terms like openness, transparency, responsibility and commitment, composing the heart of the plot.

As the late CEO of Total, Mr. Christophe de Margerie said: "Our business is not sustainable if we are not responsible operators, accepted by all stakeholders, including civil society"[28]. ExxonMobil, a traditionally more conservative company in terms of communications, shared the same views as expressed by Rex Tillerson, its CEO who remarked on "…the importance of open communications with government leaders at all levels as well as local communities"[28].

A comprehensive engagement strategy must adequately address the *when*, *who* and *how* to communicate with all concerning stakeholders. As Mr. Hansch van der Velden, communication director of NV Nederlandse Gasunie recommended: "…we need to get smarter about what we say, how we say it, and whom we engage. A shale gas project needs a communications plan, just as it needs a drilling plan"[29].

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[27] http://yosemite.epa.gov/opa/admpress.nsf/bd4379a92ceceeac8525735900400c27/58d0225b6c4023ea85257d63005ca960!OpenDocument

[28] http://www.energybiz.com/article/13/08/reconciling-social-unrest-and-energy-demands

[29] 1. van der Velden, H., & Schildmeijer, D. (2012, December). Golden age of natural gas? Not in my backyard! *Natural Gas & Electricity*, 29(5), 14–17.

The CEO of the Canadian Gas Association, Mr. Tim Egan, has stressed the need of early engagement: “If you look at the acceptance levels of communities around the nuclear sites in Canada, these are very high. The gas industry has not been as astute to engage early on”.[29]

Indeed, the first communication actions have been typically more *reactive* to riling reports, documentaries and claims from media, NGOs and community representatives. Should a timely and effective communication plan been in place at an early stage, there might have never been the need to issue *Truthland* in reply to the inflammatory documentary of *Gasland*.

The first *Golden Rule* of the IEA[1] (“Measure, disclose and engage”) refers exactly to this: “…starting prior to exploration; provide sufficient opportunity to comment on plans, operations and performance, listen to concerns and respond appropriately and promptly”.

To secure this, one of the IEHN’s recommendations[9] is for the company to have a clear and explicit policy to seeking “Free, Prior, and Informed Consent (FPIC)” of host communities, with advance written agreements with local government officials and community organizations outlining the company’s practices related to specific community concerns. “Such agreements may include operating practices *above and beyond requirements of state regulations*…” it suggests.

An example is the case of Talisman Energy of Canada in their “Global Community Relations Policy”, where it states: “Incorporating FPIC principles means we will work with communities at the earliest stages of development…engaging in a timely and honest way…to build trust and understanding through an open exchange of information…”[30].

Shell’s position is akin to the above, as Mr. Herbert Heinmann, the executive vice president explains regarding its own operating principles: “Shale gas happens in the backyard. Therefore we need people on the ground who speak the local language, who understand the communities, and who are connected[29]”

Not only must the information be understandable, as Mr. Van der Velden says: “There is more to convincing communications than presenting numbers and charts, which the industry does a lot of…facts are important to underline the story but they can never *be* the story”[29]. It also must be concrete and meaningful, answering the concrete and unavoidable question: “what is in it for me?”. The developer will rightly want to focus on the big picture, but we should keep in mind that the regular neighbor is going to be more interested in his own personal snapshot.

In this respect the IEA[1] is clear: “…it is essential that tangible benefits are evident at the local level, where production occurs. This can be difficult to achieve in a timely manner, given the delay between the start of the development project and the moment at which revenues start to flow…Early public commitment by authorities and developers to expand local infrastructure and services in step with exploration and production activities can help”.

Concrete actions can address urgent and tangible needs like water, to the more subtle but perhaps as equally sensitive ones of cultural heritage, for example. Such would be the case of Apache, who agreed to move a gas facility 25 miles in Australia, to accommodate aboriginal desires to safeguard ancient rock art.

Engagement should also explicitly address “grievance mechanisms”, and the involvement of independent third-party in the resolution of conflicts. In South Africa, Shell has published several pages of commitments to the Karoo community regarding fracturing operations there. These include, for example, setting up an independent advisory committee “to ensure we reduce and mitigate impacts as far as possible”; “provide full compensation to any landowner with evidenced

[30]http://www.talismanenergy.com/responsibility/policies_management_systems/policy_on_business_conduct_and_ethics.html

direct negative impact or loss on their land as a result of [Shell] activities; "not compete with the people of the Karoo for their water needs"; "commit to establishing mutually acceptable protocols for …independent monitoring of …water quality in existing water wells and surface water"; "conserve and recycle water where ever possible" "not use BTEX in any hydraulic fracturing operations…"[31].

Win-win situations have derived from engagement actions, like in the cases of Royal Dutch Shell at Groundbirch, Canada, and the water recycling plant built at the City of Dawson Creek; and that of Encana and the authorities of the Town of Rimbey for the use of municipal wastewater effluent, both explained in section 4.2.

Engagement occurs predominantly during the early stages of the project, however it should remain an ongoing process given the measuring, monitoring and disclosure activities – particularly in regards to water usage and the safeguard of local surface and underground aquifers – during the well life-cycle. Depending on the local rulings, engaging with authorities and regulators could also be ongoing, to support the possible need for "gap filling", or any other proposal that will ensure a level playing-field for all stakeholders involved. Stakeholder engagement requires a maintenance plan, just like the drilling equipment does.

Extending the circle, engagement should also include academia and specific sciences, in areas which exceed the operator's competence, like the seismology studies we referred to in section 4.1. Another recent example has been the resolution taken in February 2015 by a multidisciplinary panel in Michigan, with regards to the importing of allegedly radioactive fracking waste from other states, to a landfill in Van Buren Township. The panel, appointed by Michigan governor Rick Snyder, was composed of a group of regulators, academics, environmentalists and representatives from medical and landfill services, besides those of the oil and gas industry. The panel determined that the referred waste did not pose a risk, and could even handle higher natural radiation levels.

Engagement is challenging for the shale gas industry and positive outcomes require commitment and resilience. As Roger Martin, vice president of corporate affairs at Woodside Energy explained: "There will be opposition. We're not going to win everyone over in any community. But we can't get too discouraged about the fact that people don't like us"[29].

Conclusions

Popular wisdom says that the best way to accommodate watermelons in a truck is throwing them in, and start rolling. This could partly describe – in a very broad way – what has happened in the dramatic growth of shale gas since 2007. Adjustments to the way the industry is driving have clearly been done, but it's an ongoing process.

As stated by the IEA[1]: "What is reasonable will evolve over time, as technology and industrial best practices evolve".

If the hare vs. tortoise reference mentioned in section 4.1 is indeed applicable to the shale gas industry, getting the stakeholders on the same page will of course be a hard and continuing process, particularly as the hare is often running in the neighbor's backyard.

The first stage of this process is making sure we are sharing the "big picture". In words of the IEA[1]: "Society needs to be adequately convinced that the environmental issues described earlier will be well enough managed to warrant consent to unconventional gas production, in the interests of the broader economic, social and environmental benefits…".

Coupled to this is the need to lower the *precautionary principle* bar. Throughout the paper we have mentioned a number of uncertainties related to shale gas. These uncertainties play strongly against

[31] http://www.shell.com/home/content/zaf/aboutshell/shell_businesses/e_and_p/karoo/commitments.html

the industry, and during the last decade these have been addressed, with diverse degrees of success. The industry must continue striving in these efforts – using both internal and external competences – to provide as much conclusive data as possible to appease the key concerns of the public opinion. In a same way, it must support the development of appropriate regulatory framework, as the lack of rules dampens the intent to play, particularly in the shale gas game.

Driven by both external pressures and the internal need for cost-savings, the industry has made significant developments to make the shale gas activity more acceptable. Geologic scanning, Green Completion, Pad Drilling, Close Loops are some of the examples we have mentioned throughout the paper.

But coupled to these, operational excellence is the key principle gas leaders seem to agree is paramount for hydraulic fracturing, given the "new kid on the block" stigma. In the words of Shell: "We believe onshore exploration and production can and must occur in an environmentally responsible manner. Anything else is unacceptable". Indeed, there is no communication remedy for bad operations. This is especially true on well construction (a separate risk entity, according to the SPE[10]) and surface operations, where vast amount of studies seem to conclude is where the risks are posed, rather than the fracturing process itself. The terms "robust rules" and "over-reaching performance" are insistently used by the SPE[10], in the Golden Rules of the IEA[1], and in the 12 Corporate Management Goals listed by the IEHN[9].

But for this "new kid" to be known introductions are mandatory, transparency has to be the norm, promises need to be made and delivered, and the best behavior observed (and informed). For that a comprehensive engagement plan (which is way above than a simple PR plan) needs to be drawn, which has to be timely, coherent and consistent. Further, for a project to be sustainable engagement needs to be ongoing, evolving into involvement, as we have seen in some of the examples of the previous section.

Then he will have a chance to be part of the neighborhood, for good.

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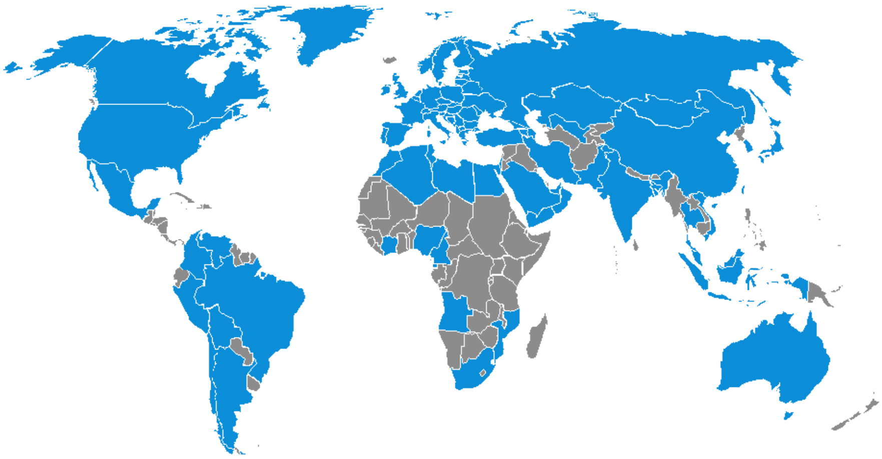

The International Gas Union (IGU) was founded in 1931 and is a worldwide non-profit organisation promoting the political, technical and economic progress of the gas industry with the mission to advocate for gas as an integral part of a sustainable global energy system. The IGU has more than 142 members worldwide and represents more than 97% of the world's gas market. The members are national associations and corporations of the gas industry. The working organisation of IGU covers the complete value chain of the gas industry from upstream to downstream. For more information please visit **www.igu.org**

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