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IMPACT ASSESSMENT

Accompanying the document

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU

{COM(2014) 23 final}
{SWD(2014) 22 final}

Content

Executive Summary Sheet
Impact Assessment on an Environment, Climate and Energy Assessment Framework to Enable Safe and Secure Unconventional Hydrocarbon Extraction
A. Need for action
Why? What is the problem being addressed?
Shale gas appears to be the unconventional hydrocarbon with the greatest potential for development in Europe, with exploration activities underway. A number of environmental impacts and risks are related to shale gas development resulting from the techniques used of High Volume Hydraulic Fracturing combined with directional drilling through rock formations, for which there is very limited experience in Europe. Existing EU legislation is not fully equipped to tackle the resulting environmental impacts and risks (e.g. surface and ground water contamination, air emissions including greenhouse gas emission). However, legal certainty and predictability over the regulatory environment is essential to enable investment in this domain and also in reassuring the public that the impacts and risks of such activities are prevented, mitigated or properly managed. These problems are expected to remain without action. The most affected stakeholders are both businesses wishing to invest in shale gas exploration and production and EU citizens.
What is this initiative expected to achieve?
The general objective is to ensure that unconventional fossil fuels developments, in particular shale gas, are carried out with proper climate and environmental safeguards in place and under maximum legal clarity and predictability for competent authorities, citizens and operators. The first specific objective is to ensure that environmental impacts and risks arising from the techniques used for exploration and production activities, both as regards individual projects and cumulative developments, are adequately identified and managed. The second specific objective is to clarify the EU legal framework so that investments in shale gas developments across the EU can take place within a predictable setting.
What is the value added of action at the EU level?
Geological estimates show that several shale gas plays spread across borders of Member States. Moreover, environmental impacts and risks do not respect national borders. This is in particular true for surface and ground water, as well as for air quality and GHG emissions: impacts in one country can give rise to, or worsen, pollution problems in other countries. Therefore action at EU level is justified; in addition, the European Parliament, the Committee of the Regions and a majority of respondents to the public consultation as well as several Member States have asked for action at EU level.
B. Solutions
What legislative and non-legislative policy options have been considered? Is there a preferred choice or not? Why?
Apart from the baseline, 4 options have been analysed in detail: Option A provides a recommendation to Member States on ways to address environmental aspects of shale gas exploration and production. It also provides for guidance on the interpretation and implementation of existing legislation in the frame of such activities. Moreover it encourages voluntary commitments of the sector. Option B proposes amendments of parts of the EU environmental acquis to provide clarification as to the applicable rules for the sector (combined with elements of option A). Option C is a framework directive proposing a set of overarching goals, including the disclosure of chemicals used and dealing with cumulative impacts, while amending the same acquis as in option B; option D is a directive setting specific requirements covering all issues identified. Options A, B, C and D are increasingly effective in addressing the identified impacts and risks, while the legislative options B, C and D are so in providing clearer and more predictable regulatory framework for investors and reassuring the public. No single preferred option is put forward as trade-offs exist between different impacts, the aim of the IA being to provide evidence for political decision.
Who supports which option?
The majority of EU citizens is in favour of harmonised and consistent approaches at EU level (Eurobarometer).

Views of individual respondents to the public consultation are split when responses are considered un-weighted, while a strong majority is in favour of a comprehensive framework at EU level when responses are weighted to reflect country population (as 5 countries made up more than 90 % of the individual responses). Environmental NGOs favour a regulatory approach strengthening the environmental safeguards. The oil and gas industry tends to prefer soft measures although it could foresee amendments to the existing EU legislation. Certain non-oil and gas operators and service companies have expressed interest in a comprehensive and specific EU legislation. Based on informal indications, one Member State would prefer to rely only on national provisions, while a number of Member States see a need for EU action, ranging from guidance to amendments to the existing EU legislation up to a stand-alone regulatory approach. The European Parliament called for "harmonised provisions for the protection of human health and the environment" and stressed, inter alia, the need for the "highest safety and environmental standards". The Committee of the Regions called for a "clear and legally binding regulatory framework of the EU, preferably in the form of a directive".

C. Impacts of the preferred option

What are the benefits of the preferred option (if any, otherwise main ones)?

The "do nothing" option is not effective, as existing problems would remain, while options A to D display an increasing level of effectiveness in tackling environmental risks and impacts of shale gas operations, with an increasing level of coverage and detail, providing enhanced legal clarity and addressing public concerns; this represents the main benefit of this initiative. Health impacts addressed by this initiative are direct impacts in terms of air emissions and indirect impacts in terms of potential water pollution by chemicals, some being recognised as hazardous to human health.

The clarification of the legal requirements for shale gas operations would provide a more secure environment for investment and would enable shale gas developments. Therefore -however with significant uncertainty-, the regulatory options (B,C,D) could lead to a limited gas price decrease or avoided increase, hence benefiting the EU economy. It is however expected that shale gas development in EU would at best replace declining conventional gas capacities and allow maintaining constant the EU's gas import dependency while potentially improving the EU's negotiation position towards external energy suppliers.

What are the costs of the preferred option (if any, otherwise main ones)?

For shale gas operators annualised compliance costs for policy options B to D amount to 1.4 to 1.6% of expected annual revenues, adding at most about 8% to the absolute costs of operations (in line with IEA calculations). Costs of option A for operators will be lower and depend whether the voluntary measures will be implemented or not.

How will businesses, SMEs and micro-enterprises be affected?

Due to the level of investment needed to conduct shale gas exploration and exploitation, shale gas operators are generally large companies. SMEs and micro-enterprises are therefore only expected to be affected indirectly (positively or negatively), through related activities (equipment, catering, transport e.g.) and should shale gas operations in the EU lead to impact on the energy prices to be paid by SMEs and micro-enterprises. However, given the uncertainty on the level of shale gas resource estimates in Europe and the many variables at stake in gas price setting, effects of the latter are very uncertain.

Will there be significant impacts on national budgets and administrations?

Options B to D represent different levels of changes to the existing environmental acquis (while option A entails no change to it). The administrations in Member States would be expected to adapt to that, in some cases with a need for capacity building. However, some elements of changes, for instance the provision of an integrated framework or requirements suggested under option C and D, could lead to lower their administrative costs.

Will there be other significant impacts?

There might be impacts on competitiveness, especially for energy-intensive industries or sectors using gas as a feedstock, should the option chosen lead to a significant shale gas production in the EU. In the latter case, this could influence EU gas prices and potentially partially reduce the gas price gap with the US. The impact on gas prices is however uncertain and EU gas prices are expected to remain twice as high as in the US by 2035 in a best case scenario. Economic impact in the Member States / regions where shale gas would develop would be positive, in terms of short term direct and indirect employment and tax collection. However, this will depend on several factors, in particular on the amount of economically recoverable shale gas available, on their current energy mix and import dependency, on the stage of development of the gas infrastructure, on the level of energy efficiency of the economy or on the administrative situation.

D. Follow up
When will the policy be reviewed?
Within an appropriate timeframe of adoption of the preferred option, the Commission would report on its implementation and on the effectiveness of the initiative. The length of the appropriate timeframe for reporting will vary depending on the preferred option, with a longer timeline needed in case of legislative options (to leave time for transposition) and a shorter for non-legislative ones. Data collection for a number of indicators is suggested to ensure monitoring of the implementation of the initiative.

1. PROCEDURAL ISSUES AND CONSULTATION OF INTERESTED PARTIES

1.1. Organisation and timing

This impact assessment is associated to the Commission 2013 and 2014 Work Programmes item 'Environment, Climate and Energy Assessment Framework to Enable Safe and Secure Unconventional Hydrocarbon Extraction'.

The work for this impact assessment started in 2012, with several studies outsourced, the establishment of a Commission Impact Assessment Group and of a Technical Working Group of Member States registered in the Commission registry of experts groups. The Commission Impact Assessment Group met 6 times, respectively in October 2012, March, June, July (twice) and September 2013. The following services were invited: DG CLIMA; ENER; TRADE; MARE; MARKT; SANCO; JRC-ISPRA; JRC-PETTEN; TAXUD; BEPA; EEAS; REGIO; EMPL; SG; ENTR; RTD, AGRI, ECFIN.

1.2. Consultation and expertise

A public internet consultation ran from 20 December 2012 to 23 March 2013, meeting the Commission standards for consultation. It collected views on the main perceived benefits and risks of unconventional fossil fuels (e.g shale gas) development in Europe and tackled issues related to the problem definition, objectives and options to address the identified risks, taking into account the existing legal framework. Among the nearly 23 000 answers received[1], individual respondents' views were almost equally split between those who support unconventional fossil fuel (e.g shale gas) anyway, those who think that it should only happen provided proper environmental and health safeguards are in place and those who think it should not develop at all in the EU[2]. Organisations' views were split according to the type of organisations, with 30% of individual companies responding that unconventional fossil fuels (e.g shale gas) extraction should be developed anyway, while this share fell to 15% for industry and trade organisations and below 10% for regional and national authorities. Overall, views were mixed on the challenges and benefits from unconventional fossil fuel development. While opinions diverged on the preferred policy options for addressing the identified challenges and risks, the option "do nothing at EU level" was the least favoured by participants. Other main elements highlighted by a majority of respondents were a strong need for information, the lack of public acceptance and the lack of a clear legal framework applicable to unconventional fossil fuels (e.g. shale gas). In addition, a large majority found it important or very important to address issues such as strategic planning, underground risk assessment, well integrity, monitoring, waste management and disclosure of the use of chemicals, in order to minimise environmental, climate and health risks of unconventional fossil fuels (e.g shale gas)[3].

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1 22 875 answers received

2 Since five EU countries (Poland, France, Romania, Spain and Germany) made up more than 90% of the individual responses, a per country weighted analysis of the results was also performed, to get an idea of what would have been the results if participation in all Member States had been proportionate to their population: this analysis shows a share of individual respondents who think that unconventional fossil fuels (e.g shale gas) extraction should not develop at all in the EU rising to almost 2/3 and the share of individual respondents in favour of its development in any case dropping to about 11%. In this methodology, each country is assigned a weight according to its population, based on Eurostat 2012 data. This weight by country is equally divided between all the individual respondents that declared themselves as living in that country. Such weighting has the following consequences: Answers from more populated countries are given a higher weight; Answers from countries where participation was high are given a lower weight, so that in total the answers from a given country have a weight equal to the population of residence in that country. On the other hand, answers for countries where participation was lower are given a higher weight.

3 The report on the consultation results can be found at:

In addition to this public consultation, numerous meetings were held with various stakeholders including business organisations, the oil and gas industry and service companies, environmental non-governmental organisations and geological surveys (see annex 2). Several exchanges also took place with the US Environmental Protection Agency. A high-level seminar was organised on 28 May 2013 by the Bureau of European Policy Advisers (BEPA) on the competitiveness implications of shale gas development in the EU, which gathered high level representatives from the industry, academics, European Commissioners and senior Commission representatives[4]. A stakeholders meeting took place on 7th June 2013[5] with about 100 stakeholders present and a same number of persons followed the meeting on live webstream and provided direct feedback through an online chat. A session of Green week[6] on 6th June 2013, focusing on air emissions and overall climate and environmental aspects of unconventional fossil fuels (e.g shale gas) as well as presenting on-going work by the Commission, was attended by about 150 participants.

A Flash Euro-barometer survey conducted in September 2012[7] on the basis of interviews with over 25 000 European citizens in 27 EU Member States included three questions relevant to shale gas developments. The responses showed that about "three quarters of respondents would be concerned if a shale gas project were to be located in their neighbourhood" (with 40% being very concerned) and that "more than six out of ten [respondents] agreed that harmonised and consistent approaches to the management of unconventional fossil fuels extraction should be developed in the EU".

The Technical Working Group of Member States on unconventional fossil fuels exploration and extraction met 4 times: respectively in January 2012 (20 Member States represented), October 2012 (16 MSs), April 2013 (14 MSs) and June 2013 (14 MSs). A specific workshop on geological aspects of unconventional fossil fuels with the participation of 15 Member States, as well as industry and NGOs representatives was organised in December 2012.

In 2011, the Commission services released guidance [8] describing in general terms the existing EU environmental legal framework applicable to unconventional fossil fuels projects involving the use of horizontal drilling and high volume hydraulic fracturing such as shale gas. It concluded that the EU environmental acquis applies to such activities. Yet more information was needed to determine whether or not the level of health and environmental protection provided under the current EU legal framework is appropriate.

Several studies were commissioned by DG ENV and other Commission services (DG ENER, DG CLIMA, DG JRC) over the course of the work on this impact assessment and used to underpin the analysis presented here. Other reports produced by other organisations and Member States[9] were used as source of information for this Impact Assessment.

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http://ec.europa.eu/environment/integration/energy/uff_news_en.htm

4 http://ec.europa.eu/bepa/expertise/seminars/index_en.htm

5 http://ec.europa.eu/environment/integration/energy/uff_event_7june2013_en.htm

6 http://greenweek2013.eu

7 http://ec.europa.eu/public_opinion/flash/fl_360_en.pdf released in January 2013

8 See annex 8.5: DG ENV note endorsed by the Commission Legal Service. The note is available here: http://ec.europa.eu/environment/integration/energy/pdf/legal_assessment.pdf

9 e.g International Energy Agency, US Energy Information Administration; US Bureau of Land Management; US Environmental Protection Agency; Resources For the Future; Canada federal and regional information; Hydrofracking risk assessment Exxon-Mobil Informations und Dialogprozess; Risk study on Exploration and Exploitation of unconventional gas in North-Rine-Westphalia; Report on fracking and its environmental impacts conducted for the German Federal Environment Agency; Environmental Aspects of Hydraulic Fracturing Treatment Performed on the Łebień LE-2H Well (Poland); UK Royal society report on hydraulic fracturing (See annex 1 for full list)

1.3. Responses to the Opinion of the Impact Assessment Board

A previous version of this impact assessment was discussed at the IAB and followed by an IAB opinion on 6 September 2013, according to which the impact assessment has been revised.

In particular, as requested by the IAB:

- the scope of the impact assessment has been clarified, by modifying sections 2.5;
- the description of the problems associated to public acceptance has been enhanced (section 3.3);
- the consequences of the legal unclarity have been better explained, with a new section 3.2.3;
- the extent to which existing legislation already covers the problems has been better explained (section 3.2.4), as well as remaining gaps, with a new section 3.2.5;
- the baseline description has been reinforced, in particular through a new section 4.4 on the foreseen developments of the problems in case of no action;
- objectives and related indicators have been fine-tuned (sections 7 and 11);
- the description of the options has been clarified so as to better explain their content, show their differences and stages of application (section 8);
- the presentation of the methodology for analysing and comparing the impacts of the options has been clarified (sections 9.1, 9.2 and annex 20.1), with the economic aspects further examined (sections 2.3.4 and 9.2).
- More information is provided throughout the report about stakeholders' positions (and in particular in section 9.1).

Other points mentioned in the IAB opinion have also been addressed.

2. CONTEXT

2.1. General presentation of the energy and gas contexts in the EU

Natural gas is an essential element in the EU energy mix. Its share in EU primary energy consumption has increased from 20% in 1995 to 25% in 2010 and then declined to represent 23.4 % in 2011[10]. This share is projected to remain mostly stable until 2030 (ranging between 22 % in the reference scenario and 25 % in the most decarbonised scenario of the Energy Roadmap 2050[11]).

On the other hand, EU gas production has been steadily declining over the past decade (by over 30% between 2004 and 2011 in EU-27)[12], and this trend is foreseen to continue[13], with conventional natural gas domestic production declining in all Member States.

EU import dependency for natural gas was 67% in 2011 (as compared to 54 % for the overall EU27 energy dependence rate[14]). Since 2000, EU gas import dependency has increased by 37%[15], and this is projected to continue to rise in a business as usual scenario[16]. The security of the EU's gas supply depends on the one hand, on its capacity to enable the future exploitation of indigenous gas resources, both conventional and unconventional in an

10 Eurostat, see annex 3.1

11 COM(2011) 885 final : 2050 Energy Roadmap

12 From 203 Mtoe in 2004 to 140 Mtoe in 2011 (Source: Eurostat)- see annex 3.2

13 IEA Golden Rules report and 2050 Energy Roadmap

14 Defined by Eurostat as net imports divided by gross consumption

15 Eurostat 2013, see annex 3.3

16 + 28% from 2005 to 2050 in the 2050 Energy Roadmap reference scenario, http://ec.europa.eu/energy/energy2020/roadmap/doc/sec_2011_1565_part1.pdf p.81

environmentally safe manner[17], and on the other hand on the diversity of the sources of its imports and on their geostrategic stability. In 2010, three quarters of the EU-27's imports of natural gas came from Russia, Norway and Algeria. Although their import volumes remain relatively small, there was some evidence of new partner countries emerging between 2002 and 2010 (notably Libya and Qatar, with the latter's share rising from less than 1 % to 8.6 % between 2003 and 2010).

The EU is the second-largest gas market in the world[18], with gas markets being traditionally regional (US, Europe, Asia), due to the difficulty (and cost) to transport gas. Gas prices in continental Europe are predominantly set through long-term contracts, largely indexed to oil prices and therefore without immediate response to market conditions, while in the USA they are rather determined on a spot gas market. However, in recent years, a mixture of the two systems has emerged in the EU, with oil-indexed prices co-existing with prices set by gas-to-gas competition, enabling certain European customers in some cases to renegotiate contracts[19]. While this type of competition represented about 20% of the market in 2005, spot trading is now relevant for about half of the gas supplied in Europe[20].

Within the context of the EU commitment to decarbonize its energy sector, gas was identified by the Energy Roadmap 2050[21] as critical for the transitional transformation of the energy system. In addition to the development of energy efficiency and renewable energy sources, substitution of coal and oil with gas could help to reduce Greenhouse Gas (GHG) emissions in the short to medium term. This overall picture, however, covers a wide range of different realities according to Member States.

2.2. Unconventional fossil fuel developments in the United States

The term "unconventional" refers primarily to the characteristics of the geological reservoirs or rock formations containing the hydrocarbons, which differ from conventional reservoirs: these formations often stretch over very large areas, are characterised by low energy content per rock volume and by low or very low permeability[22]. The main types of unconventional fossil fuels are: tight gas, shale gas, coal bed methane, methane hydrates, tight oil, shale oil, oil shales and oil sands[23].

In the United States, the past decade has seen a very rapid development of unconventional sources of gas and oil. The US has become the country of reference as regards what has been coined the "shale gas revolution".

Unconventional gas currently accounts for 60% of US domestic gas production, with shale gas featuring the highest growth rates. The US Energy Information Administration predicts an increase of the share of unconventional gas in total US gas production to 74% by 2040[24],

17 Green Paper on "A 2030 framework for climate and energy policies" (COM(2013) 169 final)

18 IEA, Golden rules report, Sept. 2012

19 Contract renegotiation led, for instance, to "the average German import price fell from USD 11.6 per MBTU in 2008 to USD 8 in 2010" (source: Considering shale gas in Europe, M. Bazilian, A. Pedersen, E. Baranes, European Energy Journal, volume 3, issue 1, January 2013).

20 Quarterly Report on European Gas Markets, European Commission, Directorate-General for Energy, Volume 5, Issue 4: 4th quarter 2012., 2012; IEA, 2013a

21 COM(2011) 885 final

22 Low permeability of a geological formation refers to the fact that hydrocarbons contained in this formation do not flow easily out of it. For comparison, the US Energy Information Agency (US EIA) defines conventional gas production as "natural gas that is produced by a well drilled into a geologic formation in which the reservoir and fluid characteristics permit the oil and natural gas to readily flow to the wellbore", hence with higher permeability.

23 See glossary.

24 EIA Annual Energy Outlook 2013, http://www.eia.gov/forecasts/aeo/MT_naturalgas.cfm

with the overall share of natural gas in the US energy mix slightly increasing (from 25.3 % in 2012 to 27.8% in 2040). This boom was possible in the US due to a combination of several factors: geological features, experience with hydraulic fracturing technique and availability of needed infrastructures (rigs, pipelines eg), energy operators ready to invest in this new sector and exemptions from certain pieces of US federal environmental legislation[25], land ownership status that incentivizes land owners to allow operators to drill on their land (contrary to the EU situation, US land owners usually own the minerals underneath their land).

The growth in US shale gas production and the consequential drop in US domestic gas price[26] have had significant impacts on the domestic US economy, with increased jobs in the shale gas regions, increased state revenues and increased competitiveness of certain gas-dependant sectors (with e.g. the reactivation of petrochemical installations). However, despite the drop in US domestic gas price, the overall structure of the US economy has not changed significantly, with the share of manufacturing in the Growth Value Added remaining broadly the same, and still below that of the EU. At the same time, however, a slight increase can be observed in the share of US energy intensive sectors mirrored by an equally small decrease in the EU[27]. The upward trend in the US starts however ahead of any significant shale gas development[28] (see annex 22).

These shifts in the US energy mix and increase in US gas self-sufficiency also had implications on the international energy markets, with greater Liquefied Natural Gas (LNG) supplies from other gas-producing countries becoming available at global level (due to lower US demand in international gas markets), indirectly influencing EU gas prices[29], and increased US exports of coal to the EU, where coal prices have plummeted by more than a third since 2011.

Furthermore, the USA has recently started approving applications for gas (LNG) export licenses and it is expected that they could become a net natural gas exporter by 2021[30]. This would have the potential to change the global gas market even more, moving prices downward, hence potentially benefiting European and / or Asian customers (although due to the significant costs of liquefaction, transportation and regasification, increasing international LNG trade would not result in harmonised gas prices). Energy-intensive companies in the USA advocate against this move towards US becoming a gas exporter, since it would decrease their energy price advantage.

2.3. Unconventional fossil fuel developments in the EU

Exploration and production of natural gas in Europe has in the past been mainly focused on conventional resources. Whilst opportunities for this type of domestic extraction are becoming increasingly limited, technological progress has opened up possibilities to extract

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25 Following notably the adoption of the Energy Policy Act in 2005 by the Congress, shale gas operations in the United States are exempted from certain pieces of environmental legislation at federal level. For instance, operators do not need a permit for hydraulic fracturing under the Safe Drinking Water Act (provided diesel fuels are not used) and wastes generated are exempt from federal hazardous waste regulations.

26 See annex 3.4: From an all-time high in 2005 of nearly 15 $/MMBtu (million British thermal units) to 2$/MMBtu in 2012. Since May 2013 the
price for natural gas futures has been in the range of 3.6 to 4.2 $/MMBtu (U.S. Energy Information Administration, www.eia.gov)

27 Energy Economic Developments in Europe, DG ECFIN, forthcoming publication

28 The most recent economic developments should be looked at in the context of the post-2008 financial crisis and the on-going recession which have differed in timing, magnitudes and duration in the EU and the US. It is therefore complicated to single out the effects of energy prices.

29 JRC IET report "Unconventional Gas: Potential Energy Market Impacts in the EU", Sept. 2012

30 IEA, World Energy Outlook 2012; US EIA April 2013

unconventional fossil fuels from geological formations which were previously technically too complex or too costly to exploit.

These new possibilities have spurred the interest of market operators as well as of a number of Member States, in the light of possible opportunities to avoid increasing EU gas import dependency, diversify energy supplies and enhance negotiating position towards external energy suppliers, and potentially benefiting from overall reduced energy prices (or avoided increase).

2.3.1. Unconventional fossil fuels in the EU

While there is still considerable uncertainty as to their precise volume, reserves of unconventional fossil fuels in the EU are deemed significant. The main unconventional hydrocarbons present in the EU include shale gas, which technically recoverable resource base has been estimated at approximately 16 tcm (trillion cubic meters), tight gas (3 tcm) and coal bed methane (2 tcm)[31]. For comparison, EU gas consumption in 2012 amounted to 0.457 tcm[32]. If all technically recoverable shale gas reserves would prove to be also economically recoverable, they would represent about 35 years of the current level of annual gas consumption. Although most of the resource is deemed to be located on-shore, there are also indications of potential for offshore shale gas resources notably in the North and Baltic seas and under the East Irish Sea[33].

At present, only tight gas is commercially produced in Europe, notably in Germany. The number of coalbed methane (CBM) projects is increasing in the EU, with pilot wells and on-going moves towards commercial production in the UK and CBM licensing occurring in BE, BG, CZ, FR, HU, IT and RO, in addition to PL, DE and UK. Tight oil (also known as shale oil) resources have been documented notably in Poland[34] and in France. However, no future plans of significant development could be identified thus far based on available literature.

Other unconventional fossil fuels are oil shale, oil sands, methane hydrates and underground coal gasification. The use of oil shales in Europe is currently limited to Estonia, where it is the dominant feedstock for electricity production. Though increasingly used for production of crude oil, it is mainly used as a kind of solid fuel comparable to lignite. There is no evidence suggesting that oil shales may be exploited in Europe outside Estonia for the foreseeable future.

There is no known oil sand potential in Europe. Methane hydrate production and underground coal gasification technology are in the early stages of development and there are no examples worldwide of commercial production.

Based on currently available knowledge[35], **shale gas** appears to be the unconventional hydrocarbon with the greatest potential for development in Europe, with exploration activities underway, although on a low scale, and production tests already on-going in Poland.

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31 IEA 2012 estimates for OECD Europe. See also JRC IET 2012. Estimates vary depending on sources.

32 DG ENER, Market Observatory for Energy: Quarterly Report on European Gas Markets; 1st quarter 2013 (to be noted: with 4917 TWh EU gas consumption in 2012 was 14 % lower than in 2010).

33 However, for cost reasons, due the higher number of wells needed for shale gas as compared to conventional gas production, shale gas development is expected to take place primarily onshore. Estimates of offshore shale gas resources can be found in the report "Assessment of shale gas and shale oil resources of the lower Paleozoic Baltic podlasie Lublin basin in Poland, March 2012" (p. 25) from the Polish Geological Institute. The British Geological survey also pointed to significant offshore potential in the UK and is investigating the possibility to access offshore resources with deviated drilling from onshore.

34 PGI 2012 quoted in ICF 2013 refers to up to 2 billion barrels of recoverable oil both onshore and offshore in Poland.

35 ICF, 2013. JRC IET 2012

Due to the fact that shale gas appears to be the unconventional fossil fuel with the highest prospect of development in the short to medium run in the EU, and due to the fact that it is the focus of public debate, the sections below focus the analysis on shale gas.

2.3.2. Shale gas resource estimates in the EU

According to the International Energy Agency, shale gas resources in the European Union are expected to be mostly found in the areas shown in the map below[36].

This document and any map included herein are without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

The IEA estimates that 73% of EU shale gas technically recoverable resources[37] are expected to be relatively equally split between France (5.1 Tcm) and Poland (5.3 Tcm). Remaining reserves would be mostly shared by Germany (0.23 Tcm), the Netherlands (0.48 Tcm), United Kingdom (0.57 Tcm), Denmark (0.65 Tcm) and Sweden (1.16 Tcm).

More recent resource estimates have been released by individual Member States (both downscaling and upscaling earlier estimates), including the United Kingdom, Poland and Germany, as well as by the US Energy Information Agency[38].

There are however large uncertainties as to the size of economically recoverable resources[39] in the EU, inter alia related to recovery rates, with current production technologies typically allowing the extraction of 15-40% of gas from shale formations[40]. Further knowledge on the estimates of economically recoverable resources of shale gas would typically depend on concrete exploration projects, involving high volume hydraulic fracturing for test purposes.

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36 Source:World Energy Outlook Special Report on Unconventional Gas: Golden Rules for a Golden Age of Gas © OECD/IEA, 2012, figu.3.7 p.121

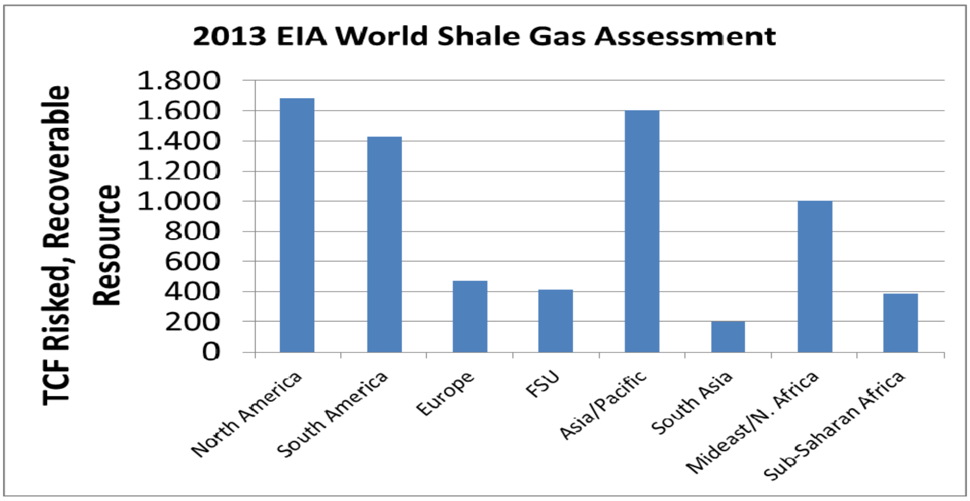
37 "Technically recoverable resources represent the volumes of oil and natural gas that could be produced with current technology, regardless of oil and natural gas prices and production costs. Economically recoverable resources are resources that can be profitably produced under current market conditions" (US EIA June 2013 report p.10)

38 Studies assess different categories of resources (gas in place versus (risked) technically recoverable resources and cannot be compared with each other. The UK Department of Energy and Climate Change and British Geological Survey published an assessment estimating the recoverable shale gas volume to amount to 150 bcm. The Polish Geological Institute estimated in 2012 that recoverable shale gas ressources in the Lower Paleozoic gas shales range from 346 to 768 bcm. The German BGR estimated in 2012 recoverable resources range from 680 to 2260 bcm.

39 http://www.eia.gov/analysis/studies/worldshalegas/pdf/fullreport.pdf?zscb=63288120,

40 JRC report " Unconventional Gas: Potential Energy Market Impacts in the European Union ", Sept. 2012

Although relatively significant compared to proven reserves of domestic conventional gas, shale gas resources in the EU appear anyhow to be far lower than in other parts of the world, as shown by the figure below:



2.3.3. State of shale gas activities in the EU

A shale gas project typically evolves from exploration (stages 1 to 4 below) to commercial production (stage 5 below) along the following project stages (Philippe and Partners (2011 NPR p7-8) quoted in AEA 2012):

1. Identification of the gas reservoir, stage during which initial geophysical and geochemical surveys are performed and seismic and drilling location permits are secured.

2. Early evaluation drilling, stage during which the extent of gas bearing formation(s) is measured via seismic surveys and geological features are investigated (geological faults or discontinuities may impact the potential reservoir). Initial vertical drilling starts to evaluate shale gas reservoir properties and core samples are often collected.

3. Pilot project drilling, stage during which initial horizontal wells are drilled to determine reservoir properties and completion techniques and initial production tests are carried out. This includes multi-stage hydraulic fracturing, involving numerous injections (10 to 15) of hydraulic fracturing fluids, and high volume hydraulic fracturing, defined in the New York SGEIS (State of New York, 2011 PR Glossary and section 3.2.2.1) as "*the stimulation of a well using 300,000 gallons or more of water as the base fluid in fracturing fluid*". This figure corresponds to 1,350 m^3 per fracturing stage. The AEA 2012 study, based on EU experience, suggests a definition of 1,000 m3 per fracturing stage (section 1.3.3, p.7). In the Lebien exploratory project in Poland, the exploratory project used over 17 000 m3 of water and the fracturing was done in 13 steps, which would constitute high volume hydraulic fracturing. According to industry sources, hydraulic fracturing in some 10-12 exploratory wells would be typically needed to decide if it is worth entering into commercial production.

4. Pilot production testing: Multiple horizontal wells from a single pad are drilled, as part of a full size pilot project. Well completion techniques are optimised, including drilling and multistage hydraulic fracturing and micro seismic surveys. The company initiates the planning and acquisition of rights of way for pipeline developments.

5. Commercial development: multiple well pads and wells are built for a single exploitation site, as well as infrastructures (pipelines, roads, storage facilities), leading to the production of natural gas. As gas wells reach the point where they are no longer commercially viable, they are sealed and abandoned.

In the EU, the following Member States are in the process of granting or have granted concessions and/or prospection/exploration licenses over the past three years: Poland, the United Kingdom, Germany, Netherlands, Spain, Denmark, Sweden, Romania, Portugal, and Hungary[41]. However, not all license holders have started concrete prospection or exploration

[41] Licenses granted by Bulgaria and France were later on revoked by laws banning hydraulic fracturing.

activities. Currently, such activities (at prospection or exploration stages) have taken place or are on-going e.g. in Poland, Germany, Denmark, Sweden, UK and Romania. There is no commercial production of shale gas yet in Europe, although a few pilot production tests have already been conducted for instance in Poland. Commercial production could start in 2015-2017 in certain Member States (e.g. Poland, UK).

2.3.4. Expected economic effects in the EU

Most analysts recognise that, in the most optimistic case, European shale gas development can compensate for the decline in EU conventional gas production[42], hence maintaining EU gas import dependency at a stable level.

Although effects on gas prices of possible domestic shale gas production in the EU still need to be ascertained, they are unlikely to be as significant as in the US[43]. The International Energy Agency projections of natural gas prices in the US, Europe and Japan under high and low exploitation scenarios of shale gas in Europe (Golden Rules versus low unconventional scenarios) are as follows[44]:

Table 2.3 ▷ Natural gas price assumptions by case
(in year-2010 dollars per MBtu)

		Golden Rules Case		Low Unconventional Case	
	2010	2020	2035	2020	2035
United States	4.4	5.4	7.1	6.7	10.0
Europe	7.5	10.5	10.8	11.6	13.1
Japan	11.0	12.4	12.6	14.3	15.2

Note: Natural gas prices are expressed on a gross calorific value basis. Prices are for wholesale supplies exclusive of tax. The prices for Europe and Japan are weighted average import prices. The United States price reflects the wholesale price prevailing on the domestic market

It shows that, if the EU follows a high shale gas exploitation route, its gas price would be, in 2035, about 18% lower than what it would be with a low shale gas exploitation scenario. However, even in this high shale gas exploitation route, EU gas price would remain well above the US price (about 50% higher).

This difference can be explained by expected higher production costs in the EU, due to geological features (shale gas reserves in the EU are deemed to be generally deeper[45] than in the US) and a lower availability of the needed infrastructures (e.g wastewater treatment plants, rigs, pipelines [46]) in some of the most concerned areas. Conditions in the EU also differ from those of the US as regards population density (and therefore potential impacts on local populations and public opposition) and regulatory environment. Furthermore, gas price formation differs in the EU and in the US, with EU gas price still largely fixed through long term contracts, oil-price indexed, while in the US, gas prices are mostly set through spot

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[42] JRC report " Unconventional Gas: Potential Energy Market Impacts in the European Union ", Sept. 2012

[43] See eg "Considering shale gas in Europe", M. Bazilian, A. Pedersen, E. Baranes, European Energy Journal, volume 3, issue 1, January 2013; House of commons report on 'The impact of shale gas on energy markets', April 2013

[44] World Energy Outlook Special Report on Unconventional Gas: Golden Rules for a Golden Age of Gas © OECD/IEA, 2012, table 2.3 p.74

[45] Although shallow shale gas plays have also been identified, for instance in Sweden.

[46] IEA Golden rules report states that, to exploit its shale gas potential, EU would need between 500 and 600 drilling rigs in 2035, while there are currently only about 25 available in the EU capable of on-shore horizontal drilling.

markets, hence allowing stronger price impacts of short term increase in shale gas production[47]. In any case, even in a "best case scenario" with high shale gas development in the EU, it would represent in 2035 about 11 % of EU gas consumption[48], hence a rather small share, with imports representing 60% of EU gas consumption in 2040[49], thus gas prices in EU would continue to be set by import prices.

Increased LNG availability due to the US shale gas developments already resulted in downward pressure on existing gas supply contracts in the EU and is expected to continue, and even more so if other regions of the world also start exploiting their shale gas (China and Australia are going towards this direction). In addition, the current balance of expert opinions suggests that the EU natural gas price will continue to move slowly away from oil indexation[50, continuing the trend of the last years:] since 2010, the share of oil indexed gas contracts in the EU decreased by 8% reaching 51% of gas consumption in Europe. In contrast, over the past 5 years, spot-priced volumes have doubled, reaching 44% of gas consumption in 2012. However, strong regional differences persist in price formation mechanisms with about 70% of gas in North-West Europe priced on a gas-on-gas (spot) basis, compared to less than 40% in Central Europe[51.]

Overall, the impacts of a potential decrease in EU gas price on the EU competitiveness are likely to be lower than in the US due to the higher level of energy efficiency of the EU economy. In 2011, the European Union was the region with the lowest energy intensity[52] in the world and, even so, registered the world largest decrease in energy intensity (-4.8%)[53]. However, EU energy-intensive sectors or sectors using gas as an input, which are currently under significant competitive pressure from the US, would benefit from any decrease in energy prices (or avoidance of further price increases).

Next to the impact on energy prices, EU indigenous oil and gas production could have further positive economic impacts in Europe such as increased (or less declining) revenues from royalties as well as employment opportunities[54].

2.4. Environmental and health aspects

In the current state of technological development, shale gas exploration and exploitation require the **combined use of high volume hydraulic fracturing and directional drilling** at a scale and intensity for which there is very limited experience in Europe**.** This combination

47 These differences between EU and US are for instance presented in Bruegel Blueprint Series, Volume XXI, Manufacturing Europe's future (non peer-reviewed publication)

48 See Golden Rules report p.81: Unconventional gas production in Europe in 2035 is reported at 27% of 285bcm, hence 77 bcm. At the same date, Europe is reported to consume 692 bcm of gas (p. 78). Hence, European shale gas production would represent 11% of its gas consumption.

49 JRC IET, "Unconventional gas: Potential Energy Market Impacts in the European Union", Sept. 2012

50 JRC IET, "Unconventional gas: Potential Energy Market Impacts in the European Union", Sept. 2012

51 DG ENER, Market Observatory for Energy: Quarterly Report on European Gas Markets; 1st quarter 2013.

52 Total energy consumption per unit of GDP

53 Enerdata, Global Energy Statistical Yearbook 2012. Even in this context of high energy efficiency, it is estimated that there is still a potential for increasing energy efficiency in the EU (see SEC(2011) 779 final, p.8: IA for the EED: http://ec.europa.eu/energy/efficiency/eed/doc/2011_directive/sec_2011_0779_impact_assessment.pdf)

54 A study commissioned by the gas company Cuadrilla Resources estimates that exploration activities involving the completion of three test wells per year would support some 250 full time equivalent jobs if all tiers of the supply chain and so-called induced jobs arising from the personal expenditure of employees are taken into account (Economic Impact of High volume hydraulic fracturing Exploration & Production in Lancashire and the UK. Final Report by Regeneris Consulting, September 2011). There are however debates as to the precise level of employment opportunities and estimates diverge widely depending on literature sources and to which extent such jobs would be additional to those existing, or replace jobs in other sectors. A study undertaken in the Marcellus shale area in Pennsylvania and co-funded by the oil and gas industry conclude that, when 13 jobs are needed for the initial phases of the activity (pre-drilling and drilling phases), less than half a job remains needed during the production phase (MSETC Needs assessment series, Summer 2010- see section 9.3.1 for more details on employment impacts)

of techniques and the fact that shale gas extraction requires the drilling of numerous wells, high use of water and significant land take, the injection of volumes of chemical additives underground and the production of large quantities of wastewater, combined with the public perception that the disclosed information is too little and not enough verified, have raised significant public concerns as to the related environmental, climate and related health impacts and risks of the practice (e.g. water and air emissions, cumulative impacts on water and land use, induced seismicity, …).

Hydraulic fracturing (or fracking) consists of injecting at high pressure in the underground a significant amount of fracturing fluids (usually water mixed with a proppant, typically sand and other additives, including chemicals) to break the rock and to extract the resources. This technique is not unknown in the EU, as low volume hydraulic fracturing was already used in some tight gas, coalbed methane projects and conventional reservoirs, essentially in vertical wells. Regulators and industry indicate that low volume hydraulic fracturing has been carried out on a total of approximately 800 conventional and unconventional wells in Europe, a small part of all current oil and gas operations in the EU (for comparison, this has been used in approximately 400,000 wells producing gas in the US). Enhanced geothermal energy systems use a hydraulic stimulation technique, but in closed looped systems, and typically at lower pressures.

In shale gas operations, it is **high volume hydraulic fracturing** which is typically used, requiring much higher volumes of water than used in hydraulic fracturing conducted thus far (see Annex 6). This increased need for water is due to the very low permeability and porosity of the unconventional fossil fuel reserves targeted, and the low gas content per rock volume. It also entails larger injection of additives into the ground (see Annex 6).

In addition to high volume hydraulic fracturing, current shale gas practices also involve the use of **directional drilling (especially horizontal)** through rock formations which constitute the reservoir. This allows increasing borehole contact with the shale formations. This technique is generally not used for conventional hydrocarbons extraction as the combination of good permeability and relatively high gas content makes it possible to extract natural gas mostly through vertical drilling (although sometimes horizontal or directional drilling may be used to access the reservoir).

In **Europe**, the concerns raised have led some Member States and regions to adopt temporary moratoria (see section 3.3 for complete description) and two Member States (France and Bulgaria) to enact legal bans on the use of hydraulic fracturing. It is indeed this technique which is at the basis of public concerns.

In the **USA**, in parallel to fast shale gas developments, similar concerns have been raised, in particular as regards potential impacts of the techniques used on drinking water quality and air emissions. This has led several states and the federal administration to propose specific and more stringent rules. For instance, the US Bureau of Land Management recently put forward draft rules[55] aiming at reducing environmental risks from hydraulic fracturing on public land, with a focus on the disclosure of chemicals, well integrity and water management. Some states have introduced legal bans / moratoria[56]. In parallel, the US Environmental Protection Agency has tightened federal rules on air emissions and is working on developing standards for wastewater discharges as well as on guidance on the use of diesel for hydraulic fracturing (see annex 10 for details).

55 http://www.gpo.gov/fdsys/pkg/FR-2013-05-24/pdf/2013-12154.pdf.

56 And California passed in Sept. 2013 a law establishing regulatory standards governing unconventional drilling.

2.5. Focus of the analysis in this Impact Assessment

The Commission 2013 Work Programme includes an initiative (subject to an Impact Assessment) on an "Environment, Climate and Energy Assessment Framework to Enable Safe and Secure Unconventional Hydrocarbon Extraction". This impact assessment focuses on shale gas, as the unconventional hydrocarbon with the greatest expected potential for development in Europe but also raising most public concerns, due to environmental and climate issues.

As most of the environmental risks and impacts associated to shale gas are actually linked to the techniques used, this impact assessment focuses on those: the combination of High Volume Hydraulic Fracturing (HVHF) with directional (especially Horizontal) Drilling (HD) through rock formations constituting the geological reservoir. **In the context of this impact assessment**, for simplicity purpose, **the acronym HVHFHD will be used to refer to this combination of techniques**.

Addressing, in a proportionate manner, the environmental and climate risks and impacts associated to HVHFHD would provide reassurance to the public and would respond to the call from investors and public authorities for regulatory clarity and predictability. If environmental and climate concerns remain unaddressed, they are seen as serious hurdles to further developments of the sector[57].

While focusing on shale gas, the analysis presented in this impact assessment aims at remaining at a generic enough level so as to provide sufficient flexibility to accommodate local conditions. This may be of use for analysis of other unconventional fossil fuels requiring the use of HVHFHD, should they develop further in the EU and raise public concerns.

2.6. EU institutional context

In February 2011, the **European Council** requested an assessment of "Europe's potential for sustainable extraction and use of conventional and unconventional (shale gas and oil shale) fossil fuel resources"[58]. In May 2013, it adopted conclusions on energy issues, stressing the need to "intensify the diversification of Europe's energy supply and develop indigenous energy resources to ensure security of supply, reduce the EU's external energy dependency and stimulate economic growth". It further acknowledged that "to that end […], the Commission intends to assess a more systematic recourse to on-shore and off-shore indigenous sources of energy with a view to their safe, sustainable and cost-effective exploitation while respecting Member's States choices of energy mix"[59].

The Informal Energy Council of 23 April 2013 discussed the possible effects of unconventional oil and gas extraction in the EU on energy supply, prices and competitiveness. At the informal Environmental Council of 16 July 2013, Member States demonstrated a diversity of views, with some expressing clear support for an EU common approach to ensure safe, secure and efficient extraction, others signalling the need for a clear

57 IEA: Golden Rules report, 2012

58 http://register.consilium.europa.eu/doc/srv?l=EN&t=PDF&gc=true&sc=false&f=ST%202%202011%20REV%201&r=http%3A%2F%2Fregister.consilium.europa.eu%2Fpd%2Fen%2F11%2Fst00%2Fst00002-re01.en11.pdf, point 7

59 http://www.consilium.europa.eu/ueDocs/cms_Data/docs/pressData/en/ec/137197.pdf, point 6b

and reliable legal framework for investments, while one expressed its opposition to any EU approach.

The **European Parliament** has also paid close attention to the issue**.** In November 2012, it adopted two resolutions in plenary session respectively on the environmental impacts and on industrial/energy aspects of shale gas and oil, stemming from the two concerned committees (ENVI and ITRE). The resolution on environmental aspects called explicitly on the Commission to introduce an "EU-wide risk management framework for unconventional fossil fuels exploration and extraction, with a view to ensuring that harmonised provisions for the protection of human health and the environment apply across all Member States". The resolution on industrial and energy aspects, while noting significant potential benefits of possible shale gas and oil production, stressed, inter alia, the need for the highest safety and environmental standards. In view of the high number of petitions received, the European Parliament PETI Committee decided, in October 2012, to keep the petitions open and called for harmonized legislation on shale gas[60].

The **Committee of the Regions** called in its opinion adopted in October 2013 for a "clear and legally binding regulatory framework of the EU, preferably in the form of a directive".[61]

3. PROBLEM DEFINITION

As presented earlier, the development of HVHFHD activities in North America has entailed economic benefits but it has also spurred public opposition and legislative adaptations, due to environmental impacts and the perceived risks of the techniques used. In the EU, as the practice is starting to develop, the same concerns over environmental impacts and risks are being raised, while public authorities and potential investors lack clarity and predictability over the regulatory framework that applies. This is not conductive to safe and secure investments in this area.

Three sets of problems therefore emerge:

1/ Potential environmental risks and impacts

2/ The extent to which the regulatory framework provides an effective and clear set of safeguards

3/ Public acceptance issues

These three sets of problems are closely linked since public opposition is based on environmental concerns and on the perception that the current regulatory framework does not provide an adequate response to these concerns.

3.1. Environmental impacts and risks

3.1.1. Approach followed

A wide range of sources have been used and a risk assessment approach has been followed as much as possible, given the limits imposed by the scarcity of consistent and publicly available data. This has led to the identification of the main risks associated to HVHFHD,

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60 The PETI Committee fact-finding mission to Poland published in Sept. 2013 highlights, inter alia, the need for monitoring at all stages, public consultation and consideration of cumulative impacts.

61 Opinion of local and regional authorities on shale/tight gas and oil adopted in October 2013: http://cor.europa.eu/en/news/Pages/fracking-environmental-impact.aspx

based on scientific sources. In addition to this science-based approach, the public perception of environmental risks has also been a source of information: in some case, perceived risks do not fully correspond to the ones highlighted by the scientific community. However, if public acceptance is to be enhanced, risk management should tackle all risks discussed by the society.
In the rest of the analysis undertaken for this impact assessment, each of the identified risks has been put in perspective with existing measures able to reduce and manage it; currently applied measures can be from regulatory origin at EU or Member State level or result from industry practice. Residual risks, not yet tackled by existing measures, have then been identified (see annex 14), so that the analysis of options focuses on ways to tackle these residual risks. Ultimately, residual risks will need to be put in perspective with opportunities provided by shale gas development.

a. Literature review provides both ranked and un-ranked assessments of the risks

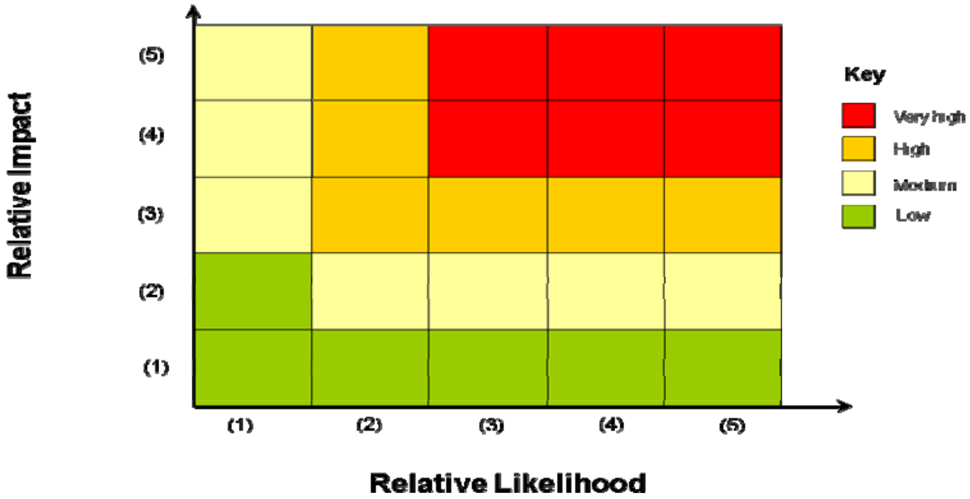
A number of impacts (that *would* occur if shale gas is extracted) and risks (that *might* occur) linked to HVHFHD activities are consistently evoked in most sources, be them from North American, European, international institutions or national public bodies[62]. Some of these sources[63] followed a standard risk assessment approach which allows for a ranking of these risks, with estimation of the probability of occurrence of identified hazards and of the magnitude of their consequences, leading to generic qualitative ranking of the severity of the risks:

Example of risk matrix[64]:

[62] See for instance: IEA Golden Rules Report, UNEP, US EPA, US Geological Survey, US Department of Energy 90 days report, Resources for the Future report, Environmental Defence Fund, German BMU study (2012), UK Environmental risk assessment (2013), French BRGM report See annex 1 for full list

[63] In particular the UK Environment Agency report 2013 (http://a0768b4a8a31e106d8b0-50dc802554eb38a24458b98ff72d550b.r19.cf3.rackcdn.com/LIT_8474_fbb1d4.pdf; but also AEA 2012.

[64] Environmental impacts should wherever possible be quantified in economic terms, but may also be included in non-quantified terms under political/social impacts. Definition of probability: (1) Very low probability: rarely encountered, never reported or highly unlikely; (2) Low probability: infrequent occurrences; (3) Medium probability: can be expected to occur several times per year; (4) High probability: repeated occurrences; (5) Very high probability. Definition of impact: (1) Very low impact: slight environmental effect; (2) Low impact: minor environmental effect localised to the point of occurrence with no significant impact on the environment or human health; (3) Medium impact: moderate, localised effect on people and the environment in the vicinity of the incident; (4) High impact: major environmental incident resulting in significant damage to the environment and harm to human health; (5) Very high impact: very significant damage to the environment and harm to human health: see European Commission Staff Working Paper "Risk Assessment and Mapping Guidelines for Disaster Management", SEC(2010) 1626 final, 21.12.2010, p.19



However, most sources limited their analysis to the identification of the risks, without ranking them. This is for instance the case of the survey-based statistical analysis of 215 experts' views (from government agencies, industries, academia and NGOs) conducted by the US research organisation "Resources for the Future"[65] to identify the priority environmental risks related to shale gas development. Although not ranking the risks, it identified several 'consensus risks'.

Section 3.1.2 below presents the risks associated to HVHFHD that where either classified "high" in the ranked risks studies or systematically mentioned in the unranked risks sources. They touch upon water quality and use, air emissions (including GHG), land use and its environmental related impacts, seismicity and communities disruptions (noise, traffic…).

b. Uncertainties due to the lack of systematic data collection

If only few sources provide a ranked risk assessment on the issue at stake, it is mainly due to lack of adequate data. Indeed, due to the rather recent deployment of the HVHFHD practice and a current lack of comprehensive and fully quantified data, uncertainties remain as regards the magnitude and likelihood associated to the risks[66]. In North America, where most experience of fracking comes from, there has been no comprehensive documentation of such impacts and risks, due to the lack of publicly accessible and systematic data collection on the situation before shale gas exploitation started (baseline), the lack of consistent monitoring of effects of operations and the non-disclosure agreements that sometimes take place between an operator and a land-owner (financially compensated by the operator in case of damages). There is at present no centralised database of incidents related to hydraulic fracturing in the United States. The issue of possible under-reporting was mentioned by the US EPA[67], which

[65] http://www.rff.org/Documents/RFF-Rpt-PathwaystoDialogue_FullReport.pdf

[66] This was one of the conclusions of the Dec. 2012 workshop organised by DG ENV on the geological aspects of unconventional fossil fuels: Studies presented at the workshop were generic qualitative risk assessments aimed at the identification and prioritisation of environmental risks. It was considered that the development of generic quantified risk assessments would be of limited value at present in particular due to two factors: the lack of consistent, appropriate and publicly available data series from unconventional fossil fuels operations using hydraulic fracturing (e.g. baseline, operational and post-closure measurements); and the specific geological conditions and circumstances (i.e. impact pathways) encountered at each project site determining the nature and the level of specific risks for that project in practice.

[67] US EPA Final study plan, 2011 and Interim 2012 report

currently examines a set of retrospective and prospective case studies on the impacts of fracturing on drinking water[68].

In Europe, an analysis of environmental aspects of hydraulic fracturing performed on the Lebien LE-2H exploratory well in Poland was conducted from June till October 2011. It concluded that the short term environmental impacts of hydraulic fracturing conducted at this specific site were limited provided it is appropriately performed. However, the analysis could not examine medium to long term effects. Further monitoring of impacts is taking place in Poland and results are expected for 2014.

It also appears that the intensity of the risks and impacts depends on the geographical and geological specificities of sites where HVHFHD activities take place. For instance, the density of population, the proximity of targeted formations to groundwater reservoirs, the presence of pre-existing (e.g. abandoned) wells may influence the likelihood of an incident or the magnitude of possible damages. In addition, experts point to possible **long term** effects that can take place even several years or decades after the exploitation has ceased and uncertainties associated for instance with the long-term presence of hydraulic fracturing fluids in the underground, their "cocktail effect" and their interaction with naturally occurring materials (e.g., heavy metals, radioactive substances) and displaced formation fluids. Chemical transformation processes in the deep underground and their interactions with the geological layers, in environments of high pressure and high temperature, are not yet well understood.

c. A consensus exists over the main risks associated to fracking

Despite uncertainties, a broad consensus exists, with some risks systematically either ranked high or consistently evoked by scientific experts and sources. These risks relate mainly to risks of water pollution, in particular stemming from the use of chemicals in the fracking process, insufficient underground characterisation and well casing, air emissions (including GHG), as well as local impacts linked to transport and land and water use in particular. Other risks are not necessarily ranked high by experts but are high in the public perception. This is for instance the case of induced seismicity risks and issues related to the asymmetry of information about the chemicals used. Most of these risks and impacts relate to both the **exploration and exploitation phases** of shale gas activities, as hydraulic fracturing tests are already conducted in the later stages of the exploration phase, before scaling up activities during the production stage.

Cumulative impacts of shale gas developments are also systematically highlighted by experts and public opinion, stressing the **differences with conventional gas extraction**: A lower productivity of unconventional wells compared to conventional ones (due to lower gas flow and a shorter well life time) leads to a significantly higher number of unconventional wells needed to produce a same volume of gas as from conventional production[69]. It also leads to the need to stimulate these wells with high volumes of water[70] and high amounts of

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68 US EPA ongoing study running over 4 years, initially planned to be published in 2014, though latest news announce possible delay until 2016.

69 AEAT 2012 estimates "that approximately 50 shale gas wells might be needed to give a similar gas yield as one North Sea gas well". In Texas, 100 000 wells are nowadays necessary in order to produce the same amount of gas that could be produced in the sixties from 20 000 wells (http://www.rrc.state.tx.us/data/production/gaswellcounts.php)

70 See 'The Energy-Water Nexus: Potential Groundwater-Quality Degradation Associated with Production of Shale Gas", from Procedia Earth and Planetary Science, Volume 7, 2013, Pages 417–422, available at: http://www.sciencedirect.com/science/article/pii/S1878522013002130

additives. Even if fracking is not a brand new technique, sources agree that the scale, frequency and complexity of the fracking technique necessary for shale gas extraction differ from all past EU experiences, with the latter having been essentially limited to low volume hydraulic fracturing in some conventional and tight gas reservoirs, mostly in vertical wells, and only in a small part of past EU oil and gas operations. Furthermore, while production from conventional reservoirs is restricted to a production site, shale gas production is spread over an area of hundreds of square kilometres requiring a wide dispersion of resources and causing the production of high volumes of possibly hazardous wastes. It also typically induces increased road traffic in order to transport these resources and materials from and to the site (esp. if pipelines are not built). So even if some of the risks of shale gas are located in the deep underground, experts agree that, even there, risks to groundwater do exist and that other types of risks also arise. According to diverse sources[71], "producing unconventional gas is an intensive industrial process, generally imposing a larger environmental footprint than conventional gas development"[72] and that "entails [...] new risk dimension that does not arise in connection with conventional gas production"[73].

This analysis is often challenged by the oil and gas industry[74] which pertains that these impacts and risks are either exaggerated or are now well controlled and managed. Nevertheless, public perception is such that opposition to shale gas projects is often fiercer than opposition to other energy projects.

d- Many of the risks can be, at least partly, managed

A broad consensus emerges among experts[75] on the best practices and measures needed to mitigate the main risks from shale gas development. If fully applied, these measures would allow to at least partly manage the risks and impacts in an appropriate manner. Therefore, currently existing measures mitigating the risks identified for this impact assessment have been gathered (be they from regulatory origin at EU or national level or from industry practices) and the remaining gaps highlighted (see annex 14). It is on these **residual risks** that the analysis presented for the definition and analysis of the options focuses (see section 8). As far as possible, proportionality of the measures proposed in the options has been assessed in view of the level of risks determined by experts.

3.1.2. Main risks to the environment

Most of these environmental risks identified are inter-linked. They are briefly presented below, by decreasing order of importance in terms of occurrence of events and in public perception, while a more detailed description and the main inter-relations between risks, their causes and effects and the different impacts pathways are described in annexes 4 and 5, as well as evidence of occurrence of these risks.

71 e.g. International Energy Agency 2012; 2012 risk assessment study sponsored by Exxon-Mobil in Germany, 2013 report commissioned by the NL government mentions land take impacts as being higher (Ministry of Economic Affairs) http://www.government.nl/documents-and-publications/parliamentary-documents/2013/08/30/shale-gas-study-findings-and-further-progress.html, US Geological Survey (http://pubs.usgs.gov/of/2013/1137/pdf/ofr2013-1137.pdf)

72 IEA Golden Rules Report 2012

73 http://dialog-erdgasundfrac.de/sites/dialog-erdgasundfrac.de/files/Ex_HydrofrackingRiskAssessment_120611.pdf, p.56- The study was focused on the situation in Germany

74 E.g. in OGP Policy Recommendations of 4 July 2013

75 From US EPA, IEA, Canadian studies, German SRU, UK Environmental Assessment… cf annex 2

3.1.2.1. Risks of surface and ground water contamination

Water contamination linked to shale gas activities has occurred in North America (see annex 5.1 for details). Several channels of contamination of groundwater and surface waters can be identified (see figures in Annex 4), and the risk of contamination is notably linked to the **chemicals** used in the hydraulic fracturing process. Should the well be ill-placed further to **insufficient underground characterisation**, and should **well integrity** not be adequate, chemicals that are injected underground may contaminate groundwater, in case of leaks, through eg improper well casing, induced fractures or existing faults. Surface waters contamination could occur via the mishandling of high volume of **wastewaters** produced, typically contaminated by the injected fracturing chemical additives, highly saline water and possibly naturally occurring heavy metals and radioactive materials (target shale formations often contain those elements)[76]. If this wastewater is not adequately handled[77], leaks or spillage may affect the quality of soil and surface waters. Instances of **water contamination by gas** have also been reported in the USA; although contamination pathways are not yet fully understood, faulty well casing and cracks in the casing induced by the high pressure seem the most likely ones.

3.1.2.2. Risks of air pollution and greenhouse gas (GHG) emissions

The US EPA pointed to "well-documented air quality impacts in areas with active natural gas development, with increases in emissions of methane, volatile organic compounds (VOCs) and hazardous air pollutants"[78]. When shale gas is extracted, fugitive methane emissions have occasionally been reported in the US. Such emissions if they occur (e.g. methane in flowback during the well completion phase, emissions through improper well casing[79]) can lead to air pollution (Volatile Organic Compounds – leading to ozone formation) and GHG release (predominantly methane in case of venting, and CO_2 in case of flaring[80]; over a 100-year time horizon, methane has 25 times higher global warming potential than CO_2). The cumulative effects of multiple wells, together with the fact that equipment (including the piping, separator, and storage tanks) is not designed to handle the initial mixture of wet and abrasive fluid that comes to the surface in the well completion phase, result in higher GHG emissions than in the case of domestic conventional gas production[81]. Unless properly mitigated, the GHG emissions per unit of electricity generated from shale gas would be around 4% to 8% higher than for electricity generated by conventional pipeline gas from within Europe[82].

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76 For instance, Cuadrilla application in the UK indicates that the "returned waters become contaminated with Naturally Occurring Radioactive Material (NORM) at levels that exceed 1 Becquerel per litre (>1Bq/l) (…) which means that the returned waters are defined as radioactive waste" in accordance with UK legislation. See http://www.cuadrillaresources.com/wp-content/uploads/2012/02/MWD_WMP_AR_082012-FINAL-Waste-Management-Plan-UPDATED.pdf

77 Water UK, representing the UK's water and wastewater utilities, states that "treating discharges of contaminated water recovered from the fracking process may not be possible in all areas because some water companies may not have a suitable site near enough to carry out the required treatment" (press release 17/7/13: http://www.water.org.uk/home/news/press-releases/challenge-on-gas-fracking?printme=true&_frameset=true)

78 http://www2.epa.gov/hydraulicfracturing

79 According to Ingraffea 2013, in the Marcellus shale gas play in Pennsylvania in the US, there was a 6% rate of well failures in 2010, increasing to 7,1% in 2011 and 8,9 % in 2012: http://www2.epa.gov/sites/production/files/documents/ingraffea.pdf

80 See glossary for definition of venting and flaring

81 "Climate impact of potential shale gas production in the EU" – a study conducted for DG CLIMA in 2012. The conclusions are based on experiences drawn largely from the U.S. Whilst attempts have been made to take into account the different circumstances in Europe, and how this may influence overall emissions, this comparison is still largely hypothetical. Where the shale gas industry develops in Europe this information should be used to update the results of the analysis.

82 According to a hypothetical analysis of potential lifecycle GHG emissions that may arise from shale gas exploitation within Europe (see annex 5 for details).

3.1.2.3. Risks of water resource depletion[83]

High volume hydraulic fracturing necessitates large quantities of water (about 15 000 m3 / well on average[84]). This water is not fully recovered after the hydraulic fracturing process (some 25-90 % of the initially injected fracturing fluids may remain in the underground and be no longer part of the hydrologic cycle, depending on geological conditions[85]). When assessed on a per unit of energy produced, this is far more than conventional gas (2000 to 10 000 times more[86]). While, according to the gas industry, shale gas water efficiency per unit of energy produced can compare favourably to some other energy sources, it remains that, "in areas of water scarcity, the extraction of water for drilling and hydraulic fracturing can lower the water table, affect biodiversity and harm the local ecosystem. It can also reduce the availability of water for use by local communities and in other productive activities, such as agriculture"[87]. And all the more so if this takes place in areas where other energy sources are already drawing on the available water[88].

3.1.2.4. Seismicity risks

This risk often ranks high on public concerns. Earth tremors can happen in case of fractures extending beyond the shale gas strata and triggering an active fault. Minor seismic tremors[89] occurred in the UK following two hydraulic fracturing tests in 2011, while the injection of large volumes of waste water in the underground in Ohio also led to induced seismicity[90]. Such induced seismicity has also been reported for geothermal activity. With the scarce data available, the US National Academy of Sciences estimates that hydraulic fracturing does not pose a high risk of seismic event[91].

3.1.2.5. Land related impacts, community disruption and cumulative impacts[92]

On average, the size of hydrocarbon concessions aiming at shale gas activities in the EU currently ranges from approximately 300 km^2 in the Netherlands up to approximately 2900 km^2 in Denmark. In Poland, concessions granted spread across over some 87 000 km^2, representing 27% of the Polish territory. Due to the large number of wells needed for shale

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83 For more details, see annex 5.3

84 This figure is used as average in AMEC study 2013 conducted for DG ENV. Water volumes used vary depending on geological specificities. The US DOE 90-days report 2011 refers to a range of 3800 m3 - 19 000 m3 per well. NYDEC 2011 refers to a range of 9000 m3 to 30 000 m3 per well. The report done in 2013 by the San José State University "Water Resource Reporting and Water Footprint from Marcellus Shale Development in West Virginia and Pennsylvania" (non peer-reviewed) refers 16 to 19 000 m3 used in the US, see http://www.earthworksaction.org/files/publications/FINAL_marcellus_wv_pa.pdf)

85 A report from the US Geological Survey (Kappel et al, 2013) finds that "Anecdotal information from drillers and the Susquehanna River Basin Commission [Appalachian] indicates that approximately 10 percent of all HVHF water used is recovered from the drilled and fractured formation in northeastern Pennsylvania. Any water remaining downhole is considered to be a consumptive loss and is no longer part of the hydrologic cycle."(see http://pubs.usgs.gov/of/2013/1137/pdf/ofr2013-1137.pdf)

86 IEA Golden rules report 2012. However, it can be less than other hydrocarbons, according to industry sources and in particular the International Gas Union.

87 IEA Golden rules report, p.31-32

88 The 2013 Wood Mackenzie research report "Troubled waters ahead ? Rising water risks on the global energy industry" highlights that more than half of shale and tight gas reserves in the US and in the top 10 countries by reserves volume outside the US are located in medium to extremely high baseline water stress areas, where competition is high over local water users.

89 Micro-seismic activity is less than 3.5 on Richter scale.

90 IEA Golden rules report, p.26. In the EU, wastewater from HVHF cannot be injected underground for disposal unless it is free of pollutants or authorised under a relevant derogation under the Groundwater Directive.

91 "Induced Seismicity Potential in Energy Technologies", available at: https://pangea.stanford.edu/researchgroups/scits/sites/default/files/NRC_Induced%20Seismicity%20Potential(1).pdf

92 For more details, see annex 5.4

gas extraction (IEA estimates that in a high shale gas development scenario, 50 000 wells would have been drilled by 2030[93]), and related infrastructure (roads in particular) built on these surfaces[94], this is likely to lead to additional **land fragmentation, land take**[95] and disturbance to biodiversity. It may exacerbate competition over land in a given region (e.g for agriculture or tourism). HVHFHD activities also entail significant increase in local **road traffic** (as often large volumes of water, chemicals, and waste have to be hauled to / from the site of extraction), which, in turn, can lead to air pollution, noise and soil pollution in case of road accidents (e.g. through chemicals or wastewater leakage).
The IEA[96] stresses the importance of taking into account cumulative and regional effects of multiple activities associated to the development of unconventional hydrocarbons such as shale gas (water use, waste water management, land use, air quality, traffic and noise).

3.1.2.6. Residual risks

The next section presents the gaps in the current regulatory framework, highlighting how some of the risks presented earlier are currently left un-tackled or unclearly managed. This analysis, synthetized in annex 14, will form the basis for the definition of the policy options aiming at mitigating the residual risks.

3.2. The regulatory framework applicable

Some of the environmental issues presented above are already covered, at least partially, by the EU environmental acquis and / or by national legislation or industry initiatives. However, for some of the environmental issues presented above, the interpretation of applicable EU legislation is unclear, while other environmental problems remain unaddressed.

3.2.1. The EU legislative framework applicable to unconventional fossil fuels[97]

General EU legislation applies to unconventional fossil fuels. This relates for instance to the Framework Directive 89/391/EEC on the introduction of measures to encourage improvements in the safety and health of workers at work, the Directive (92/91/EC) on minimum requirements for improving the safety and health protection of workers in the mineral extracting industries through drilling, the Hydrocarbon Licensing Directive (94/22/EC), or to the recently adopted Directive on safety of offshore oil and gas operations (2013/30/EU). The EU environmental acquis also applies to unconventional fossil fuels, from planning until cessation, as recalled in a 2011 EC services guidance[98]. Pending further information on the impacts and risks from unconventional fossil fuels activities, the analysis undertaken for this guidance could not conclude as to the appropriateness and sufficiency of such legislation, nor was the document sufficient to prevent diverging interpretations of the EU acquis at national level[99].

93 Golden rules report p.89
94 Although it is unlikely that shale gas production would take place across the whole area.
95 Land take is defined as land being turned into an artificial surface
96 International Energy Agency, Golden Rules Report, Sept. 2012
97 see Annexes 8.5 for precise information on the applicable EU acquis
98 http://ec.europa.eu/environment/integration/energy/pdf/legal_assessment.pdf - It should be highlighted that no conclusions can be drawn regarding the EU acquis on health and safety at work, as this area was not part of the above-mentioned analysis. The on-going ex-post evaluation of the EU acquis in this area (outcome expected in 2015) may address this issue more in detail.
99 As shown in the Milieu study 2013 conducted for DG ENV

Meanwhile, investors who consider shale gas projects in the EU are confronted to uncertainties and unpredictability as to how shale gas activities are dealt with in the environmental acquis, as regards the following aspects:

3.2.2. Uncertainties and ambiguities in the EU environmental acquis applying to unconventional fossil fuel activities, leading to divergent MS interpretations[100]

Ambiguities exist in the application of certain regulatory provisions or pieces of EU environmental legislation. This leads to differences in understanding at national level as to which rules apply to hydraulic fracturing and associated practices (e.g. legislation on water, waste, environmental impact assessment, industrial emissions and liability – see annex 9 for details), which, in turn, does not provide legal certainty nor guarantee that impacts and risks be optimally addressed. In particular:

- Member States have different interpretations as to whether or not high volume hydraulic fracturing is allowed and under which conditions under the water legislation (**Water Framework Directive** (2000/60/EC) and **Groundwater Directive** 2006/118/EC). There are also divergent interpretations as to whether or not wastewater resulting from high volume hydraulic fracturing can be injected underground for disposal[101].
- There are also diverging interpretations with regard to **waste provisions** and how they apply to injected fluids remaining underground: some Member States consider that the latter would qualify as mining waste and therefore be subject to the Mining Waste Directive provisions, while others consider it would not. Operators have also requested clarification as to whether wastewater is still waste if it is re-used in other fracturing operations[102].
- In addition, there are differences in understanding at national level as to when **an Environmental Impact Assessment** (EIA) is required and whether or not it covers the concession area, the well pad or wells individually. EIA-related requirements for unconventional gas exploration and/or extraction differ amongst Member States. While certain Member States require a mandatory EIA for both exploration and extraction of unconventional hydrocarbons (e.g BG; LT), or for drilling projects involving the use of hydraulic fracturing at both phases (DK; AT), other Member States transposed the EIA Directive without a specific reference to unconventional gas activities or hydraulic fracturing, leaving the authorities decide on a case by case basis. The absence of a systematic EIA for shale gas exploration and production projects is perceived as an issue by the European Parliament[103] and certain stakeholders (e.g environmental NGOs), which consider that this results in a sub-optimal knowledge basis for licensing decisions and does not allow for public consultation. This perceived issue is also raised in studies conducted for the European Parliament[104] and the Commission[105].

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100 This section and the following ones are mostly based on "Support to the identification of potential risks for the environment and human health arising from hydrocarbons operations involving hydraulic fracturing in Europe", AEA, Sept. 2012 and on the findings of the Milieu study 2013 conducted for DG ENV in eight selected Member States (BG; DE; DK; ES; LT; PL; RO; UK)

101 Milieu study for DG ENV, 2013

102 OGP position paper, July 2013

103 The European Parliament resolution on environmental impacts of shale gas and shale oil extraction activities adopted on 21 November 2012 calls for the insertion of projects including hydraulic fracturing under Annex I of the EIA Directive.

104 Impacts of shale gas extraction on the environment and on human health, 2011 commissioned by the Environment Committee of the European Parliament

105 AEA 2012

- There are uncertainties surrounding the application of the **Integrated Pollution Prevention and Control (IPPC)/Industrial Emissions Directive** (IED): As of March 2013, only one Member State out of the eight examined would require an IPPC (/IED) permit for unconventional gas projects. As a result, it is uncertain whether project-specific measures such as those aimed at mitigating emissions to air are required or not. In the 8 Member States examined, decisions may or may not be taken on a case by case basis by authorities. The Effort Sharing decision applies to fugitive methane emissions but this would depend on whether the latter are correctly reported in the GHG inventories, which is unlikely to be the case at present.
- There are divergent views on the applicability of strict **liability** to unconventional gas activities. Under the Environmental Liability Directive, activities associated to HVHFHD such as management of mining waste are covered by this strict liability regime, however the whole lifecycle of the project may not be fully encompassed under the ELD (e.g.underground risks). The requirements applicable to the post-closure phase are also subject to uncertainties: the Mining waste Directive requires a **financial guarantee**[106] covering all obligations under the permit issued, including after-closure provisions but these relate to the management, closure and after closure of the "waste facility", which would apply, should the underground structure be considered as waste facility. In most of the Member States analysed[107], a financial guarantee is required from the operator prior to the start of the hydrocarbon mining activities, but it does not always cover environmental and health damage.

3.2.3. Consequences of this legal uncertainty

A number of **competent authorities** are unclear as to which rules apply in certain situations and have requested clarification to the EC. At present, "a lot is left to the permitting authorities' discretion"[108], potentially leading to differentiated treatments of projects across/within Member States, resulting in differences in the requirements and timing of permitting procedures and therefore a lack of level playing field across the EU. "This could raise problems, depending on the level of experience and expertise available to the competent authority, given that a thorough understanding of possible impacts and risk pathways is essential and authorisation conditions may not always be fully effective, appropriate and transparent and may lead to a differentiated treatment of projects across/within Member States"[109]. In such a situation, there is no guarantee that a minimum level of environmental protection is ensured everywhere and that competent authorities' interpretation is not legally challenged.

This uncertainty on public authorities' side has, in turn, led to uncertainties for **operators/investors** as to the applicable framework, regarding, eg, the stage in which an EIA is required, whether and when the MWD or IED applies. For instance, the international Oil and Gas Producers association (OGP) requested the EC to clarify the legal status of flowback water as to whether or not it is considered as waste when re-used in other fracturing operations[110]. In addition, relevant provisions of the EU's regulatory framework that can

106 Technical guidelines for the establishment of the financial guarantee in accordance with Directive 2006/21/EC concerning the management of waste from extractive industries (2009/335/EC)
107 Milieu study conducted for DG ENV 2013
108 Milieu study, 2013
109 Milieu study, 2013
110 OGP Position paper, July 2013

apply to such projects are contained in several instruments, which may add to the overall complexity and can further reinforce the legal uncertainty for the involved actors and discourage investment[111].

According to the online EC Public consultation[112], the lack of level playing field for operators due to different national approaches was raised by more than 50% of industry/trade associations as a major or significant challenge while inadequate legislation was raised as a major or significant challenge by about 45% of industry/trade associations.

This situation of legal uncertainty for investors and public authorities reinforces the **public perception** that impacts and risks from HVHFHD activities are not necessarily adequately addressed.

In addition to these unclarities, some of the environmental impacts and risks described earlier are not fully addressed by the legal framework, hence letting the public concerns unaddressed.

3.2.4. Some issues remain unaddressed by the environmental legislation at EU and national level

Analyses[113] of the appropriateness and comprehensiveness of the EU environmental acquis in addressing the impacts and risks linked to shale gas activities have identified the following issues:

- REACH (1907/2006/EC) covers the registration, evaluation, authorisation and restriction of chemicals in the EU[114]. Information on chemical substances which have been registered under REACH and for which registration dossiers have been submitted to the European Chemicals Agency (ECHA) are made electronically available[115], unless certain information is listed as confidential for reasons of commercial interests. No proposal for specific restrictions[116] on the **use of chemicals** for hydraulic fracturing purposes has been made so far (which is a perceived gap by certain stakeholders[117]). The ECHA dissemination portal does not allow at present for a search of substances registered for use in hydraulic fracturing nor does it allow for the **public disclosure** of chemicals used specifically for hydraulic fracturing on a well by well basis (which has been recommended by a wide range of stakeholders including academic experts, the International Energy Agency and most respondents to the EC public consultation).

111 Legal uncertainty was raised among the possible reasons for some international shale gas companies announcing their intention to leave Poland in 2013

112 See consultation report (BioIS) p. 41

113 Notably in reports commissioned by the European Commission and the European Parliament as well as by Member States

114 For further information on the registration, authorisation and restriction processes, please refer to Annex 9.6.

115 Such as the classification and labelling of the substance and physiochemical data or results of toxicological and ecotoxicological studies. Information accessible on the ECHA website (http://echa.europa.eu/web/guest/information-on-chemicals/registered-substances) is available per substance and should be searchable by "uses" by the end of 2013. It does not provide information on a well-by-well basis.

116 Under REACH, a restriction process can be initiated on a case by case basis, subject to an initiative of Member States or ECHA after it is demonstrated that a substance poses an unacceptable risk to health or the environment.

117 Food and Water Europe position paper, 2013

- At national level[118], no public disclosure of chemicals used for hydraulic fracturing could be identified in law in the Member States examined, although this can be requested as part of the EIA/permitting conditions in certain Member States.
- National requirements applicable to the **geological characterisation** prior to the extraction of conventional hydrocarbons are typically general and do not necessarily provide a level of underground risk characterisation that would be sufficient to prevent, manage or reduce risks associated with HVHFHD projects (e.g presence of faults, abandoned wells, deep aquifers). At EU level, the Water Framework Directive does not provide for particular technical parameters to support site-specific hydrogeological risk assessments. The Mining Waste Directive provides for geological and hydrogeological parameters to be taken into account prior to the location of "waste facilities" and the Commission decision on waste characterisation (2009/360/EC) refers to geological aspects, geotechnical and geochemical behaviour of the waste. However, their application relies on the qualification of the underground structure as a "waste facility" which is subject to diverging interpretations at national level (see above section). The sub-surface dimension of projects is not explicitly mentioned in the existing EIA Directive[119] and there is no detailed coverage of geological/hydrogeological aspects as part of such an assessment.
- The EU acquis does not provide for project-specific regulatory requirements on **baseline reporting** (of e.g water, air, seismicity) prior to drilling or fracturing, which would form a comparison point to monitor whether environmental conditions are changed afterwards or in case of incident. The Water Framework Directive, as a horizontal instrument to ensure water protection, requires baseline water monitoring at river basin level but not specifically at the project site. Groundwater baseline reporting would be foreseen under the IED, but its applicability to shale gas projects is uncertain (see above section). The Mining Waste Directive requires the operator to locate, construct, manage and maintain the "waste facility" so as to prevent pollution or contamination of soil, air, surface water or groundwater in the short and long-term perspectives. This does not explicitly refer to the need for baseline reporting. Among the Member States examined[120], no specific regulatory requirements on baseline reporting prior to drilling or fracturing have been identified at national level. These may be set under the EIA or permit conditions on a case by case basis, but without explicit legal guarantee.
- The EU acquis does not include specific legal requirements **on monitoring of the hydraulic fracturing process**. Among the Member States examined, only the UK and Denmark have specific provisions[121] at permitting level for monitoring seismicity induced by hydraulic fracturing.
- **Air emissions** from HVHFHD activities are currently not subject to project specific EU provisions[122]. There are no particular legal restrictions on venting or flaring at national level, although a few Member States may set limits in the permit conditions.
- **Strategic planning and environmental assessment** at the level of the shale gas play: At present, only a few Member States are developing plans or programmes setting the

118 Milieu study conducted for DG ENV based on information collected until April 2013 in eight Member States.
119 Subject to an on-going revision
120 Milieu study commissioned for DG ENV, 2013
121 ibid
122 unless the IED applies. The MWD requires the prevention or reduction of dust and gas emissions from the management of extractive waste.

framework for shale gas projects (e.g Lithuania and the UK[123]). Adopting such plans or programmes triggers, under current EU legislation, the obligation to conduct a strategic environmental assessment. In the absence of such plans or programmes, Member States would have complete latitude to take or not into account, at an early stage, the cumulative effects of shale gas development over large areas.

3.2.5. Extent to which environmental risks and impacts remain unaddressed, despite existing legislation

Annex 14 presents the links between, on the one hand, the environmental problems and drivers and, on the other hand, the existing initiatives (legislative or not) able to cover them. By identifying the remaining gaps, it also shows which of the environmental issues (problems and drivers) remain insufficiently covered. It shows that, for all environmental issues, some important aspects are not or only partially tackled by existing legislation and practices.

3.3. Public acceptance issues

Acceptance of shale gas projects in the EU varies by Member State and overtime[124]. Currently, in several Member States, and even in the ones in which governments support shale gas, public opposition is quite vocal, with local, regional or national actions (marches, public meetings…). The European Parliament PETI Committee received more than ten petitions from six Member States[125], some of which signed by some 15 000 citizens, most calling for a ban or a moratorium on shale gas and/or the use of hydraulic fracturing, on the basis of health and environmental concerns. The Committee of the Regions has published a draft opinion in which it "stresses that addressing health and environmental risks will be of paramount importance if the industry is to gain public acceptance and calls on the EC to deliver a framework on managing the risks and addressing shortcomings in relevant EU regulation"[126].

Most of the concerns raised among the public relate to risks of water and air pollution, through the release of chemicals in the fracking fluids and through methane and VOC emissions. Seismic risks rank also high in the public worries. The consistency of the further extraction of fossil fuels with commitments towards a transition to low carbon energy sources is also being questioned. In addition, and as for any other potentially polluting activities, local populations tend to oppose to the projects developments too close from their habitations (Not In My Backyard effect).

Public protests often refer to the insufficient level of precaution, transparency and consultation applied to these activities. When asked about what they consider as the main challenge of the sector development, about 60% of individual respondents to the EC consultation (unweighted rate, rising to about 80 % in the weighted case) identified the lack

123 ibid

124 In Poland, public acceptance is higher than in any other EU Member State, with some 60% of the Polish individual respondents to the EC public consultation (March 2013) in favour of shale gas developments, whatever the conditions are. According to the Eurobarometer survey released in January 2013, public opinion in Poland is evenly divided between those welcoming the opportunities of shale gas in their area and those expressing concerns. However, there have also been some local protests in Poland, e.g. recently against Chevron.

125 RO, PL, DE, UK, BG and FR

126 Point 8 of the draft opinion for the 7-9 October 2013 Plenary session: http://cor.europa.eu/en/news/Pages/fracking-environmental-impact.aspx

of transparency and public information (together with inadequate legislation) as the main challenges. There is indeed an asymmetry of information between the operators and competent authorities or the general public, in particular in relation to the composition of fracturing fluids, as well as to the characterization of the underground. Operators do not necessarily have all incentives to release full information about the composition of the injected materials and the geology in which they intend to drill (e.g. proprietary information, fear to alert local communities).

In addition to complaints about insufficient consultation and information sharing, public opposition also stems from doubts about the effectiveness of the current EU and national legislative framework, in particular as regards mining legislation, environmental impact assessment or air and water protection (as echoed in numerous parliamentary questions, e-mails and petitions received by the Commission over the past two years).

In response to these public concerns, a number of EU Member States or regions, including the United Kingdom[127], the Netherlands, North Rhine Westphalia (Germany), Cantabria and La Rioja (Spain), Romania[128], Denmark have adopted temporary moratoria on hydraulic fracturing practices and two Member States (France and Bulgaria) have enacted legal bans on the use of hydraulic fracturing for exploration and exploitation of hydrocarbons. Germany has prepared draft legislation to ban fracking in water protection areas and provide for a mandatory Environmental Impact Assessment for activities involving hydraulic fracturing[129].

Although depending on specific social contexts, public perception and acceptance of different kinds of risks are based on the information provided on these risks, and therefore on the remaining uncertainties. In the risks perception of a large part of the EU population, shale gas activities are more salient than other activities (conventional fossil fuel extraction e.g.), as demonstrated by the current moratoria in place, by the Eurobarometer survey and by the responses to the EC public consultation.

Evidence suggests that public concerns might be lessened as long as certain important conditions for the protection of the environment are met. Although risk aversion may be sometimes greater than what is justified scientifically, as long as uncertainties remain at a level considered too high by the society, public concerns would persist. Building sufficient knowledge, based on reliable and verifiable data collection and further research on the issues of concerns, takes time. While this is being built, a precautionary approach can reassure the public over short and long term risks[130].

A number of experts[131] and the respondents to the online consultation undertaken for this impact assessment consider that the lack of public acceptance represents a barrier to further unconventional gas development[132]. The oil and gas industry itself has highlighted this as a key issue, already encountered at the exploration stage[133].

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127 As of December 2012, the United Kingdom lifted its moratorium and is in the process of considering new applications from operators, while developing guidance.

128 Romania lifted its temporary moratorium following parliamentary elections in December 2012.

129 Draft law proposed by the Ministries for Environment and Economy in Spring 2013, not adopted before the election of Sept. 2013, but part of the post-election Coalition treaty.

130 The recent report of the European Environmental Agency on "Late lessons from early warnings" (EEA Report No 1/2013) highlights the fact that policy makers have to be particularly attentive to early warning signs of environmental risks associated to new technological developments, which are spreading fast, and hence challenge the capacity of societies to tackle the associated risks in due time.

131 eg International Energy Agency Golden rules report, US Department of Energy 90 days report

132 Public acceptance was among the three main challenges identified by respondents in the EC public consultation.

133 E.g JRC IET workshop on shale gas, March 2013

4. BASELINE

4.1. Foreseen shale gas development in the EU

Among the Member States preparing for possible shale gas exploitation, some are pressing ahead with exploration projects and express willingness to exploit their shale gas resources as soon as possible, while other are keen to conduct further scientific studies before granting new exploration licences.
In Poland, 108 concessions for prospecting and exploration of hydrocarbons from shale gas formations have been granted so far[134], with several production tests already conducted[135]. Up to 345 wells are planned to be drilled by 2021 (122 obligatory wells according to licensing conditions and 223 optional ones)[136]. In the United Kingdom, four shale gas wells have been drilled so far, one of which has been fracked[137] and two exploratory wells are expected to be hydraulically fractured in 2014. Extensive development of well pads across the current licensed area in Northern Ireland is expected, should the commercial viability of the resource be proven by current exploratory works. Commercial shale gas production could start in these two Member States as of 2015-2017. The IEA Golden rules scenario foresees that EU could have about 50 000 wells in 2035.

Further prospecting and/or exploration is on-going or may be planned notably in Lithuania, Denmark, Portugal, Spain, Romania, Hungary, Ireland and Sweden (see Annex 11 for details). A ban on the use of hydraulic fracturing for the exploration and exploitation of oil and gas is in place in Bulgaria and France.

To allay public concerns and enhance local acceptance, information campaigns about shale gas potential impacts and benefits have been set up in certain Member States[138] and measures to associate local communities to the potential returns are envisaged in the Member States currently most advanced (in Poland and UK, possible financial incentives / sharing of benefits with local communities are being discussed). Demonstration projects are foreseen by certain industry players[139]. However, the extent to which these initiatives will prove sufficient to ensure wide public acceptance in the short to medium term is uncertain.

4.2. Foreseen regulatory developments at EU and MS level

At EU level, a revision of the EIA Directive is currently discussed by the legislator and the outcome of this discussion will be integrated into the analysis undertaken for this impact assessment[140]. Some other pieces of EU legislation relevant for unconventional fossil fuel extraction will be reviewed in the coming years (e.g. ELD (2014), Water FD (2019), but it is uncertain whether or not these reviews will lead to revising the legislation (see annex 12 for the foreseen developments under existing EU legislation).

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134 as of 14 June 2013

135 as of September 2013

136 As of 3rd June 2013, 46 shale gas exploration wells were completed, three wells were in the process of being drilled, ten wells with a vertical section were hydraulically fractured; six wells with a horizontal or directional section were hydraulically fractured, three wells were subject to diagnostic fracture injection test or were micro- hydraulically fractured. Source: Official information from Polish Authorities, June 2013

137 Source: Official information from UK authorities, June 2013

138 Public hearings to be organised in three Member States (LT, PL and RO), with EU co-funding from a budget appropriation granted by the European Parliament.

139 e.g Exxon in Germany. Source: JRC IET Shale gas workshop, March 2013.

140 The Environment Committee of the European Parliament on 11th July adopted an amendment of Annex I of the EIA Directive requiring a mandatory EIA both at the exploration and production phases and independently from the amount of petroleum or gas extracted. This will be subject to plenary adoption in the autumn 2013.

In Member States, the situation is mainly characterized by varying national approaches, as described above (see Annex 11).

At national level, a complex array of rules applies, essentially similar to those for conventional gas extraction (see Annex 8 for details), with very few specific requirements for unconventional gas. To regulate such activities, most Member States examined in the study conducted by Milieu for the EC rely mainly on the general mining, hydrocarbons and environmental legislation, transposing the EU legislation, and its related permitting procedure.

At the same time, a number of Member States have started reviewing or revising their legislation in the light of unconventional fossil fuels developments, in particular with regard to environmental protection, and several Member States are beginning to introduce specific measures in their national legislation to deal with unconventional fossil fuels (e.g shale gas) practices.

Such reviews also show varying approaches: for instance, in some countries (e.g Germany, Spain), current draft legislation foresees the specific inclusion of shale gas projects or hydraulic fracturing under the mandatory EIA regime. In Poland, under the recent draft rules presented in June 2013, no screening nor EIA would be required for most shale gas projects[141]. In addition, there is an on-going review of the environmental legislation applicable to shale gas exploration in the UK, of the mining code in France and a proposal in Germany to prohibit hydraulic fracturing in drinking water areas and to impose mandatory disclosure of chemicals[142].

Without further EU action, Member States will most likely pursue current various policies and may further develop specific regulatory frameworks with differing requirements from one Member State to another. Exploratory drillings could be expected to continue in EU Member States that have already issued permits and may be extended to Member States where no moratoria is in place and substantial reserves are predicted based on preliminary geological data, provided there are no significant public acceptability issues. Those Member States that have bans in place or de facto moratoria may continue a "wait and see" approach. Member States which share a shale gas play may need to agree bilaterally or multilaterally on common exploration and production rules, since environmental risks and impacts may occur across borders.

4.3. Foreseen technological developments and industry practices

Reducing environmental risks linked to unconventional fossil fuel extraction and high volume hydraulic fracturing activities is a current area of research, with ongoing work towards making the current practices less environmentally intrusive, e.g. towards using chemicals that would be less hazardous for health and the environment, using alternatives to freshwater[143] or improving waste water management[144]. Since its first commercial application

141 Draft ordinance adopted on 26th June 2013. Poland proposed to exempt drilling projects located above 5000 m depth from national EIA rules. According to a report from the Polish Oil and Gas Institute, shale gas deposits in Poland are typically situated at the depth of 1200 to 2500 m in the north, to the depth of 2500 to 4500 m in the south. Halina Jędrzejowska-Tyczkowska, Polish Shale Gas, Oil and Gas Institute, Krakow, May 2011 available April 2013 at: http://www.inig.pl/inst/nafta-gaz/nafta-gaz/Nafta-Gaz-2011-05-01.pdf The Polish Geological Institute refers to shale gas formations between 1000 m and 5000 m deep. Assessment of shale gas and shale oil resources of the lower paleozoic Baltic-Podlasie- Lubin Basin in Poland, Polish Geological Institute, March 2012, p.12

142 Official information from German authorities. The adoption of the German draft law is pending elections foreseen in the autumn 2013.

143 There is for instance on-going research on the use of Baltic sea water for hydraulic fracturing due to its low salt content.

144 E.g use of closed storage tanks instead of open ponds.

in the US a decade ago, the combined practice of directional drilling with high volume hydraulic fracturing has evolved and some improvements have been made: for instance, according to the industry, water needs have been reduced, a single well pad can now be used for multiple and longer horizontal wells, thus reducing land impacts[145]. Furthermore, the industry has indicated that it is now able to reuse/recycle up to 70-90%[146] of the wastewater recovered after the operations. However, it is not clear whether there are sufficient incentives to do so.

At the same time, techniques alternative to high volume water-based fracturing are being explored and/or tested. Some have reached a commercial stage in North America (e.g. LPG fracturing, CO2 fracturing and propellant fracturing) but are still very little used as compared to HVHFHD, probably for costs and technical reasons (see details in annex 13)[147]. Depending on the applicability of the alternative techniques to European geological conditions, those could provide an alternative to HVHFHD in the future. However, HVHFHD is likely to remain the dominant technology for the next few years (5 to 10 years) according to the majority of experts in the field[148]. Therefore, public concerns, which are mostly associated to this technique, are likely to remain.

The industry may continue developing good practices. The oil and gas federation (OGP) has launched a website[149] to voluntarily share information about chemicals, once they have been injected for shale gas operations in the EU, on a well-by-well basis. It follows the same approach as the American FracFocus web-based registry[150]. However, the completeness and timeliness of the information released in a register such as Fracfocus has been questioned[151].

4.4. Foreseen developments of the problems

Without further EU action, shale gas developments may continue in certain Member States, where it may become established and, ultimately, publicly accepted. However, throughout the EU, a heterogeneous development of rules at Member States' level is likely to take place, with possible strengthening or weakening of national environmental protection in different Member States. In some Member States, over-protection may lead to exaggerated production costs; in others, possible incidents due to insufficient protection may fuel public opposition, even in Member States other than the ones in which incidents happen. Without a clear legislative environment, there is a risk that the national or regional interpretations and practices become legally challenged. Current moratoria might remain in place due to public acceptance issues.

Even though the techniques used by the industry are likely to evolve, best practices or Best Available Techniques will not necessarily be widely taken up at a sufficient speed (e.g. in the

145 However, land impacts are still likely to be larger than in conventional extraction since it is estimated that approximately 50 shale gas wells might be needed to give a similar gas yield as one conventional gas well (AEA 2012)

146 e.g. Voluntary agreement between environmental organizations (incl. EDF), philanthropic foundations, energy companies (incl. Chevron, Shell) and other stakeholders in the US to maximize water recycling with a 90% target.

147 Furthermore, the technique that appears the most advanced (propane-based) would, according to industry sources, fall under the Seveso Directive due to the volumes involved. In addition, according to service companies, fracturing products not relying on water-based products are currently a niche market and not common practice.

148 Industry representatives interviewed by the French 'Office parlementaire d'évaluation des choix scientifiques et technologiques (Opecst) in view of a report on alternative techniques clearly stated that there is no alternative to hydraulic fracturing at the moment: http://www.senat.fr/compte-rendu-commissions/20130415/opecst.html#toc4

149 www.ngsfacts.org, launched on 18 June 2013

150 *www.fracfocus.org*: publicly accessible website providing information on hydraulic fracturing fluid products, including trade name, supplier, purpose and composition used in the US.

151 Konschnik, K., Holden, M., & Shasteen, A. (2013). *Legal Fractures in Chemical Disclosure Laws.* (p. 15). Harvard Law School. Retrieved from http://www.law.harvard.edu/news/2013/05/03_hls-study-finds-legal-fractures-chemical.html

USA, the green completion mechanisms have not taken up even as widely as expected as companies found it easier to drill new wells instead of capturing (and selling) the gas exiting the existing wells).

Environmental problems might materialise, sometimes with some delay, while cumulative impacts of the sector development might remain mostly unaddressed, thereby increasing pressure on land, air and water. The IEA Golden rules scenario foresees, in a high development scenario, 50 000 wells in the EU in 2035, which would, in certain areas, exacerbate competition over land and water use[152], even more so if climate change leads to reduced precipitations in already water-stressed regions (see map in annex 5.6). For illustration purposes, applying to this number of wells the estimated likelihood of incidents currently used by the US Department of Interior of 0.03 % and 2.70% per hydraulic fracturing operation[153] would lead to an occurrence of 150 to 13 500 incidents over the period (in case no mitigation or risk management measures are implemented).

A summary of the baseline and remaining gaps is provided in annex 14. It shows that, under the baseline scenario, the current problems identified are likely to remain.

5. WHO IS AFFECTED AND HOW?

5.1. Directly:

- Local communities and individuals in the vicinity of shale gas activities:
  - can benefit from increase in local economic activities, with new jobs opportunities, in the shale gas activities but also in the related local sectors (e.g. housing[154], catering).
  - may be facing environmental, health and safety risks and impacts (as described earlier).
  - are sometimes offered (by the shale gas operating companies) payments if shale gas activities develop in their neighbourhood, to compensate for nuisances and possible damages[155].
  - impacts on land price can be twofold, with a possible upward trend in land price at first as demand will increase with shale gas developments (as with any economic activity). However, shale gas activities might in the longer term negatively affect local land and housing prices[156].
- Market operators who are likely to be willing to invest in shale gas activities in EU: those include large international oil and gas companies such as Exxon, Chevron, Total, Conoco Philips, Talisman, Marathon Oil, San Leon Energy, Dart Energy, Repsol. European (partly) state-owned companies are also present (PGNiG in Poland,

152 The US EPA study on impacts of fracking on water (2011-p.22) compares the yearly water use for 35 000 wells using hydraulic fracturing in the US in 2006 to the yearly consumption of 40- 80 cities of 50 000 inhabitants or 1-2 cities of 2.5 million people .

153 Estimates refer to individual fracking stages. To initiate production, a well is typically fractured in 10-15 stages. This might be repeated several times during the life time of a well. Currently 10 700 horizontal wells are permitted in the Marcellus shale (www.macellusgas.org) implying the occurrence of 30 to about 3000 incidents.

154 On the increased demand in housing, see e.g. : http://www.marcellus.psu.edu/resources/PDFs/housingreport.pdf; and similarly on the "Boomtown economy": http://cce.cornell.edu/EnergyClimateChange/NaturalGasDev/Documents/City%20and%20Regional%20Planning%20Student%20Papers/CRP5072_Housing_Final%20Report.pdf. However, the impact on housing price seems to be twofold in the US, as shown in a report from the NBER (2012): http://www.nber.org/papers/w18390.pdf?new_window=1 : In a 2 km area around shale gas wells, properties prices decrease up to 24 %, due to increased groundwater pollution risks.

155 See e.g. http://www.ukoog.org.uk/news.php

156 http://www.rff.org/RFF/Documents/RFF-DP-12-40-REV.pdf

EBN in the Netherlands, Romgas SA in Romania and Basque Energy Board in Spain).

- Companies providing products and services to operators, such as hydraulic fracturing and drilling services (rigs, cementing, steel casing) and chemicals providers. Those are so far mostly large international ones (e.g Dow Chemicals, Halliburton, Schlumberger) but it can be expected that some EU SMEs would also get involved. This is likely to happen as far as general services are concerned (e.g catering, transport), but also for more specific sectors (rigs and compressors providers e.g.).
- Downstream companies, and in particular wastewater treatment companies, that would see an increase in the volume of wastewater to treat.
- Competent authorities (local, regional, national) involved in permitting, oversight, risk management and collecting royalties and taxes (also sometimes offering tax cuts to operators and compensations to local communities).

5.2. Indirectly:

- Energy consumers (individual and companies, especially in energy-intensive sectors and sectors using gas as a raw material[157]), affected by possible changes in energy prices and in security of supply.
- Fossil fuel companies (other than shale gas) if the concerns raised about HVHFHD spill over to their sector.
- Other energy producers, who might be facing competition from increased gas production or conflicting uses of the underground. In some cases (e.g CCS, geothermal energy production, energy storage), an accumulation of underground activities might be perceived as a risk and therefore compete in public acceptance.
- Economic sectors facing a possible competition over key resources:
  - In terms of quantity (and price): in water-scarce regions, water used for HVHFHD might lead to a lower availability of (and / or a higher price for), eg water for agricultural use;
  - In terms of quality: water-using sectors (drinking water, food and drinks in general, agriculture) have expressed concerns that shale gas development could affect the quality (and availability) of the water they use, or at least of the perception of its quality, hence leading to possible reputational damages[158]. Tourism might suffer from reputational damages in shale gas areas.
- Member States in general, especially those with high gas import dependency and / or high carbon intensity of their economy.

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157 E.g. for manufacturing ammonia (precursor to fertilizers and food), natural gas would represent 80% of production costs; for nitrogen fertilizer, between 40 to 80% of manufacturing cost would be natural gas. *Source: Fertilizers Europe.*

158 For instance, German brewers have raised in May 2013 the risk of polluting water used for beer brewing and asked for more research before allowing the extraction of shale gas: http://euobserver.com/tickers/120226; Water UK, which represents all major water suppliers in UK, have also raised concerns (see July 2013 press release: http://www.water.org.uk/home/news/press-releases/challenge-on-gas-fracking?printme=true&_frameset=true). In Germany again, an Alliance of Water and Beverages industries, gathering more than 700 companies, demanded in Nov. 2013 a fracking ban, to preserve the water quality (http://www.spiegel.de/wirtschaft/soziales/fracking-buendnis-von-700-wasser-unternehmen-fordert-strenges-gesetz-a-935035.html).

6. THE EU'S RIGHT TO ACT AND JUSTIFICATION

EU right to act: Treaty base

As per Article 191 of the Treaty on the Functioning of the European Union (environment), the "Union policy shall aim at a high level of environment protection taking into account the diversity of situations in the various regions of the Union. It shall be based on the precautionary principle and on the principles that preventive action should be taken, that environmental damage should as a priority be rectified at source and that the polluter should pay". It stems from this that the EU has the right to act in order to address environmental impacts and risks as well as to clarify and/or complement existing environmental legislation. This therefore applies to environmental risks and impacts associated to HVHFHD activities, while fully acknowledging that choices of energy mix remain in the hands of Member States (Art 194.2).

Subsidiarity: is the EU better placed than Member States to act?

Necessity test: Environmental risks and impacts may ***spread across national borders***. This is in particular true for surface and ground waters[159], as well as for air quality and GHG emissions. Although available evidence (from the US) does not show geographically wide-spread effects of water pollution from shale gas extraction, this cannot be excluded: there are at least 268 transboundary groundwater bodies[160] in the EU and several shale gas plays spread across borders of Member States (e.g. Bulgaria-Romania; Ireland-United Kingdom; Poland-Baltic states)[161]. In order to avoid that possible impacts in one country give rise to, or worsen, pollution problems in other countries, action could be undertaken bilaterally at MS level. However, this would not be sufficient to deal with issues where several countries are involved (GHG and air emissions e.g.). The need to address cross-border environmental issues related to shale gas development was highlighted by several Member States[162].

EU Value Added test: Article 194 of the Treaty on the Functioning of the European Union (energy) stipulates that the Union policy on energy shall aim, in a spirit of solidarity between Member States, to inter alia ensure security of energy supply in the Union. A 2013 study of the EU Commission on the economic benefits from the completion of the internal energy market demonstrates that addressing security of supply within national boundaries only results in welfare losses[163].

Possible development or incidents occurring in one country are likely to influence the public perception of shale gas activities in other countries either positively or negatively.

While regulation of shale gas activities may be adopted at national level to provide some domestic legal certainty, a multiplication of (possibly inconsistent) national approaches and uncertainties as regards the applicability of EU environmental legislation would send mixed signals to investors and weaken the perceived predictability of operating frameworks within the EU. This would become ever more problematic in case of cross-national shale gas plays. An EU-wide approach that would tackle the current ambiguities and gaps in the EU legal

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159 See map of groundwater aquifers in annex 5.7. A hundred of cross-border karstic aquifers particularly sensitive to contamination may be close to shale gas formations.

160 In their River Basins Management Plans (RBMPs), Member States reported 268 trans-boundary Ground Water Bodies. This information is likely to be under-estimated as information reported in RBMPs was not always complete

161 see map in section 2.3.2

162 July 2013 Informal Environmental Council; 2012 and 2013 meetings of the Technical Working Group of Member States on environmental aspects of unconventional fossil fuels.

163 http://ec.europa.eu/energy/infrastructure/studies/doc/20130902_energy_integration_benefits.pdf

framework would therefore make the economic case of shale gas clearer. It would also contribute to developing credible knowledge-based risk response strategies, thus better responding to public concerns and public authorities' questions about the applicability of the EU environmental acquis.

Although most shale gas reserves are located on-shore, lessons can be learnt from the evolution of the EU legislation applicable to off-shore fossil fuels extraction. For years, the regulatory framework for offshore oil and gas in the EU was characterized by a variety of national safety approaches. This became to be seen as a shortcoming as the sector developed and public worries over oil and gas spills increased. In particular, concerns were raised as regards the "inconsistency of emergency planning between Member States", the "incompleteness of existing liability regimes", the "lack of evenness in compliance of individual operators with the rules and regulations applicable in respective jurisdictions" and "the uneven technical expertise amongst regulators in the EU"[164]. To respond to these concerns, the newly adopted Offshore Safety Directive[165] harmonizes national approaches to safety as regards offshore oil and gas prospection, exploration and production activities.

Lessons can also be drawn from the evolution of Northern American regulation as regards large scale unconventional fossil fuels production. For instance, the US EPA has adopted specific mandatory air rules aimed at reducing VOCs and methane emissions and is working on developing wastewater discharge standards and updating chloride water quality criteria[166]. The US Bureau of Land Management has released draft fracking rules to be applicable to public land. Several States have also strengthened their regulatory framework.

Action at EU level does not put into question the right of Member States to go beyond requirements of the EU environmental acquis.

7. OBJECTIVES

7.1. General objectives

The general objective of this initiative is to ensure that unconventional fossil fuels developments, in particular shale gas, are carried out with proper climate and environmental safeguards in place and under maximum legal clarity and predictability for competent authorities, citizens and operators, providing a level playing field for its safe and secure extraction. This is a key enabling condition to reap the potential economic and energy security benefits of such developments, while respecting the EU's commitments towards decarbonisation, environmental protection and resource efficiency.

7.2. Specific objectives

- To ensure that environmental (including climate) impacts and risks arising from HVHFHD activities are identified and managed, both as regards individual projects and cumulative developments;
- To clarify, in a timely manner, the EU legal framework applicable to shale gas developments.

[164] Offshore IA, p. 11, 12: SEC/2011/1293 final
[165] adopted on 10th June 2013 (2013/30/EU)
[166] http://www2.epa.gov/hydraulicfracturing

Based on the available literature and experts' views, Annex 15.2 associates to each identified environmental issue an area of action in which expert recommendations and best practices can be defined, that also correspond to the areas identified in the IEA Golden Rules (see annex 15.1). For instance, in order to ensure water protection, well integrity has to be ensured, site selection carefully conducted and underground risks characterisation undertaken, water and waste carefully managed and chemicals use controlled and disclosed. Seven specific areas are identified (air, groundwater and surface water, chemicals, underground risk characterisation, well integrity, wastewater management and treatment,) as well as six cross-cutting ones (site selection and planning; liability; monitoring and reporting; environmental assessment; disclosure of information; permitting, inspections and enforcement).

7.3. Operational objectives

- For each of the 13 identified areas, to ensure that expert recommendations and best practices for HVHFHD are implemented in a systematic and timely manner, taking into account geological specificities, in order to ensure that the associated environmental impacts and risks are effectively addressed in a proportionate way.

- To clarify the applicable legal framework as soon as possible and preferably before the commercial development of the sector, in order to ensure clarity for investors and public authorities and to reassure citizens that environmental risks and impacts associated to HVHFHD activities are adequately addressed.

7.4. Consistency of the objectives with EU policies and strategy

These objectives are consistent with broader EU goals, such as security of energy supply, growth and jobs, decarbonisation and resource efficiency.

With a clearer regulatory framework, the shale gas sector can develop in a more secure way, hence potentially ensuring wider effects on EU security of supply and growth and jobs.

In addition, gas is considered as a potential transitional fuel towards a decarbonized energy sector, at least until 2030, should it substitute more carbon-intensive fuels (coal in particular[167]), be used as a potential back-up for intermittent renewable energy[168] and without delaying further energy efficiency efforts. Addressing the GHG emissions stemming from shale gas extraction[169] therefore contributes to the overall consistency of the approach[170].

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167 Under the AEA 2012 study commissioned by DG CLIMA, a hypothetical analysis of potential lifecycle GHG emissions from shale gas exploitation within Europe concluded that emissions from shale gas based electricity generation (CO2/kWh electricity) would be significantly lower (41% to 49%) than emissions from electricity generated from coal. AEA analysis was based on methane having a 100-year Global Warming Potential of 25, as the UNFCCC reporting guidelines recommend using 100-year time horizon for compiling greenhouse gas inventories. The use of 20-year GWP of 72 from the IPCC Fourth Assessment Report would certainly increase lifecycle emissions for electricity generation from shale gas, but these would still be lower than emissions from electricity generated from coal using the same assumptions. The study however underlines the scarcity of data available on methane emissions from shale gas operations.

168 On the other hand, as noted in the Energy Roadmap 2050 (p.10), "with sufficient interconnection capacity and a smarter grid, managing the variations of wind and solar power in some local areas can be provided also from renewables elsewhere in Europe. This could diminish the need for storage, backup capacity and baseload supply."

169 In particular methane, with a very high GHG potential. According to DG CLIMA study Sept. 2012, in the worst case (where all flowback emissions at well completion are vented), shale gas emissions would be similar to the upper emissions level for electricity generated from imported LNG and for gas imported from Russia.

170 As noted in the Energy Roadmap 2050, for all fossil fuels, Carbon Capture and Storage would need to be applied from around 2030 onwards in the power sector in order to reach the decarbonisation targets.

Addressing the air, water and land impacts that could result from shale gas development contributes to delivering on the commitments made in the Resource Efficiency Roadmap[171] as well as in the new Environment Action Programme to 2020[172].

8. POLICY OPTIONS

8.1. General considerations

It has been shown that some of the risks and impacts identified in the problem definition are not sufficiently covered by existing legislation or current industry practices or that the management of such risks and impacts may be currently uneven[173]. In tackling these remaining risks and their management, the right balance needs to be found to ensure the *proportionality of the measures* proposed to the impacts and risks at stake, as well as their perception (some risks might be higher in public perception than in experts' assessment, e.g. seismicity risks). More stringent measures could be expected for more severe risks of public health and environmental damages (e.g. water contamination and air emissions), hence better responding to acceptability issues. A balance is to be found to ensure an appropriate level of environmental protection and precautionary approach, in particular in cross-border contexts, while leaving flexibility to Member States to cater for specific local geophysical conditions.

A balance is also to be found between measures aiming at preventing a problem (e.g. by obtaining a thorough knowledge of the geology before starting operations, hence making it possible to drill in areas where risks and impacts are lower) and measures aiming at remediating its consequences (e.g. by making sure that contaminated wastewaters are safely treated, with the costs of externalities borne by the polluter).

In order to reassure the public and to follow a precautionary approach, preventive measures are more adapted and would be more effective if targeted at the sources of the problems, also entailing that the same measure could act on several problems. There could be an inversely proportional link between the stringency of the approaches taken for prevention and remediation/liability: if a rigorous measure is implemented to ensure the prevention of damages, then the need for remediation measures would be lower, and vice versa. However, since it can never be assured that prevention will always be enough (incidents/accidents happen), remediation and liability measures would always have to be to some extent foreseen.

In any case, due to the early stage of development of the sector in the EU and the technological nature of the activity, the approach taken in defining the options has to be flexible: the content of the options can be better defined in ways of implementing key principles and measures for addressing environmental impacts and risks (as set out e.g. in the Golden Rules and recommended by many other experts) rather than in very precise or prescriptive terms.

8.2. Areas of actions and technical measures to tackle the identified environmental and climate challenges

Based on experience from North America, the work of the International Energy Agency, recommendations put forward by a wide range of experts, including in reports commissioned by Member States and the Commission, 13 areas of action were identified in order to address

[171] See Roadmap to a Resource Efficient Europe, COM(2011) 571 final
[172] http://ec.europa.eu/environment/newprg/index.htm
[173] see annex 14 for details

the environmental problems identified in Chapter 3.1 and assessed against existing legislation (see annex 15.2 and 16.1 for details on these areas). These areas of actions were considered as "important or very important" by more than 63% of the individual respondents (un-weighted) to the public consultation undertaken for this impact assessment. Such areas include, e.g. the assessment of cumulative impacts, imposing a distance between drilling and sensitive zones (eg aquifers, high density dwellings or fragile biodiversity zones), adequate characterisation of the underground, ensuring integrity of the wells, disclosure of information, specific waste and water management measures.

Within these areas of action (that broadly correspond to the Golden Rules principles put forward by the IEA – see annex 15.1, but also to the UK guidance and consultative documents[174] and the German draft bill), measures were identified, aiming at providing illustrative examples, also to be used for estimating the costs of the options[175]. Wherever it was possible from a technical perspective, measures of different levels of stringency were identified (i.e. technical sophistication or level of prescriptiveness). For example, the area of action related to underground risk characterisation could be addressed by one of the following aggregated measures:

1. Basic risk characterisation based on available data,

2. Collection and assessment of specific geological and hydrogeological data,

3. Modelling of operations and their impacts.

Potential measures to address a given risk were limited by available technologies. In most cases, measures appeared more complementary than offering true alternatives.

All measures identified are relevant as soon as a project stage foresees HVHF, hence already for some parts of the exploratory stage. Some of the measures identified would apply in advance of HVHF operations, as they aim at preventive measures (eg, measures dealing with underground risk characterisation, well integrity or baseline reporting) and make more sense if implemented before HVHF takes place.

For exploration stages not involving HVHF (e.g exploration phase in which only vertical drilling and core sampling are concerned), no measures are proposed beyond the existing ones. This delineation in the application of the proposed measures between phases involving or not HVHF is fully in line with experts' views which associate environmental risks to this technique[176], and it is also addressing the source of public concerns. Therefore, all options proposed would apply when HVHF is foreseen to be used, but not to the preparatory stages not involving HVHF (such as vertical drilling and core sampling).

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174 https://www.gov.uk/oil-and-gas-onshore-exploration-and-production; http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1317140158707

175 See AMEC report for a presentation of the individual measures

176 See inter alia, CIRAIG Study on the environmental lifecycle of shale gas (non peer-reviewed study done for the Quebec government), Aug. 2013: http://ees-gazdeschiste.gouv.qc.ca/wordpress/wp-content/uploads/2013/09/Rapport-etude-GES1-1-et-EC2-3_CIRAIG.pdf, which shows that between 15 and 25% of the Life cycle impacts (taking into account damages in terms of human health, ecosystems quality, climate change and resources occurs in the exploration phase, even before the pilot production testing starts.

8.3. Description of policy options: Instruments to implement the measures

For each of the areas of action (corresponding to the broad principles to be covered), potential legal and non-legal tools to implement these actions were identified (see Annex 16.2). For some areas, some measures are already required by EU legislation or are standard industrial practice (see annex 14). However, for other areas, no legal requirements have been defined so far.

Since the objective of the current initiative is to ensure that an adequate framework is in place, the options analysed below present different implementation instruments and coverage rather than their technical content, thus allowing flexibility to cater for varying local conditions.

The form of the options range from:

Option 0: Business as usual (baseline)

Option A: Recommendation, guidance and voluntary approaches

Option B: Amendments of parts of the EU environmental acquis (integrating elements of option A)

Option C: Goal-setting legislation (Framework Directive) building on the EU environmental acquis (integrating elements of options A and B)

Option D: Legislation setting specific provisions (Directive) (integrating elements of option A)

Option discarded at an early stage of analysis: An option acting only on remediating the problems (and not on preventing them), displaying a very strict liability regime (e.g requiring operators to set aside money in a fund to address remediation needs after accidents/incidents) was also envisaged and discarded, as it was not deemed practically feasible nor sufficient to respond to public concerns.

*8.3.1. **Baseline***

This option would rely on the existing EU regulatory framework as well as on national legislation. Please refer to chapters 3.2 4.2 for a description of this option.

*8.3.2. **Option A:** Recommendation, guidance and voluntary approaches*

This option would build on a **Recommendation** to Member States covering relevant risks and impacts of shale gas exploration and exploitation over the project life-cycle such as site selection, underground risk characterisation, setback distances from protected/sensitive areas, minimisation of community impacts[177], baseline reporting, monitoring and reporting of

[177] E.g land take, noise, traffic, biodiversity, cumulative abstraction of water

environmental parameters and seismicity, monitoring of the fracturing process, use of chemicals, control of air emissions; wastewater management, storage and treatment, water consumption, reporting of incidents and accidents as well as provisions on financial security and capacity and liability. This would build on good practices developed by stakeholders (e.g operators, Member States) as well as on experience from North America.

This recommendation would be accompanied by:

1. Interpretative guidance on related environmental legislation, providing legal interpretation of certain provisions of **water** and **waste** legislation[178].
2. Mandate to CEN to develop EU standards on **well integrity** (well design, construction and well testing).
3. Technical guidance could also be envisaged (eg providing recommendations on the detailed parameters to be taken into account when conducting a site-specific hydrogeological risk assessment prior to fracturing[179]).

Under option A, the application of the Industrial Emissions Directive (IED) would remain an ad hoc decision by permitting authorities, mainly depending on the volumes of waste considered as stored underground[180] and the expected characteristics of such waste[181].

This could also be accompanied by:

- Voluntary agreement by the industry/stakeholders on a reduction of hazardous **chemicals** use and public **disclosure** of chemical additives used; on minimising **air emissions**, incl. on-site fugitive greenhouse gas (GHG) emissions via voluntary deployment of reduced emissions completion and minimisation of flaring (this could be assorted with a precise timeframe providing the possibility for legal measures if the agreement does not deliver).
- Exchange of good practice within the IMPEL[182] network on e.g. permitting or inspections.

This option would not provide a legal basis for eg, addressing cumulative impacts, mandatory disclosure of chemicals, nor for the mandatory capture of gas nor independent evaluation and verification of the well integrity. All the other identified problem areas would be tackled in a non-prescriptive way. The implementation of measures not mandated by EU law would remain entirely voluntary.

*8.3.3. **Option B:** Amendments of parts of the EU environmental acquis (combined with elements of option A)*

This option would build on the existing EU environmental legislation and entail the following:

1. **Amendment of the Environmental Impact Assessment (EIA) Directive**: Explicit introduction of HVHFHD projects into Annex I of the EIA Directive. This would

[178] e.g concept of direct discharge vs. indirect discharge in groundwater; prohibition of injection of waste water from high volume hydraulic fracturing operations into the underground for disposal under the Water Framework Directive

[179] Such site-specific hydrogeological risk assessment is required to ensure that the hydraulic fracturing process is compatible with the precautionary principle and with the environmental objectives of the Water Framework Directive.

[180] Under the IED, there is threshold on volume of waste triggering its application.

[181] Residuals of injected fracturing fluids, reaction and degradation products combined with naturally occurring material accumulated underground.

[182] European Union Network for the Implementation and Enforcement of Environmental Law

entail that such projects are preceded by an EIA whenever high volume hydraulic fracturing is planned to be used. The early exploration phase would only be subject to a screening. This amendment depends on the on-going co-decision procedure in the framework of the revision of the EIA Directive[183].

2. **Amendment of the Mining Waste Directive (MWD)** that would provide for the following:
   - Clarification that the scope of the MWD covers both surface waste management and the underground accumulation of waste resulting from the fracturing process. This would imply that the underground structure would qualify as waste facility. The associated BREF/BAT conclusions may then be able to cover aspects of underground risk characterisation and well integrity.
   - Best Available Techniques (BAT) conclusions developed for these projects would be the reference for setting the permit conditions. This would give the BREF/BAT conclusions a legal effect and would foster uptake of BAT in the permitting phase for the management, treatment and storage of waste from HVHFHD activities.
   - The application of the MWD would trigger the application of the Environmental Liability Directive for activities related to the management of extractive waste.

   And / or:
3. **Amendment of the Industrial Emissions Directive (IED):**
   This would explicitly cover HVHFHD projects under its scope. This would ensure that the main principles of the IED apply to the activities, especially for the operational phase of the project. This option would include in particular operational monitoring of the fracturing process, mitigation of air emissions (with the development of Best Available Techniques and associated emissions levels); handling and storage of dangerous substances, if any[184]. The application of the IED would trigger the application of the Environmental Liability Directive related to the activities covered by the IED. It would also trigger an integrated approach for permitting as well as the application of provisions on inspections, public participation, reporting of incidents, accidents.

These amendments could be introduced in the frame of possible future revisions of these Directives or by a single legal act and would be accompanied by the development in parallel of (in line with option A):

- Combined technical and legal guidance on **water** related aspects[185] ;
- Mandate to CEN to develop EU standards on **well integrity.**

It could also be accompanied by voluntary agreement by the industry/stakeholders on a reduction of hazardous **chemicals use** and public **disclosure** of chemical additives used (as under option A).

183 The Commission did not propose to amend Annexes I and II of the EIA Directive as part of the on-going revision process. However should co-legislators foresee such amendments, the Commission will consider those. An amendment to the EIA Directive to provide for a mandatory EIA in the context of unconventional fossil fuels extraction activities such as shale gas for both exploration and production phases has been put forward by the ENVI Committee in the European Parliament as part of the co-decision procedure on the proposal for a revised EIA Directive, subject to adoption in plenary session in the autumn 2013.

184 That would not be covered under the Seveso thresholds

185 Under options B and C, underground risk characterisation and well integrity aspects would be addressed by BREF/BAT conclusions under the Mining Waste Directive. An accompanying guidance on water legislation would clarify how such conclusions would be relevant for conducting the site-specific hydrogeological risk assessment required under the Water Framework Directive.

This option would not provide a legal basis for addressing cumulative impacts, for an independent evaluation and verification of the well integrity nor for mandatory disclosure of chemicals or mandatory capture of gas.

8.3.4. *Option C:* *Goal-setting legislation building on the existing EU acquis (Framework Directive) (and on elements of A and B)*

This piece of legislation would present, in a single act, building on existing EU legislation, the framework for HVHFHD activities aiming at the protection of human health and the environment including the climate. The proposed overarching goals would cover the basic steps that experts recommend to systematically implement, ie:

- a thorough knowledge of the hydro-geological characteristics of the underground and associated risks is available prior to the start of operations
- environmental impacts are properly assessed
- underground risks are prevented, managed and mitigated
- fewer hazardous chemicals are used
- chemicals intended to be used for high volume hydraulic fracturing are disclosed and incidents/accidents are reported
- proper waste management is ensured
- air emissions (incl. methane emissions) are mitigated
- baseline data on key environmental parameters (e.g water, air, seismicity) and monitoring data during and after operations are collected
- well integrity is ensured
- independent evaluation and verification of key safety and environmental aspects are conducted
- monitoring of operations, in particular the high volume hydraulic fracturing process is carried out
- strategic planning and environmental assessment are conducted at the level of the play
- liability and financial security aspects are addressed
- there is sufficient assurance as regard the financial capacity and technical competence of the operator.

Furthermore, this option would build on the existing EU legislation by providing for amendments of the Mining Waste Directive and the Industrial Emissions Directive in a coordinated manner. Member States would have flexibility as to the means of achieving the identified goals. Detailed Best Available Techniques conclusions that would serve as reference for permitting would be developed.

This option would be supported by the following accompanying measures:

- Combined technical and legal guidance on **water** related aspects (in line with option A)
- Mandate to CEN to develop EU standards on well integrity (as under option A)

This option would tackle all identified problems in a goal-setting manner, letting precise implementation decisions to Member States.

8.3.5. ***Option D**: Legislation setting specific provisions (Directive)*

This option would comprise a Directive setting provisions for the protection of human health and the environment adjusted to the needs of the sector. The main difference to option C is that option D would come forward with provisions covering both general principles and objectives and specific detailed obligations.

Option D would provide a comprehensive approach It would:

- provide for the mandatory disclosure of chemicals.
- set criteria for the characterisation and assessment of the underground prior to high volume hydraulic fracturing as well as criteria for establishing baseline and monitoring provisions (during and after closure).
- contain provisions on operational core activities such as the monitoring of the fracturing process as well as on well integrity
- requires the operator to address GHG and VOC emissions, avoid venting and flaring, in particular by requiring mandatory capture and subsequent use of gas during the well completion phase[186].
- set requirements for baseline reporting, monitoring and inspection
- identify provisions for financial security and liability, financial capacity and technical competence of the operator
- provisions on site closure and the post-closure phase
- It would not rely on the IED and would restrict the applicability of the MWD to waste management on the surface.

This option would be supported by the following accompanying measures:

- Combined technical and legal guidance on **water** related aspects (in line with option A)
- Proposal to develop EU standards on well integrity (as under option A).

This option would tackle all identified problems in a more detailed and more prescriptive manner, leaving less flexibility than option C for operators and Member States. Whenever appropriate, detailed measures could be discussed through comitology, and if it appears there are significant impacts, then another Impact Assessment would be undertaken.

**

A Recommendation to Member States as outlined under option A could be developed in parallel to either option B, C or D, so as to cater for the need for urgent action.

[186] As will be the case in the US from 2015. The study 'Measurement of methane emissions at natural gas production sites in the US' by Allen et al (2013) demonstrated on a limited sample of 27 well completions that Reduced Emission Completions (RECs) are able to significantly reduce emissions and that they are gradually being phased in various states of the US, probably because of the upcoming stringent legislation by US EPA. Out of the 27 well completions, 67% of the wells used RECs, which resulted for these wells in capturing 99% of potential emissions.

Annex 16.3 presents in a synthetic manner the content of each of the proposed options for each of the identified areas of action.

9. Analysis and comparison of Impacts

The analysis considers how the different options fares as regard their effectiveness in meeting the objectives pursued (including timeliness and enforceability), as well as their broad economic and social impacts.

9.1. Effectiveness in reducing environmental impacts and risks, addressing public concerns and providing legal certainty

In the table below, a synthesis of the analysis of the effectiveness of the different options is presented, while a more extensive examination is provided in annex 17. Effectiveness is assessed as regard the ability of the options to:

- Prevent, manage and reduce environmental impacts and risks;
- provide legal certainty and predictability to competent authorities and operators;
- respond to public concerns.

In order to do all this in a useful way, the legal framework has to be clarified as soon as possible so that investments are made within a predictable context and environmental impacts and risks are dealt with as soon as operations are starting on the ground. Hence, timeliness is assessed as part of the effectiveness of the options. Furthermore, in order to prevent incidents or accidents and reassure the public, options have to create credible incentives to implement best practices and widely recognised expert recommendations. Hence, the enforceability of the options is assessed.

Whenever available, the stakeholders' views on the options are also presented.

Effectiveness	Baseline	Option A	Option B	Option C	Option D
in preventing, managing and reducing environmental impacts and risks	Not effective (see section 3.2) Risks and impacts insufficiently addressed	Low effectiveness: Wide uptake of measures dependent on the willingness of Competent Authorities and operators to follow as well as on whether or not there is public pressure in MS Scope of voluntary agreements and their level of ambition may be limited due to the need for consensus among all operators	Good effectiveness but ultimate level of coverage of the risks uncertain due to piecemeal approach and not comprehensive: No systematic SEA (=cumulative effects insufficiently tackled) No mandatory disclosure of chemicals[187]. Member States would be supported in the implementation phase by BAT conclusions that would serve as reference for permitting. The level of technical stringency of the BAT conclusions depends on the process of exchange of information between Member States and industry.	High effectiveness: Overarching goals covering all issues identified (including those not addressed by B) Member States would be supported in the implementation phase by BAT conclusions that would serve as reference for permitting. The level of technical stringency of the BAT conclusions depends on the participative process.	Very High effectiveness: Specific requirements covering all issues identified Permit conditions need to comply with specific requirements
In providing legal certainty and predictability to competent authorities and operators	Not effective (see section 3.2) Remaining legal ambiguities and gaps identified in the EU environmental acquis Remaining uncertainties in its application and diverging implementation Continuous requests for clarification of the EU acquis and call for legal predictability from MS and operators	Low effectiveness: Allows to explain further how the existing EU legislation applies to the sector (esp. water, mining waste, industrial emissions legislation) Guidance notes may be contested by some MS and challenged by some economic operators at the permitting stage, hence not ensuring legal predictability	Average/good effectiveness: in the case of a coordinated set of amendments. Piecemeal approach entails that baseline reporting and monitoring requirements are spread across various pieces of EU legislation. No guarantee of coherence and consistency of the scope of amendments of the EIA Directive, MWD, IED[188] if individual amendments are made in a non-coordinated manner. Should the amendments be made	High effectiveness: Overall framework, providing clarification in law of the applicability of existing pieces of EU legislation (esp. MWD and IED), hence resolving legal ambiguities identified[189]. Amendments of existing EU legislation done in a coordinated manner, hence responding to the need for predictability of operators, as compared to option	Very High effectiveness: Set of detailed requirements supporting permitting authorities and providing clear rules for operators in a single act

187 The disclosure of chemicals used for high volume hydraulic fracturing can on the one hand address the call for transparency from the general public while at the same time enhance the level of information of permitting authorities and be used in the case of remediation action and liability after an incident.

188 Should there be an amendment of the IED to encompass explicitly the HVHFHD activities, it would trigger the application of the ELD, and would therefore not require a separate amendment of the ELD.

189 The ambiguities surrounding underground risk characterisation identified under the Water Framework Directive would be addressed under the Mining Waste Directive specific BREF on mining waste, which would be complemented by a guidance note on water legislation.

			separately, it would result in individual/fragmented timelines for implementation, which would not be desirable for ensuring operators' predictability	B.	
In responding to public concerns	Not effective (see section 3.3) Moratoria in several MS; bans in 2 MS Operators concerned by lack of public acceptance, which was one of the three top challenges identified in the EC public consultation	Low effectiveness: unlikely to fully allay public concerns: risk that voluntary agreements do not deliver + uneven implementation of recommendation and guidance	Good effectiveness: Would partly meet public expectations, but absence of mandatory chemicals disclosure on a well-by-well basis and lack of compulsory and systematic public consultation prior to licensing round.	high effectiveness: Provides for mandatory disclosure of chemicals (content to be discussed by stakeholders) Provides for public consultation prior to licensing rounds (via SEA)	Very high effectiveness: Provides for mandatory disclosure of chemicals (with specific content) Provides for public consultation prior to licensing rounds (via SEA)
Timeliness of implementation	N/A	High effectiveness: Development of a recommendation to MS may be done relatively quickly. Average effectiveness: Guidance notes may take more time to develop, depending on the procedure involved (e.g comitology, CIS). Time needed to set-up formal voluntary agreements is uncertain, depends on how fast the sector can come to a consensus (may take a couple of years).	-a) Low effectiveness in the case of individual amendments made in a non-coordinated manner: Review of the EIA Directive already in co-decision but no reviews of the MWD and the IED planned in the near term (IED at the earliest in 2016); BREFs require 3-4 years for development. Compatible with the development in parallel of a guidance (as under A) so as to cater for the need for urgent EU action. -b) Average effectiveness in the case of amendments made in a coordinated manner.	Average effectiveness: Could be transposed and implemented as of 2017, hence more timely than Ba. The development of BREFs/BAT conclusions under the IED would take some 3-4 years and this process has not yet started. Compatible with the development in parallel of a guidance (as under A) so as to cater for the need for urgent EU action.	Good effectiveness Could be transposed and implemented as of 2017, hence more timely than B. The development of legal requirements is timelier than the development of BREF/BAT conclusions under option C. Compatible with the development in parallel of a guidance (as under A) so as to cater for the need for urgent EU action.
Enforceability	N/A	None : recommendation and guidance notes have no binding effect	Average: Amendments provide clarification in law of existing rules, hence enhance enforceability for the areas covered by these rules.	Good: A single act clarifies overarching rules applicable, hence further enhancing enforceability.	High A single act provides specific legal requirements, as clear legal basis for enforcement.

Stakeholders position (MS/industry/NGOs/EP/CoR)	Call for EU action put forward by a majority of respondents to the EC public consultation (incl. individuals, organisations and public authorities), as well as by the EP: this call would remain unaddressed. A few MS may prefer to rely only on national provisions; while a wider number of MS see a need for EU action[190]	Oil and gas industry[191] as well as chemicals industry[192] are in favour If taken alone, environmental NGOs[193] unlikely to be favourable Issue of uneven implementation of guidance raised by several MS[194] Split views[195] of individual respondents to the EC consultation	Stakeholders' views are difficult to disentangle between the different regulatory approaches (B, C and D), as views expressed as "in favour of an EU regulatory approach" do not necessarily convey a preference for the type of legal instrument to be developed. The EP calls for an "EU-wide framework ensuring harmonised provisions" and the committee of the Regions draft opinion calls for a "clear and legally binding regulatory framework of the EU, preferably in the form of a directive"[196]. Some MS made informal indications[197] of their support for a stand-alone regulatory approach, others for a regulatory approach building on the existing EU legislation, while one fully disagrees with an EU approach. The Oil and Gas producers association (OGP) called for more focus at large scale planning level[198]. Parts of the non-Oil and Gas industry in favour of a comprehensive regulatory framework[199] ; certain suppliers called for a "framework of best available technologies for the sector"[200]. Environmental NGOs favour changes to existing legislation towards more environmental safeguards, some being clearly in favour of a comprehensive and specific legislation[201]. Majority of EU citizens in favour of harmonised and consistent approaches at EU level (Eurobarometer[202]), and a majority of individual respondents in favour of a comprehensive framework at EU level (Public consultation[203]).		

EP= European Parliament
CA= Competent authorities
CoR: Committee of the Regions

190 Technical WG of MS, 24th June 2013- Informal positions of MS
191 OGP Contribution to EC public consultation and Position paper, 2013; UK Onshore Operators Group position paper, March 2013
192 CEFIC response to EC public consultation, 2013
193 Food and Water Europe and Friends of the Earth Position paper, April 2013; WWF Position paper, 2013
194 Technical WG of MS, 24th June 2013- Informal positions of MS
195 Some 51% in favour of exchange of information, guidance on best practices, voluntary approaches; some 41% in favour of guidelines on EU legislation (non-weighted results) and respectively about 45% and 55% (weighted results)
196 Committee of the Regions Draft opinion: http://cor.europa.eu/en/news/Pages/fracking-environmental-impact.aspx
197 Lunch of the Informal Environment Council of 16 July 2016 and technical Working Groups in the context of this IA.
198 OGP position paper, July 2013
199 Industry Federation of Industrial Energy Consumers (IFIEC) and Fertilizers Europe which, in their Position paper from Feb. 2013 "recognise recognizes a need for a comprehensive regulatory framework that also includes an effective mechanism for monitoring compliance, but also councils against unreasonable regulation which could stop the development of this energy resource and damage European industry"; EUROFER (European Steel association) response to EC public consultation, March 2013
200 General Electric Position paper, March 2013 in favour of a "framework of Best Available Technologies"
201 Food and Water Europe and Friends of the Earth Position paper, April 2013; WWF Position paper, 2013; France Nature Environnement response to EC public consultation, 2013- These position papers do not distinguish if amendments to the existing EU legislation should be conducted separately or within a legal instrument
202 Eurobarometer survey released in Jan. 2012 http://ec.europa.eu/public_opinion/flash/fl_360_en.pdf - Most (61%) agree that harmonised and consistent approaches should be developed: 28% totally agree, and a further 33% tend to agree. Three in ten disagree that harmonised and consistent approaches should be developed: 17% totally disagree while 13% tend to disagree
203 51% in favour with unweighted results and 65% in favour with weighted results per country population

MS= Member States
NGOs= Non-governmental organisations
CIS= Common Implementation Strategy (under the Water Framework Directive)
SEA= Strategic Environmental Assessment
O&G= oil and gas
BAT= Best Available Techniques (BAT)
HVHFHD= high volume hydraulic fracturing combined with horizontal drilling

In summary:

The baseline would not fully respond to the problems identified nor to the call for action put on the Commission by the majority of respondents to the public consultation, the European Parliament and several Member States, and is therefore not considered effective.

As for the options proposed, there is a gradation in the coverage of the **environmental impacts** and risks from options A, B, C to D:

- Option **A** would not guarantee an effective coverage of the impacts and risks, as its implementation depends on the willingness of permitting authorities and operators to follow the recommendations / voluntary practices. It may however be usefully developed in parallel to a regulatory approach (options B, C or D), so as to respond to the need for urgent EU action.
- Neither options **A nor B** provide a legal basis to ensure that cumulative environmental impacts are assessed and taken into account at regional level, nor capture of gas, well integrity or disclosure of chemicals. These options do not guarantee a proper control of air emissions or water contamination.
- Options **C and D** allow for a more complete coverage of environmental impacts and risks, as all identified environmental issues are covered by these options: from mandatory chemicals disclosure to systematic assessment and monitoring of cumulative impacts over wide areas[204]. They thus better respond to public concerns. The main difference between C and D is that option D is more prescriptive, entering into detailed specifications as to how things should be done which option C focuses more on what should be done, leaving more flexibility to Member States and operators to adapt to local circumstances.

In terms of **legal predictability**: Option **B** appears less effective than C and D due to the piecemeal approach that would normally be applied (although it may be considered to group all foreseen amendments into a single legal proposal). Even in the latter case, requirements such as on baseline reporting and monitoring would be spread across various pieces of legislation. Option **D** entails clear rules for operators in a single legal act that can be more easily enforced. It is estimated that option **C** ranges between B and D as it sets overarching rules.

Stakeholders' views on the options

The main policy options were part of the public consultation. While views diverged among respondents as to the best policy option, there was a clear **call for EU action**, which was the most favoured option. Industry responses tended more towards soft measures, while environmental and social NGOs responses expressed a preference for a regulatory approach. As for citizens, there were 51 % to favour a comprehensive and specific EU piece of legislation (rising to 66% in the weighted results[205]). This is line with the results of the Eurobarometer[206], where more than 60% of the respondents expressed views in favour of the development of harmonised and consistent approaches in EU. There was a significant difference between responses from a few national authorities, generally less inclined towards EU action, and those from local/regional authorities, expressing a strong support for EU action.

204 hence tackling cumulative effects, especially prior to the exploitation phase, as well as community impacts (e.g land take, traffic, noise, biodiversity, cumulative abstraction of water, air emissions)

205 See footnote 2 for an explanation of the weighting methodology.

206 Survey of 25 000 citizens from January 2012

Informal views from Member States were expressed at the July 2013 Informal Environment Council[207] and during the Technical Working Group meetings organised for this impact assessment. While there were diverging views on the best option, several Member States called for a reliable and clear legal framework to enable investments; a number being open to consider adaptations / clarification of the existing framework (e.g EIA; MWD) and/or development of BREFs; others called for EU-wide uniform conditions set in a separate EU instrument. While some expressed preference for guidance and best practices, others considered it as insufficient (due to the difficulty to enforce it and its unability to respond to public concerns). Only one country expressed a preference for no EU common action.

9.2. Economic impacts

Due to the novelty of shale gas activities in the EU, there is limited data available on the level of impacts at stake. Therefore, in the assessments of economic and social impacts undertaken for this impact assessment, a sensitivity analysis was undertaken in order to mitigate the absence of European data, and in particular as regards the amount of shale gas available. Quantitative results presented in this section are therefore to be considered as providing ranges rather than precise estimates.

9.2.1. Costs to operators

In order to provide illustrative estimates of the costs of the options, the individual measures (identified as outlined in Chapter 8.2 and presented in annex 15.2) were assigned to the different policy options. However, it has to be stressed that this assignment was only developed in order to illustrate the costs of the policy options and does not necessarily imply that a measure would, as such, become part of a given option. For example, when an option recommends (option A) or requires (in options C and D) appropriate underground characterisation, there are several measures able to do so (listed in Annex 15.2), and it would be up to Member States to decide on the most suitable method, taking into account local geological situation, although option D sets some precise specifciations. For the purpose of estimating the costs of the option, it was assumed that the most sophisticated method (i.e. underground characterisation by a 3D seismic survey) would be applied. However, such a method may not be necessary everywhere, implying that compliance costs presented below are likely to be overestimated.

For illustrative purposes, individual measures were assigned to policy options according to the following scheme:

- Measures that could be implemented by amendments of existing legislation or by development of supporting documents with a legal effect (e.g. BREFs) were assigned to option **B**. Some of these measures would need to be identified as Best Available Techniques (BATs) in order to have a legal effect. However, as BATs are to be defined in a participative process, it is not possible to predict which measures would become considered as BATs and hence included into option B; it was therefore assumed that all measures that could become BATs would enter into option B, hence leading to a likely over-estimates of the costs of this option.

[207] Member State name not mentioned as these were informal statements (Informal Environment Council under LT Presidency, 16 July 2013).

- Measures that would require a dedicated legislation for their implementation were assigned to option **D**.
- As for the cost of option **A**, it was assumed that, depending on the level of uptake of the recommendation in Member States, costs could range between zero (in case of a total absence of uptake of the recommended measures) up to the costs of option B (it was assumed that uptake would not be higher than the level of ambition of the measures included in B).
- As for the costs of option **C**, it is considered that they would range between the costs of options B and D, since those 3 options propose a gradation in their level of coverage of the problems and stringency of the measures.
- For illustrative purposes, the costs of the measures from option A that were retained in options B and C were included with a 50% factor: due to their non-legal character, it is assumed that not all Member States would apply these measures, therefore 50% was chosen as illustrative.

Costs for these policy options were calculated as follows[208]:

(1) Measures were categorised into Business As Usual (BAU) and non-BAU measures. Measures already required by existing EU legislation were considered as BAU and were taken fully into account in the baseline. Measures that were considered standard industry practice or widely used by industry were taken partially into account depending on sector uptake[209].

(2) The compliance costs and administrative costs of each measure were considered. Where there was sufficient information, the costs were quantitatively estimated on the basis of assumptions drawn from existing literature and inputs from experts. When drawing from practical experience of HVHFHD projects in other regions of the world, EU–specific assumptions such as hourly wage for operators and external consultancy were applied. When there was not sufficient information, associated costs were not taken into account[210].

(3) Some measures apply to an individual well, to a pad or to an entire play/concession area. In order to integrate these data into annualized compliance costs per pad, a representative concession site[211] was developed by selecting a number of parameters that are required in relation to calculations of "per measure" costs, including physical aspects (number of wells and pads), the physical resources required (fuels, water and chemicals in hydraulic fracturing) and outputs generated (volume of flow back water).

The table below presents the annualised **compliance costs for operators** for policy options A to D, based on an average well lifetime of 10 years. As many experts assume a well life time of 30 years[212] (and hence lower yearly costs), **annualised compliance costs per pad** shown below therefore present the higher end of estimated costs.

208 Complete methodology described in AMEC 2013

209 See Drat final report AMEC study 2013

210 Measures of this category typically imply restrictions such as zones exempted from operations or a ban of the use of certain chemicals that could result in production losses. However, such losses would very much depend on local geological situations and cannot be estimated on the basis of currently available information.

211 see illustrative concession in annex 18

212 Draft final report JRC IET 2012 Study e.g.

Policy option	Option A Recommendation	Option B Recommendation /Guidance + Amendments to existing legislation	Option C Framework Directive + Amendments + Recommendation / Guidance	Option D Directive + Amendments + Recommendation / Guidance
Total annualised compliance costs per pad with 8 wells for operators in €	0 to 595 000	595 000	595 000 to 643 000	643 000
Annualised compliance costs as a percentage of expected annual revenues on the basis of the current gas price of € 0.43/m3	0 to 1.4 %	1.4 %	1.4% to 1.6 %	1.6%

source: AMEC 2013

The costs above can be put in perspective with earlier findings:

- According to the International Energy Agency, complying with key environmental risk mitigation measures ("golden rules") would add some 7% (around 580 000 dollars) to the **overall cost of drilling and completing a shale gas well**. Such additional investments[213] may however be compensated by reducing operating costs (e.g. gas captured and not vented can be sold). As a way of comparison, the costs of option D are estimated to add 8% to the absolute costs of the operations[214], hence around the same order to magnitude as the IEA estimates.
- The US EPA has calculated that its 2012 air rules[215] requiring the capture of gas would actually allow revenues from selling the gas to offset the costs of compliance, while significantly reducing air pollution (reduction by 95% of VOC emissions from new wells and significant reduction of methane emissions). EPA's analysis of the rules shows a cost savings of $11 to $19 million when the rules are fully implemented in 2015.
- The US Department of Interior has released draft rules on fracking aiming at reducing environmental risks, focused on the disclosure of chemicals, well integrity and water management. The average total compliance costs for the industry in the first year of regulation is considered "insignificant when compared with the drilling costs in recent

213 Most of the additional costs happen at the time of drilling and fracking and only few are operating costs (IEA Golden Rule Report, p. 54: http://www.iea.org/publications/freepublications/publication/WEO2012_GoldenRulesReport.pdf).

214 The costs of option D were determined as annualized compliance costs for an entire pad consisting of 8 wells and an average well life time of 10 years. In order to convert this cost figure into the costs of a well, annualised compliance costs are multiplied by the number of years of the well life time (10) and are divided by the average number of wells per pad (8), resulting in implementation costs of € 803 750 per well (643 000 x 10 ÷ 8). Most experts consider a price of € 10 mio for the drilling and completion of a well in Europe, e.g. in Poland, as realistic. Therefore, the additional costs per well (803 750 €) would represent 8% of the absolute costs of operations (10 M€).

215 See http://yosemite.epa.gov/opa/admpress.nsf/d0cf6618525a9efb85257359003fb69d/c742df7944b37c50852579e400594f8f%21OpenDocument

years, the production gains from hydraulically fractured wells operations, and the net incomes of the oil and gas industry"[216].

Administrative costs for operators were estimated, based on the costs of additional permitting requirements, additional monitoring and reporting obligations and interpretations of guidelines[217]. In a Business as Usual situation, an operator has to obtain several permits under the existing regulatory framework (e.g permit for water abstraction, for waste management, permits based on national mining legislation). Option A would not change this situation and the administrative costs related to permitting procedures would remain the same for the operators, except if Member States themselves develop single permitting.

For option B to D, which require integrated permitting, calculations lead to administrative start-up costs for exploration and operation of € 22 600 for the illustrative concession (8 wells) in the most detailed case (option D). It also leads to annual recurring costs for monitoring, reporting and compliance checking around € 6 000 for each well pad (for option D). Since unconventional gas concessions would have many pads (the illustrative concession assumes 250 pads) that would progressively be taken forward over many years, efficiencies are likely to be gained in permit development, drawing from data from earlier site applications and operations.

These estimates over-state the likely administrative costs of the regulatory options since they represent only additional costs that would be brought up by the policy options and do not take into account reduction in already existing costs of several permitting procedures. In fact, the implementation of the options could result in an overall reduction of costs for permitting (since single permitting would replace existing permitting costs under the IED and the MWD e.g). However, considering the relative low amount of these costs estimates (22 600 € for start-up costs), it was not deemed proportionate to investigate into the exact amount of the net administrative costs for each option.

U.S. experience as well as licensing activities in Europe indicate that **SMEs** are not present in the shale gas extraction sector[218] and would therefore not be directly affected by the implementation of the options[219] (and nor will micro-enterprises). Some SMEs are however likely to develop in the downward and upward sectors (eg compressors providers, transport, catering) and could therefore be indirectly affected by the options, in case the large shale gas extraction companies would change their production decision because of the regulatory framework. However, with compliance costs of around 1.5% of revenues, this seems unlikely. Hence it is very unlikely that SMEs would be negatively affected, even indirectly, by any options. A contrario, the establishment of an enabling framework through any of the options may indirectly benefit downstream and upstream SMEs.

216 http://www.blm.gov/pgdata/etc/medialib/blm/wo/Communications_Directorate/public_affairs/hydraulicfracturing.Par.91723.File.tmp/HydFrac_SupProposal.pdf

217 Calculations were based on the Standard cost model analysis undertaken for the CCS Directive, which has broadly the same kind of requirements as the ones proposed here, and completed with specific analysis of the measures proposed in this IA (see AMEC 2013, p.94)

218 See annex 19

219 It is often stated that shale gas developments in the US were made possible by "small" companies whereas the majors followed the trend later on. However, while indeed the major international oil and gas companies (e.g. Exxon or Chevron) initially saw shale gas as a less attractive investment choice compared to conventional oil and gas (e.g. offshore), a recent assessment on the origins of U.S. shale gas development [Wang, Zhongmin/Krupnick, Alan: US Shale Gas Development. What Led to the Boom? Resources for the Future Issue Brief 13-04, May 2013] concluded that shale gas exploitation as a highly capital intensive industry exceeds the financial and technical capacity of small natural gas firms, In contrast, the shale gas boom was started by large, independent (from the majors) oil and gas companies like Mitchell Energy.

9.2.2. *Broader economic aspects*

In a business as usual situation, the **regulatory uncertainties** and unclarities would mostly remain the same as they currently are and public opposition would most likely continue in several EU countries, as would the unsecure investment context. Investments opportunities in the sector could therefore be missed and the full potential of the sector could not be exploited. In some countries, some investment may be made at a lower immediate cost (less stringent rules) but entail a potentially higher social cost at a later stage (if risks or impacts materialise).

In order to enable economic benefits, a balance needs to be found between options that clarify sufficiently the regulatory context of the sector (hence responding to public concerns and ensuring legal certainty for operators) without unduly constraining its development. In the case of the proposed options, public acceptance is likely to be enhanced, with a clearer regulatory framework, hence making the investment context increasingly stable and secure.

Indeed, investments decisions are based on the trade-off between risk and financial return, the latter depending on expected revenues (based on the amount of available reserve and on gas price perspectives, both highly uncertain) and costs (operations, labour, taxation, all regulatory costs). As for risks, their analysis is complicated by the absence of EU experience, hence entailing a lack of in-depth knowledge of EU reserves and specific geological challenges. However, a number of risks such as citizen opposition and, in case of environmental damage, image risk and liability risk, are high. A clearer regulatory framework for shale gas would at the same time moderately reduce the expected yields (by increasing compliance costs) but it would also significantly reduce the risks (including image and liability risks but also local citizen acceptance) and possibly reduce some operating costs (as highlighted in the IEA Golden Rules) [220].

Considering that the options present a range of ways for ensuring the implementation of expert recommendations and best practices with as much flexibility as possible left to operators, and considering the relative low costs they entail (with a conservative estimate between 1.4 and 1.6% of the revenues for the legislative ones), none of them is expected to significantly affect production decisions.

From an investment perspective, there is no indication that EU shale gas production would differ in the three legislative options. Therefore, the impacts on gas price are also unlikely to differ, and therefore all wider economic and social impacts, including on competitiveness. These impacts are described below, but with no clear-cut way to distinguish between the options as the differences between these impacts are deemed to be negligible.

The impact of the different options on EU **gas price** is difficult to ascertain, as energy prices depend on a wide range of factors. Options more likely to better allow shale gas developments in the EU could lead to a gas price decrease, hence benefiting the EU economy in the short to medium run. However, this potential gas price decrease is likely to remain limited: The US experience shows that, in the early years of shale gas development, sweet spots are exploited, leading to price decrease (as gas is not easy to store) in the short term and jobs creation (as much more staff is needed in the very first years of a well life). In the longer

[220] In the responses to the EC public consultation, the majority of investment companies expressed their support to a legislative adaptation of the EU framework.

term (after about a decade in the US case), production costs increase (as sweet spots are no longer available), initial jobs are lost, and prices start again to increase (gas prices in the US have started to rise again since 2012 and are foreseen to keep rising according to the US EIA). The macro-economic study undertaken for this impact assessment[221] shows a very marginal effect of any policy affecting shale gas development on EU gas price, mostly due to the fact that EU shale gas production would be relatively small, hence not sufficient to influence prices[222]. On the other hand, the IEA predicts, in a high EU shale gas development scenario (Golden Rules), a decrease of EU gas price of 18% by 2035, hence demonstrating the relatively wide range of uncertainties between analyses[223]. In any case, experts agree that price effects in the EU would be much smaller than in the US, for a wide array of reasons, from higher production costs to difference in positions on gas markets: A larger share of long term contracts in the EU compared to US, hence smoothing any price decrease; a high share of EU gas consumption coming from imports, projected to remain high (60%) even with shale gas production[224], hence EU gas price will continue to be largely set from its gas import price (that may decrease in case of larger world supply of shale gas).

Anyhow, any gas price decrease (or limitation in gas prices increase) would be beneficial to the EU economy, and especially to **energy-intensive sectors** (steel, aluminium e.g. see annex 21 for details) and sectors using gas as an input (chemical, fertilizers e.g.). However, analysis undertaken for the US shows that these impacts are quite small, as the economic sectors which represent the largest consumers of gas (as feedstock and as fuel) represent slightly more than 1% of the US economy[225]. Despite the "US shale gas boom", there was no significant change in the structure nor the share of the manufacturing sectors in the US as compared to the EU since 2005 (more or less when the shale gas boom started in the US), and the rise in the share of energy-intensive sectors in gross value added in the US as compared to the EU is visible on a longer period (since 1995) and thus cannot be attributed to the sole shale gas effect[226]. This analysis is in line with the findings of the macro-economic study undertaken for this impact assessment, which shows that, in the scenario with an average shale gas resource, sectoral impacts would be marginal (less than 0.1%).

In addition to the sectors that might be impacted by a change in gas prices, some **sectoral impacts** of the options proposed in this impact assessment could be felt in the sectors that may be, at least in the public perception, associated to shale gas: this can be the case for conventional gas production, geothermal industry and other unconventional fossil fuel. The concerns currently being raised in the EU about the risks and impacts of shale gas could also draw attention to those sectors, and any clarity brought in the shale gas sector might also benefit these sectors (any marginal additional burden being compensated by improvement in safety and reputation). Furthermore, for the water-using sectors, a clearer regulatory framework applied to shale gas, ensuring a lower risk of water pollution, would limit possible

221 For methodology and results description, see annex 20

222 Possible effects linked to increased negotiating power could not be taken into account in the modelling.

223 It has to be highlighted that the IEA analysis compares a scenario with no shale gas in the EU and a scenario with high shale gas (Golden rules scenario), which are more extreme than the scenarios used in the macro-economic modelling undertaken for this IA: In the Golden Rules case, all potential obstacles are overcome; supportive policies and a lack of constraints leads to an assumed lower unconventional production cost, greater recoverable reserves, less gas-oil indexation. The IEA Low Unconventional case is exactly the opposite, leading to no shale gas development at all in the EU. In ICF modelling, the baseline includes shale gas development, and options come on top of it, increasing the cost of production depending on the requirements of the different options..

224 JRC IET report and IEA

225 BEPA monthly brief June 2013

226 DG ECFIN, Energy Economic Developments in Europe (forthcoming), see graphs in annex 22

reputational risks[227]. Finally, the possible competition over investors' financial resources between shale gas and renewable energy projects cannot be excluded (as this seems to be the case in some US states).

In terms of **international competitiveness**, a limited gas price decrease due to EU shale gas development would not be sufficient to put the EU on a level playing field with the USA as regards energy prices. An analysis of world gas markets over the long term shows that US gas prices have structurally been lower than EU prices since the 1960ies[228]. Although this difference has increased further to recent shale gas development in the US, it seems to have stabilized again since 2012 as US gas prices started to rise[229] (see graphs in annex 3). While still expected to remain below EU prices, US natural gas prices are actually projected to rise[230], due to an expected increase in shale gas production costs after 2015, as resources in inexpensive areas would progressively deplete. As presented in section 2.3, gas price differences between EU and USA would therefore remain, whatever is the development of shale gas in the EU: According to the IEA Golden Rules analysis, even if the EU follows a high shale gas exploitation route, its gas price would remain about 50% higher than the US price. Over the long term, energy efficiency remains a strong and sustainable source of competitiveness for the overall EU economy as it leads to a reduction of energy costs per unit of output (see annex 21)[231]. Analysis[232] based on historic data shows that, since 2005, the share of the manufacturing sector in GDP has consistently been higher in the EU than in the US and the magnitude of the difference (in percentage point) remains in the same range over the period; as for the share of energy-intensive sectors in the US economy, it started to rise already since 1995, hence before the US shale gas boom, and no change in the longer term trend can be associated to the start of shale gas exploitation in the US. Furthermore, in terms of direct trade in goods, "which constitutes one of the key indicators for assessing (changes in) competitiveness, […] the EU-US goods balance has shown a persistent surplus for the EU since 2001, without any clear sign of deterioration"[233], hence not showing any clear effect of "the widening of EU-US energy price gap on the EU industry's market performance vis-a-vis their US counterpart, at least on the EU and US markets".

EU shale gas development might also lead to direct **domestic economic effects**, in particular via the investments made in the shale gas sector and upstream and downstream sectors. However, this effect is likely to be low: The IEA estimates[234] that, in case of a high shale gas development scenario in Europe, investments in the sector would amount to about 2/3 of the investments that would anyhow go into conventional gas production over the same period in the EU in a low shale gas development scenario.

227 e.g concerns raised by Water UK in its July 2013 press release: http://www.water.org.uk/home/news/press-releases/challenge-on-gas-fracking?printme=true&_frameset=true

228 Except for the period 2000-2004 where prices were in a similar range, see graphs in annex 3 for details

229 World Bank commodities prices

230 US EIA, April 2013: http://www.eia.gov/forecasts/aeo/MT_naturalgas.cfm#natgas_prices

231 Analysis shows that, despite the EU being already a leader in energy efficiency, there is still some potential for improvements, including in the industrial sector: see SEC(2011) 779 final, p.9: IA for the EED: http://ec.europa.eu/energy/efficiency/eed/doc/2011_directive/sec_2011_0779_impact_assessment.pdf and more recent analysis in: http://regions202020.eu/cms/themes/industry/ and http://www.isi.fraunhofer.de/isi-media/docs/e/de/publikationen/BMU_Policy_Paper_20121022.pdf for long term projections of the industrial potential (section 4.3).

232 DG ECFIN, Energy Economic Developments in Europe (forthcoming), see graphs in annex 22

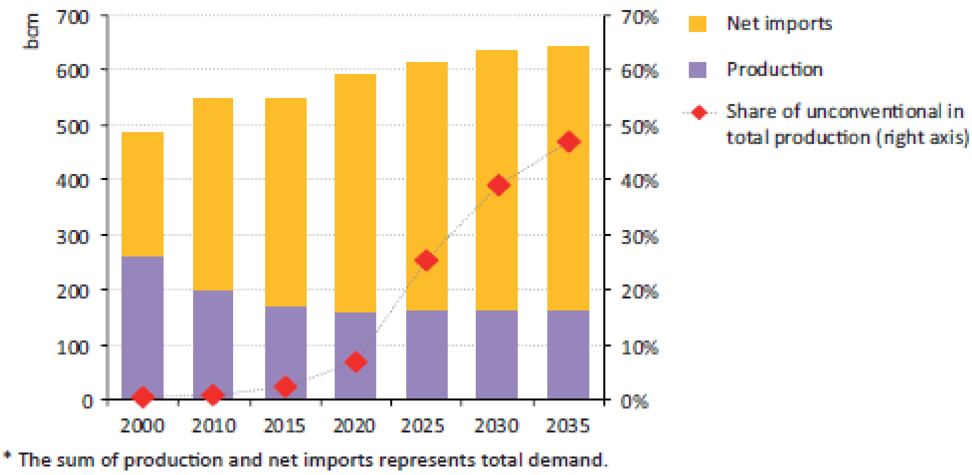
233 DG ECFIN, Energy Economic Developments in Europe (forthcoming), see graphs in annex 22

234 Golden rules report

9.2.3. *Security of supply impacts*

The JRC estimates that, in the best case scenario of EU shale gas development, shale gas could replace declining conventional gas capacities, hence reducing the otherwise increasing Europe's dependence on gas imports by an average of 6% in 2020 to more than 20% in 2040. Given the projected increase in demand, this would therefore allow to maintain EU gas import dependency at a stable level of around 60%[235]. It is also expected that maintaining a certain level of indigenous gas production, e.g. from shale formations, could help improving the negotiation position of EU consumers towards external energy suppliers by increasing gas-to-gas competition.

Natural gas balance in the EU in the Golden Rules scenario (IEA, 2012)[236]



According to the results of the macro-economic study undertaken for this impact assessment, both options A and D would lead to a contribution of shale gas to EU gas consumption that would gradually reach 10% in 2030. This is in line with the findings of the IEA[237]; applied to projected share of gas in the energy mix of at most 30% (IEA), shale gas would therefore represent less than 3% of EU energy mix in 2030.

In the US, increased shale gas production has replaced coal used in domestic consumption and led to an increase in US coal exports. It is unclear whether such a situation would happen in the EU, ie whether shale gas development would lead some EU countries to export coal.

9.2.4. *Budgetary consequences on public authorities*

In order to fully develop shale gas potential, some EU countries would need to invest to upgrade their gas infrastructure[238]. In addition, in regions where shale gas would develop, there would be a need to develop / maintain road infrastructure and water treatments plants, hence leading to additional expenses for public authorities.

235 JRC IET 2012 Report, see also annex 3

236 World Energy Outlook Special Report on Unconventional Gas: Golden Rules for a Golden Age of Gas © OECD/IEA, 2012, Fig.3.9 p.129

237 See Golden Rules report p.81: Unconventional gas production in Europe in 2035 is reported at 27% of 285bcm, hence 77 bcm. At the same date, Europe is reported to consume 692 bcm of gas (p. 78). Hence, European shale gas production would represent 11% of its gas consumption.

238 eg in Poland about half of the households would need to be connected to the gas network, according to a report by the German Institute for International and Security Affairs, Dec. 2012

On the other hand, shale gas development could bring tax revenues to the public authorities in the regions / countries where it develops, provided a right balance is found so that too high tax perspectives would not frighten some investors. However, in some countries, public authorities are envisaging to introduce tax reductions to stimulate shale gas developments (UK).

Calculations developed in AMEC 2013 lead to administrative costs for public authorities that would be, in the most demanding case (option D), per well pad per year, around € 11 000 for start-up of exploration and operation and € 1 600 for recurring costs for monitoring, reporting and compliance checking. This represents a likely over-estimate of the costs since the implementation of the options would decrease existing costs, by streamlining permitting procedures eg. However, in some Member States, capacity building expenses will be needed in order to develop the administrative capacity to implement options B, C and D (costs for the set-up of inspection units, for data collection, databases and training of inspectors). This would not however be specific to this initiative, as capacity building is a horizontal investment usually serving several policy fields. Costs would therefore also depend on the pre-existing inspection network in Member States and whether it would be sufficiently staffed and skilled to perform inspections on shale gas activities.

9.2.5. Distribution of economic impacts among Member States

Precise economic impact per Member States cannot be ascertained at this stage; it will depend on a combination of factors, for instance, on the perspective of shale gas development in each MS (depending inter alia on their level of economically recoverable shale gas resource), on their current energy mix and import dependency, on the stage of development of their gas infrastructure, on the level of energy efficiency of their economy, on their administrative situation (need for capacity building e.g.).

Countries most dependant on gas imports in their energy mix[239] and / or with higher energy intensity[240] would benefit most from a potentially improved negotiation position towards supplier countries (and potentially reduced gas price) that could be associated with increased EU shale gas production hence potentially more in the case of options that would more easily enable the development of the sector. Local community benefits due to taxes raised on shale gas companies and induced economic activities (hotel, restaurants, transports eg) are also likely to take place in the regions where shale gas would develop.

The macro-economic modelling undertaken for this impact assessment shows no significant impacts on GDP in both options A and D - the options considered in the exercise which by extension apply to B and C - when shale gas resource estimates are assumed to be in the average of their estimates range. However, when assuming the higher end of shale gas resource estimates, the modelling shows that some countries would experience a GDP increase of 2 to 4% (Denmark, Poland, Bulgaria e.g.) even if option D is implemented.

[239] According to the Commission contribution on energy to the European Council of 22 May 2013 (http://ec.europa.eu/europe2020/pdf/energy2_en.pdf), countries that do not produce gas and which show a high share of gas in their energy mix are AT, BE, HU, IT, LT, PL (2011 data)

[240] EU-10 countries are above EU-27 average as regards energy intensity of the economy (Eurostat)

9.2.6. Impacts on innovation and research

Research and innovation aiming at making unconventional fossil fuel activities less environmentally risky is already undertaken by the industry. In a business as usual situation, the incentives to work towards this goal would come from public pressure, possible specific Member States requirements and the business case of innovations: for instance when improving the environmental performance would also provide additional income (for instance when gas can be recovered and sold instead of being vented) or when innovations at the same time improve efficiency of operations and thereby reduce costs.

In case of further regulatory requirements (options B, C, D), incentives for innovation would be increased since companies would need to respond to new legal or permitting requirements, provided the cost of those additional requirements would not discourage them from engaging into the activity, as is likely to be the case considering the relatively low level of the foreseen costs. Innovation would privilege the development of cost-effective approaches that would be adopted by operators. Spill-over effects of such innovations could happen to the benefits of other sectors (e.g conventional oil and gas; geothermal). Enabling such technology intensive sectors to develop may induce further research, innovation and technology development, benefiting other sectors in the economy. Unconventional fossil fuel exploitation in the EU may also give rise to the development of a new European industry with related technology and innovation potential; however, the leading position of the US in this sector is likely to last for some time before the EU could catch up. However, since some innovative processes may have to target the adaptation of operations to local geological and environmental conditions, there might be a niche for national / local firms to develop. **Overall, broader economic impacts** are uncertain and likely to be more positive in case of options better enabling the sector to develop.

9.3. Social impacts

The main social impacts stemming from the policy initiative are likely to be linked to jobs opportunities (in the shale gas sectors and in related sectors), to health issues (for the workers and the general population) and to the price of energy for final consumers. These impacts are described in the following sections.

9.3.1. Job-related impacts

Options that would better enable the development of shale gas in the EU are also the ones that would enhance employment in this sector. However, this sector is relatively capital intensive, therefore increase in employment is likely to be less than proportional to the growth of the sector and mainly temporary[241].

The macro-economic modelling undertaken for this impact assessment shows no significant impacts on employment in both options A and D when shale gas resource estimates are assumed to be in the average of their estimates range. When assuming the higher end of shale

[241] In the US, it is often mentioned (based on the IHS Global Insight Study "Economic and employment contribution of shale gas in the US") that some 600 000 jobs were created in the shale gas sector (for around 500 000 wells). However, these jobs would remain only as long as the drilling continue at the same pace, as it is estimated that around 13 persons are needed to operate a well in the pre-drilling and drilling phases, but this falls to less than half a person in the production phase (Marcellus Shale Workforce Needs Assessment, 2010, co-funded by the oil and gas industry: http://pasbdc.org/uploads/media_items/pennsylvania-statewide-marcellus-shale-workforce-needs-assesment-june-2011.original.pdf

gas resource estimates, the modelling shows a 0.15% increase in EU employment when option D is implemented, which is assumed to translate to around 350 000 jobs (full time equivalent) across Europe. This can be put in perspective with the figures presented by the UK's Institute of Directors report[242] which associates to shale gas drilling the creation of 74 000 jobs in the UK, while it reports that, in 2012, the shale gas sector represented 600 000 jobs in the US. However, impact on EU employment level would depend a lot on the amount of economically recoverable resources in the EU (as shown in ICF 2013). Furthermore, **lack of trained staff** might delay the development of HVHFHD activities in the EU, as identified by two UK-based organisations[243]. A "recent survey found that 68% of offshore contractors and 75% of operators experience problems in recruiting suitable employees in particular occupations. Although many of the jobs required onshore are not highly skilled, recruiting suitably-qualified personnel will be a challenge for an emerging UK shale gas industry"[244].

In addition to direct jobs impacts in the HVHFHD activities, some **related sectors** can benefit from a potential development of fracking activities or suffer from it. The sectors which could benefit from HVHFHD development are likely to be found in upstream (e.g. mining equipment) and induced activities (e.g. catering, transport). In those sectors, the more clarity and transparency there is on fracking activities, the more the sector can develop in confidence, hence potentially leading to larger jobs creation. However, some other sectors might suffer from HVHFHD development in a given region: This could be the case of sectors related to tourism or water-using sectors that may suffer from real or reputational effects of HVHFHD developments. The more confidence there is among the public on the environmental safeguards provided by the regulatory framework, the less risk there is that downstream sectors suffer from HVHFHD activities.

9.3.2. Workers health and safety impacts

Hydraulic fracturing sand contains up to 99% silica (also known as Silicon dioxide), exposure to which has been shown to be associated to increased probability of developing lung diseases, in particular silicosis (incurable), but also lung cancer, tuberculosis, chronic obstructive pulmonary disease, as well as kidney and auto-immune diseases[245]. Although silicosis is not only associated to fracking activities, the huge amounts of sand used in fracking and its high proportion of silica makes fracking workers particularly exposed to it. The American National Institute for Occupational Safety and Health (NIOSH) reviewed 116 air samples at 11 fracking sites in Arkansas, Colorado, North Dakota, Pennsylvania and Texas. Nearly half of the samples had levels of silica that exceeded the Occupational Safety and Health Administration's (OSHA) legal limit for workplace exposure, while 78 % exceeded OSHA's recommended limits. Nearly one out of 10 of the samples exceeded the legal limit for silica by a factor of 10, exceeding the threshold at which half-face respirators can effectively protect workers[246]. In addition to silica hazards, fracking workers may be

242 http://www.iod.com/influencing/press-office/press-releases/new-iod-report-getting-shale-gas-working

243 UK's Institute of Directors (http://www.iod.com/influencing/press-office/press-releases/new-iod-report-getting-shale-gas-working) and Oxford Institute for Energy Studies (http://www.oxfordenergy.org/wpcms/wp-content/uploads/2011/01/NG46-CanUnconventionalGasbeaGameChangerinEuropeanGasMarkets-FlorenceGeny-2010.pdf)

244 http://www.iod.com/influencing/press-office/press-releases/new-iod-report-getting-shale-gas-working, p.18

245 Source: Recommendation from the Scientific Committee on Occupational Exposure Limits for Silica: ec.europa.eu/social/BlobServlet?docId=3858&langId=en and OSHA, US Department of Labour: http://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html

246 U.S. Occupational Safety and Health Administration, *Hazard Alert: Worker Exposure to Silica During Hydraulic Fracturing*, http://www.osha.gov/dts/hazardalerts/hydraulic_frac_hazard_alert.html

exposed to other worksite health hazards that can include exposure to diesel particulate and exhaust gases from equipment and high noise levels[247].

Workers health and safety is covered by specific legislation[248]. However, one may assume that the more transparent fracking activities are, the easier it would be to ensure workers safety.

9.3.3. Public health impacts

Assessment of health impacts of fracking is only starting, due to the novelty of the practice at the current scale. However, main concerns[249] relate to the direct impacts in terms of air emissions and indirect impacts in terms of potential water pollution by chemicals, some being recognised as carcinogens. For instance, the American Academy of paediatrics lists 12 chemicals used in fracking as highly toxic substances[250]. Air pollution impacts are linked to heavy truck traffic and compressor stations, when Volatile Organic Compounds (VOCs) and fugitive methane gas mix with nitrogen oxides (NOx) from truck exhaust and produce ground-level ozone, leading to respiratory troubles. In the USA, several analysis report higher air pollution and health symptoms (headaches, eye irritation, respiratory problems and nausea) near to fracking sites[251].

One may assume that the more transparent and clear the regulatory framework applied to fracking activities is, in particular as regards chemicals and air emissions, the fewer impacts on human health can be expected[252].

9.3.4. Energy price for final consumers

In the case of options that would allow an easier development of shale gas in the EU, households using natural gas for heating might benefit from a gas price decrease, provided changes are passed through to final consumers. As for electricity end-users, the impacts would be more diluted, as only some electricity plants use gas in the EU.

According to the macro-economic study undertaken for this IA, impacts of shale gas development on income is small and fairly uniform across income quintiles (+ 0.1% for the whole EU in the case of high shale gas resource, even with option D); it results from the small employment creation and lowering of gas prices.

Overall, social impacts of the options proposed are likely to be small, and more positive in the case of options better enabling the development of the sector and ensuring environmental protection.

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247 Source: OSHA, US Department of Labour; furthermore, extraction and collection of inflammable materials under pressure pose also a risk to workers.

248 E.g Directive 89/391/EEC on the protection of health and safety of workers health at work and other relevant individual directives adopted in accordance with Article 16 of this Directive

249 See e.g.: Colborn et al, 2011, Natural gas operations from a public health perspective, Human and Ecological Risk Assessment, 17(5): 1039-56; Bamberger et al, 2012, Impacts of gas drilling on human and animal health, Journal of Environmental and Occupational Health policy, vol 22/1; McKenzie et al.2012, Human health risk assessment of air emissions from development of unconventional natural gas resources.*Science of the Total Environment*. 424: 79–87

250 http://aapdistrictii.org/update-on-hydrofracking/

251 http://www.wral.com/asset/news/state/nccapitol/2012/09/20/11571598/The_Costs_of_Fracking_vNC.pdf and McKenzie, L.M., Witter, R.W., Newman, L.S., Adgate, J.L. (2012): Human health risk assessment of air emissions from development of unconventional natural gas resources. Science of the Total Environment.424: 79–87. Doi:10.1016/j.scitotenv.2012.02.018.

252 See for instance the recommendations made in http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1317140158707

10. COMPARING THE OPTIONS

options	Effectiveness in			Economic costs (€ - broad estimates)	Economic benefits	Efficiency (effectiveness / costs)	Social impacts	Timeliness of implementation	Easiness to enforce	Consistency with relevant EU goals	Overall score
	reducing environmental impacts and risks	providing legal clarity	addressing public concerns								
Baseline	0	0	0	0	0	0	0	0	0	0	0
A	+	+	+	0 to 595 000	+	+	0	++++	n.a.	+	+
B	+++	++/+++	+++	595 000	++	++	+	+/++	++	++	++
C	++++	++++	++++	595 000 to 643 000	++	+++	+	++	+++	+++	+++
D	+++++	+++++	+++++	643 000	++	++++	+	+++	++++	++++	+++/++++

Ranking for effectiveness stems from the analysis presented earlier (section 9.1); environmental impacts are covered through the effectiveness in reducing environmental impacts and risks. Economic costs and benefits were analysed in section 9.2. Efficiency is estimated by comparing the ratings obtained for the effectiveness of the options and the economic costs of these options (when economic costs are presented in form of a range, the mid-point of the range was used in the computation). Social impacts were presented in section 9.3. Timeliness and easiness to enforce were assessed together with the effectiveness of the options in section 9.1. As for their consistency with broader EU goals, the options are compared as to their ability to deliver on the EU decarbonisation and growth and jobs objectives: in terms of decarbonisation, options rank in the same way as for the other environmental impacts (increasing consistency from A to D since GHG emissions are increasingly well tackled from

A to D). As for jobs and growth, options rank the same way as they do for economic benefits (similar kind of benefits for all legislative options, all better than the non-legislative option and even more so when compared to baseline).

11. FUTURE MONITORING AND EVALUATION OF THE POLICY PROPOSED

Within an appropriate timeframe of adoption of the preferred option, the Commission would report on its implementation and on the effectiveness of the initiative to prevent, manage and reduce environmental impacts and risks, address public concerns and respond to the need for legal certainty expressed by competent authorities and operators. The appropriate timeframe for reporting will vary depending on the preferred option, with a longer timeline needed in case of legislative options (to leave time for transposition- a four year timeframe is envisaged) and a shorter for non-legislative options that could be implemented right away.

Review clauses could also be envisaged in order to take into account technical and knowledge developments and the actual degree of follow up of the Commission proposal.

Data collection for a number of indicators is suggested to ensure monitoring of the implementation of the initiative. As the proposed measures aimed at improved transparency via public disclosure and reporting will contribute to the monitoring and evaluation of the policy option proposed and allow for comparability between Member States. To this end, the following indicators could be used, based on data publicly disclosed by operators and public authorities while implementing the policy proposed:

- Number of incidents/accidents, location, reasons and impacts thereof
- Results of inspections, level of non-compliance issues and possible sanctions granted
- Number of complaints, petitions, infringement procedures
- Public acceptance, as revealed in surveys / opinion polls
- Number of Member States assessing cumulative impacts and risks ahead of shale gas developments
- % of permits granted after thorough underground risk characterisation (per MS)
- Volumes and types of chemicals used in such operations on a well basis and possible trend
- Number and share of HVHFHD wells certified by a 3rd party (per MS)
- In case of a non-legislative option, level of uptake of the Commission recommendation in Member States.

Further meetings within the Technical Working Group of Member States on environmental aspects of unconventional fossil fuels (e.g shale gas) will allow for exchange of views on the concrete implementation of the measures.

A Eurobarometer survey would be conducted periodically, so as to measure the evolution of public acceptance after measures have been adopted.

The current initiative applies to shale gas, but it proposes a generic approach which is deemed sufficiently flexible to be applied to other unconventional fossil fuels, should their development in the EU raise public concerns.

GLOSSARY[253]

The abbreviation **HVHFHD** is used in this Impact Assessment in reference to the combination of the **High Volume Hydraulic Fracturing** technique combined with **Horizontal Drilling**.

- **C*onventional fossil fuels***: refers to oil and/or gas which can be readily extracted from a high permeability and high energy content formation, usually sandstone, siltstone and carbonate (limestone) reservoirs, without generally requiring artificial stimulation.
- ***Unconventional fossil fuels*** refer to oil and gas obtained from geological formations which are typically more difficult to access and which require the use of specific stimulation techniques such as hydraulic fracturing. Shale gas, tight gas and coalbed methane are examples of unconventional fossil fuels.
- ***"Unconventional"*:** does not refer to the characteristics or composition of the oil/gas itself, but to the porosity, permeability, fluid trapping mechanism, or other characteristics of the reservoir or bearing rock formation from which the oil/gas is extracted, which differ from conventional sandstone and carbonate reservoirs. These characteristics result in the need to alter the geological features of the reservoir or bearing rock formation using artificial stimulation techniques such as hydraulic fracturing in order to extract the oil/gas.
- ***Shale gas***: natural gas that remains tightly trapped in shale and consists chiefly of methane, but with ethane, propane, butane and other organic compounds mixed in. It forms when black shale has been subjected to heat and pressure over millions of years, usually at depths of 1,500 to 4,500 metres. Economic production requires hydraulic fracturing and is typically carried out with horizontal, multi-stage wells. Shale plays often have a transition from oil production at shallow depths (see tight oil), to wet gas areas at intermediate depths, and to dry gas in the deep areas.
- ***Coalbed methane** (CBM):* natural gas in coal reservoirs. Production may or may not require hydraulic fracturing. Past wells were typically vertical but more recently, horizontal and directional methods are used. The reservoirs tend to be at shallow to moderate depths (approximately 610-1,830 meters) and well productivity varies widely.
- ***Tight oil:*** crude oil production from very low permeability self-sourced reservoirs. Economic production requires hydraulic fracturing. In some cases the play involves the oil window updip of shale gas plays. They also include tight oil sandstone and carbonate plays. In the case of the oil portion of shale plays, this resource may be termed "shale oil." Tight oil may be developed with either vertical or horizontal wells, although in most areas of moderate to deeper depths (approximately 2,440-3,660 meters), horizontal wells have much better productivity and economics.
- ***Tight gas sands***: natural gas in very low permeability sandstone reservoirs. Artificial fracturing is required to produce economic volumes. Tight sand reservoirs may exist

[253] Sources: adapted from AEA 2012 study, ICF 2013, Mining Waste Directive, Offshore Safety Directive (2013/30/EU), IEA 2013: Resources to Reserves; US EPA

across a very wide range of depths, and may be produced at depths of approximately 5-6,100 meters.

- ***Methane hydrates*** is natural gas trapped in crystal structures of water, buried under ocean beds or under the permafrost in the Arctic (World Energy Council 2010);
- ***Oil shales*** refer to shale formations containing kerogen, a semi-solid hydrocarbon that must be heated in the ground or mined and heated on the surface to produce oil (Rogner et al. 2012); NB: this is different from **shale oil**, which is an unconventional oil produced from oil shale and which can be used immediately as a fuel or upgraded to meet refinery feedstock specifications.
- ***Oil sand*** (or tar sand or bituminous sand): type of unconventional petroleum deposit.
- ***Shale oil*** is light oil trapped in low-permeability shale formations

- ***Hydraulic fracturing (or fracking)*** is the process by which *fracturing fluids* – a mixture consisting primarily of water, sand and a small percentage of chemical substances (generally between 0.5% and 2%) are injected under high pressure into a geological formation that contains hydrocarbons so as to break the rock and to connect the pores that trap the hydrocarbons. As the injection pressure exceeds the rock strength, the process results in the opening or enlargement of fractures. Injected sand prevents these fractures from closing after the pumping pressure is released, thereby enabling natural gas and oil to flow from the geological formation into the well. Once the hydraulic fracturing process is completed, roughly 30% to 70% on average of the initial fracturing fluids (depending on geological conditions) now mixed with fluids displaced from the geological formation, rises to the surface where it can be collected.

- ***Proppant/propping agent*:** A granular substance (e.g sand grains, ceramics, aluminium pellets, or other material) that is carried in suspension by the fracturing fluid and that serves to keep the cracks open when fracturing fluid is withdrawn after a fracture treatment
- ***Casing:*** Pipe cemented in the well to seal off formation fluids and to keep the hole from caving in.
- ***Play:*** A set of oil or gas accumulations sharing similar geologic, geographic properties, such as source rock, hydrocarbon type, and migration pathways
- ***Porosity:*** Percentage of the rock volume that can be occupied by oil, gas or water
- ***Prospection:*** 'prospecting' means the search for mineral deposits of economic value, including sampling, bulk sampling, drilling and trenching, but excluding any works required for the development of such deposits, and any activities directly associated with an existing extractive operation; (Legal definition in the mining waste directive)
- ***Exploration:*** drilling into a prospect and all related oil and gas operations necessary prior to production related operations
- ***Production*** *of oil and gas* : extraction of oil and gas for commercial purposes including processing of oil and gas and its transportation through connected infrastructure
- ***Off-shore*** *oil and gas operations*: all activities associated with an installation or connected infrastructure, including design, planning, construction, operation and

decommissioning thereof, related to exploration and production. *This* does not include conveyance *of oil and gas* from one coast to another

- ***On-shore*** *oil and gas operations*: all activities related to exploring for, producing or processing of oil and gas which do not occur off-shore
- ***Flowback water*** is generally defined as "fluid returned to the surface after hydraulic fracturing has occurred, but before the well is placed into production. It typically consists of returned fracturing fluids following hydraulic fracturing which are progressively replaced by produced water". (AEA 2012) According to the US EPA, "flowback," is a subset of produced water. The definition of flowback is not considered to be standardized. Generally, the flowback period in shale gas reservoirs is several weeks (URS Corporation, 2009).
- ***Produced water*** is generally defined as "fluids displaced from the geological formation, which can contain substances that are found in the formation, and may include dissolved solids (e.g. salt), gases (e.g. methane, ethane), trace metals, naturally occurring radioactive elements (e.g. radium, uranium), and organic compounds". (AEA 2012) According to the US EPA, there is no clear transition between flowback and produced water.
- ***Formation water*:** Water that occurs naturally within the pores of rock.
- ***Waste water*** is a term used to designate collectively fracturing fluids returned to the surface as flowback and produced water –which continues in many cases to flow to the surface from shale gas wells during the well completion phase and during the production phase of the well. After the initial recovery of hydraulic fracturing fluid, waste water usually consists of fluids displaced from within the shale play (referred to as "produced water") with decreasing quantities of hydraulic fracturing fluid. (AEA 2012)
- ***Venting*** is release of gases directly into the atmosphere.
- ***Flaring*** is controlled burning of natural gas. The process is typically used as an alternative to venting, e.g. during the well completion phase.