Sustainability **2015**, *7*, 2473-2489; doi:10.3390/su7032473

OPEN ACCESS

sustainability

ISSN 2071-1050

www.mdpi.com/journal/sustainability

Article

Controversies Regarding Costs, Uncertainties and Benefits Specific to Shale Gas Development

Jianu Daniel Muresan [1,†,*] and Mihail Vincentiu Ivan [2,†]

[1] Faculty of Economic Sciences, Department of Business Administration, Petroleum-Gas University of Ploiesti, Bd. Bucuresti, nr. 39, Ploiesti 100680, Romania

[2] Faculty of Economic Sciences, Department of Cybernetics, Economic Informatics, Finance and Accountancy, Petroleum-Gas University of Ploiesti, Bd. Bucuresti, nr. 39, Ploiesti 100680, Romania; E-Mail: mihailivan@yahoo.com

† These authors contributed equally to this work.

* Author to whom correspondence should be addressed; E-Mail: jianu_muresan@yahoo.com; Tel.: +40-730-116-776.

Academic Editor: Istudor Nicolae

Received: 24 November 2014 / Accepted: 19 January 2015 / Published: 2 March 2015

Abstract: The shale gas exploration and development is now a delicate and controversial subject. It is often assumed that unconventional exploration and extraction automatically brings prosperity for local, national and regional economies. In this paper, we argue that shale gas development requires a contextualized understanding of regional issues. We are also trying to identify the opportunities and the risks of shale gas development in Eastern Europe (referring to Romania's case) and offer a cost-benefit analysis model that may be of interest to any policymakers and investors.

Keywords: shale gas; cost-benefit analysis; environmental impact; hydraulic fracturing technology; Romania

1. Introduction

The true magnitude of environmental risks due to the use of unconventional technologies in shale gas exploitation continues to be the topic of discussions that take place in both scientific environments and civil society. A series of assessments of greenhouse gas emissions, of life cycles as well as of the resources and the local needs are in the attention of researchers, industrial actors and non-governmental organizations with a view to clarifying their impact at local, regional and global level. At the same time, insufficient regulations in the legal system of the U.S. and especially in European states (including the E.U.), put the main actors involved in a position to observe the impact of unconventional extractions upon the environment, to outline new rules, to comply with new requirements and to re-evaluate overall costs from a new point of view.

In addition, uncertainty concerning the extent of the effects on human life, the refusal of some companies to provide sufficient information on their drilling and extraction technologies and techniques, the perception of incompetence and even the corruption of policy makers, have increased the level of distrust in the practice of hydraulic fracturing among an important segment of the population.

Unluckily, polemics on the subject have always provided too little relevant information about technical operations, managerial and political interventions which could reduce the effects associated with unconventional extraction of resources as well as with the costs and real benefits of shale gas exploitation, in comparison to other conventional and renewable resources.

Even the most efficient and more organized industrial activities generate effects on the environment and on human life. The current paper intends to focus on the need for the contextualization of such consequences in relation to the impact of other methods of energy production as well as on the need for the analysis of local and regional circumstances that determine the level and dynamics of benefits and costs associated with the exploration and development of shale gas.

2. What is Shale Gas and How to Extract It?

Shale gas is a natural gas produced from shale. It belongs to unconventional sources of natural gas. Unconventional sources are [1]:

- Gases which are found in the source rock, formed by the decomposition of organic matter—in this category are:
- The shale gas—The gas stored in the source rock containing organic matter (shale gas)
- The gas which can be found in coal deposits, in mines, tunnels, caves (coal gas)
- Gases trapped in inorganic sediments with low permeability (tight gas)
- Methane hydrate (gas in solid form, frozen gas)

As compared to conventional resources, unconventional deposits are trapped in compact rocks, they have a small content of hydrocarbons as compared to the volume of rock and are dispersed over a considerably large area, around 2–3 km deep (far below the level of conventional hydrocarbon deposits). To be extracted, unconventional deposits require special supplementary work (as in Figure 1): first fracturing the rock to increase its permeability and then injecting considerable amounts of fracturing fluids to release the gases from rocks and guide them to the surface.

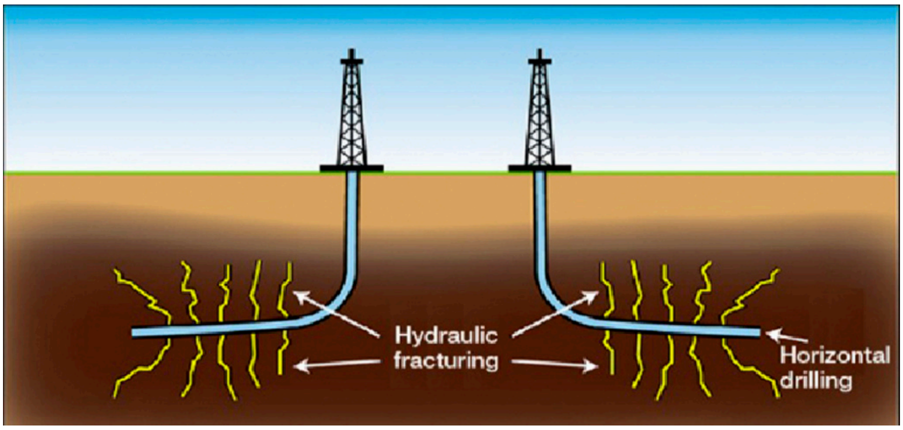

Figure 1. The hydraulic fracturing process Graph source: Unconventional gas: Potential energy market impacts in the European Union—Joint Research Centre.

The exploration phase generally takes 3 to 8 years and includes [1]:

- identifying the deposits
- their qualitative and quantitative assessment
- determining the technical and economic operating conditions

The development phase for shale gas extraction includes the following main steps [1–4]:

(1) **Site development and preparation** involving the construction of access roads, of extraction and drilling rigs.
(2) **Vertical drilling** to a depth of several thousand meters (1000–4000 m), where the shale formations are.
(3) **Horizontal drilling** starting at the top of the vertical well, once the vertical wellbore is at the same depth as the shale bed. The horizontal drilling is performed across the length of the shale bed, sometimes using multiple horizontal wells in different directions, on distances of 1000–2000 m, so that the drilling well would intersect as many cracks.
(4) **Hydraulic fracturing** of shale formations uses a fracturing fluid that includes about 99.5% water and sand and 0.5% chemical additives. The hydraulic fracturing is the procedure by which small section cracks are made in geological strata with very low permeability in order to retrieve natural gases trapped there. Since the cracks naturally present in shale soils are not sufficient for trade flows and for a profitable high-end production, artificial cracks are created using water pumped with extreme pressure (hydraulic fracturing). By means of these cracks the gases accumulated in rocks are subsequently drained/collected. Hydraulic fracturing and horizontal drilling are two well-known techniques in the industry. What can be considered new in the field of shale gas operations as related to these techniques is a combination of the technologies used and, in particular, their use on a large scale for the exploration and exploitation of shale gas.
(5) **Recycling or disposal of the waste waters** which have been used in the process of hydraulic fracturing including drill cuttings, drilling mud, produced water, formation water, condense water from the natural gas, surface water from the drilling pad and any water produced naturally which is brought to the surface.

(6) **Construction of manifolds, collecting pipes and utilities**.

Changing from the development phase to the operations phase is made for each well pad when the drilling wells in that location are dug, equipped and cracked, and surface infrastructure in the area is completed, including a connection to the mains or the final consumer.

The operational phase, having the longest duration in the entire concession period, stretches usually over 15–25 years and includes the petroleum operations carried out for the extraction of the resource, its collection, treatment, transport, as well as its transit to pipelines, with a view to profit capitalization.

As main activities of the operations phase we note [5–7]:

- Petroleum operations, which are to be regarded as the routine of extraction, processing, transport, and optimizing the use of natural gas.
- Resuming the procedure of hydraulic fracturing in the wells, at intervals of 4–5 years, to increase the recovery factor and to reconfirm supplementary reserves obtained during these operations.
- Permanent monitoring of well flow, of the level of impurities (waste) and environmental parameters.
- Reporting the quantities of gas obtained out of each deposit, for the purpose of severance tax.
- Prompt remediation of any technical accident which could lead to the pollution of water, air, soil and subsoil.

The termination of exploitation at the level of each deposit (well pad) shall be made when the operation is unable to continue for technical, geological or economic reasons.

It must be noted that in Germany, for example, the difference between development and operation phase is defined in agreement with the regulatory. However, if the condition of the gas fits the requirements of the gas dryer, the operation is started [8].

3. Risks and Uncertainties

- There are a lot of risks and uncertainties associated with shale gas development, as results from American expertise, and which certainly must be taken into account (see Figure 2). These can be listed as follows [9]:
- Major changes to the landscape which will be the depositary of numerous equipment, fluids in very large quantities and obviously transport infrastructure to ensure delivery of the inputs and outputs of this very complex system.
- Possible water pollution with chemicals used in or resulting from hydraulic fracturing process, but also with tap water contaminated with heavy metals or radioactive particles;
- Air pollution and noise pollution due to numerous engines put into service, the evaporation of various fluids including the resulting waste waters as well as to the highly intensified (heavy machinery) transportation;
- Earthquakes caused by technological processes;
- Mobilization of radioactive substances which can be found naturally in the underground;
- Consumption of natural resources as well as of derived material resources;
- Major impact on biodiversity in particular natural habitat and wild flora and fauna;
- Regional water balance (availability *vs.* consumption, ownership).

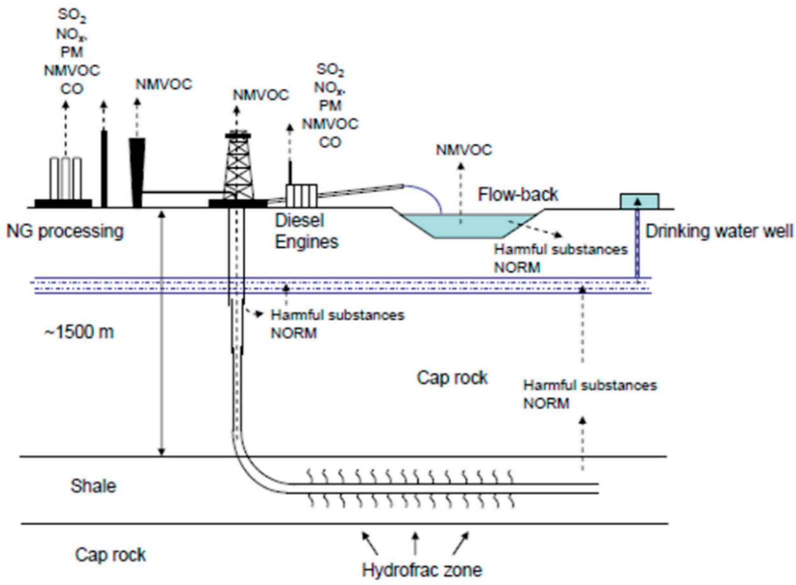

Figure 2. Potential flows of air pollutant emissions, harmful substances into water and soil, and naturally occurring radioactive materials Source: [9].

3.1. Impact on Landscape

In the US, shale gas formations development involves the deployment of drilling wells with densities between 1 well per 2.6 km^2 to 6 wells per km^2 [10,11]. These wells involve rigging up various industrial equipment and chemical storage spaces, containers for necessary supplies of water but also for resulting residual waters, in the event that this is not discharged in ponds specially designed for this purpose. In addition, wells must be connected through roads to withstand transportation with heavy trucks and tanks, all of which increase the ecological footprint.

What's more, once extracted, gases must be transported, which requires a pipeline network (built on the surface or underground) but also sufficient premises for temporary storage, until they will be delivered through distribution networks.

Another aspect worth noted refers to the problems of exacerbated soil erosion, destruction of natural habitat and generally the failure of ecosystem mechanisms [12].

3.2. Impact on Water

The most intensely debated issues relating to the development of shale gas focus on the possible impact upon water resources, on the quality of the groundwater but also on the issue of faulty waste water disposal. The large volume of resulting residual water but also its polluting chemical compounds doubled by the migration of methane toward the drinking water resources (contamination of fountains and wells) as the landowner drilled their well for drinking water in the shale formation and since no independent water quality control is established, this failure was misused to increase the level of anxiety among the public opinion [13,14].

First, the massive use of local water resources, sometimes insufficient, not only affects the ecosystems but enter in competition with the demand of water at regional level [7]. Large quantities of water are used during drilling operations to cool and lubricate the drilling head, but also to evacuate the drilling mud. Furthermore, the fracturing operation is resumed even 10 times for each well. Each stage of re-fracturing may require quantities of water higher than the previous fracture [10].

Second, close to the surface of the ground, where there may be water resources, the wellbore is lined with several concentric layers of metal tubing and cement. However, physical wear can cause cracks in these protective layers, thus compromising the structure of this insulation and the contamination of aquifers is made possible [15,16].

Finally, relating to waste water (sewage sludge), it has to be said that an important percentage of the quantities of water injected into the underground, between 10% and 40%, returns to the surface after fracturing has occurred. Depending on the formation this water can be loaded with radioactive metals, dissolved minerals, chemicals that are specific to fracturing and dissolved hydrocarbons [17,18]. Huge quantities of such waste waters, in the hundreds of thousands of cubic meters, are either temporarily stored and then re-used in future fracturing operations, or transported to be treated in special water treatment plants. This presents a risk of accidental spillage from storage tanks or during transport, which creates new challenges in terms of logistics operations.

3.3. Pollution of Air, Soil and Noise Pollution

According to the studies and analyses conducted until now, polluting emissions would come from the following sources [9,19]:

- An emission from trucks, heavy machinery and drilling equipment. The drilling equipment emits large amounts of CO_2 produced by burning fuels.
- Emissions of SO_2, NO_x, NMVOC, CO but also noise and various particles, resulted from the usual processing and transport operations. In addition, during the production, processing and transport stages there can be sporadic emissions of methane, a dangerous greenhouse gas.
- Evaporation of chemicals from sewage ponds.
- Emissions due to oil well leaks and explosions. Most times they are due to the incorrect operation of equipment, either through the lack of staff training, or through non-compliance with the requirements and specific work safety standards.

In addition to emissions of aromatic compounds such as benzene and xylene, some researches [20] confirm the presence of some carcinogenic and neurotoxic substances in the air. Fortunately in the EU the emission of such substances is limited by law [19,21].

3.4. Consumption of Resources

The consumed resources and the energy needed for each cubic meter of extracted gas vary widely from one deposit to another. Therefore a separate assessment is required of each shale formation to obtain relevant data. The information available shows however that the demand in resources for the development of shale gas operations is higher than for the development of conventional gas operations.

3.5. Radioactive Substances and Their Impact

Radioactive elements such as uranium, thorium and radium are present in all geological formations but by hydraulic fracturing they are brought to the surface with the fluids discharged from underground.

In addition, it is possible that certain radioactive particles be deliberately injected along with fracturing fluids. The amounts in which these elements are present differ from a mining area to another and usually they accumulate in the pipes or tanks. Therefore the most exposed to the radioactive risk are workers handling pipes, cleaning tanks or reconditioning the equipment [10]. Other potentially toxic substances that gain additional mobility because of hydraulic fracturing are mercury and arsenic. They can find a way to seep into underground sources of drinking water when fracturing extends underneath shale gas formations.

On the other hand, fracturing fluids include approximately 98% water and sand with the remaining 2%, 17 are considered toxic represented by chemical additives whose composition is confidential and is not disclosed to the public on the grounds of industrial secrecy. However, such additives include carcinogenic, toxic substances, allergens and mutagens. A survey carried out in 2011 in the State of New York reveals the following aspects [22,23]:

- 58 of the 260 substances analyzed have one or more properties which raised questions and fueled concerns to aquatic fauna and flora;
- 38 are considered toxic and affect human health;
- 8 are carcinogenic substances;
- 6 are suspected to be carcinogens;
- 7 are mutagens;
- 5 have effects on reproduction.

3.6. Risk of Earthquakes

The fact that hydraulic fracturing can induce earthquakes with magnitudes measuring between 1 and 3 on the Richter scale is assumed. In Romania, the risk of such small earthquakes occurring once the shale gas exploration began in Barlad has fueled the fears of public opinion that these relatively minor seismic movements might trigger more intense earthquakes in areas with major earthquake risk like Vrancea, which is located at about 100 Km from the site to be explored. Until now the hypothesis of such causal relationship has not been verified.

4. Shale Gas in Romania

Romania is third place in Europe in terms of its potential for the exploration of shale gas. First place is shared by France and Poland, each with a reserve estimated at about 5000 billion cubic meters. Norway, on second place, could be able to extract over 2200 billion cubic meters of shale gas, while in Romania the exploration of this unconventional resource might bring to the surface, in theory, 1440 billion cubic meters of natural gas. Worldwide, gas exploitation champions in shale gas extraction are the United States and Canada, whereas in France this process forbidden. The only European country which at this point in time is exploiting shale gas by hydraulic fracturing is Poland. However, first, Romania should determine whether it has shale gas that can be exploited. This can be established only after some exploratory drilling, followed by on-spot or laboratory simulation of the hydraulic fracturing process.

Preliminary studies have identified Romania’s potential with respect to shale gases but to find out if they are exploitable deep drilling is needed, in order to reach the clay geological formations containing such gases. In Romania, for instance, shale gases are located at about 3500–4000 m deep. To assess the size of the geological formations, which determine the cost-effectiveness of the exploitation process, at least three such exploration drill holes are required. In the USA, where exploitation has proved cost-effective, the geological formation must be between 20 and 100 m thick.

So far in Romania, based on Petroleum Act no. 238/2004, ten land areas were concessioned in view of the exploration and exploitation of hydrocarbons. For the other areas on map, no agreements have yet been signed to proceed with the exploration and exploitation, apart from the concession being granted. Of the 10 concluded agreements, the only agreements declassified at the request of the civil society are the three petroleum exploration agreements held by Chevron in Dobrogea.

The three perimeters affected by this declassification are EX 19 Adamclisi, EX—18 VamaVeche and EX—17 Costinesti located in the south-east of the country (as in Figure 3), being delimited to the east by the Black Sea and the border between Bulgaria and Romania. From the administrative point of view these perimeters are located in Constanta County.

Figure 3. Location of respective areas EX—19, EX—18 and EX—17. Source: [1].

The three petroleum concession agreements for exploration, development and exploitation have been approved in March 2012 by Government Decision.

In Romania, various classifications apply in relation to nature conservation [1,24]. In particular, a number of sites were combined under the name Natura 2000 [25], thus becoming part of a network of protected areas under the European Union Directive 1992 on habitat and of E.U. Directive 1979 relating to birds. Restriction in petroleum operations on sites of Community importance, natural reserves, Natura 2000, *etc.* was understood and assumed by holders even from the tender stage. They have undertaken to conduct petroleum operations only in the locations specified in the regulatory acts issued by the competent authority for environmental protection, which placed under restrictions all protected areas, minor river beds and lakes basins, the areas of sanitary protection and the hydrogeological protective perimeters of water abstractions.

Currently the three petroleum agreements are in the initial phase of exploration by which the hydrocarbons potential is to be determined. The exploration works should be carried out over a period of 4 years and include seismic surveys and drilling exploration wells, using the oil industry's traditional methods which apply in Romania for decades.

Another area for exploration (Figure 4), development and exploitation is located in the East of Romania, near the border with the Republic of Moldova, approximately 260 kilometers E-NE of Bucharest. From the administrative point of view the area covers areas from the counties of Vaslui, Galati and Bacau as shown in the illustration below.

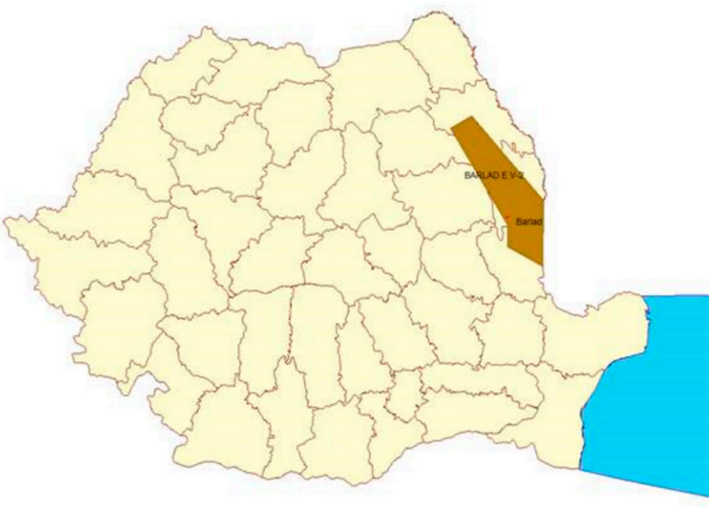

Figure 4. Location of eastern sites. Source: Agentia Nationala pentru Resurse Minerale, [1].

Drilling exploration wells Popeni-1, Silistea-1 and Paltinis-1 by Chevron Romania Exploration and Production SRL in rural Gagesti, Pungesti and Bacesti, all located in Vaslui County, sparked great discontent among the population.

Nationwide, the population informed or perhaps manipulated in connection with the harmfulness of shale gas started to protest. In Barlad there were five protests, with more than 5000 participants each time. Lawsuits were filed against the State, the civil society succeeding, in the case of Barlad site, to block the granting of an environmental approval to begin explorations in 3 villages.

A local referendum organized in the month of December 2012 in Costinesti has been declared valid and expressed the general option to reject shale gas extraction by the negative vote of over 94% of the people taking part in the referendum.

On 4 April 2013, 28 cities took to the streets to say no to shale gas exploitation. This coming under pressure from the media determined Local Councils in 17 villages in Romania to issue decisions prohibiting shale gas exploration and exploitation by hydraulic fracturing in areas under their administration.

5. A Model of Cost-Benefit Analysis

From studies performed or funded by the petroleum and gas industry the general conclusion is that there will be major positive economic effects on both national and local economies. These studies point out obvious benefits such as job creation, increasing income as well as fund collection from taxes and duties. Some authors on the other hand [5] claim that the benefits estimated by these studies sponsored by the industry itself would be overestimated. Any economic activity, including the development of shale gas operations, will generate profits for entrepreneurs and opportunities for people looking for a job but decision-makers should ask themselves whether these benefits are exaggerated and economic impact in the long term is far from the one expected.

A model of input-output analysis is used frequently by petroleum and gas industry to show the direct and indirect effects of shale gas operations development [26,27]. Using this technique studies identify some benefits that shale gas exploitation brings on the growth of auxiliary industries. The working premise is represented by a table of coefficients linking every industry in a region to all other industries. An input-output matrix reveals how much output of an industry is used as input for other industries. However, in a region where shale gas exploitation never existed in the past it is very difficult to determine what these coefficients are and implementing them from other regions or industries could lead to inaccurate analyzes and conclusions [28,29]. Furthermore, Kinnaman also claims that "economic resources necessary to fuel a growing industry would either relocate from other regions of the country or shift from local industries within the region…" [5,28–30].

In the last few years working models have evolved to an input-output matrix far more sophisticated, multiregional and multisectoral that considers both the production recipe, the level of polluting emissions and the use of renewable energies and land [30,31].

On the other hand, the dichotomy is well known between the benefits the development of shale gas operations can bring at national level and the damage which may arise at local level. In this situation it is very likely that the authorities at national level pursue separate interests from the regional or local authorities. An issue that should concern any public authority, at any level, is whether the development of shale gas operations (which includes the exploration, production and possibly export) covers the costs incurred by regional and local communities and the individuals directly involved.

In this context, it is necessary to take into account the issue of increase-decrease cycles (boom-bust cycles) which characterize developments in extractive industries. The negative economic consequences of the decrease (bust) cycle may exceed the positive economic impact from the growing (boom) period. D. Black *et al.* have studied periods of growth (the 70's) and of decrease (the 80's) in coal mining industries in several States in the U.S.A. They reached the conclusion that "for each 10 jobs produced in the coal sector during the boom, we estimate that fewer than 2 jobs were produced in the local-good sectors of construction, retail and services. The spillovers from the coal bust were larger. During the coal bust, for each 10 jobs lost in the coal sector, 3, 5 were lost in construction, retail and services sector" [32,33].

When assessing the costs involved in shale gas extraction the following aspects must be taken into account:

A development in shale gas operations can transform an area considered "clean", with a welcoming natural environment, because of industrial contamination, heavy vehicles and heavy traffic with excessive noise. Due to concerns over water, air and soil contamination, industries that are vital to a community can be brought into decline. Such sectors which are incompatible with high levels of industrialization and environmental degradation are: agriculture (in particular organic agriculture), tourism, pisciculture, viticulture, brewing industry, *etc.*

Industrial activities such as shale gas extraction may irremediably affect the "brand" of a region. Fear of pollution, whether grounded or not, is likely to affect public perception of certain areas where tourism traditionally brings a lot of non-monetary benefits that contribute to an adequate level of the residents' quality of life. Hotels, restaurants, shops, outdoor recreation areas, parks, museums, festivals, vineyards, the entire landscape in general, are necessary and beneficial for both residents and visitors [34]. Furthermore, these are resources that attract investments and increase labor mobility at regional level.

- Additional costs necessary to be estimated are those associated with an increase in demand for local services, such as public order, fire department, emergency services and hospitals.
- One cannot ignore the costs resulting from degradation of the transport infrastructure as well as the costs caused by traffic congestion in the area.
- The impact on the real estate market is also negative. Although demand on the regional real estate market experiences a growth spurt, hence an impact on the sales prices of properties, but also on rents, studies prove that this price increase is canceled by the fact that the properties located in close proximity of extraction areas are increasingly harder to insure [16]. This adversely affects the price range because mortgages are subject to the existence of insurance policies for the properties in question.
- A thorough economic assessment may not exclude costs associated with degradation in public health. A series of analyzes emphasize the adverse impact on the overall state of health caused by water and air contamination with carcinogenic substances or chemicals that affect the endocrine system. They are associated with many serious diseases or with birth deficiencies, both involving major costs. Such costs can be measured by assessing costs for the required health care services, of expenditure determined by premature mortality and those reflected by the decrease in the life expectancy of its inhabitants over the affected the region.

In any decision-making process with respect to the opportunity of shale gas exploitation, all the benefits and potential costs should be taken into account to determine, eventually, whether the potential benefits are worth taking risks that will be reflected on the environment, public health and local economies.

In this respect we suggest a model of cost-benefit analysis (Table 1) which, far from being exhaustive (it can be filled in base on the regional and local specificity), can serve as a necessary tool to economic and social policy holders in any area with potential in the development of shale gas operations.

Table 1. Model of cost-benefit analysis for shale gas development.

Potential Benefits	Possible Costs
- Jobs created (total but also for each stage of the development of shale gas operations); Very often the oil and gas companies come along with their own employees. - Revenue for the state budget from fees, taxes and contributions; - Revenue for local budgets from fees, taxes and contributions; - Proceeds from severance taxes; - Stimulating industries in the system, vertically and horizontally (an estimate of potential revenue and the number of jobs created in these industries); - Positive effects upon the environment due to a reduction in greenhouse gas emissions; - Reducing the price of electricity in the operational phase (the impact on bills incurred by household and industrial consumers);	- The cost of the degradation of health of the local population; - Costs associated with air pollution and contamination of water and soil; - Costs generated by an increased seismic activity resulting from hydraulic fracturing; - Costs due to the decline in other sectors (tourism, agriculture, cultural sectors); Decrease in revenue from taxes and fees resulting from these sectors; - Relocation costs for some communities; - Costs associated with the deterioration of the transport infrastructure; - Costs in property insurance; - Decrease in the price of real estate; - Costs of additional public services and utilities; - Costs associated with the decrease stage within the economic cycles specific to extractive industries; - Costs of water quality control; - Costs associated with assessment of environmental effects; - Costs of post operation aftercare;

Clearly these costs and benefits may be overshadowed by other things, which cannot be valued in monetary terms, for example mortality caused by incurable diseases resulting from the pollution with hazardous chemicals. All of these costs stir tension among the public, which may lead to projects being blocked as early as in the exploration phase.

6. Results and Discussion

The development of shale gas operations brings to the fore a series of new problems and challenges in terms of decision-making. Here are a few [34–41]:

- Currently, extractive industries are facing problems due to insufficient legislative regulations or even a lack thereof. Oftentimes legislation at national level is based on needs from the past, and there is yet no European mining framework Directive.
- There is insufficient information available to political decision makers and the general public about the chemicals used in the technologic recipe. Chemical industry offers a wide variety of chemical additives but often it does not declare their exact composition due to the alleged industrial and commercial secrecy. Legal regulations should establish clearly the obligation to declare and the duty to comply with certain limit values allowed in the process of hydraulic fracturing.

- After the completion of the operational phase a series of chemicals remain underground. They get dissipated and disperse over time, naturally, in ways almost impossible to control or foresee.
- It is obvious that citizens should claim more rights in the decision-making process relating to industrial operations with a measurable impact on the environment as well as a possible one on public health. Some opinions claim that the process of public consultation should be part of the authorization procedure.

Legal regulations at European level relating to mining industries do not take into account aspects specific to hydraulic fracturing. There are major differences between the regulations of the various member states of the EU. In many situations industrialists rights prevail against citizens' rights and local authorities do not have enough influence given the fact that mining industries fall into the care of the central authorities [9,41]. Regional authorities should be endowed with greater autonomy so they can decide whether to ban or license the hydraulic fracturing operations in the territory they govern. European legislation requires an evaluation of the impact on the environment only if the average production of an oil well exceeds 500,000 cubic meters per day. This value is excessive considering that the average production of an oil well is in the tens of thousands of cubic meters, at least during the first phases of operation. In this context, an assessment of the impact on the environment and public consultation would be required for each well in particular.

7. Conclusions

Hydraulic fracturing technology is practiced for decades in the U.S.A., the only relevant source for long term statistics. From the American expertise we learn that the technology of shale gas exploration has special features that indicate the following aspects: (1) impact on the environment is inevitable; (2) major risks are when technology is not properly used; (3) there is a risk of damage to the environment and to human health even when technology is used correctly.

Risks associated with improper handling of technology may occur due to leakage of waste waters or fracturing fluids, but also to aquifer contamination. These risks can be reduced through appropriate technical directives, the prudent use of the equipment and supervision from public authorities. However, all of these safety measures increase the costs of the project and slow down the process of implementing it. On the other hand American expertise in the field also shows us that many times accidents are caused by the desire of companies to cut down on costs (costs with safe equipment, with process monitoring or staff training).

At this stage, in which sustainability must be the backbone of any development, the question arises of whether injection of toxic chemicals in the underground should be allowed or prohibited since this would exclude or restrict the possibility of the future use of contaminated layers. In an active area of shale gas extraction approximately 0.1–0.5 L of chemicals are injected per square meter [22].

Gas production at European level has recorded a rapid decline in recent years and estimates are that the decline would continue with a further 30% by 2035, while a continuous increase in demand is expected during all this time. It is, therefore, necessary to increase imports to deal with these trend but it is very unlikely they would cover an additional need (as a result of the difference between the increase in demand and a fall in production) of approximately 100 Billion cubic meters. At the same time, unconventional European gas resources are insufficient to respond to such a demand, even if they could be exploited in their entirety (which is practically impossible).

It is very likely that the investments in the development of shale gas, with relatively short term effects on the increase of demand on gas market, to have a negative psychological impact, as it would give the impression of an abundant supply gas in a context in which the signal that should be given to consumers would be to reduce dependency by effective measures of saving or substitution.

Author Contributions

The authors contributed equal to this paper. Mihail Vincentiu Ivan is responsible for identifying the risks and uncertainties of shale gas development. Jianu Daniel Muresan assessed the opportunity and the problematic issue of shale gas exploration. Both authors developed the cost-benefit analysis. Both authors reviewed the paper, and contributed equal to discussion and conclusions sections. All authors have read and approved the final manuscript.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Agentia Nationala Pentru Resurse Minerale. Available online: http://www.infogazedesist.eu/ (accessed on 9 November 2014).
2. Ames, R.; Corridore, A.; Ephross, J.N.; Hirs, A.E.; MacAvoy, P.W.; Tavelli, R. The Arithmetic of Shale Gas. Available online: http://digitalcommons.law.lsu.edu/cgi/viewcontent.cgi?article=1017&context=jelr (accessed on 14 November 2014).
3. Arthur, J.D.; Bruce, P.E.; Langhus, P.G. An Overview of Modern Shale Gas Development in the United States, ALL Consulting, 2008. Available online: http://www.all-llc.com/publicdownloads/ALLShaleOverviewFINAL.pdf (accessed on 9 November 2014).
4. Bamberger, M.; Oswald, R.E. Impacts of Gas Drilling on Human and Animal Health. *New Solut.* **2012**, *22*, 51–77.
5. Kinnaman, T. The Economic Impact of Shale Gas Extraction: A Review of Existing Studies. *Ecol. Econ.* **2011**, *70*, 1243–1249.
6. Korn, A. Prospects for Unconventional Gas in Europe, 5 February 2010. Available online: http://www.eon.com/content/dam/eoncom/en/downloads/ir/20100205_Unconventional_gas_in_Europe.pdf (accessed on 10 November 2014).
7. Nicot, J.; Scanlon, B.R. Water use for shale-gas production in Texas, U.S. *Environ. Sci. Technol.* **2012**, *46*, 3580–3586.
8. Dannwolf, U.; Heckelsmüller, A. *Environmental Impacts of Hydraulic Fracturing Related to the Exploration and Exploitation of Unconventional Natural Gas, in Particular of Shale Gas*; Environmental Research of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety: Bonn, Germany, 2014.

9. Impacts of Shale Gas and Shale Oil Extraction on the Environment and on Human Health. European Parliament; Directorate General for Internal Policies: Brussels, Belgium, 2011. Available online: http://www.europarl.europa.eu/document/activities/cont/201107/20110715ATT24183/20110715ATT24183EN.pdf (accessed on 9 November 2014).
10. Sumi, L. *Shale Gas: Focus on Marcellus Shale*; For the Oil & Gas Accountability Project; Earthworks: Washington, DC, USA, 2008.
11. New York State Department of Environmental Csonservation (NYSDEC), Division of Mineral Resources on the Oil, Gas and Solution Mining Regulatory Supplemental Generic Environmental Impact Statement (SGEIS) prepared Program. Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, 2010. Available online: http://www.dec.ny.gov/energy/47554.html (accessed on 14 November 2014).
12. Johnson, N.; Gagnolet, T.; Ralls, R.; Zimmerman, E.; Eichelberger, B.; Tracey, C.; Kreitler, G.; Orndorff, S.; Tomlinson, J.; Bearer, S.; *et al*. For the Nature Conservancy 2010. Pennsylvania Energy Impacts Assessment Report 1: Marcellus Shale Natural Gas and Wind. Available online: http://www.nature.org/media/pa/pa_energy_assessment_report.pdf (accessed on 9 November 2014).
13. Osborne, S.G.; Vengosh, A.; Warner, N.R.; Jackson, R.B. Methane contamination of drinking water accompanying gas-well drilling and hydraulic fracturing. *Proc. Natl. Acad. Sci. USA* **2011**, *108*, 8172–8176.
14. Smith, M. Dimock Residents to Share $4.1 Million, Receive Gas Mitigation Systems Under DEP-Negotiated Settlement with Cabot Oil and Gas. Commonwealth of Pennsylvania Department of Environmental Protection Press Release, 2010. Available online: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=15595&typeid=1 (accessed on 10 November 2014).
15. Gény, F. Can Unconventional Gas be a Game Changer in European Gas Markets? The Oxford Institute for Energy Studies. NG 46, 2010. Available online: http://www.oxfordenergy.org/wpcms/wp-content/uploads/2011/01/NG46-CanUnconventionalGasbeaGameChangerinEuropeanGasMarkets-FlorenceGeny-2010.pdf (accessed on 10 November 2014).
16. Gresh, K. DEP Fines Chesapeake Energy More Than $1 Million. Commonwealth of Pennsylvania Department of Environmental Protection Press Release, 2011. Available online: http://www.portal.state.pa.us/portal/server.pt/community/newsroom/14287?id=17405&typeid=1 (accessed on 9 November 2014).
17. Stepan, D.J.; Shockey, R.E.; Kurz, B.A.; Kalenze, N.S.; Cowan, R.M.; Ziman, J.J.; Harju, J.A. Bakken water opportunities assessment—Phase 1 Final Report Summary, Energy & Environmental Research Center University of North Dakota, prepared for: Karlene Fine North Dakota Industrial Commission Oil and Gas Research Council.2010. Available online: http://www.nd.gov/ndic/ogrp/info/g-018-036-fi.pdf (accessed on 9 November 2014).
18. Shaari, M.S.; Hussain, N.E.; Rashid, I.M.A. The relationship between energy use, economic growth, and CO_2 emission in Malaysia. *Econ. Manag. Financ. Market.* **2014**, *9*, 41–53.
19. De Perthuis, C.; Trotignon, R. Improving carbon markets governance: What can we learn from the EU emission trading scheme? *J. Self. Govern. Manag. Econ*. **2014**, *2*, 53–68.

20. Wolf Eagle Environmental. Town of Dish, Texas, Ambient Air Monitoring Analysis, Final Report, 15 September 2009, Available online: http://townofdish.com/objects/DISH_-_final_report_revised.pdf (accessed on 14 November 2014).
21. Agarwal, N. Buying high return low volatility technology stocks. *Econ. Manag. Financ. Market.* **2014**, *9*, 73–85.
22. Wood, R.; Gilbert, P.; Sharmina, M.; Anderson, K. Shale Gas: A Provisional Assessment of Climate Change and Environmental Impacts. January 2011. Available online: http://www.tyndall.ac.uk/sites/default/files/tyndall-coop_shale_gas_report_final.pdf (accessed on 14 November 2014).
23. Hoen, H.V. Globalization and institutional change: Are emerging market economies in Europe and Asia converging? *J. Self. Govern. Manag. Econ.***2014**, *4*, 44–66.
24. Naert, F. The new EU economic governance: Vertical and horizontal power shifts. *J. Self. Govern. Manag. Econ.* **2014**, *2*, 77–100.
25. Nationwide Insurance: No Fracking Way. The River Reporter, 11 July 2012. Available online: http://www.riverreporter.com/news/14/2012/07/11/nationwide-insurance-no-fracking-way (accessed on 10 November 2014).
26. Boxall, P.C.; Chan, W.H.; McMillan, M.L. The Impact of Oil and Natural Gas Facilities on Rural Residential Property Values: A Spatial Hedonic Analysis. *Resour. Energy Econ.* **2005**, *27*, 248–269.
27. Christopherson, S.; Rightor, N. How Should We Think about the Economic Consequences of Shale Gas Drilling? In *Working Paper Series, a Comprehensive Economic Impact Analysis of Natural Gas Extraction in the Marcellus Shale*; Cornell University: New York, NY, USA, 2011.
28. Tiess, G. *Legal Basics of Mineral Policy in Europe—An Overview of 40 Countries*; Springer: New York, NY, USA, 2011.
29. U.S. Department of Commerce. Regional Multipliers, A User Handbook for the Regional Input Output Modeling System. Available online: http://www.bea.gov/scb/pdf/regional/perinc/meth/rims2.pdf, 1997 (accessed on 14 November 2014).
30. Wiedmann, T.; Lenzenb, M.; Turnerc, K.; Barrett, J. Examining the Global Environmental Impact of Regional Consumption Activities—Part 2: Review of Input-Output Models for the Assessment of Environmental Impacts Embodied in Trade. *Ecol. Econ.* **2007**, *61*, 15–26,
31. Mauter, M.S.; Palmer, V.R.; Tang, Y.; Behrer, A.P. The Next Frontier in United States Shale Gas and Tight Oil-Extraction: Strategic Reduction of Environmental Impacts. In *Energy Technology Innovation Policy Discussion Paper Series*; Belfer Center for Science and International Affairs: Cambridge, MA, USA, 2013.
32. McKenzie, L.M.; Witter, R.Z.; Newman, L.S.; Adgate, J.L. Human Health Risk Assessment of Air Emissions from Development of Unconventional Natural Gas Resources. *Sci. Total Environ.* **2012**, *424*, 77–87.
33. Black, D.; McKinnish, T.; Sanders, S. The Economic Impact of the Coal Boom and Bust. *Econ. J.* **2005**, *115*, 449–476.
34. Barth, J.M. The Economic Impact of Shale Gas Development on State and Local Economies: Benefits, Costs, and Uncertainties. *New Solut.***2013**, *23*, 85–101.

35. Dutzik, T.; Ridlington, E.; Rumpler, J. *The Costs of Fracking: The Price Tag of Dirty Drilling's Environmental Damage*; Penn Environment Research and Policy Center: Philadelphia, PA, USA, 2012.
36. Rumbach, A. *Natural Gas Drilling in the Marcellus Shale: Potential Impacts on the Tourism Economy of the Southern Tier*; Southern Tier Central Regional Planning and Development Board: New York, NY, USA, 2011.
37. Stepan, D.J.; Shockey, R.E.; Kurz, B.A.; Kalenze, N.S.; Cowan, R.M.; Ziman, J.J.; Harju, J.A. Bakken Water Opportunities Assessment: Phase 1. University of North Dakota Energy and Environmental Research Center for North Dakota Industrial Commission Oil and Gas Research Council. Available online: http://www.undeerc.org/bakken/pdfs/FracWaterPhaseIreport.pdf (accessed on 9 November 2014).
38. Glac, K. The Influence of Shareholders on Corporate Social Responsibility. *Econ. Manag. Financ. Market.* **2014**, *9*, 34–72.
39. Thomas, A.R.; Lendel, I.; Hil, E.W.; Southgate, D.; Chase, R. An Analysis of the Economic Potential for Shale Formations in Ohio (Study Commissioned by the Ohio Shale Coalition). Available online: http://engagedscholarship.csuohio.edu/cgi/viewcontent.cgi?article=1454&context=urban_facpub (accessed on 9 November 2014).
40. Gheorghe, H.P. The economic impact of rising temperatures. *J. Self. Govern. Manag. Econ*. **2014**, *2*, 44–49.
41. Jørgensen, T.B.; Rutgers, M.R. Tracing public values change: A historical study of civil service job advertisements. *Contemp. Readings L. Soc. Just.* **2014**, *6*, 59–80.