

The dash for gas in Ukraine

Current trends in the production
of unconventional reserves



CEE bankwatch
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Executive Summary

Hydraulic fracturing combined with horizontal drilling used for the production of hydrocarbons from unconventional resources is a relatively new technology, the use of which causes effects which still require further study but has already raised concerns.

This technology requires a lot of resources, particularly land and water. Close well spacing leads to aesthetic pollution of landscapes, degradation and contamination of fertile soil and possible violation of landowners' rights. Fracturing a single well may require up to 15 thousand m³ of water. However, there may be thousands of such wells, and the hydraulic fracturing operation may be repeated up to 10 times for each of the wells. Once used for fracturing, water will never return to the natural water cycle because there is no economically sound technology for clearing it of industrial contaminants, heavy metals and radionuclides.

The issue of liquid waste disposal also remains open, as Ukraine has no treatment facilities capable of receiving and purifying waste of such hazard class and in such quantity. The US practice of injecting such waste into disposal wells shows that this can cause seismic activity in areas that are tectonically and geodynamically complex in nature. In addition, scientific research suggests that fracking fluid can uncontrollably migrate to groundwater, affecting drinking water resources.

Scientists have established the relationship between unconventional gas drilling and pollution of water and air, and the relationship between this pollution and the deterioration of locals' health. Chemicals used in hydraulic fracturing affect the human endocrine system. Pregnant women, children and animals are the most exposed to their harmful effects.

The extraction of unconventional gas and any other hydrocarbons gives rise to an increased risk of accidents. Local communities may suffer from explosions, fires, chemical spillages and the release of toxic gases.

As unconventional gas drilling is a complex operating procedure, it is unlikely that it will create many jobs for local residents. Even if new jobs are provided, these will be for unskilled workers, few in number and temporary. The traffic load on local roads will increase significantly because the maintenance of wells requires a huge number of trucks.

There is no scientific data on the existing reserves of unconventional gas in Ukraine. Due to technological and geological reasons, the price of unconventional gas will not be lower than that of conventional gas. Moreover, according to experts it could be much higher, reaching USD 560-650 thousand per m³.

Producing even a small amount of gas will require massive support from the state in the form of fiscal incentives. As a result, unconventional gas will be competing directly with renewable energy sources such as wind and solar energy, and meaning that economic and infrastructural investments would be tied up in the extraction of a finite resource obtained from exhaustible reserves.

In Ukraine, the government does not control application of the hydraulic fracturing method. There are no specific rules or laws that would regulate the use of this technology. The activities of relevant companies are governed by laws applicable to conventional oil and gas production.

An alternative to extracting unconventional hydrocarbons should be an efficient national energy policy, reducing the consumption of conventional fuel and energy resources and focusing on the development of renewable energy sources.

Introduction



A piece of shale rock. Photo: Matthew Lloyd / Getty Images

Natural gas extraction history dates back decades. Usually one well reaching a natural underground reservoir with accumulated gas would be drilled to release gas to the surface under its own pressure. However, over time, such traditional fields became depleted and people started looking for new reserves. They directed their search towards the fields, which up to the present day have not been considered attractive because of the technical complexity and unfeasible cost of extracting gas from them. These are so-called unconventional fields where gas molecules have not yet migrated through the rock bed to underground voids and remain «locked» in rocks of different densities (shale gas, compacted sandstone gas and coal bed methane, etc.).

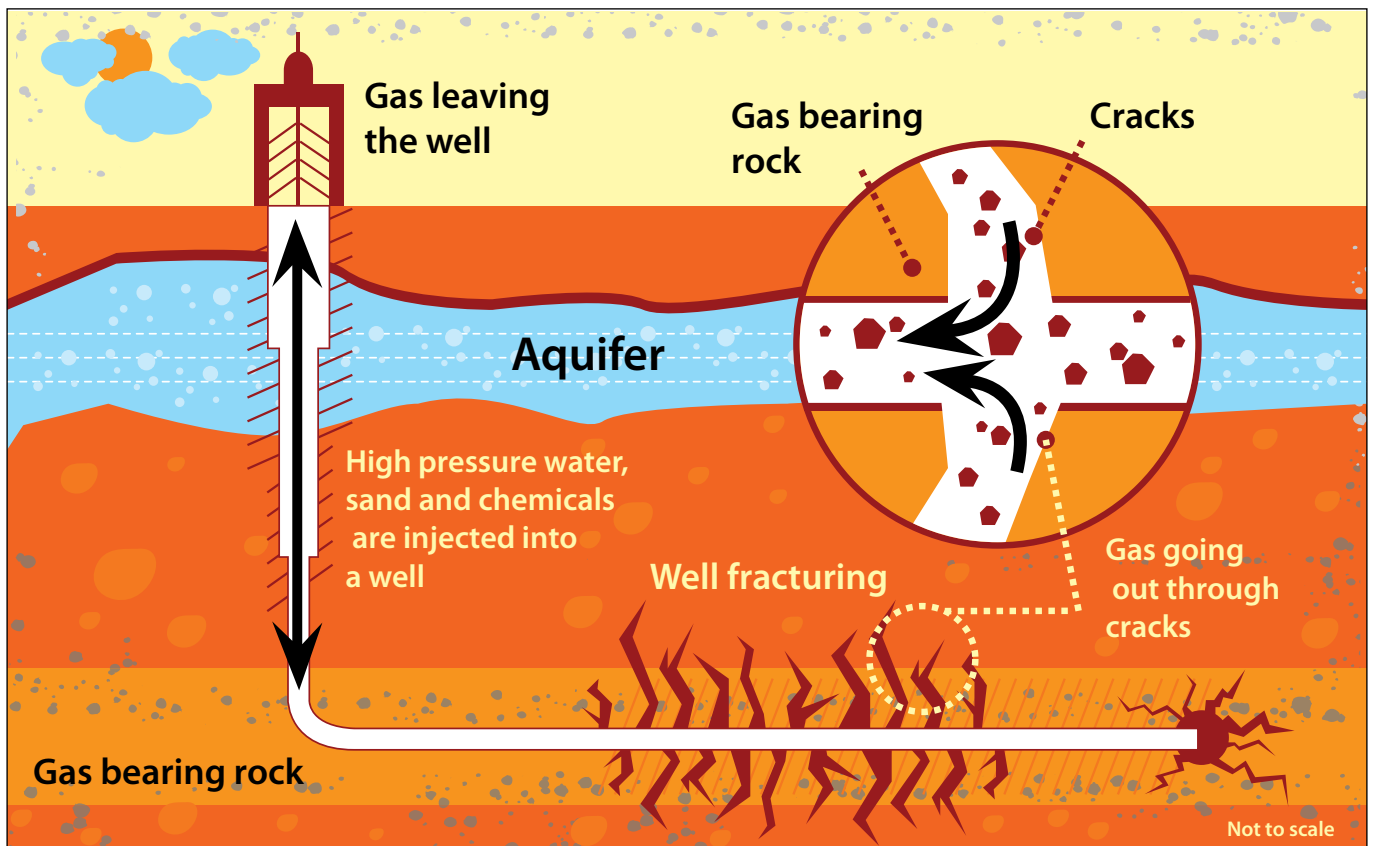
Unconventional gas extraction using the hydraulic fracturing (fracking) method

To extract this gas, significant efforts may be required, more specifically, drilling a well and injecting water mixed with sand and

chemicals under high pressure so that the rock cracks and releases the gas. Sometimes not only vertical but also horizontal wells are drilled for more efficient release of gas molecules. This method is called hydraulic fracturing or fracking.

It would be accurate to say that it is this method of production, which is unconventional, not the gas itself. This terminology is of common use, and we will apply it hereinafter.

Although horizontal drilling and hydraulic fracturing methods have been known in the oil and gas industries for a long time (particularly in Ukraine), quite recently the U.S. came up with combining these two techniques to produce unconventional gas. This is how a new technology was created. According to the resolution of the European Parliament dated November 21, 2012,





Oil production in Alaska. Photo: Mineral Management Service

fracturing performed for the purpose of unconventional gas extraction should not be confused with fracking, which for many years was used to intensify conventional natural gas production through a combination of horizontal drilling, with varying degrees of environmental impact¹.

This is not to say that “fracturing” and “horizontal drilling” are completely separated. The full name of the technology widely known as fracking is “high volume hydraulic fracturing”: it provides for more water, more wells, a larger drilling area, and, most significantly, aggressive chemical components in the fracking fluid. This extraction method poses the greatest threat to the environment and public health and in this publication, we will therefore consider the effects of applying it.

It should be noted that any production of hydrocarbons is a “dirty” process: equipment failures, difficult geological conditions, severe weather conditions, and, finally, human error lead to leakages and accidents. However, while in the case of conventional fields pollution is concentrated mainly around a well, unconventional gas extraction involving hundreds of wells that are maintained using thousands of equipment units affects the welfare of people in heavily populated areas, across much larger territories.

In addition, when considering the negative effects of fracking it should be kept in mind that environmentalists and local activists mean the whole process of gas production from unconventional deposits: geological exploration, site preparation, drilling, fracturing itself, waste management and disposal of spent solution and the construction and operation of the necessary infrastructure. Representatives of mining companies under the term “fracking” or “fracturing” mean only the process of fracturing that occurs at depth without considering its connection with other operations.

The United States is the only country in the world conducting unconventional gas production on an industrial scale. The example of this country makes it possible to predict the consequences of applying fracking in Ukraine. The author of this review visited the United States in the summer of 2013 at the invitation of the U.S. State Department and participated in the program “The impact of shale gas extraction – the vision of the United States”. As part of the program, representatives of Ukraine visited Washington, DC, Texas, Colorado, Ohio and Pennsylvania and met with industry representatives, academics, civil society leaders and activists from more than 30 organizations².

¹ European Parliament resolution of 21 November 2012 on the environmental impacts of shale gas and shale oil extraction activities (2011/2308(INI)) <http://goo.gl/E7Rr2Y>

² To get the full text of the business trip report “Shale gas production in the USA from outside perspective” please follow the below link http://necu.org.ua/wp-content/uploads/Shale_gas_development_in_the_USA_Look_from_th.pdf

Water

Consumption

Extracting unconventional gas requires a large amount of water. The volume of water depends on the type of unconventional gas: extracting compact sandstone gas requires injecting hundreds of cubic meters of water mixed with sand and chemicals for a single fracturing, while fracturing a shale gas well requires thousands of cubic meters of water per one operation.

More specifically, fracturing one shale gas well requires approximately 15 thousand cubic meters of water. The procedure of hydraulic fracturing for a single well can be conducted up to 10 times, and each subsequent time it requires more water. This water is taken from local water sources, including groundwater. Representatives of the oil and gas industry are used to citing the fact that a golf course irrigation needs much more water than hydraulic fracturing. However, they conceal the fact that 15 thousand cubic meters are required for just one fracturing treatment per well, while there can be up to 10 fractures and up to 6 wells per square kilometre. All the water used for a golf course irrigation will re-enter the water cycle, while water used for fracking is permanently removed from nature, posing a real threat to all living things.

According to the Production-Sharing Agreements as entered into force between the Government of Ukraine, Shell and Chevron, both companies have the special right to free use of water and are not required to keep compulsory records of the quantity of water consumed.

According to preliminary estimates, the consumption of water for shale gas extraction in the Oleska area, subject to the

drilling of 128 wells per year, will reach roughly 2 million cubic meters per year. In total approximately 1000 wells are to be drilled by 2030 and the total volume of water used in connection therewith is estimated at approximately 15 million m³, provided that fracturing will not require any extra water and will not be performed more than once for each of the wells³. This amount is sufficient to satisfy the water requirements of a city the size of Ivano-Frankivsk for 7 months, based on calculations using the official monthly consumption rate of 10 cubic meters per capita. If we take the actual numbers, that is two cubic meters per month, this amount of water would be enough to cover almost the water requirements of the residents of a town the size of Ivano-Frankivsk for almost 3 years.

Contamination

As we noted at the very beginning, any extraction of fossil fuels is a “dirty” process. The extraction of unconventional gas does not constitute an exception to the general rules and causes even more pollution per thousand cubic metres of gas than conventional field drilling, but within a larger and often more densely populated area. The main sources of water contamination during fracking include:

- spills of drilling mud fluid and spent fracking fluid, leakages from storage pits, pipes or vehicles during transportation;
- leakages or accidents caused by incompetence of staff or the use of outdated or faulty equipment;
- leakages caused by poor concrete casing of wells: documents show that 6% of fracturing wells start leaking during the first year of operation and 50% do so during the first 15 years after they are put into operation⁴;

³ Use of the water for the shale gas extraction at Oleska area <http://shalegas.in.ua/spozhyvannya-vody-dlya-vydobutku-slantsevoho-hazu-na-oleskij-ploschi/>

⁴ The Sky is Pink, “Annotated documents” from Southern Energy, Oilfield Review Schlumberger, Watson Bacchu, Archer, Colorado Oil and Gas Conservation Commission (COGCC)

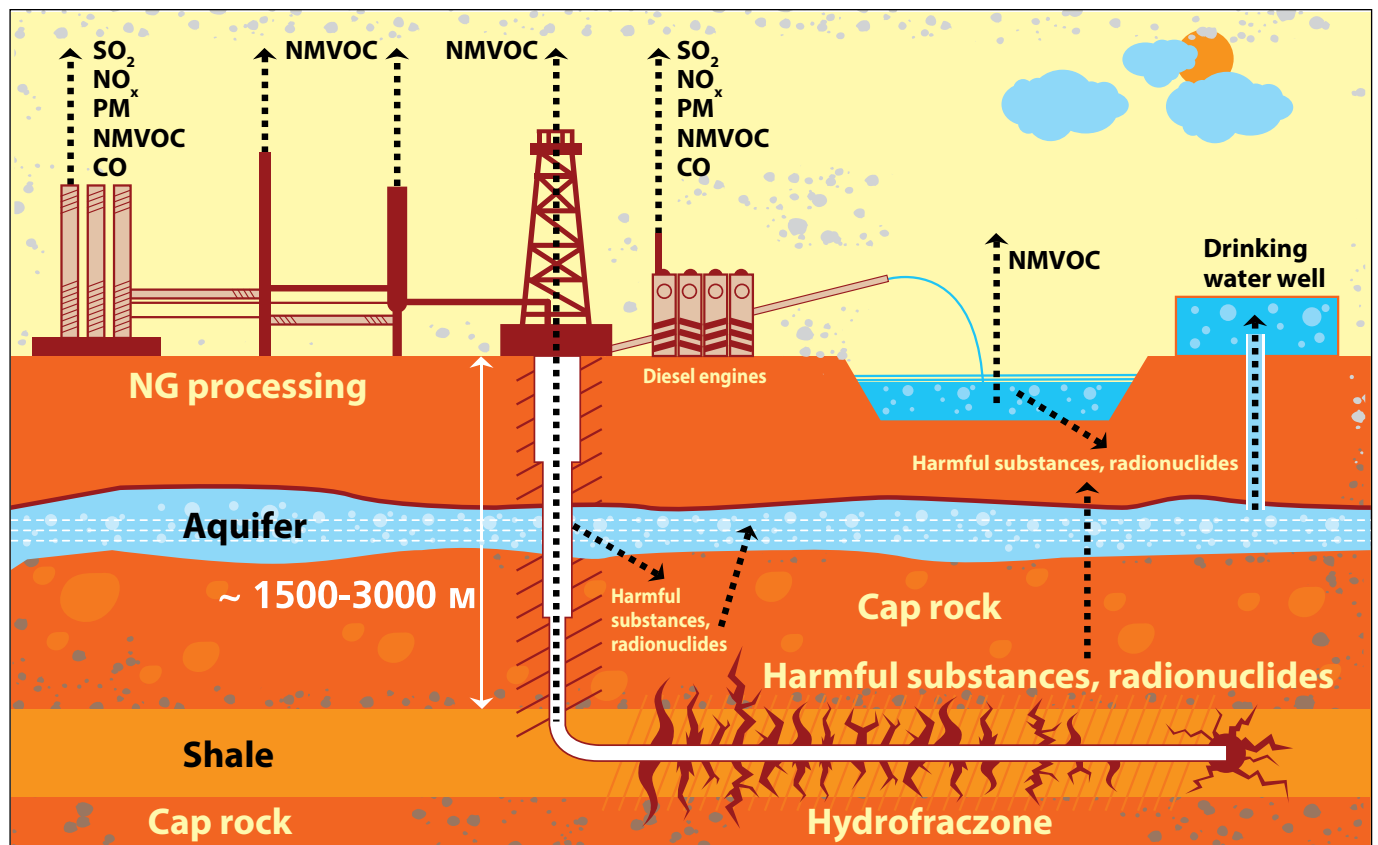
A storage pit is a large pit designated for storing spent drilling mud (fracking fluid). The bottom of the storage pit is compacted with clay soil providing minimum filtration or a plastic film to prevent seepage of wastewater into groundwater.

- underground leakages through natural or artificial cracks. The majority of fracking fluid remains under the ground (up to 80% of the injected volume). Today research shows that the fluid can migrate, most commonly after a few years, to groundwater used as resources for drinking water (such as aquifers and springs)⁵.

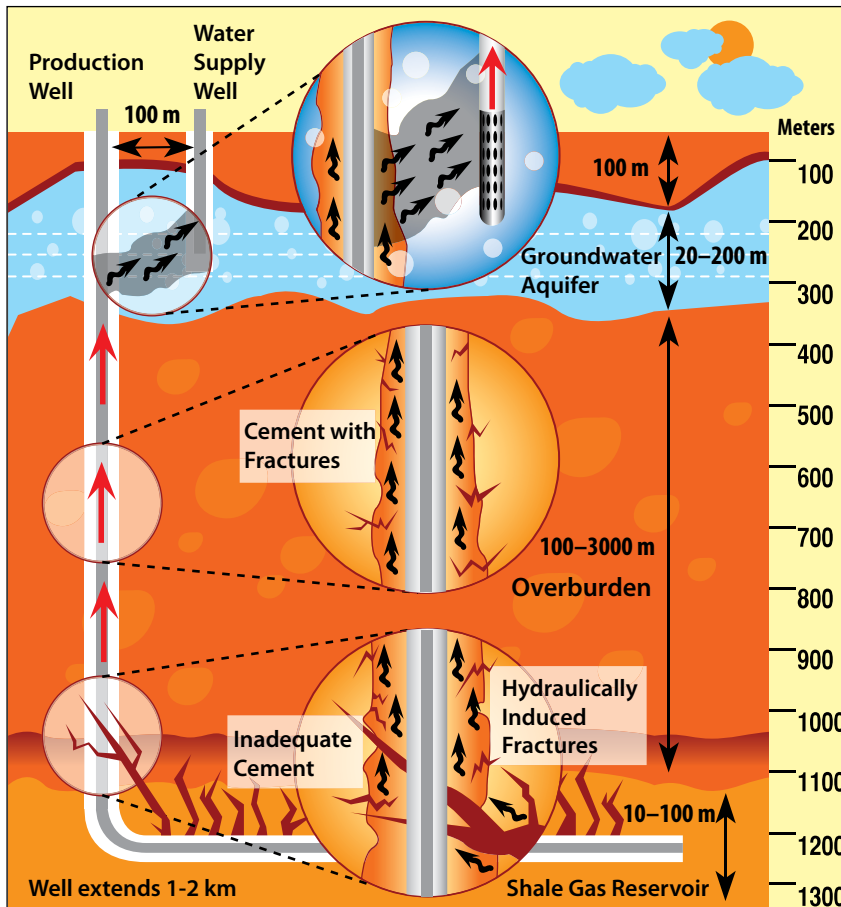
In regions where the production of unconventional gas is conducted, ground waters are filled with methane. This is due to the physical impossibility of making the concrete casing of a well hermetically join the walls of the well. Over time it cracks. Through these cracks methane present in the lower layers intersected by the well rises to the surface and fills the aquifers on its way.

Because of this, water from the tap or drinking well can go up in flames from a match as demonstrated by Josh Fox, a US activist, in documentaries about the production of unconventional gas in the United States. In 2007 a residential building exploded in the state of Ohio ⁶. This explosion was caused by a well used for unconventional gas extraction near the building, which started leaking and releasing gas into water pipes of the building along with water. The gas exploded as a result of its interaction with the water heater.

⁵ Myers, T. "Potential Contaminant Pathways from Hydraulically Fractured Shale to Aquifers", National Ground Water Association, May 2012 <http://www.energyindepth.org/wp-content/uploads/2012/05/myers-potential-pathways-from-hydraulic-fracturing4.pdf>
 "New Study Predicts Frack Fluids Can Migrate to Aquifers Within Years", 01/05/2012, Abraham Lustgarten, ProPublica <http://www.propublica.org/article/new-study-predicts-frack-fluids-can-migrate-to-aquifers-within-years>
⁶ Report on Investigation of the Natural Gas Invasion of Aquifers in Bainbridge Township of Geauga County, Ohio, 2008 http://s3.amazonaws.com/propublica/assets/natural_gas/ohio_methane_report_080901.pdf



Potential flows of air pollutant emissions and harmful substances into water and soil
 Source: European Parliament, Directorate General for Internal Policies
 Impacts of shale gas and shale oil extraction on the environment and human health



One of hypothetical gas and fluids migration pathways.

Source: United States Environmental Protection Agency⁷

Given the intensity of technological operations performed during fracking, the contamination of water is just a matter of time. Cases of pollution of drinking wells as a result of mining companies' activities were officially recorded in four states in the USA where unconventional gas is extracted most intensively (Pennsylvania, Ohio, West Virginia and Texas)⁸.

The Law of Ukraine on Drinking Water and Drinking Water Supply prohibits, among other things, the exploitation of mineral resources in sanitary protection zones of drinking water intake structures. The Water Code of Ukraine prohibits the exploitation of mineral resources on water reserve lands, but, unfortunately, allows for exploration and drilling due to a recent amendment thereto⁹.



In this photo Steve Lipsky demonstrates how the water from his well ignites when he puts a flame to the flowing well spigot outside his family's home near Weatherford, Texas. The U.S. Environmental Protection Agency had evidence that a gas company's drilling operation contaminated Lipsky's drinking water with explosive methane, and possibly cancer-causing chemicals, but withdrew its enforcement action, leaving the family with no useable water supply. As a result the Lipsky family was left without a source of drinking water. This is an example of how the Agency changes its opinions under the pressure of the Republican Party and the industry who criticized the Agency for inefficiency and "hasty decisions". Later the Agency loosened the regulations that apply to mining companies. Photo: LM Oltero/Associated Press



After two well fracturing operations were performed near their house in Pennsylvania the McEvoy family, like many other families living in the same area, can no longer use water from the tap. Analysis demonstrated the presence of arsenic, manganese, ammonia and volatile organic compounds in the water. They have to bring water for cooking and everyday life in canisters¹⁰. Photo: Iris Marie Bloom



A resident of western Pennsylvania pouring water from the tap. She links the deterioration of water with gas drilling performed nearby.

Photo: Keit Sracochich / Associated Press

⁷ The Potential Impacts of Hydraulic Fracturing on Drinking Water Resources: Progress Report (December 2012) <http://www2.epa.gov/sites/production/files/documents/hf-report20121214.pdf>

⁸ 4 states confirm water pollution from drilling <http://www.usatoday.com/story/money/business/2014/01/05/some-states-confirm-water-pollution-from-drilling/4328859/>

⁹ Law of Ukraine on Amending the Water Code of Ukraine <http://zakon2.rada.gov.ua/laws/show/1990-14>

¹⁰ SOS Butler County: Black Water + Purple Water = A Fracking Nightmare <http://protectingourwaters.wordpress.com/2012/02/11/sos-butler-county-black-water-purple-water-a-fracking-nightmare/>



Utica field, Ohio, USA. Drilling platform with six wells, a compressor station and fracking fluid storage pit.

Photo: Ted Auch, FracTracker

Eight of the fifteen water intake structures in the Kharkiv, Donetsk and Luhansk regions are being created on the river Siverskyi Donets¹¹, which is located in the very heart of the Yuzivska area. In those regions of Ukraine where hydraulic fracturing is already conducted (Dnipro-Donetsk Basin) people often complain that the water quality is significantly decreasing and that water disappears from the wells¹².

Within the territory of the Oleska area there are numerous water intake structures used for supplying drinking and service water, and mineral water deposits. According to experts, given the density of population in the Lviv region it is difficult or even impossible to deploy a drilling rig and storage pits in compliance with public health standards because the sanitary protection zone of a toxic waste tank should be located no closer than 3 kilometres from urban settlements¹³.

Waste Disposal

The main issue of unconventional gas extraction to which a solution is still required relates to fracking fluid disposal. Sand and toxic substances are added to water in order to prevent damage to drilling equip-

ment and maintain the necessary consistency of the solution used for hydraulic fracturing (lubricants, thickeners, biocides, anti-corrosion agents, solvents, etc.). According to extracting companies, chemicals account for 0.5–1.5 % of the total mixture. Mining companies often withhold accurate data on the composition and volume of fracking fluid used.

One operation on average requires 15 thousand cubic meters of water and consequently one hydraulic fracturing operation can entail the use of dozens of tonnes of chemicals. Moreover, a single well fracturing can be performed up to 10 times.

After fracturing 20–80 % of the fluid returns to the surface, and, in addition to specially added chemicals, often contains solutions of heavy metals and radionuclides¹⁴, which naturally occur in deep rock beds. This results in dozens of tonnes of toxic waste that should be carefully collected and disposed off.

There are currently no economically sound technologies in the world for fracking fluid treatment and processing that are able to make the fluid safe for animals and humans and return it to the water cycle. Today spent fracking fluid is disposed of in the following ways:

- It is injected into underground cavities. This is precisely why toxic liquids eventually migrate to aquifers.
- It is evaporated in tanks. In this case carcinogenic volatile organic compounds evaporate into the air and toxic dry depositions are either taken to the landfill where they are dispelled by the wind (the most “economical” entities use it to scatter roads for the thawing of ice or fields for “fertility”) or stored at shallow depths underground without isolation, leading to soil pollution.
- It is poured directly on the ground or discharged into water bodies or rivers. This leads to direct pollution of water with heavy metals, toxic technical admixtures and radionuclides.

¹¹ Website of the Laboratory Service of Siverskyi-Donets Basin Water Resources Board
<http://www.sdbuvr.slav.dn.ua/UA/tasks.htm>

¹² Residents of a village in Kharkiv region falling unconscious as a result of using water from the drinking well located near the drilling site
<http://fakty.ictv.ua/ru/index/read-news/id/1474856>

¹³ Interview with Volodymyr Kharkevych, PhD in Geology, February 8, 2013
<http://www.gazeta.lviv.ua/ecology/8330>

¹⁴ Radioactivity in shale NORM and TENORM
<http://www.marcellus-shale.us/radioactive-shale.htm>



The sump for drilled solids at the well No. 17 owned by Ukrgasvydobuvannia company in the Kamianska area (village of Yaremivka, Kharkiv region), 2013. Photo: Oleh Savvitskyi

- It is partially purified and re-used for hydraulic fracturing. This method does not solve the problem as such because the water is still permanently removed from nature and the issue of the disposal of concentrated toxic residues remains.

Furthermore, storing fracking fluid in open sumps poses a threat to wild and domestic animals and birds drinking from them or taking rest at them during migration. In many U.S. states, open waste storage sumps are prohibited¹⁵ and companies are required to use closed tanks.

As for the disposal of liquid fracking waste in Ukraine, western regions of the state are missing treatment facilities that would

handle waste of such hazard class and in that volumes¹⁶. In the Oleska Area Chevron is going to inject spent fracking liquid underground¹⁷. The Oleska Area is located in the third sanitary protection zone. Resolution N 2024 of the Cabinet of Ministers of Ukraine on the Legal Regime of Water Bodies Zone dated 1994 prohibits placing slime pits and injecting waste water for the purpose of disposal thereof.¹⁸

Yet it is unknown how Shell will dispose fracking fluid in the Yuzivska Area. The company currently pours fracking fluid into open storage pits that are isolated from the ground only by a polyfilm layer¹⁹.

Earthquakes

Seismic activity is one of the consequences of unconventional gas development. Contrary to popular belief, earthquakes are caused by fracking fluid disposal rather than drilling and hydraulic fracturing. As mentioned above, one of the disposal methods involves injecting the fracking fluid into so-called absorption wells (exhausted oil and gas wells) or other underground repository.

According to the Geological Society of America, over the period from 2009 to 2012 the average number of earthquakes in the central United States was 11 times higher compared to previous 30 years²⁰. Scientists clearly relate the growth in the number of earthquakes to intensive injection of spent fracking fluid into underground cavities²¹. In their opinion, this is due to the physical effect produced by hundreds of thousands of cubic meters of water injected underground at high pressure. The fluid contains certain chemicals, including lubricants. The effect caused by pressure and lubricants results in the displacement of rocks along natural fault lines. The U.S. Geological Survey, a U.S. government research organization, confirms this information²².

In July 2011, the government of Arkansas was forced to ban injecting spent fracking fluid into absorption wells within the state's territory because their operation was directly related to a sharp increase in the number and strength of earthquakes.

¹⁵ U.S. DEPARTMENT OF THE INTERIOR BUREAU OF LAND MANAGEMENT: Fluid Minerals Operations – Reducing Preventable Causes of Direct Wildlife Mortality <http://goo.gl/FYg11D>

¹⁶ Shale gas exploration and development: social, legal and environmental challenges, ICO "Environment – Law – Human" http://epi.org.ua/fileadmin/user_upload/publications/Fracking_01.pdf

¹⁷ Opinion of the state environmental impact assessment and ecological expert assessment of the draft Hydrocarbons Sharing Agreement for Oleska Area (page 9) <http://www.orada.if.ua/fileadmin/documents/Rizne/SlancevyjGaz/ekspert.pdf>

¹⁸ Interview with Volodymyr Kharkevych, PhD in Geology, February 8, 2013 <http://www.gazeta.lviv.ua/ecology/8330>

¹⁹ From gas exploration to environmental disaster? Water in south and east regions has become inappropriate even for technical use <http://uanews.kharkiv.ua/society/2013/04/13/2906.html>

²⁰ Katie M. Keranen, Heather M. Savage, Geoffrey A. Abers and Elizabeth S. Cochran, Potentially induced earthquakes in Oklahoma, USA: Links between wastewater injection and the 2011 Mw 5.7 earthquake sequence, *Geology*, March 26, 2013, doi: 10.1130/G34045.1 <http://geology.gsapubs.org/content/early/2013/03/26/G34045.1.abstract>

²¹ Induced Seismicity Potential in Energy Technologies, 2012 <http://i2.cdn.turner.com/cnn/2012/images/06/15/induced.seismicity.prepublication.pdf>

²² Fracking Tied to Unusual Rise in Earthquakes in U.S., Bloomberg, 2012 <http://www.bloomberg.com/news/2012-04-12/earthquake-outbreak-in-central-u-s-tied-to-drilling-wastewater.html>



Barbara Brown, a resident of Texas, shows how much medicine she has to take after her health deteriorated due to intense unconventional gas drilling was deployed near her house. She lives less than two kilometres from the drilling site and fracking fluid storage pit. In November 2013, her house cracked due earthquakes that occurred soon after the company started injecting spent fracking fluid into the ground.

Photo: Julia Demianski, 2014



Mary Mahan, a resident of Greenbier, points to a crack in the floor tile of her home that was a result of an earthquake.

Photo: Jim Young / Reuters

A 4.7 magnitude earthquake, the strongest over the past 35 years, hit Greenbier, Arkansas, in February of the same year. Companies involved in fracking are impelled to take out liquid waste for disposal in the territory of other states²³.

Seismic activity may also contribute to water pollution as it provokes the formation of new cracks in the rock. Special attention should be paid to a difficult situation observed within the Oleska area. In particular, when it comes to the Oleska area, it is necessary to consider the presence of tectonic disturbances of various ranks and associated fracturing, invasion and tectonic fragmentation zones. Conducting artificial high-volume hydraulic fracturing in such zones creates conditions for gas and pollutants to breakthrough to upper aquifers and surfaces (causing contamination of soil, groundwater and surface waters and generally increased intensity of total methane emissions)²⁴.

One of the risks arising during hydraulic fracturing or the injection of fracking fluid underground is that the fluid may migrate underground through existing non-registered wells and mines and reach the surface or aquifers thereby contaminating them²⁵.

The chemical composition of fracking fluid and its impact on public health

Companies typically underestimate the risks associated with chemicals used for hydrocarbons extraction, arguing that these substances are often part of household detergents, cosmetics and even food, and, therefore, inhaling or swallowing them poses no threat to health. Even if this is true, the idea of pouring a bottle of detergent or car antifreeze into one's drinking well and then being able to safely drink water out of it is laughable.

In addition, according to the companies, fracking fluid may contain chemicals that are classified as toxins, allergens, carcinogens and mutagens²⁶. These substances are dangerous because they may have delayed effects. They affect the human endocrine system leading to an increased incidence of diseases such as cancer, diabetes, infertility, miscarriages, birth defects, autism and developmental delays in children. Unlike other poisons, toxins disturbing normal functioning of hormonal signals are biologically active in extremely low concentrations. Scientists have proven that any dose of such substances is dangerous for pregnant women, infants, and children²⁷.

In particular, in Colorado (USA) scientists have studied the relationship between how close mothers live to areas where natural gas is extracted and new-borns' health²⁸. The study has shown that among children whose mothers lived in areas where drilling was conducted the number of cases of congenital heart disease was 30 % higher when compared to those whose mothers lived 12–15 kilometres away from the drilling area. In addition, scientists have established a positive relationship between the number of cases of neural tube defects in children and extraction of natural gas.

23 Natural Gas: Arkansas Commission Votes To Shut Down Wells http://www.huffingtonpost.com/2011/07/27/natural-gas-arkansas-commission-shut-down-wells_n_911541.html

24 Interview with Ihor Dmytrovych Bahriy, Head of Environmental Geology and Exploratory Research Department, Institute of Geological Sciences, NAS of Ukraine; PhD in Geology; laureate of state prize in science and technology <http://shalegas.in.ua/gidroeoeekologichnyj-monitoring/>

25 A Case of Fracking-Related Contamination <http://www.nytimes.com/interactive/us/drilling-down-documents-7.html#document/p1/a27935>

26 European Parliament, Directorate General for Internal Policies: "Impacts of shale gas and shale oil extraction on the environment and on human health", 2011 <http://europeecologie.eu/IMG/pdf/shale-gas-pe-464-425-final.pdf>

27 C.D. Kassotis, D.E. Tillitt, J.W. Davis, A.M. Hormann, and S.C. Nagel, Estrogen and Androgen Receptor Activities of Hydraulic Fracturing Chemicals and Surface and Ground Water in a Drilling-Dense Region, *Endocrinology* en.2013-1697; doi:10.1210/en.2013-1697

28 Birth Outcomes and Maternal Residential Proximity to Natural Gas Development in Rural Colorado, USA <http://ehp.niehs.nih.gov/1306722/>



In 2011 the Strudley family sued Antero Resources. They argued that the company's drilling operations resulted in the contamination of water and air around their home in Colorado. The health of Bill, Betty and their two small children deteriorated so much (fainting, nosebleeds and severe skin rashes) that they were forced to leave their home. Now they are suing the company. Photo: Rash on the skin of one of their sons²⁹. Source: www.postindependent.com



Bob and Emma Parr, who live near the Barnett fields in Texas, are also sick. Bob is 50 and until last year had only experienced a nosebleed about 3 times in his life. Now his nose bleeds regularly. Sometimes Bob and Emma have simultaneous nosebleeds. His wife Emma has been suffering from asthma recently, whereas she was previously a healthy and active woman³⁰. Source: TXSHARON, 2010



In 2009 in Louisiana, USA, 17 cows died a few hours after they drank water mixed with fracking fluid from neighbouring drilling site of Chesapeake Energy Corp. Photo: Michelle Bamberger

In 2013 a child with birth effects was born in the village of the Yaremivka, Iziium region, Kharkiv oblast, where Ukrgasvydobuvannia PJSC carries out its activities³¹. The parents who had previously delivered two healthy children say that this was due to the deterioration of water in the drinking well as a result of gas extraction. Shortly after the child's birth they moved from the village.

Impacts on animals

In their recent study Bamberger and Oswald concluded that animals, especially livestock, are sensitive to the environmental pollution caused by the drilling process and its integrated effect. Case studies in six U.S. states show that the extraction of unconventional gas heavily affects people, pets, cattle, horses and wildlife in general³².

Michelle Bamberger is a practising veterinarian and Robert Oswald is a professor of pharmacology in the Cornell University College of Veterinary Medicine. Over the course of a year, they investigated all cases of disease contraction or death of animals associated with the extraction of unconventional gas. The study includes descriptions of several cases: at one farming enterprise 60 cows grazed near a stream into which fracking fluid was poured, while 36 cattle grazed farther away and did not have access to this stream. Of the 60 cows, 21 cows died, and 16 were unable to produce offspring next spring. All 36 cows that did not drink water from the stream had no health problems.

Another natural experiment was conducted at another farm where 140 cows drank water contaminated because of leakage from a spent fracking fluid pit. Of the 140 cows about 70 died and many cases of stillborn or premature born calves were reported. Sixty other cows from the same herd grazed on another pasture and did not have access to toxic substances. None of them had problems relating to health or birth of offspring.

²⁹ Strudleys win appeal in poisoning case <http://www.postindependent.com/news/7176505-113/court-case-strudleys-frick>

³⁰ Fracked: Barnett Shale drilling chemicals found in blood and organs <http://www.dailykos.com/story/2010/09/26/905373/-Fracked-Barnett-Shale-drilling-chemicals-found-in-blood-and-organs>

³¹ In the village of Yaremivka two healthy parents delivered their third child with an undeveloped hand as a birth defect. <http://www.youtube.com/watch?v=1yyEq9hoEI>

³² Michelle Bamberger et al. (2012), «Impacts of Gas Drilling on Human and Animal Health», appeared in *New Solutions* (Jan. 2012). http://www.psehealthyenergy.org/data/Bamberger_Oswald_NS22_in_press.pdf

How much land does unconventional gas need?



Utica field, Ohio, USA. Drilling site, access roads and pipelines.
Photo: Ted Auch, FracTracker

Extraction of unconventional gas in this manner requires much land. Each well needs a special site for placing technical equipment, trucks with compressors, chemicals, sand, water and containers for waste drilling mud. The drilling site on average takes up 1.6 to 2 hectares; after partial completion of works and restoration of the area its size ranges from 0.4 to 1.2 hectares³³. An additional area is used for building roads for trucks and storage pits.

Unlike conventional gas reservoirs where drilling is performed at one point, unconventional gas extracting provides for the drilling of a huge number of wells evenly

covering the entire territory of the field. A typical shale gas field in the U.S. includes on average about 1.15 wells per square kilometre³⁴. In the case of compacted sandstone gas extraction, wells are spaced more densely – six wells per square kilometre, because drilling is predominantly vertical.

After extraction, it is necessary to transport the gas. Since the vast majority of wells deliver a small amount of gas (or low flow rate) and quickly become exhausted, gas can be stored right on the site and transported by trucks. If drilling sites are placed densely and provide a good yield, they can be connected with a pipeline network and compressor stations can be built there. The installation of this infrastructure also requires some additional space.

Maintaining a typical well in a shale gas field may require up to 2,000 truck trips. Trucks will supply machinery, heavy equipment, water, sand, chemicals, etc.³⁵. The weight of such trucks can reach 35–45 tonnes. This leads to the destruction of access roads (both dirt and asphalt), bridges, road barriers and so on.

However, there is a high risk of soil contamination resulting from leakage of drilling mud, chemicals and spent fracking fluid, inflammation of tanks and open mines, explosions and wells overflowing³⁶.

Most notably, about 1,000 wells are expected to be drilled by 2030 in the Oleska area, which would need about 200 sites with an area ranging from 1 to 3 hectares.

³³ Supplemental Generic Environmental Impact Statement (SGEIS) prepared by the New York State Department of Environmental Conservation (NYSDEC), Division of Mineral Resources on the Oil, Gas and Solution Mining Regulatory Program, Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, Draft September 2009, <http://dec.ny.gov/energy/45912.html>, and Final Report 2010: <http://www.dec.ny.gov/energy/47554.html>

³⁴ Sumi L. (2008). Shale gas: focus on Marcellus shale. Report for the Oil & Gas Accountability Project/ Earthworks. May 2008

³⁵ New York State Department of Environmental Conservation, Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program, 2009 <http://www.dec.ny.gov/energy/58440.html>

³⁶ <http://theyee.ca/News/2012/01/25/Landowners-Against-Fracking/>, <http://af.reuters.com/article/energyOilNews/idAFN2015195120110420>



Impact of the shale gas development infrastructure on the landscape, Colorado river, Roan Plateau, 2006.
Source: EcoFlight

Collision of trucks transporting drilling mud, West Virginia, USA.
Photo: Ed Wade Jr., Wetzel County Action Group



Why should landowners care?

Ukrainian legislation allows for the alienation of land for public needs. Public needs include, among other things, the needs of the oil and gas industry: construction and maintenance of oil and gas wells and production facilities required for their operation, underground oil, gas and other substances and materials, storage facilities, disposal of hazardous substances and production waste and construction of oil and gas pipelines³⁷.

In addition, according to the agreements with Shell and Chevron, if an investor needs a land plot which is privately owned and the owner does not agree to the terms offered by the investor, the government shall provide assistance to the investor in acquiring rights to the land plot. Furthermore, the landowner is not entitled to compensation for the land plot lost and lost profit from the use thereof, etc.³⁸.

³⁷ The Law of Ukraine on Alienation of Privately Owned Land and Other Real Property Placed Thereon for Public Needs and Public Necessity
<http://zakon4.rada.gov.ua/laws/show/1559-17>

³⁸ Shale gas exploration and development: social, legal and environmental challenges, ICO "Environment – Law – Human"
http://epl.org.ua/fileadmin/user_upload/publications/Fracking_01.pdf

Air contamination



The photo on the left depicting an element of a compressor station was taken using an ordinary camera, while the photo on the right depicting the same element was taken using an infrared camera. We can see leakages of volatile organic compounds.

Photo: United States Environmental Protection Agency



Emissions at the Range Resources well near the town of Mount Pleasant, Washington (DC).

Source: www.post-gazette.com



Burning gas flare, Pennsylvania.

Photo: Kelan Borovets

At the initial stage of unconventional gas development the main sources of air pollution include emissions from the engines of trucks and diesel engines, and equipment operated on at drilling sites. These emissions consist mainly of dust, sulphur dioxide, nitrogen oxides, lead, nonmethane volatile organic compounds (NMVOC) and carbon monoxide. NMVOC are mostly benzene, toluene, ethylbenzene and xylenes.

In the U.S. fracking was proved to cause air pollution with increased doses of benzene³⁹ and other potentially toxic petroleum hydrocarbons such as ethylbenzene, toluene and dimethylbenzol that cause irritation of the eyes, headaches, sore throat, shortness of breath and an increased risk of cancer, including leukaemia⁴⁰. Lead adversely affects the neurological development of children. In adults, it causes disorder of the reproductive system, hypertension and nerve disorders. Sources of pollution include diesel engines, leakages of volatile organic compounds from compressor stations, pipelines and evaporation from storage pits.

About 25% of adults and children in areas of unconventional gas extraction suffer from asthma. The disease is contracted even by those who before felt quite healthy⁴¹.

Infrastructure deployment will bring similar emissions from jet fires at the wellhead, leakages from compressor stations and evaporation from collection ponds where spent fracking fluid will be stored⁴².

People living near compressor stations and drilling sites display the following main symptoms: dizziness, headaches, nausea, faintness, loss of appetite, loss of balance, nosebleeds, asthma, palpitations etc.

³⁹ "Study shows air emissions near fracking sites may impact health", 19/03/2012
http://www.pennlive.com/editorials/index.ssf/2010/03/what_we_can_and_should_learn_f.html (http://www.eurekalert.org/pub_releases/2012-03/uocd-ssa031612.php#)

⁴⁰ McKenzie, L. Witter, R. Newman, S. Adgate, J. "Human health risk assessment of air emissions from development of unconventional natural gas resources",
Science of The Total Environment, Volume 424, 1 May 2012, Pages 79–87

⁴¹ Study: More fracking health concerns than previously thought
http://www.upi.com/Health_News/2013/04/29/Study-More-fracking-health-concerns-than-previously-thought/UPI-26861367208811/

⁴² Air sampling reveals high emissions from gas field
<http://www.nature.com/news/air-sampling-reveals-high-emissions-from-gas-field-1.9982>



Accident at well Ruth 87-2H of LeNormand company in 2013, Texas, USA. Source: Drilling Head, World Oilfield Network



Seepage at the well of Chesapeake Energy, 2011, Pennsylvania, USA. Photo: Lynn Weldon



Susan Wallace-Babb forced to wear a protective mask when going out for a walk with her dog. Winsborough, Texas, 2012. Photo: Erin Trieb/ProPublica

In addition to fast, easily diagnosed and adverse health effects, chemical compounds formed near drilling sites can accumulate in the body and lead to consequences that cannot be seen immediately but which may become evident after months, years and even decades.

Accidents

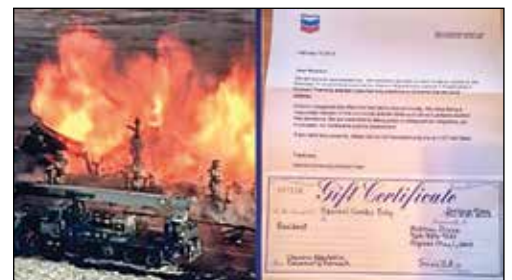
In addition to possible contamination during regular operation of a well, locals should consider probable accidents that occasionally occur at drill sites. As the U.S. experience shows, similar accidents happen frequently in practice. Partly because of outdated or faulty equipment, partly because of the desire of companies to “cut corners” and save time and money on occupational safety, and partly because of the uncontrollable nature of drilling and the hydraulic fracturing process.

Depending on the field, gas contains various components in varying proportions, including methane, carbon dioxide, hydrogen sulphide, radon gas etc. The U.S. reported cases of accidental releases of hydrogen sulphide (which in high concentrations acts as an extremely neurotoxic substance) that led to the hospitalization of people⁴³.

A fracking fluid emission was registered in April 2011 at one of the wells of Chesapeake Energy in Pennsylvania because of equipment failure. Overflow from the well resulted in tens of thousands of cubic meters of slime being spilled onto the ground. Slime pits that were built for collecting it suddenly became overflowed and the fluid began to flood the site. The exact amount of water released remains unknown. Local residents had to dig ditches to isolate their land plots from liquid waste. Seven families were temporarily relocated. The company faced the maximum penalty in the amount of USD 250 thousand⁴⁴.

A gas explosion that developed into a fire was reported in February 2014 at one of Chevron’s wells in Pennsylvania⁴⁵. One worker was injured and another went missing. The fire persisted for four days. According to local activists, Chevron sent a certificate for a pizza and a bottle of fizzy drink to all those who lived near this well as compensation⁴⁶.

These are just some examples of the hundreds of accidents that occur during the extraction of unconventional gas.



Source: Peter Sinclair, Climate Denial Crock of the Week

⁴³ Ohio Woman Fights Natural Gas Industry After Illness Caused by Drilling <http://ecowatch.com/2012/07/20/ohio-woman-fights/>

⁴⁴ Pennsylvania Fracking Spill: Natural Gas Well Blowout Spills Thousands Of Gallons Of Drilling Fluid http://www.huffingtonpost.com/2011/04/20/pennsylvania-fracking-spill-gas-blowout-2011_n_851637.html

⁴⁵ One Injured, One Missing at Southwest Pa. Gas Well Fire <http://www.wtrf.com/story/24691233/gas-well-explosion-reported-in-southwest-pa>

⁴⁶ Free Pizza if your Fracking Well Explodes! <http://climatecrocks.com/2014/02/18/free-pizza-if-your-fracking-well-explodes/>

Impact on the local economy



A resident of the village Dobryniow, where the exploration of unconventional gas deposits is carried out. Poland, 2013.

Photo: Filippo Bardazzi

Investors planning to extract unconventional gas in Ukraine claim that such activities will ensure rapid economic growth whilst providing the country with cheap gas and local communities with jobs.

A dramatic increase in new jobs for local communities is hardly possible. Unconventional gas drilling is a sophisticated, high-tech process, and as a result employment opportunities can be offered only to skilled experienced and English speaking specialists. New jobs may be created for truck drivers and heavy equipment operators, but the question is whether members of local communities will meet the requirements for such positions. In addition, all operations related to preparation of sites are temporary and after hydraulic fracturing is performed only a few technical staff are required to maintain the well in proper condition⁴⁷.

Indirect jobs may be created in the service industry: hotels, restaurants, personal services, etc. But we must remember that the drilling of wells is a temporary process after which technical staff move to the new site, so it can hardly be expected that there will be a continued demand for these services in a given village or town. Urban settlements where shale gas is extracted get some profit from gas but lose much more due to the depreciation of the real estate and lost tourism and loss of land for recreational use. People living in the vicinity of drilling sites complain about the twenty-four-hour noise, vibrations and light⁴⁸. Vibrations can cause damage to buildings.

Due to the sophisticated nature of hydraulic fracturing equipment, extractive industry operators prefer to buy it only from reputable suppliers and it is therefore unlikely that it will be purchased in Ukraine. However, it is still possible that the companies will purchase consumables (chemicals, sand) from local suppliers, but, as the U.S. experience shows, since these substances should conform to certain specifications, the companies prefer to buy them from a reliable supplier rather than a local supplier, even if that means obtaining materials from a supplier that is located in another state.

It should also be remembered that maintenance of a single well require up to 2,000 truck trips (within one site there may be several such wells). This results in local roads being used in the transport of heavy loads. As the Production Sharing Agreement (PSA) does not require investors to repair damaged roads at their own expense, these costs are borne by local governments.

This is reflected in allocations to local budgets under production sharing agreements. When agreeing upon the terms and conditions of the Production Sharing Agreement with Chevron⁴⁹, members of Lviv and Ivano-Frankivsk Regional Councils set a condition

⁴⁷ "Exposing the Oil and Gas Industry's False Jobs Promise for Shale Gas Development: How Methodological Flaws Grossly Exaggerate Jobs Projections", November 2011, Food and Water Watch (<http://www.foodandwaterwatch.org/reports/exposing-the-oil-and-gas-industrys-false-jobs-promise/>)

⁴⁸ The fiscal effects of Fracking in Otsego County, NY, 2011 <http://www.scribd.com/doc/63144744/Fiscal-Effects-of-Gas-Drilling-in-Otsego-County-NY-8-15-11-Final>

⁴⁹ http://zik.ua/ua/news/2014/04/08/deputyatv_lvivshchyny_vyrishyly_doopratsyuvaty_rishennya_shchodo_slantsevoi_ugody_477779



Hundreds of trucks servicing gas wells daily crossing the town of Springville, Pennsylvania, USA.

Photo: Spencer Platt / Getty Images

Denton, Texas. A drilling site located 60 metres away from residential buildings.

Photo: Julia Demianski, 2013.



requiring the allocation to local budgets of 10% of the proceeds to the state acquired from the sale of minerals extracted under the PSA.

The relevant bill⁵⁰ was adopted by the Ukrainian Parliament in October 2013 and amendments were introduced to the Budget Code of Ukraine, under which a half of the above mentioned 10% should be allocated to the council of the region where mineral resources are developed, 3.5% to a district council, and 1.5% to a village, town or city budget. These amendments took effect on January 1, 2014⁵¹.

Since the law has no retroactive effect, it is unclear whether these amendments will apply to the Donetsk and Kharkiv regions, which, unlike western regions, agreed upon the PSA with Shell with no objections as early as January 2013, when the law did not provide for allocations to local budgets.

As we have already noted, the legislation allows for gas distributors to expropriate the land plots that are required for their needs without providing compensation for damages or lost profit to landowners. However, the companies usually take this measure as a last resort, if negotiations have led nowhere. It may happen that all members of a village community oppose gas extraction, but eventually one of them is offered five thousand Hryvnias as rent for his land plot, so that it can be used for drilling, and the game is over – one person receives a small amount of compensation while all other villagers see water disappear from their drinking wells.

This practice also threatens the agricultural business of farmers who lease lands because extracting companies are willing to pay much more for the land lease than farmers would be.

50 Resolution of the Ukrainian Parliament on the Adoption as a Basis of the Law of Ukraine on Amending the Budget Code of Ukraine as to the Proceeds from Use (Sale) of the State Share of Products Manufactured under Production Sharing Agreements
<http://zakon2.rada.gov.ua/laws/show/647-18>

51 Law of Ukraine on Amending the Budget Code of Ukraine as to the Proceeds from Use (Sale) of the State Share of Products Manufactured under Production Sharing Agreements
<http://zakon4.rada.gov.ua/laws/show/665-18>

Economic aspects of unconventional gas extracting

Price

It is believed that shale gas will be cheaper than that imported into Ukraine from Russia. This statement is based on data provided by the U.S. (the only country in the world where shale gas is extracted on an industrial scale) where gas costs 60–70 U.S. Dollars per thousand cubic meters. The fact is that unconventional gas has not been extracted until now due to the economic inexpediency of such a decision.

Today low gas prices are possible in the U.S.A. due to several very important preconditions: the availability of technology, specialists, developed infrastructure and favourable geological conditions. All of these factors enabled the quick adaptation of the existing facilities for new technology. It should be mentioned that the current price of natural gas at 60–70 U.S. Dollars is unreasonably low and much lower than the extraction cost⁵². Some companies manage to maintain profitability only due to the production of gas condensate, but the “wet gas” does not occur in all fields.

In the U.S., gas prices slumped from USD 350 per thousand cubic meters in 2008 to USD 66 per thousand cubic meters in April 2012 due to the overproduction of shale gas⁵³. Today the break-even price of natural gas should

be at least equal to USD 280 dollars per thousand cubic meters. Why not cut the production and raise prices? There are three reasons why the production has not been reduced:

- Shale gas producers successfully insured their risk and ensured appropriate prices independent from current market prices using financial instruments and futures transactions;
- There was a reserve of unfinished wells that supported supplies whilst they gradually became exhausted;
- at some sites it was necessary to begin drilling despite economic uncertainty, as the terms and conditions of a land lease contract required a company to proceed with drilling within 5 years of the permit date otherwise the permit would become null and void⁵⁴.

But as investments, land lease contracts and decisions on the number of wells to drill were based on incredibly high 2008 gas prices, today many operators, including Total⁵⁵, Statoil⁵⁶ and Chesapeake are suffering damages. Low prices inflicted damages on all shale gas operators from minerals extraction to the extent of at least 9.3 billion U.S. Dollars. After a wave of mergers and acquisitions that swept through the industry new players came to the market (such as large oil and gas companies) and invested the necessary capital that has ensured the continuation of gas being produced at an unprofitable price.⁵⁷

⁵² The New North American Energy Paradigm: Reshaping the Future <http://www.cfr.org/north-america/new-north-american-energy-paradigm-reshaping-future/p28630>

⁵³ U.S. Energy Information Administration <http://www.eia.gov/dnav/ng/hist/n9190us3M.htm>

⁵⁴ Creeping to a Correction? Why the US Gas Market May be Poised to Recover, June, 2012 <http://kimmeridgeenergy.com/Kimmeridge2.pdf>

⁵⁵ Christophe de Margerie: “Le changement climatique, c’est sérieux” http://www.lemonde.fr/planete/article/2013/01/10/christophe-de-margerie-le-changement-climatique-c-est-serieux_1814993_3244.html

⁵⁶ Statoil to Shed U.S. Natural Gas Wells in November Sale <http://bit.ly/1hz2UEI>



An employee changing the drilling nozzles, Colorado, USA, 2013. Photo: Brennan Linsley, Associated Press

The industry is suffering as a result of low prices because they do not allow for the covering of drilling and extracting costs. That is why extracting companies are actively lobbying for the creation of export LNG terminals to enter the markets of Europe and Asia and enable the sale of gas at a much higher prices⁵⁸. They expect to raise prices significantly once exports are established.

Only six permits for the construction of terminals were issued in 2014⁵⁹. The construction of one LNG terminal requires about USD 10 billion, while the construction of an export complex would cost up to 30 billion U.S. Dollars overall. The rapid adjustment of exports to Europe (and Ukraine in particular) can therefore hardly be expected.

In the case of Ukraine it is necessary to take into account additional costs that may be required for creating necessary infrastructures, as well as costs arising from difficult geological conditions⁶⁰. For example, it is expected that shale gas deposits in Poland (whose geological environment is similar to Ukraine) are located one and a half times deeper than those in the United States. This, according to experts of Schlumberger, a mining service company, will increase the cost of drilling threefold⁶¹. High-powered pumps are required and drilling rigs must be designed for deep drilling at high temperatures. All of this increases costs and requires the development of new equipment and technologies that cannot simply be moved from America⁶².

Attempts undertaken by consulting companies such as Wood MacKenzie⁶³, Bloomberg New Energy Finance⁶⁴, or Poyry⁶⁵ to predict the impact of shale gas on gas prices are based on very optimistic assumptions and disregard the cost of the infrastructure that is required. ZEW, a reputable German economic research institute, recently published even more impressive findings. They gathered the views of more than 200 experts on gas and the gas industry, suggesting that shale gas will only be economically feasible if sold at USD 560 – USD 650 per thousand cubic meters⁶⁶.

Nevertheless, experts agree that not even small amounts of gas will be extracted without support from the state. It is evident that additional incentives in the form of tax deferment and exemptions, tax reductions and accelerated depreciation will be required. This is apparent from the terms and conditions of the Production Sharing Agreements with Shell and Chevron, under which investors pay minimal taxes and are exempted from many charges and duties, and no taxes are charged on any transactions with hydrocarbons until they are shared.

Therefore, by enjoying the financial support from the state unconventional gas competes directly with renewable energy sources such as biogas, biomass, and can take up economic and infrastructural investments whilst emitting large amounts of greenhouse gases (such as methane and its leakages) and only being present in exhaustible reserves.

57 Creeping to a Correction? Why the US Gas Market May be Poised to Recover, June, 2012 <http://kimmeridgeenergy.com/Kimmeridge2.pdf>

58 If Barack Obama wants a cleaner world and a richer America, he should allow natural-gas exports <http://econ.st/1d6Hg9F>

59 Feds grant sixth license to export US natural gas <http://fuelfix.com/blog/2014/02/11/feds-grant-sixth-license-to-export-us-natural-gas/>

60 Crawling nowhere: development of shale gas in Europe <http://bit.ly/ON6od5>

61 Poland Stumbles as Shale Gas Industry Fails to Take Off <http://www.naturalgaseurope.com/poland-shale-gas-industry-fails-to-take-off>

62 Shale-Gas Drilling Cost in Poland Triple U.S., Schlumberger Says <http://www.bloomberg.com/news/2011-11-29/shale-gas-drilling-cost-in-poland-triple-u-s-schlumberger-says.html>

63 Wood Mackenzie (2012), UK Shale Gas: Fiscal Incentives not Enough. Understanding exploration and extraction process. Full version is unavailable over the Internet. To read the executive summary, please follow the link below: <http://www.woodmacresearch.com/cgi-bin/wmprod/portal/corp/corpPressDetail.jsp?oid=10989661>

64 UK Shale Gas No «Get Out of Jail Free Card» <http://about.bnef.com/press-releases/uk-shale-gas-no-get-out-of-jail-free-card/>

65 The Impact of Unconventional Gas on Europe, June 2011 http://www.poyry.co.uk/sites/www.poyry.uk/files/The_Impact_of_Unconventional_Gas_on_Europe.pdf

66 Research of ZEW, Economic Research Institute, Germany <http://bit.ly/1mMx4cM>

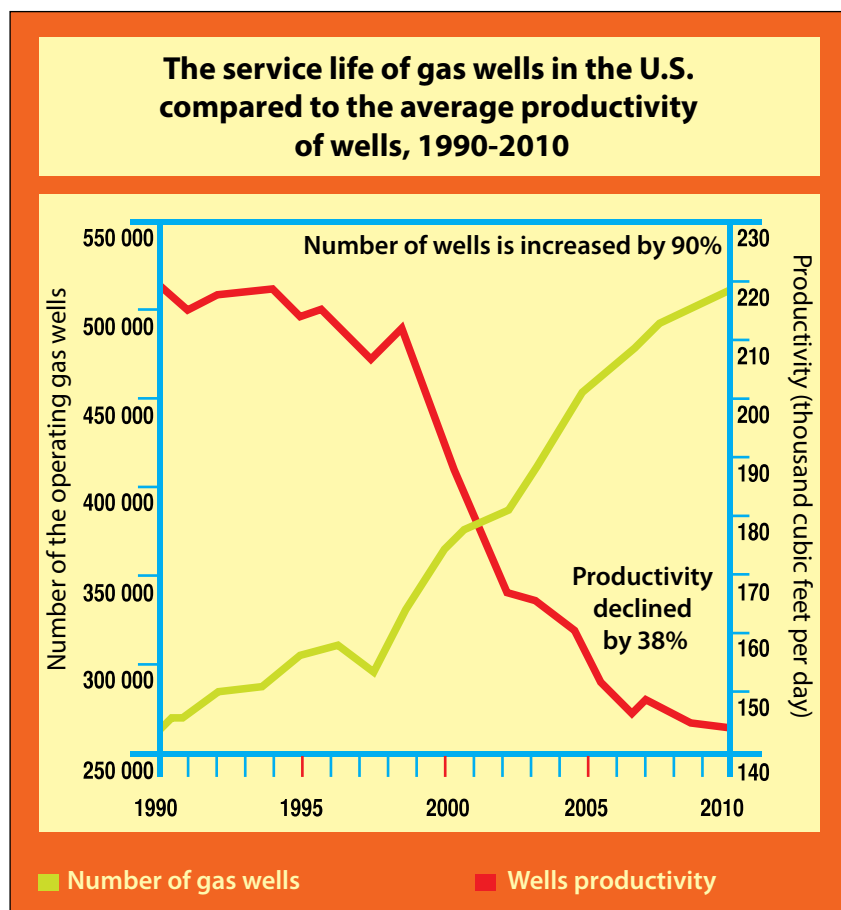


Fig. 1. The service life of gas wells in the U.S. compared to the average productivity of wells, 1990-2010.⁷¹

Reserves and extraction rates

At present there is no reliable data on the quantities of unconventional gas deposits in Ukraine. Estimates vary depending on the optimism and political prejudice of a given expert (from 1 to 30 trillion m³), without specifying the percentage which is technically extractable. Exact figures require major geological exploration. The experience of neighbouring Poland⁶⁷ and Hungary⁶⁸ having similar geological conditions shows that a number of companies have already curtailed their activities in those countries because drilling results were not satisfac-

tory, while the first “shale well” of Shell in Ukraine has fallen short of expectations concerning its reserves⁶⁹.

The efficiency of shale gas extraction is very low; only 6.5 % of available resources can be extracted⁷⁰. Furthermore, unconventional gas wells become exhausted rapidly and deliver about 70 % of their gas reserves (or flow rate) during their first year of operation. In other words, after the first year of operation wells deliver only 20–37 % of the initial flow rate, and this percentage continues to decline throughout the period of operation of the well.

According to Eduard Stavvtskyi, the commencement of production was scheduled for 2014 and it was expected that by 2030 the volume of production would increase so much that Ukraine could start exporting gas. These predictions are completely unrealistic, since exploration alone normally takes 5 years. Drilling the planned number of wells and infrastructure deployment will take years. In the U.S., for example, about 2,500 drilling rigs are operated while in Europe there were only 72 drilling rigs as of 2012, not all of which were adapted for hydraulic fracturing⁷².

The chief economist of BP said that “it will take years to launch and ramp up production of shale gas in Europe” while “the amount of production in Europe could reach only 68 million m³ per day by 2030 compared to 566 million m³ per day in the USA today”⁷³. In the 2012 World Energy Review the International Energy Agency suggested that it is unlikely that unconventional gas could offset the depletion of conventional gas resources in Europe in 2020, and forecasted that by 2030 shale gas production in Europe would reach only 2–3 % of the total gas consumption in Europe⁷⁴.

⁶⁷ North American firms quit shale gas fracking in Poland <http://www.bbc.co.uk/news/business-22459629>

⁶⁸ Why European Shale Is Totally “Fracked” <http://onforb.es/1oedQYW>

⁶⁹ Shale gas reserves in Ukraine failed to square with the facts <http://bit.ly/1hNVlBD>

⁷⁰ <http://www.ojg.com/articles/print/vol-110/issue-12/exploration-development/evaluating-production-potential-of-mature-us-oil.html>

⁷¹ Drill, Baby, Drill: “Can Unconventional Fuels User in a New Era of Energy Abundance” <http://www.postcarbon.org/reports/DBD-report-FINAL.pdf>

⁷² The impact of unconventional gas on Europe, Poyry <http://bit.ly/1i1NQIX>

⁷³ <http://www.telegraph.co.uk/finance/newsbysector/energy/oilandgas/9806638/Shale-gas-is-not-a-game-changer-for-the-UK-says-BP.html#>

⁷⁴ <http://www.worldenergyoutlook.org/>

Role of unconventional gas in the gas consumption balance in Ukraine

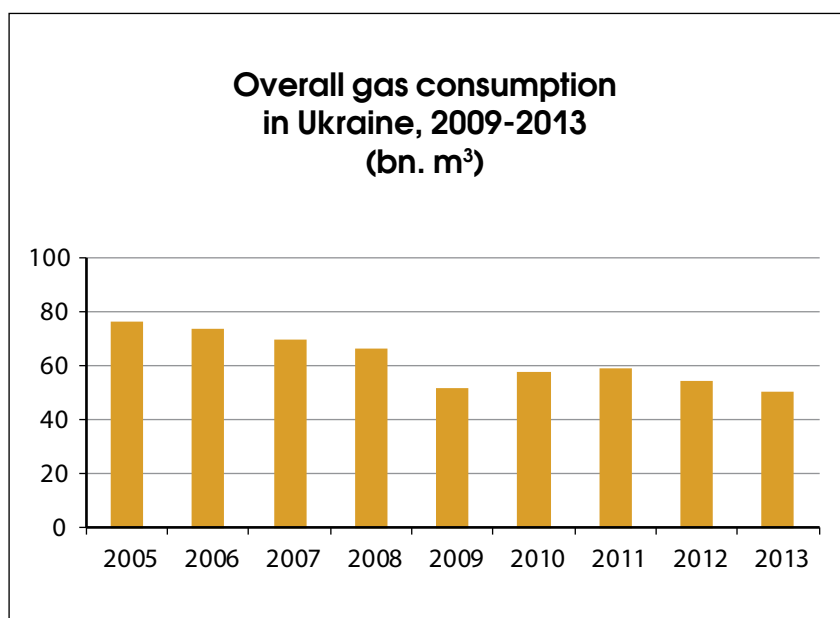


Fig. 2. Overall gas consumption in Ukraine, 2009-2013

Source: Website of the Ministry of Energy and Coal Industry of Ukraine

The Energy Strategy of Ukraine up to 2030⁷⁵ provides for a gradual decline in natural gas consumption: according to the baseline scenario for the natural gas balance, in 2030 total consumption will decline to 49.4 billion m³. In 2013 the total estimated consumption of natural gas in the country was equal at 51.6 billion cubic meters but actually 50.3 billion m³ was consumed, of which 27.9 billion m³ accounts for imported gas.⁷⁶

Moreover, according to its Energy Strategy Ukraine will increase its own natural gas pro-

duction more than twice (according to the baseline scenario from 20.5 billion m³ to 44.4 billion m³ in 2030), which in turn will allow for the reduction of natural gas imports to 5 billion m³. It was expected that the volume of domestic gas development would be increased due to the development of a deep marine shelf in the Black Sea and unconventional gas reserves, as existing conventional gas reserves are depleted.

The prospects of extracting gas at the Black Sea deep marine shelf remain uncertain because after the occupation of Crimea by Russia the self-declared government of Crimea, which has not been recognized by Ukraine, has been attempting to gain control over the national company "Chornomornaftogas"⁷⁷ and the natural resources of the Black Sea.

As for unconventional gas production reserves, as we have noted in the "Reserves and Production Rates" section, there is no scientific data on unconventional gas reserves in Ukraine. Firstly, even if geological exploration confirms the existence of such reserves, unconventional gas wells, unlike conventional reserves, deliver up to 70% of their gas volume during their first year operation and quickly become exhausted thereafter.

Secondly, in order to maintain the volume of gas that would offset the cost of drilling, it would be necessary to drill a large number of wells that could create an intolerable financial burden for companies and reduce the quality of life of local communities living close to extraction sites.

⁷⁵ Energy Strategy of Ukraine to 2030 as approved on July 24, 2013 <http://zakon0.rada.gov.ua/laws/show/n0002120-13/paran3#n3>

⁷⁶ Statistics of the Ministry of Energy and Coal Industry of Ukraine http://mpe.kmu.gov.ua/fuel/control/uk/publish/article?art_id=260835&cat_id=35081

⁷⁷ Kyiv will sue the Russian Federation for misappropriation of Chornomornaftogaz <http://www.epravda.com.ua/news/2014/05/13/451908/>

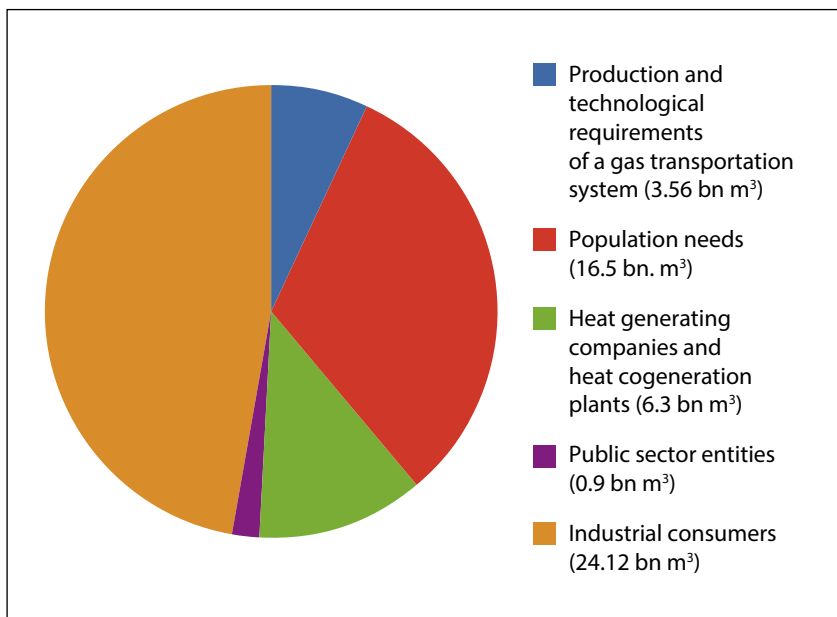


Fig. 3. The projected balance of natural gas consumption in Ukraine in 2013 (excluding gas injected into underground storage facilities – 8.45 billion).
Source: Resolution N 327-p of the Cabinet of Ministers of Ukraine dated April 29, 2013

This in turn will encourage the state to provide fiscal incentives and state aid which means sponsoring private companies at the expense of taxpayers, i.e. the very people who suffer from this industry.

Furthermore, it is unlikely that a large number of wells will be drilled in Ukraine so rapidly as to double natural gas production by 2030 because of, among other things, a lack of adequate equipment and qualified personnel.

In summary, unconventional gas is too unreliable, expensive and risky an energy source for hopes about Ukraine's future energy safety to be pinned on it.

If we take the projected balance of natural gas consumption in 2013⁷⁸, we can see that the biggest consumers are the industry (47 %), the population (32 %) and heat and electricity generation plants (12 %). The share of electricity produced from natural gas in Ukraine does not exceed 10 % (in 2010).

As seen from the figures, at 22 billion m³ domestic gas production in Ukraine almost completely covers the needs of the population and heat generating companies to the extent of 22.8 billion cubic meters. As a result these categories of consumers would not be affected by the high price of imported gas or interruptions to its supply. The lion's share of gas consumption

accounts for the industry. With the express aim of satisfying the industry needs it is necessary to either import natural gas or produce unconventional gas.

Ukraine has a huge potential to reduce gas consumption. The baseline scenario of economic development as laid down in the Energy Strategy of Ukraine provides for reaching gas consumption at 49 billion m³ and heat consumption at 271 million Gcal per year by 2030. This ambition requires active implementation of measures aimed at improving energy efficiency and reducing gas and heat consumption by roughly 40 % and 25 % accordingly, in particular due to the following efforts:

- Upgrading the industry with energy-saving technologies;
- Reduction of gas and heat loss due to the reconstruction of gas transportation and heat supply systems;
- Adjustment of tariffs to cover production costs;
- Amending the laws of Ukraine to tighten buildings insulation requirements and heat supply system reconstruction;
- Upgrading residential and commercial buildings through conducting energy audits of facilities and implementing personalized metering of gas and heat consumption;
- Switching to alternative sources of heat in rural areas;
- Promoting alternative sources of heat generation.

However, the same basic scenario assumes that in the absence of energy efficiency measures the total volume of gas and heat consumption in the economy by 2030 will reach approximately 82 billion m³ and 366 million Gcal per year respectively. We believe that this projected consumption growth is unrealistic as the Energy Strategy provides for an unrealistic economic growth rate (5 %) and overestimates the growth of energy consumption. However, all of the above energy-saving measures are realistic and can be implemented if there is political will and can lead to a real reduction in gas consumption.

⁷⁸ Resolution N 327-p of the Cabinet of Ministers of Ukraine dated April 29, 2013 on Approval of the Projected Balance of Natural Gas Supply and Distribution in Ukraine for 2013 <http://zakon4.rada.gov.ua/laws/show/327-2013-%D1%80>

Energy efficiency measures in the housing and utilities sector and heat supply

Implementation of energy efficiency measures in the heat consumption sector would involve a decrease in specific fuel consumption by about 30% through conducting energy audits, subject to further increase in thermal efficiency of buildings resulting from the application of modern construction regulations and standards, especially with respect to constructing and reconstructing residential and industrial building stock. Priority should be given to the introduction of energy efficient technologies in the public sector, the objects of which offer the greatest energy efficiency potential and are state-owned, thereby allowing a significant effect to be achieved in the short term because of centralized coordination.

The Energy Strategy of Ukraine outlines a systematic approach to improve energy efficiency in the housing and utilities sector. In particular, special attention should be paid to improving the technical equipment of residential and public buildings, wider use of international experience in implementing energy efficient air conditioning and ventilation systems providing for heat recovery and ventilation emissions disposal and low temperature heating systems based on modern boilers and heat pumps. To enable the implementation of such projects it is necessary to make the transition to economically sound tariff making, which will become another important factor in improving the efficiency of heat use by changing consumer behaviour. A comprehensive approach should be taken to changing the behaviour of heat energy consumers and should provide for non-tariff incentives such as public awareness, soft loans for energy-saving equipment, etc. in addition to the aforementioned tariff-based methods.

During the reconstruction of the existing housing stock particular attention should be paid to redesigning house heat distribution networks according to two-pipe schemes providing for the installation of thermal valves and systems for heat energy consumption meters.

As numerous engineering and technical studies show, reconstructing central heating systems using modern heat network isolation materials, individual heat supply stations with perfect weather regulation systems and modernization of boiler plants, provided that prices for energy and equipment are economically sound, can offer undeniable economic and environmental benefits compared to the implementation of individual heating in apartment blocks (of 3 floors or more).

The implementation of such projects requires a speedy abandonment of cross-subsidizing by the industry in the areas of gas, electricity supply and heat production while introducing mechanisms of targeted subsidies for socially vulnerable groups of the population.

Another important condition for implementation of the energy saving policy in relation to central heating systems should be establishing fully-fledged automatic control and commercial metering of heat flow through installing meters at all stages of production, transportation, distribution and use of heat energy. This will create the necessary economic prerequisites for the implementation of energy efficiency projects in the reconstruction of obsolete heating systems while increasing their economic efficiency and reliability.

A further measure for the reduction of gas consumption both in individual and central heating systems involves switching from gas, oil and coal to wood and crop waste and the use of the recoverable heat energy resources of industrial corporations and development of urban thermal cogeneration plants. In Ukraine forms of biomass such as agricultural crops, firewood and wood waste, liquid fuels obtained from biomass, solid municipal waste and biogas comprise the greatest sources of potential energy. According to various estimates, installed capacity in the bioenergy sector can reach 10-15 GW of heat and 1-1.5 GW of electricity.

As for wide commercial use, in the coming years it would be expedient to apply technologies that involve burning biomass in boilers and technologies providing for the use of biogas collected from livestock farms and solid municipal waste landfills, since these technologies are currently the most developed.

Particularly noteworthy projects include introducing heat regulating pumps designed to balance the inefficiencies of the electric power system with the functions of an energy efficient and environmentally friendly heat source by harnessing heat lost from existing equipment or environmental heat energy.

Why should the industry be interested in reducing gas consumption?

Firstly, gas is an exhaustible raw material, and investing billions in the development of infrastructure for the extraction of a fuel from reserves that will eventually be depleted would therefore be a short-sighted practice. Second, the policy, which aims to support the production of natural gas, sends the wrong message to consumers, creating an ill-founded belief that the extracted gas would cover long-term needs at a reasonable price. It results in wasting time and money that could be used to reduce consumption, improve energy efficiency and promote switching to renewable energy sources.

This is evidenced by the findings of a study showing that shale gas has not made the American industry more competitive. German bank KfW conducted a study that compared the level of competitiveness of the German and American industry over the past 10 years, i.e. the period

of the shale boom. The study showed that the manufacturing sector of the U.S. economy gained no significant benefits from lower energy prices. The authors attribute this to the fact that energy prices represent only a small percentage (2%) of the total price of the products⁷⁹. They even suggested that in the long run fracking would also give no competitive advantages to the U.S. economy. To the contrary, it is concluded that low energy prices discourage businesses to implement measures to increase production efficiency, which could jeopardize their competitiveness in the future⁸⁰.

Who governs?

In Ukraine, the use of the hydraulic fracturing method is practically uncontrolled by the state. There are no specific rules or laws that would regulate the use of this technology. The activities of relevant companies are governed by laws applicable to conventional oil and gas production. The ministry of Environment and Natural Resources does not require that the companies assess the environmental impact of hydraulic fracturing operations. The state Service

for Mining Supervision and Industrial Safety neither collects nor processes information about fracturing⁸¹.

Ukraine is following the same path as the United States, where state supervisory bodies not only applied the legislation governing the extraction of conventional hydrocarbons to fracking companies, but also provided the industry with various law exemptions (having removed fracking from the scope of the Laws on Clean Water, Clean Air, etc.). They understood that something had gone wrong only when the environmental consequences of hydraulic fracturing technology became apparent. The European Parliament realized the danger of this approach and in a resolution dated November 12, 2012⁸² called on the European Commission to develop specific legislation which would take into account the specifics of unconventional gas extraction.

In Ukraine today about two dozen companies are conducting or are declaring their intentions to conduct hydraulic fracturing or are licensed to engage in the exploration/extraction of unconventional gas (see Annex 1).

79 https://www.kfw.de/Download-Center/Konzernthemen/Research/Research-englisch/Fokus-PDF-Dateien/Fracking_you-snooze-you-lose_en.pdf

80 https://www.kfw.de/Download-Center/Konzernthemen/Research/Research-englisch/Fokus-PDF-Dateien/Fracking_you-snooze-you-lose_en.pdf

81 Hydraulic fracturing in Ukraine: truth will out
<http://www.zfront.org/gidrorazryvy-v-ukraine-taynoe-ne-stanovitsya-yavnym/>

82 European Parliament resolution of 21 November 2012 on the environmental impacts of shale gas and shale oil extraction activities (2011/2308(INI)) <http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P7-TA-2012-0443&language=EN>



Conclusions

Hydraulic fracturing conducted within the framework of unconventional gas extraction should not be confused with hydraulic fracturing that has been performed over many years to intensify the extraction of conventional natural gas through a combination of horizontal drilling and different impact degrees.

Extracting unconventional gas using hydraulic fracturing method is an extremely dangerous process that threatens to contaminate strategic drinking water reserves in heavily populated regions of Ukraine. Improper application of the technology involves a high risk of accidents. Even if applied properly, the technology poses a commensurable risk to the environment and human health. In addition, the issue of liquid waste disposal still needs to be addressed.

A number of peer-reviewed pieces of research have shown a direct link between unconventional gas drilling and pollution of water, air and soil in these regions, as well as the relation between drilling and the deterioration of locals' health.

Ukrainian legislation has a number of gaps in terms of regulating unconventional gas development. Government authorities do not exercise control over the application of hydraulic fracturing. Today there are no mechanisms for the disposal of waste water, rehabilitation of land plots after drilling, compensating local residents for environmental damage, biodiversity conservation etc. Lack of proper legal regulation means that local communities have virtually no access to justice. There is a risk of mass expropriation of land for the members of these communities on the ground of public needs.

Because of technological and geological reasons the cost of unconventional gas extraction cannot be lower than that of conventional gas, and, according to international experts, the price of such gas will be not less than USD560 per thousand cubic meters. For the same reasons unconventional gas production cannot be ramped up to a sufficient extent or at a sufficient speed to allow for the cancelling of imports from Russia, let alone starting exports from Ukraine.



Recommendations

According to the Constitution of Ukraine, mineral resources belong to the people of Ukraine. The Constitution also provides that the title to mineral resources should not be used to the detriment of a person or society. In this regard, it is necessary to consider whether it is rewarding to allow the use of technology that involves injection of toxic chemicals into the ground and which generates liquid waste that cannot be properly treated.

Hydraulic fracturing combined with horizontal drilling should be recognized as a new practice, which is still understudied in Ukraine. The Ukrainian legislation governing the oil and gas industry should be revised taking into account the specifics of hydraulic fracturing technology to ensure adequate control and monitoring. In particular, the following points should be taken into account:

- Hydraulic fracturing should be unconditionally prohibited near areas where main drinking water reserves are located, in areas where seismic faults are present, areas with a shortage of drinking water, environmentally protected territories (and their soil) and in urban settlements (and their soil).
- All relevant chemicals should be disclosed, their number should be limited and their use should be strictly regulated.
- Environmental impact assessment should be an essential requirement for geological exploration and production of unconventional gas.
- Water condition should be inspected before drilling and should undergo regular monitoring during drilling and hydraulic fracturing. The inspections' findings should be regularly published.
- The use of open sumps (storage pits) for spent fracking fluid should be prohibited.
- Supplying water to treatment facilities should be prohibited if it is impossible to remove toxic and radioactive materials.
- Road transport should undergo compulsory specification during transportation of wastewater and necessary safeguards should be taken to prevent leakage in the event of an accident or negligence of the driver, including conducting relevant training on safe handling of substances.

The state should require that every company practising hydraulic fracturing develops and agrees upon action plans and procedures with the Ministry of Emergency Situations to follow in the case of possible emergencies. An extracting company should prove that it has the necessary resources, equipment and qualified personnel to implement these plans and procedures. These plans and procedures should be published on the corporate website and made available to local communities where operations are expected to be carried out.

It is necessary to abolish the exemption of extracting companies from liability in accordance with the requirements of environmental legislation of Ukraine, and develop a mechanism of bringing them to liability for damage caused to a group of individuals or communities as a result of unconventional gas extraction.

The State Environmental Inspection of Ukraine, the State Sanitary and Epidemiological Service of Ukraine and the Ministry of Agrarian Policy and Food of Ukraine should conduct proper and regular environmental monitoring and laboratory analysis of soil and water in areas where unconventional gas is extracted.

Prior to implementing such projects it is necessary to analyse the project life cycle subject it to a mandatory cost-benefit analysis in order to determine which particular benefits the citizens of the country will gain and whether they outweigh harm to the environment and human health that will be caused by the project.

The energy Policy of Ukraine should be revised in favour of the systematic reduction in primary energy consumption rather than an increase in unconventional hydrocarbon extraction. This should be done by reducing energy consumption and improving energy efficiency. A further alternative path to achieving energy independence should be increased energy generation from renewable energy sources.

Annex 1.

Companies that apply hydraulic fracturing in Ukraine



Drilling rig of Ukrgasvydobuvannia Company on Kamianska area, well N 17 (village of Yaremivka, Kharkiv region), 2013.

Photo: Oleh Savytskyi

As mentioned, the method of wells stimulation has been applied in Ukraine since the 50s of XX century while companies have only been applying the hydraulic fracturing method for the extraction of unconventional gas since 2011. This list includes those companies that in one way or another apply or declare that they are planning to apply the hydraulic fracturing method. This list is not exhaustive as the Ukrainian market is extremely attractive for new players, and companies that produce conventional gas may at any time shift to this method.

According to preliminary estimates, unconventional gas reserves in Ukraine are located within the Dnieper-Donets oil and gas basin in the east and the Lvov-Lublin basin in the west of the country. Active hydraulic fracturing operations are carried out in the Poltava region (Rudenkivsko-Proletarskyi oil and gas bearing area).

Ukrgasvydobuvannia PJSC

Ukrgasvydobuvannia, a state-owned company established in 1998 as a subsidiary of Naftogaz of Ukraine National Joint Stock Company. In December 2012 the state-owned company was transformed into a private joint-stock company.

Ukrgasvydobuvannia PJSC carries out geological exploration works in search of new hydrocarbon fields in the Dnieper-Donets basin and the Carpathian region. Today Ukrgasvydobuvannia PJSC is developing 136 hydrocarbon deposits in Ukraine⁸³.

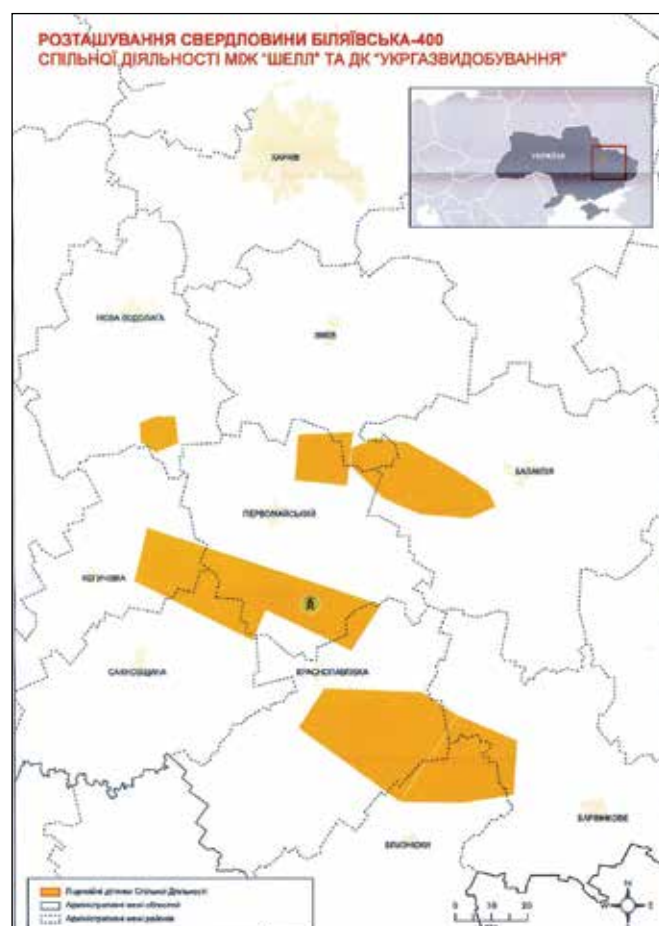
Operating on old, depleted fields, the company faced a situation in which it was no longer able to maintain production volume. As a result of this Ukrgasvydobuvannia PJSC plans to increase hydrocarbon production by means of exploratory drilling at a great depth over 6,000 m in the Eastern oil and gas region of the country, as well as the implementation of horizontal drilling and hydraulic fracturing.

Joint venture of Shell and Ukrgasvydobuvannia PJSC

On September 1, 2011 Shell and Ukrgasvydobuvannia signed an updated Joint Venture Agreement on the basis of the initial agreement dated 2006. The agreement contains plans for the operation of six licensed sites with a total area of approximately 1,300 square kilometres⁸⁴ in the Kharkiv region: the Pavlivsko-Svitlivska area, the Hersevanivska area, the Novo-Mechybylivska area, and the Efremifske and Melykhivske fields. These sites are located within the Balakliyskyi, Novovodolazskyi, Pervomayskyi, Lozivskyi, Kegychivskyi, Sahnovschynskyi, and Blyzniukivskyi districts. Each of the companies holds a 50 % stake in the project. Shell is acting as the project operator during the initial phase of geological exploration.

⁸³ <http://ugv.com.ua/activities/exploration-department>

⁸⁴ Shell official website <http://www.shell.ua/>



Source: Shell official website

Three exploratory wells are planned to be drilled within 3–4 years. As of today two exploratory wells have been drilled: the Biliaivska-400 well was drilled in September 2013 in the Pervomayskiy district, Kharkiv region⁸⁵, and Novomechybelivska-100 well⁸⁶ was drilled in March 2014 in the Blyzniukivskiy district of the Kharkiv region.

Joint venture of Ukgasvydobuvannia and Karpatygas (Svenska Capital Oil)

In 2012 Ukgasvydobuvannia SE and Swedish company Svenska Capital Oil, which owns Ukrainian company Karpatygas, entered into a joint venture agreement providing for, inter alia, the ramping up of gas production at the existing fields of Ukgasvydobuvannia SE in the Poltava, Lviv and Kharkiv regions. In particular, the parties to the joint venture agreed upon the repair and renewal of inactive and low-yield wells, complex development of individual fields and implementation of new technologies: the injection of nitrogen into beds, hydraulic fracturing and the extraction of viscous oil⁸⁷.

Nadra Yuzivska LLC

In addition to the joint venture with Ukgasvydobuvannia PJSC, Shell plans to develop the Yuzivska area. In May 2012, the company was announced as the winner of the tender for entering into a production sharing agreement (PSA) for the development of the Yuzivska area, and on January 24, 2013 Shell Exploration and Production Ukraine Investments (IV) B.V. and Nadra Yuzivska LLC signed the PSA in question. The PSA was signed for a 50 year period. Shell and Nadra Yuzivska LLC each hold a 50 % stake in the project (as investors). Shell acts as the project operator responsible for all works performed under the agreement.

The Yuzivska area is located within the territory of two regions: Donetsk (the Krasnolymanskiy, Slovianskiy, Oleksandrivskiy, Konstantynivskiy, Artemisvkiy, Dobropilskiy and Yasynuvatskiy districts) and Kharkiv (the Balakliyskiy, Iziunskiy and Barvinkivskiy areas)⁸⁸. Compacted sandstone gas will be extracted there. The area where compacted sandstone gas is to be extracted is about 7,800 km².

As of June 2014, an assessment of basic environmental conditions has been underway within the Yuzivska area. Contradictory information regarding the cessation of works as a result military actions in the region has been obtained from different sources, but Shell has denied it⁸⁹.

Zasiadko Mine PJSC

In December 2010 Zasiadko Mine PJSC obtained licenses for geological exploration and further production of hydrocarbons within nine oil and gas areas in the Kharkiv and Luhansk regions⁹⁰.

In 2011 Zasiadko Mine PJSC transferred four of these nine areas for use to Donetsk-based Inter-Regional Gas Company LLC,

⁸⁵ Village of Vesele, Pervomayskiy district, Kharkiv region <http://goo.gl/maps/BNZPZ>

⁸⁶ Blyzniukivskiy district, Kharkiv region <http://goo.gl/maps/n9MMn>

⁸⁷ Ukgasvydobuvannia and Svenska Capital Oil to produce gas in Ukraine <http://goo.gl/fEOMWk>

⁸⁸ Fig. Annex 6. Location plan – Yuzivska area

⁸⁹ Shell refuted rumors about the suspension of shale gas exploration in the east of Ukraine <http://goo.gl/PORDSp>

⁹⁰ Special permits to mineral resources use in Luhansk and Kharkiv regions as issued by the State Service for Geology and Mineral Resources of Ukraine to OF Zasiadko Mine PJSC http://zasyadko.net/images/stories/geodoc2013/geodoc_2013_09.pdf

which belonged to Oleksandr Yanukovich (son of Ukrainian President in that time): Nyzhniortyschivska, in the Kharkiv region, Syrotynska, Serbska and Zolotarivska (all in the Luhansk region)⁹¹.

As of January 2014 Zasiadko Mine PJSC has been engaged in the development of the nine areas – Volodarska (in the Kharkiv region), Zakutna, Pivnichnolobachivska, Zakhidnoderkulska, Yampilka, Baydivska, Veselevska, Starobilka and Novooleksandrivska (all in the Luhansk region).

The company has announced that it is applying the slant drilling and hydraulic fracturing methods⁹². In 2011 it signed a cooperation agreement with Halliburton Co, a leading service company in the U.S. specializing in hydraulic fracturing. Previously Zasiadko Mine PJSC and Halliburton cooperated in the area of coalmine methane removal. The new agreement provides for their cooperation in the area of shale gas extraction.

KUB-Gas (Serius Energy, Cub Energy Inc)

In 2010 Polish company Kulczyk Oil Ventures purchased a controlling stake in KUB-Gas LLC (70 %). The remaining 30 % is owned by American company Cub Energy Inc. In 2013, Kulczyk Oil Ventures changed its name to Serius Energy.

Currently, KUB-Gas is one of the largest private gas producers in Ukraine. The company is licensed to operate the following sites in the Lugansk region: Verhunske field (Slovyanoserbskyi district, 10 km north of Luhansk), Krutohorivska area (Slovyanoserbskyi district, 12–15 km northwest of Luhansk), Makeyivske field with Pivdenno-Makeyivskyi section (Kreminskyi district, 15 km north-west of Kreminne), the Olhivska area (Kreminskyi district, 30 km northwest of Kreminne) and the Pivnichnomakiyivska area (Kreminskyi and Svativskyi districts, Luhansk region)⁹³.

The Company applies the hydraulic fracturing technology to increase the production rate of existing wells and extract unconventional gas. In May 2011, the European Bank for Reconstruction and Development (EBRD) granted a EUR 40 bn loan to Kulczyk Oil Ventures⁹⁴. The loan provided for the modernization the equipment and implementation of new technologies to stimulate existing wells.

The company conducted its first hydraulic fracturing in October 2011 at the Olhivska 6 well in Olhivske field and at the Olhivska 8 well⁹⁵ at the end of that year. Hydraulic fracturing at the following wells is scheduled for 2014: Olhivska 24, Olhivska 11, Makiivska 15 and Makiivska 17⁹⁶.

Cub Energy Inc

In addition to the licenses held by Cub Energy Inc through KUB-Gas Ltd., the American company owns permits for hydrocarbon extraction in the Oskolonivska, Kriakivska and Skhidno-Verkhunska areas in eastern Ukraine (the official holder of the licenses is Tehnogasindustrija LLC)⁹⁷.

In the Transcarpathian region the company is licensed to operate in the Stanivska, Rusko-Komarivska, Uzhgorodska and Korolivska areas (in 2011 Cub Energy Inc bought 100 % of Tysgas that held these licenses).

Geo Alliance Group (EastOne, Arawak Energy Ukraine BV)

Geo Alliance Group, which is owned by Viktor Pinchuk, has been extracting unconventional gas using hydraulic fracturing⁹⁸ since 2011. As of today hydraulic fracturing is being carried out in the Lutsenkivske (by Schlumberger Oilfield Eastern LLC) and Vysochanske (by Halliburton, a U.S. oil service company) fields.

In 2012, Geo Alliance Group and Arawak Energy Ukraine BV (Netherlands, a member of Vitoil group) agreed upon joint ownership, management and investments aimed at the further development of gas and oil fields in Ukraine belonging to Geo Alliance⁹⁹.



Source: Cub Energy Inc website



Source: Cub Energy Inc website

⁹¹ Kings of Ukrainian Gas. Who “eviscerates” the mineral resources of the country: Yanukovich Family and Kolomoyskyi
<http://argumentua.com/stati/koroli-ukrainskogo-gaza-kto-potroshit-nedra-strany-yanukovich-i-kolomoiskii>

⁹² http://www.ukrrudprom.ua/analytics/Uglevodorodniy_bonus.html

⁹³ http://www.kulczykoil.com/ukraine_facts_numbers.html

⁹⁴ <http://www.ebrd.com/english/pages/project/psd/2011/42159.shtml>

⁹⁵ Kulczyk Oil Ventures Announces Successful Fracturing in Ukraine
<http://www.naturalgaseurope.com/kulczyk-oil-ventures-announces-successful-fracking-in-ukraine-3324>

⁹⁶ Cub Energy Inc. M – 17 Well Makes New Gas Pool Discovery in the S7 Zone
<http://www.reuters.com/article/2014/05/06/idUSnMKWb2lpJa+1c2+MKW20140506>

⁹⁷ <http://www.cubenergyinc.com/dnieper-donets-basin.php>

⁹⁸ Pinchuk invests in Ukrainian shale gas
<http://businessua.com/industriya/pinchuk-investue-v-ukrainskii-slancevii-gaz-7492.html>

⁹⁹ Pinchuk to share the oil and gas assets management with Arawak Energy
<http://ua-energy.org/post/23660>



Source: Geo Alliance Group website



Source: Iskander Energy website

Geo Alliance has 16 licensed areas for the development of hydrocarbons with a total area of 1,090 km², 15 of which are located in the Dnieper-Donets basin¹⁰⁰.

- Sumy region: Yasenivske field (Okhtyrskiy district, 14 km of Okhtyrka), Riznykivska and Berestivska areas (both located in Lypovodolynskiy district, village of Lypova Dolyna).
- Kharkiv region: Zakhidno-Efremivske field (located at the boundary of the Pervomayskiy, Novovodolazskiy and Kegychivskiy districts, 19 km of Pervomaysk), the Myroliubivska site (Lozovskiy district, 35 km north-west of Lozova) and the Taranushynska site (Balakliyskiy district).
- Luhansk region: Vysochanske field (village of Slovyanoserbks), Zaytsivske (Svativskiy district, village of Rayhorod and village of Kovaliv), and Lvivske field (Stanichno-Luhanskiy district, Stanytsia Luganska).
- Poltava region: Lutsenkivske field (Lokhvitskiy district, 20 km of Lokhvytsia), Pivdenno-Koshevoyska site (Mirgorodskiy district) and Makartsivske field (15 km of Poltava).
- Chernihiv region: Bokhanivske field (Varvynskiy district).
- Dnipropetrovsk region: Pivdenno-Orilskaya site (Yuryivskiy district).
- Ivano-Frankivsk region: Kosachivska area (Gorodenkivskiy and Kolomyiskiy districts)¹⁰¹.

Iskander Energy

Iskander Energy is a Canadian energy company in possession of licenses for the extraction of coal bed methane and compacted sandstone gas from three sites: Chervonoarmiiska (235 km², a joint venture with Ekometan), Krutoyarivska (685 km², a joint venture with Carbona Energo LLC) and the Pivdenno-Donbaska area (431 km², a joint venture agreement with ISD Corporation).

In 2013, the first well for extracting compacted sandstone gas¹⁰² was drilled in the Chervonoarmiiska area (KRA-1). By the end of the year hydraulic fracturing had been performed at 7 other wells¹⁰³. Drilling and fracturing at two vertical wells in the Pivdenno-Donbaska area is scheduled for 2014 and six new wells in the Krutoyarivska area are expected to be drilled by 2014. As of today all attempts to gain industrial volumes of gas have failed¹⁰⁴.

Prom-Energo Product LLC (Smart Holding)

Prom-Energo Product LLC, a company founded in 2001 and in possession of a special permit for the extraction of hydrocarbons in the Vasyshevske gas condensate field in the Kharkiv region (in the village of Vvedenka, Chuguivskiy district and the village of Ternova, Kharkiv district)¹⁰⁵.

Ukrgasvydobutok PrJSC (Smart Holding)

Ukrgasvydobutok PrJSC, a company founded in 1998. Since 2000 the company has developed Ostroverhivske gas condensate field with Ukrgasvydobuvannya (a subsidiary of Naftogaz Ukraine NJSC), under a joint venture agreement (Kharkiv district, Kharkiv region, 4 km of city Merefya)¹⁰⁶.

Regal Petroleum Corporation Ltd. (Smart Holding)

Regal Petroleum Corporation Ltd., a company founded in 1996. The Company has special permits for the use of mineral resources in two large gas condensate fields in the north of Poltava region – Mekhedivsko-Holotovschynske and Svrydivske¹⁰⁷.

¹⁰⁰ http://www.cysec.gov.cy/Downloads/PublicCompanies/Newsletters/2010/Geo-Alliance%20Prospectus_16%20November%202010.pdf

¹⁰¹ Vysochanske field (the license belongs to Geo Alliance Vysochanske LLC), Lvivske field (the license belongs to Geo Alliance Lvivske LLC), Myrolubivska site (the license belongs to Geo Alliance Myrolubivske LLC), Yasenivske field (the license belongs to Geo Alliance Yasenivske LLC), Zakhidno-Efremivske field (the license belongs to Geo Alliance Zakhidno-Efremivske LLC), Taranushynska site (the license belongs to Geo Alliance Taranushynske LLC), Pivdenno-Orilskaya site (the license belongs to Geo Alliance Pivdenno-Orilskaya LLC), Kosachivska site (the license belongs to Geo Alliance Kosachivske LLC), Lutsenkivske field (the license belongs to Pryrodni Resursy PJSC), Koshevoyska, Riznykivska and Berestivska sites, Makartsivske field (the license belongs to Skhidnyi Geologichniy Soyuz LLC), Zaytsivske field (the license belongs to Oberon-Vugillia LLC).

¹⁰² Hutton Energy and Iskander Energy complete well in Ukraine http://www.huttonenergy.com/latest_news/hutton-energy-and-iskander-energy-complete-well-in-ukraine

¹⁰³ <http://www.iskanderenergy.com/Presentation-December.pdf>

¹⁰⁴ No accurate data on coal methane reserves in Ukraine is available http://www.ukrudprom.com/news/Tochnie_zapasi_ugolnogo_metana_v_Ukraine_ne_opredeleni.html

¹⁰⁵ <http://www.smart-holding.com/ru/our-investments/smart-energy/prom-energo-product/>

¹⁰⁶ <http://www.smart-holding.com/ru/our-investments/smart-energy/ukrgazvydobutok/>

¹⁰⁷ <http://www.smart-holding.com/ru/our-investments/smart-energy/regal-petroleum/>

Chevron Ukraine B.V.

In 2012 Chevron won the tender and gained the pre-emptive right to enter into a PSA regarding the Oleska area, and in 2013 signed a Production Sharing Agreement with the government of Ukraine. The Ivano-Frankivsk and Lviv region councils endorsed the hydrocarbon sharing agreement between Ukraine, Chevron Ukraine BV and Nadra Oleska LLC on September 20, 2013 and October 3, 2013 respectively.

The Oleska area is located in the Lviv region (Sokalskyi, Zhovkivskyi, Kamianka-Bugskyi, Buskyi, Pustomyivskyi, Zolochivskyi, Mykolayivskyi, Peremyshlianskyi and Zhydachivskyi districts) and the Ivano-Frankivsk region (Rohatynskyi, Kaluskyi, Galytskyi, Tismenytskyi, Tlumatskyi and Horodenkivskyi districts)¹⁰⁸. The total area amounts to 6,324 km². Shale gas exploration and extraction activities are planned to be performed within the area.

According to the draft PSA, the geological exploration phase will last 5 years. During that period it is planned that 13 wells will be drilled. It is expected that the first well will be drilled in 2015 and 4 wells will be drilled each year for the subsequent 3 years. The commencement of pilot and industrial development phases providing for intensive well drilling is scheduled for 2019. In total 1000 wells are planned to be drilled by 2030, at a rate of 128 wells per year¹⁰⁹.

Zakhidgasinvest LLC (ENI S.p.A, Cadogan Petroleum Plc, Zakhidukrgeologia)

Zakhidgasinvest was established in February 2012. It was founded by Zakhidukrgeologia, a subsidiary of Nadra Ukrayny NJSC, and Kolomyiska Oil and Gas Company "Delta", a Ukrainian-Canadian joint venture owned by British Cadogan Petroleum Plc.

Zakhidgasinvest holds licenses to develop 9 shale gas fields located in the Lvivsko-Volynskyi basin, with a total area of about 3.8 thousand square kilometres: the Baulinska and Filimonivska areas (Volyn region), the Kurinna, Sanduheyivska and Yakovlivska, Zhuzhelyanska and Reklynetska areas (Lviv region) and the Debeslavyska and Cheremhivsko-Strupkivska areas (Ivano-Frankivsk region)¹¹⁰.

In May 2012, Italian ENI S.p.A purchased the controlling interest in Zakhidgasinvest LLC in the form of a 50.01 % stake (the shares of Cadogan Petroleum and Nadra Ukrayny constituted 15 % and 35 % respectively). Thereafter ENI S.p.A announced its intention to engage in the development of shale gas in the Lvivsko-Lublynskyi basin and announced that it possessed the necessary licenses. This raised an objection from members of the Volyn and Lviv regional councils¹¹¹. Pursuant to the law, no special permits for the development of mineral fields should be issued unless they are endorsed by local councils at such mineral field locations. The permits in question can be issued to a stated-owned company only, as opposed to foreign investors.

In March 2012, Volyn regional council endorsed a permit for Zakhidukrgeologia SE¹¹² for operation in the Baulinska and Filimonivska areas. In April 2012, Lviv regional council issued Zakhidukrgeologia with a special permit for use of mineral resources in the Kurinna, Sanduheyivska and Yakovlivska areas¹¹³, as well as permits for exploring mineral deposits on Zhuzhelyanska and Reklynetska areas (specifically for shale gas).

Zakhidukrgeologiya further transferred the special permits for use of the mineral resources of the Baulinska, Kurinna, Sanduheyivska, Yakovlivska, Filimonivska, Zhuzhelyanska and Reklynetska areas to Zakhidgasinvest LLC¹¹⁴. Cadogan Petroleum assigned the title to the Cheremhivsko-Strupkivska area to Zakhidgasinvest LLC.

According to the State Service of Geology and Mineral Resources of Ukraine, ENI S.p.A submitted a program of exploration works to the Ministry for the period 2012-2015, with a total value of USD 55m. These works provide for the implementation of four exploration clusters, at each of which vertical and horizontal drilling and hydraulic fracturing technologies are expected to be applied.

¹⁰⁸ Fig. Annex 7. Location plan – Oleska area

¹⁰⁹ http://www.orada.if.ua/fileadmin/documents/Ugoda_Shevron_new.pdf

¹¹⁰ <http://www.cadoganpetroleum.com/~media/Files/C/Cadogan-Petroleum/pdf-media/Cadogan-annual-report-2012.pdf>

¹¹¹ "Shale Case", the General Prosecutor's Office checks the legitimacy of Eni S.p.A license <http://www.gazeta.lviv.ua/ecology/18822>

¹¹² <http://volynrada.gov.ua/session/10/72>

¹¹³ Resolutions N 480, 481, 482 of Lviv regional council dated May 15, 2012

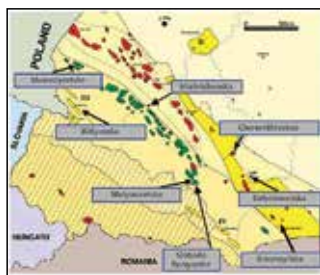
¹¹⁴ <http://www.dkrs.gov.ua/kru/uk/publish/article/95523>



Source: Brochure of Cadogan Petroleum Plc, 2008¹¹⁵



Drilling site of Yusenko Nadra LLC on Bitlianska area (Turkivskiy district). Photo: Mariana Verbovska



Source: Cadogan Petroleum Plc website¹¹⁶

Cadogan Petroleum Plc

In Ukraine Cadogan Petroleum Plc is individually engaged in the development of the Pirkivska area (Poltava region) and the Sloboda-Rungurske field (Ivano-Frankivsk region). In cooperation with ENI S.p.A the company is developing the Pokrovske and Zagoryanska fields (Poltava region), the Bitlianske, Monastyretske fields (Lviv region) and the Debeslavetske and Cheremhivsko-Strupkivske fields (Ivano-Frankivsk region).

After ENI S.p.A purchased the controlling stake in Zakhidinvest LLC, Cadogan Petroleum announced focusing from that point on the exploration of unconventional gas and planning to join ENI S.p.A as a partner in financing the development of shale gas in Western Ukraine, particularly within the territory of the Monastyretska and Bitlianska areas (in the Gorodotskyi and Turkivskiy districts of Lviv region).

It should be noted that in 2008 Cadogan Petroleum had already started developing these areas under the name of Yusenko Nadra LLC¹¹⁷. In 2009, the company drilled the Borynia 3 well in the Borynska area, but soon stopped work there because of problems with licenses.

Work resumed in 2013 with the cooperation of ENI S.p.A. Drilling is conducted by Astro Service, a service subsidiary. Bitlyanske field covers an area of 390 km² and consists of the Bitlianska, Borynska and Vovchenska areas.

In the Monastyretska area there is an operating well named Blazhyv 1¹¹⁸. The company plans to re-launch two other already existing wells.

Galicia Energy Company

In April 2014, Lviv regional council endorsed a special permit for Galicia Energy Company to engage in geological exploration of oil and gas deposits, including pilot development, subject to further extraction of oil and gas in the Hryadivska area in the Zhovkivskiy district, Lviv region¹¹⁹.

According to information from the Uniform State Register of Legal Entities and Private Individuals Engaged in Entrepreneurial Activities, the authorized capital of Galicia Energy Company is equal to UAH 1,000 (less than Eur100)¹²⁰. This gives reason to believe that the company was created with the intention to sell it once the necessary licenses have been obtained.

Poltava Oil and Gas Company, JVC (JKX Oil&Gas)

British oil and gas company "JKX Oil & Gas", through the intermediary of its subsidiary company "Poltava Oil and Gas Company", as established in 1994, is developing the Novomykolayivske field, a site in the Poltava region of Ukraine with a total area of 271 km², and has permits to explore the Zaplavska, Yelyzavetivska areas and Rudenkivske field (Poltava area) and Chervonoyarske-Skhidne field (Kharkiv region) with a total area of 171.2 km².

¹¹⁵ Zahorianske field (the license belongs to Astroinvest-Energy LLC), Pirkivska area (Astrogas LLC), Sloboda-Rungurske field (Kolomyiska Oil and Gas Company "Delta" JVC), Pokrovska area (Gasvydobuvannia Industrial Company LLC), Bitlianske and Monastyretske fields (Yusenko Nadra LLC).

http://files.investis.com/cadogan/investor/reports/final_uk_prospectus.pdf

¹¹⁶ http://files.investis.com/cadogan/investor/reports/final_uk_prospectus.pdf

¹¹⁷ Yusenko Nadra LLC, a company established in 2007 by Zakhidukrgeologia, a subsidiary of Nadra Ukrayny NJSC, and Usenko Ukraine, a 100% foreign investment subsidiary of British Cadogan Petroleum Plc. At that time the company held licenses to operate Monastyretska and Bitlianska areas and Krasnoilske field.

¹¹⁸ <http://eircenter.com/news/britanska-kompan-%D1%96ya-skonzentruyetsya-na-ukrayinskomu-slancevomu-gaz%D1%96/>

¹¹⁹ <http://gw1.oblrada.lviv.ua/rada/rishennialor.nsf/52889c345440ab40c2257b55007e8f51/5f61dd05f6ad0ff9c2257cb300543888?OpenDocument>

¹²⁰ Two firms today may enjoy permits for oil and gas extraction endorsed by Lviv regional council <http://goo.gl/jr0jXy>



Source: JVC "Poltava Oil and Gas Company" website

In late August 2013, the company conducted 10-stage hydraulic fracturing at R-103 well (or Rudenkivska-103) in Rudenkivske field (Poltava region, 10 km of the village of New Sanzhary)¹²¹. According to the company, it was the largest hydraulic fracturing operation in Europe so far¹²². According to the company, the field is used for the extraction of compacted sandstone gas.

The results of the hydraulic fracturing operation at Rudenkivska-103 well turned out to be unsatisfactory. Rudenkivska-105 well is expected to be drilled in Q'4 2014. It will only have a vertical section where 4-5-stage fracturing will be performed¹²³.

The first well in the Yelizavetynske field 35 km southeast of Poltava was put into operation on January 15, 2014¹²⁴.

Naftogaz of Ukraine National Joint-Stock Company

The Company has a license for the geological exploration of shale gas deposits in the Pysarivska area (Reshetylivskiyi district, Poltava region). In addition, the company holds licenses in the Poltava region: in the Obolonska area (Semenivskiyi district) and the Budyshchansko-Chutkivska area (Poltava district); and in the Luhansk region: in the Stelmahivska area (Kremi-netskiy area), Sukhodil'ska area (Krasnodonskiy region), and Pivdenno-Yampil'sko-Droniv'ska area (Kremiński district).

National Joint-Stock Company "Nadra Ukrayny", PJSC

National Joint Stock Company "Nadra Ukrayny", PJSC, a co-founder of Nadra Yuziv'ska LLC and Nadra Oleska LLC, holds licenses for the geological exploration and search for shale gas deposits in the following areas: Zhadov'ska, Krasnoil'ska and Storozhynetska (all in the Storozhynetskiy district, Chernivtsi region).

Ukrenergo PJSC

Ukrenergo PJSC was incorporated in 1998. In 2005 in conjunction with Nadra Ukrayny NJSC and Zakhidukrecologia SE the company conducted exploration works in the Ciscarpathian region and discovered gas reserves in Hutsuliv'ske field¹²⁵.

The total area of Hutsuliv'ske gas field is 58.75 km². Its estimated operating life is 10 years. Its estimated gas reserves are 300 million cubic meters, at a depth of 900 meters. A part of the field is located within the territory of the National Park "Hutsulshchyna".

The license for geological exploration and search for shale gas deposits in Hutsuliv'ske field belongs to Nadragas LLC.

Pari LLC (Sunrise Energy Resources)

In 2010–2011 Pari LLC obtained permits for the commercial production of shale gas in Niklovyske, Semyhyniv'ske (Lviv region) and Sheremetiv'ske (Chernivtsi region) fields. The company has licenses for extracting natural gas in Peremyshlyanske (Lviv region) and Pylpiv'ske (Ivano-Frankivsk region) fields. Furthermore, Pari obtained a permit to carry out geological study of the Chemyhiv'ska area in the Ivano-Frankivsk region.

According to the media, Pari is owned by American Sunrise Energy Resources formerly controlled by Mykola Zlochevskiy¹²⁶.

First Ukrainian Oil and Gas Company, LLC

In 2010–2011 the company was granted the right to extract shale gas in the Pivdenno-Boryslav'ska fold of the potentially productive Pivdenno-Boryslav'ska area in the Lviv region and natural gas in Proletarske field in Crimea, Ohultsivke field in the Kharkiv region and Zymnyske field in the Chernihiv region.

Moreover, First Ukrainian Oil and Gas Company obtained a permit to explore Proletarske field in the Dnipropetrovsk region and the Pivdenno-Boryslav'ska area in the Lviv region

121 Press-release of JKC Oil&Gas dated August 28, 2013 <http://www.jkx.co.uk/~media/Files/J/JKC/press-release/2013/JKC-Progress-Report-3-on-R-103-Frac-Ukraine-28-08-13.pdf>

122 JKC Starts Largest Onshore Frac Ops in Europe So Far <http://oilpro.com/post/473/jkx-starts-largest-onshore-frac-ops-in-europe-so-far>

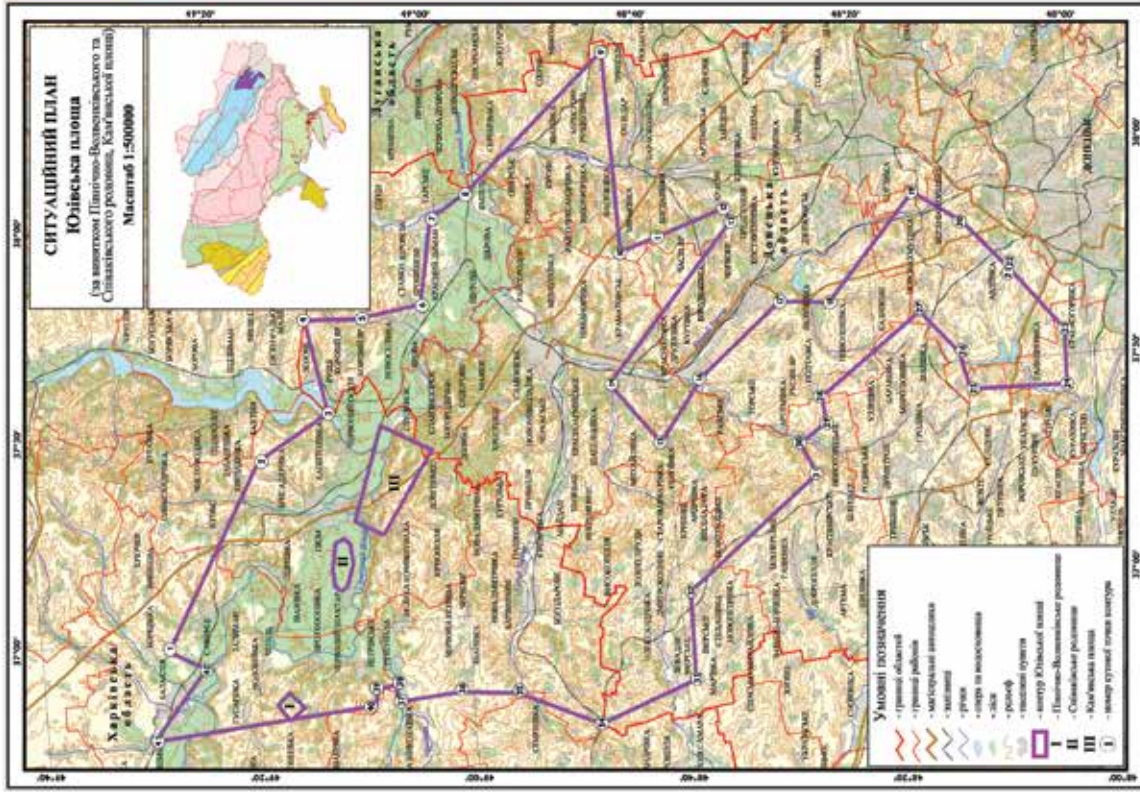
123 JKC Oil&Gas: Final Results for the Year Ended 31 December, 2013 <http://otp.investis.com/generic/regulatory-story.aspx?cid=519&newsid=399952>

124 <http://economics.unian.net/energetics/874271-neftegazovaya-kompaniya-jkx-zapustila-novuyu-skvajinu-v-poltavskoy-oblasti.html>

125 A gas field discovered in the village of Trach, Kosivskiy district <http://www.ukrenergo.lviv.ua/ru/media.htmltcl0005>

126 Fields of Mykola Zlochevskiy <http://www.epravda.com.ua/publications/2012/02/28/317182/>

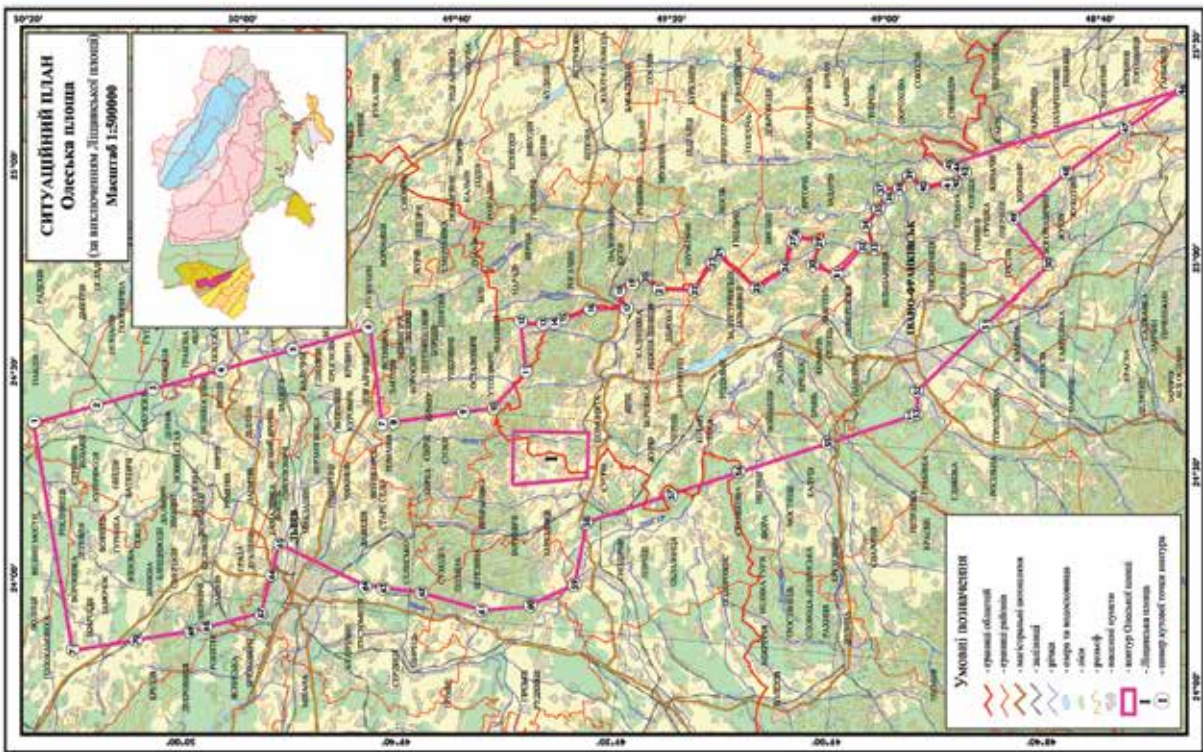
Додаток 6. Ситуаційний план – Юзівська площа



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Додаток 7. Ситуаційний план – Олеська площа



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The issue of unconventional gas production today is relevant in the entire world. Inspired by the example of the United States, governments develop programs and encourage investors aiming to achieve energy independence and / or start their own energy exports due to unconventional gas development. In Ukraine, the issue of unconventional gas extraction has acquired even a greater importance after massive protests in Maidan Nezalezhnosti (Independence Square) and the aggravation of relations with Russia.

In this review, we will consider the issue of unconventional hydrocarbons extraction in Ukraine, the technologies used for this purpose, and possible environmental, social and economic consequences thereof.