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# UKRAINE SHALE GAS: VOLUME I: ENVIRONMENTAL AND REGULATORY ASSESSMENT

**May 1, 2012**

This report was produced for review by the United States Agency for International Development (USAID). It was prepared by International Resources Group (IRG).

# UKRAINE SHALE GAS: VOLUME I: ENVIRONMENTAL AND REGULATORY ASSESSMENT

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# ACRONYMS

| | |
|---|---|
| BAT | Best Applicable Technique |
| BINU | Biodiversity Indicators for National Use |
| CBD | Convention on Biological Diversity |
| CITES | Convention on International Trade in Endangered Species of Wild Fauna and Flora |
| DSTU | State Committee of Ukraine for Standardization, Metrology and Certification |
| ECODIT | Author (company): preparer of Ukraine FAA119 Biodiversity Analysis |
| EEE | Expert Ecological Examination |
| EIA | Environmental Impact Assessment |
| EPA | Environmental Protection Agency |
| ESA | Endangered Species Act |
| Expertiza | Process and law regarding expert examination of environmental analysis reports |
| GSGI | Global Shale Gas Initiative (US Department of State, now UGTEP, see below) |
| HARC | Houston Advanced Research Center |
| IOCs | International Oil Companies |
| IOCs | International Oil Companies |
| LEA | Law on Environmental Audits |
| LEE | Law of Ecological Expertise of 1995 |
| LNG | Cryogenically liquefied natural gas |
| MAC | Maximum Allowable Concentration |
| MCM | Thousand cubic meters of gas |
| MENR | Ministry of Environment and Natural Resources, Ukraine |
| MEP | Ministry of Environmental Protection |
| MFE | Ministry of Fuel and Energy (Ukraine) |
| mmbtu | Millions of British Thermal Units |
| NGO | Non-governmental Organization |

| | |
|---|---|
| NORM | Naturally occurring radioactive materials |
| OVNS | Environmental assessment document; “Ostinka vplyvu na navkolyshnie seredovyshche” |
| PA | Protected Area |
| PEA | Programmatic Environmental Assessment |
| PSA | Production Sharing Agreement, sometimes referred to as a PSC (production sharing contract) |
| ROP | Rate of production |
| SAFR | State Agency of Forest Resources, formerly called the State Forestry Committee (SFC) |
| SDWA | Safe Drinking Water Act |
| SEE | State Ecological Expertise |
| SGIFU | State Geological Information Find |
| SI | International System of Units |
| Tonne | Metric ton (2204 lb.) |
| UGTEP | Unconventional Gas Technical Engagement Program (new name for GSGI) |
| UIC | Underground Injection Control |
| U.S. | United States |
| USAID | United States Agency for International Development |
| USDW | Underground Source of Drinking Water |

# FOREWORD AND ACKNOWLEDGEMENTS

This report represents the collaboration of a diverse team of disciplines from three countries. Supported by the US Agency for International Development (USAID), the Team organized by the International Resources Group (IRG) has endeavored to address the key issues that could arise in contracting for exploring, producing, and regulating shale gas in Ukraine.

The report makes use of source material from the United States, Ukraine, and other international sources. Full citations are provided for material published on paper in a book or journal. Some of the source material is available on the web and, where that is the case, a full http citation is provided.

Units used in this report are either English/U.S. or SI (metric). Whichever is used in a sentence the other is provided in parentheses.

The sections of this report were written by the various subject-matter specialists. Each member of the Team worked to provide the most recent, relevant, accurate, and otherwise appropriate source material and discussions of the key issues. Subject-matter specialists on the Team were:

- Houston Advanced Research Center, Rich Haut and Liz Price – environmental aspects of shale gas production stages, mitigation measures, best international practices
- University of Leoben, Austria, Gerhard Thonhauser and Michael Prohaska – Ukraine resource assessment, production profiles, drilling methods, local capabilities
- University of Colorado, Natural Resources Law Center, Kathryn Mutz and Matthew Michael Sura – legal and regulatory elements of Ukrainian law, best international legal and regulatory practices
- JurEnergo, Oksana Kyshko-Yerli – Ukrainian law and regulation, production sharing agreements
- DecisionWare – Gary Goldstein with Pat DeLaquil – modeling of shale gas integration in Ukraine
- International Resources Group, Donald Hertzmark – technical project management, economics of shale gas and alternatives, production sharing contracts/agreements

Other specialists contributed to the legal (Law Institute of Prykarpatsky National University) and simulation modeling of shale gas and alternatives (Ukrainian Institute of Sciences and Pat DeLaquil). We thank all of those whose efforts were essential to the project's completion. In this regard, it is critical to cite the help and guidance on Ukrainian affairs provided by the U.S. Embassy in Kyiv. Jacquelyn Henderson gave generously of her time and expertise throughout the project. It is difficult to imagine a successful outcome without her continuous involvement. Her predecessor, Monica Bland, was instrumental in helping to set up the project design mission in 2010 without which the project would not have materialized. Other U.S. Embassy economic counselors, including Chever Voltmer and Elizabeth Horst, provided important sounding boards and local sensitization of the project's specialists.

We also wish to thank the Ukraine Ministry of Ecology and Natural Resources. Ministerial advisor Dr. Ignashenko and his staff graciously gave of their time and guidance to the IRG Team on matters specific to the priorities, policies, and implementation issues that are key to a successful shale gas program in Ukraine.

In particular, a Ministry team coordinated by Mr. Ivan Ivanets met with the IRG Team members on several occasions and gave instrumental feedback for the Team's efforts.

Other institutions and persons in Ukraine who provided information, guidance, and feedback included the American Chamber of Commerce, Fuel and Energy Committee, the law offices of CMS-Cameron McKenna, and several international oil company representatives. The IRG Team solicited input from a number of non-governmental organizations (NGOs) in Ukraine, including Environment-People-Law (Lviv) and the Center for Energy Transparency (Kyiv).

The report was assembled and edited by Donald Hertzmark, the IRG Technical Project Manager. IRG's Project Managers, Jason Steele and Masood Malik, gave overall managerial direction to the project and with IRG's editorial assistant, provided essential stylistic and document preparation work. Errors of fact and omissions of substance remain the responsibility of Donald Hertzmark.

# 1. SUMMARY OF FINDINGS AND RECOMMENDATIONS

This project, the regulatory and environmental review of USAID assistance to possible shale gas development in Ukraine, began with an initial project design mission in December 2010. Following up on specific recommendations for environmental, legal, regulatory, and economic assistance, USAID engaged International Resources Group (IRG) to mobilize a team to undertake the necessary work in these areas.

This Environmental Assessment (EA) represents the efforts of a multi-disciplinary team of oil and gas, legal, and environmental specialists. The work of the project team, under the direction of IRG, is reflected in this EA, which covers key areas of environmental concern for shale gas exploration, development and use. The Government of Ukraine, through its Ministry of Ecology and Natural Resources (MENR), has been involved at each step of the project and this report reflects their cooperation and inputs.

The IRG Team is comprised of specialists in the following areas: environmentally sound drilling technology, legal analysis of oil and gas-related environmental and commercial laws and regulations, economic analysis of shale gas and regulation and modeling analysis, and assessment of the potential impacts of shale gas on the overall energy balance of the country.

This environmental assessment is a requirement under U.S. law to ensure that proposed projects that receive assistance from USAID:

1. Are reviewed with regard to possible environmental consequences and that such consequences can be fully identified and will adopt proper safeguards with respect to such consequences
2. Provide the host country with enhanced means of mitigating, regulating and managing potential environmental impacts
3. Can be implemented in a manner consistent with sustainable development of the targeted resource, including appropriate environmental restoration activities

## 1.1 OBJECTIVES OF THIS ASSESSMENT

In line with the requirements of the relevant U.S. regulations, explained more fully in Section 1, this environmental assessment aims to prepare the Government of Ukraine to augment significantly its capabilities to regulate and support shale gas activities. Ultimately, the activities of this environmental assessment, along with potential follow-on work (see Section 5), would assist in the following outcomes:

1. Help the government of Ukraine to develop an environmentally sound framework for pursuing shale gas development
2. Develop more refined environmental reviews for shale gas development
3. Develop improved regulatory approaches
4. Assist in the development of more transparent and efficient contract tendering

The current work is seen as the initial step to establish key rules of the road for environmental information, analysis, and assessment of the legal/regulatory matters, identification of key environmental mitigation efforts, and probable production profiles for Ukraine's shale gas production efforts.

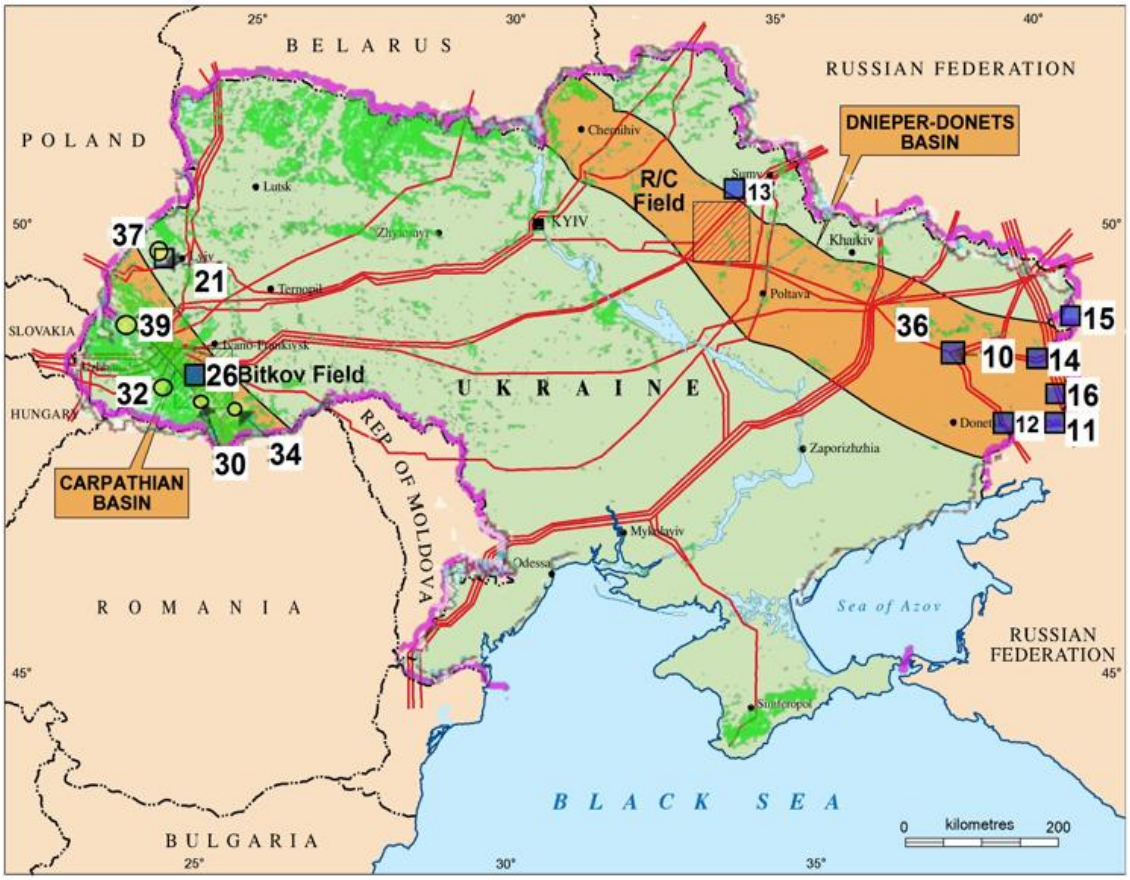
## 1.2 MAJOR ACTIVITIES OF THIS ASSESSMENT

In order to implement the requirements of the relevant U.S. law[1] and to provide Ukraine's Ministry of Ecology and Natural Resources with an initial assessment that could both implement the objectives of the project and provide Ukraine with a solid basis for its future activities in this area, the IRG Team undertook the following broad activities:

1. Comparison of shale gas to other energy alternatives
2. Coordination with energy and environmental stakeholders
3. Identification of technical, economic, legal, and regulatory issues
4. Scoping assessment of the environmental impacts of shale gas development

The legal and regulatory analysis is intended to cover the entire country, though the local government analysis focuses primarily on the Western Ukraine. The environmental and drilling technology analysis focuses on two of the country's three potential shale gas basins, the Carpathian and Dnieper-Donets (see Figure 1). The Kuban Basin is omitted because it involves maritime issues that were beyond the scope of this assignment and are not included in near-term development plans for Ukraine.

[1] The requirements for environmental assessment are contained in http://www.usaid.gov/our_work/environment/compliance/22cfr216.htm. The trigger for a review such as the present one is generated by the need to (i) develop new lands for shale gas production in Western Ukraine (22 CFR 216 216.2(d)(vi); (ii) build new power plants to use the output of the shale gas production (22 CFR 216.2(d)(ix);[1] (iii) possible threats to endangered species (22 CFR 216.5); and (iv) prevention of biodiversity loss (Foreign Assistance Act 119). Based on this positive determination a programmatic environmental assessment (PEA) must be completed in accordance with 22 CFR 216.6, with an environmental scoping statement (ESS) to be completed pursuant to 22 CFR 216.3(4).




Note: numbers in figure represent nature reserves in Ukraine

**Figure 1: Map of Ukraine with Dnieper-Donets and Carpathian Basins Identified**

As can be seen in the figure, the country is traversed by seven major gas transmission lines. Any possible production from the two candidate basins is likely to occur near a gas transmission line and therefore, relatively easy to market, regulations permitting.

**GAS IN UKRAINE, IMPORTANT CONSIDERATIONS**

- Current (conventional) gas production ~ 700 bcf/y (19.6 bcm)
- Current gas imports ~ 1,200 bcf/y (34 bcm)
- 3 shale basins – Carpathian (around Lviv), Donets (around Kharkiv), Kuban (SE)
  - *postulated* reserves of 43 tcf (1.22 tcm)
  - no modern geological evaluation of shale gas potential
- Currently finalizing agreement with USGS regarding data acquisition and assessment
- 2 hydraulically-fractured wells have been completed recently, both for conventional gas

**Activity 1**, the comparison of shale gas to other supply or efficiency alternatives, is intended to determine whether output from shale gas development will (i) augment overall energy supplies of the country; (ii) replace current imports; (iii) replace current coal use; or (iv) some combination of the three. In addition, the technique used for this analysis is designed to provide quantitative estimates of the carbon impact of shale gas vis-à-vis other alternatives, as well as the cost impact of shale on Ukraine's overall energy supply. Production scenarios for shale were generated, based on expected success rates, gas production per well and costs of production.

**Activity 2**, coordination with Ukrainian stakeholders, occurred throughout the course of the project activities. The IRG Team coordinated with MENR counterparts on each visit by a Team member and

by phone and email at other times. The MENR counterpart team was given a preliminary summary of major findings and recommendations in early-February 2012. Other local stakeholders include the Council of Ministers of Ukraine, which oversees the energy sector, as well as residents of the potentially affected regions.

**Activity 3**, the identification of technical, economic, legal, and regulatory issues, took much of the attention of the IRG Team. Specialists from the University of Leoben looked at important issues around the capabilities of Ukrainian companies and personnel in shale gas activities. Attorneys from the University of Colorado and JurEnergo looked at Ukrainian laws and regulations as they pertain to shale gas land acquisition, water use and disposal, air pollution, and oil and gas contracting. IRG and JurEnergo looked at the current production sharing legislation in light of shale gas needs and international practices. Recent decrees in relevant areas, especially production sharing, were assessed for their effects on potential investment activities.

**Activity 4,** the Houston Advanced Research Center (HARC) group, together with the University of Leoben, looked at each of the key potential environmental impacts of shale gas exploration, development and production. For each stage of the process, the Team enumerated impacts on air, water, land, and natural environments. The impacts were assessed with regard to their severity and provided one or more mitigating measures or best practices to avoid the potentially adverse impact in each case.

For both drilling technology and potential environmental impacts, especially water, the evolving state of the art in shale gas technology was discussed. This evolving understanding is especially important with regard to two of the key concerns in shale gas – water use and hydraulic fracturing chemicals.

## 1.3 SUMMARY OF FINDINGS

### 1.3.1 COMPARISON OF SHALE GAS AND ALTERNATIVES

The IRG Team generated three production profiles for future shale gas activity in Ukraine. These three forecasts are carried over 20 years, based on estimates of the potential rates of investment, speed of construction of pads and wells and productivity of men and equipment.

The "Medium" forecast for potential shale gas production gives the following pertinent milestones for investment activity and production of gas:

- Year 5 shale gas production of 780 bcf (22 bcm), 3.4 tcf in Year 20 (97 bcm). This level of output requires approximately
- 44 drilling/production pads in Year 5, rising to 729 pads in Year 20
- Investment of $2 billion in Year 5, $9 billion in year 20
- Total cost of production of $5.5 billion in Year 5, rising to $34 billion in Year 20

This production scenario would account for approximately 75% of the country's postulated shale gas reserves of 43 tcf.[2] Production and investment activity can be accelerated or retarded depending on the outcome of improved geophysical work and better understanding of the quantity and quality of the reserves.

The production levels in the Medium scenario are sufficient to more than double the country's domestic gas output by Year 5 and generate sufficient gas for exports after Year 15. The Year 20 level

[2] See Figure 6 and the discussion in Section 4.1 for the production buildup.

of shale gas output in this scenario is approximately what the U.S. produced in 2007, so the production goal is not unattainable or unduly ambitious based on history.

Production costs in the early years, including the heavy investments in exploration and development, are expected to fall in the range of $7/mmbtu ($250/mcm), about 40% less costly than oil-linked Russian gas. In the out years, with lower relative exploration and development costs and more production the cost of gas should fall to less than $5/mmbtu ($180/mcm).[3] Both prices are at the wellhead and do not include treatment or transmission, which can add $1-2/mmbtu ($35-70/mcm) to unit costs for domestic delivery. Still, shale gas looks to be highly competitive with other conventional energy sources for the country, especially if the power sector and combined heat and power (CHP) plants can convert to highly efficient combined cycle plants using shale gas.

A production forecast of this magnitude requires that Ukraine acquire far better drilling infrastructure and technology over the initial period of exploration. In particular, this means more and more modern drilling rigs, better trained production crews, more pressurization equipment for hydraulic fracturing, among other things. On the last point, it should be noted that two promising shale gas shows in Poland, in the same Carpathian trend as Western Ukraine, could not be declared commercial based on the lack of sufficient power in the pressurization equipment. Such equipment, commonplace in the U.S. and Canada, will need to become an ordinary feature in the stable of drilling technologies in Ukraine for shale gas to be produced successfully. It should be noted that such hydraulic fracturing equipment typically includes 10-15 pumping trucks, 1-2 high rate blenders, data vans, treating iron trucks, chemical vans, a hydration unit, manifold trailers, sand conveyors plus heavy duty trucks with investment costs of US$ 15 -20 million.[4]

Initial analysis of the cost-effective role for shale gas was made using a simulation model (MARKAL-Times) of the country's energy system and was performed by the Ukrainian Academy of Sciences Institute for Economic Forecasting. Shale gas was compared with key alternatives, including enhanced energy efficiency, renewables, more gas imports, and advanced coal technologies.

The current analysis shows that expected competitively produced and cost-effective shale gas production is likely to exceed projected natural gas consumption levels in Ukraine. The high production case has the potential to achieve this by 2024, the medium production case by 2028, and the low production case after 2035.

In the economic analysis of the medium and high production cases, shale gas production starts in 2015 and reaches 45.1 and 54.2 billion $m^3$ annually (1.6 and 1.9 tcf/y, respectively). That level represents 50-60% of the *potential* production level calculated by the IRG Team's petroleum engineers.

In the low production case, shale gas production does not start until 2027, but grows rapidly thereafter. Production costs for shale gas in the medium case of less than $5/mmbtu would result in generation costs for new electricity that are lower than advanced coal plants with their much higher initial costs.

Of the four alterative scenarios investigated, the energy efficiency incentives have the greatest impact on economic production of shale gas starting in 2020. In the medium and high production case, it reduces annual shale gas production by between 44% and 38% during the 2020 to 2030 period. However, economic shale gas production remains significant in both cases at more than 26 billion $m^3$ (920 bcf/y).

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[3] US$ (2011)

[4] Simmons & Company International: "Perspectives on the NAM Pressure Pumping Market," Report, May 2010

The advanced coal technology scenario also shows an impact on shale gas production starting in 2020, but the impact is only an 8 to 10% reduction in overall production. The renewable energy scenario has a minimal economic impact on shale gas production. Under a gas import contract extension policy, the shale gas production levels out at about 7.5 billion $m^3$ (265 bcf/y).

Shale gas development shows a dramatic potential to decrease natural gas imports to almost zero by 2024. The alternative scenarios have only a small impact on the reduction in natural gas imports with energy efficiency and advanced coal technologies speeding up the decrease. Renewable energy mandates and continuation of the gas import contracts will act to slow the decline in gas imports. Only the gas import contract extension policy scenario has the impact, not surprisingly, of maintaining gas imports at about 85% of 2012 levels. The economic impact of this scenario is an increase in the annual energy system cost of €2.4 (US$3.2) billion in 2030 relative to the medium market penetration case.

Shale gas development shows a slight increase in energy sector related $CO_2$ emissions (by almost 3% in 2030) relative to the energy efficiency and renewables-oriented scenarios. When shale gas is favored that more economical primary energy source displaces not just coal, oil and imported electricity, but also some renewables as well. The balance of these additions and subtractions from $CO_2$ output sum to a slight rise in $CO_2$ output in comparison to the efficiency and renewables-heavy scenario. However, the shale gas scenario provides higher levels of energy and electricity supply at lower cost than other scenarios, with far less $CO_2$ than a scenario dominated by domestic coal use.

The model results also show that shale gas production has the potential to achieve significant savings in energy system costs, particularly in the medium and high rate of production (ROP) cases. These savings reach almost €2.8 billion (US$3.6) *annually* in the medium ROP case by 2030. In the high ROP case, the potential *annual* savings reach almost €7.8 billion (US$10 billion) by 2030. Almost all of these savings are in fuel costs.

Overall, shale gas development has the potential to alter dramatically the energy system in Ukraine. Energy efficiency and renewable energy represent viable choices, but their economic potential is not of the same scale, in the time frame studied, to significantly impact the benefits that safe development of the shale gas resource can achieve. In many ways, energy efficiency and renewables, when implemented in tandem with shale gas development are complementary in nature and further enhance energy security, diversity, and affordability, while also mitigating emissions.

### 1.3.2 EMISSIONS AND MITIGATION OF POTENTIAL ENVIRONMENTAL DAMAGES

Environmental professionals and regulators remain concerned and, frankly, skeptical about the ability to produce shale gas in Ukraine in a manner that is consistent with maintaining or improving environmental quality. Of the two potential shale gas basins in the country to be opened for development, the one in Western Ukraine raises issues of land use, interference with protected and environmentally sensitive areas, and water supply and quality. In the Dnieper-Donets Basin the particular location of shale gas activity will need to be known with greater certainty before one can determine whether shale gas production will take place in agricultural or industrial/mining areas.

The IRG Team's environmental specialists, affiliated with the Environmentally Friendly Drilling Program, examined an exhaustive list of potential adverse impacts on land, air, water, endangered species and protected areas. The results of these efforts are found in Sections 4.2 and 4.3 of the main text.

Specific environmental impacts covered by the IRG Team were listed in the Scope of Work (see Appendix 1 of this report for the full list. With most of the concern surrounding shale gas in the water

quality and impacts area it is useful to illustrate the Team's approach for that area. The methodology of the Team was to catalogue the significant impacts on water supply and quality, assess the stage of production in which these impacts might occur and then show the best practices or mitigation measures that can be useful in minimizing potentially adverse impacts. This approach is demonstrated in Table 1. Once the issues and potential problems were catalogued the Team provided an extended discussion of the state of the art in each of these emissions or problem areas, what steps are available to mitigate or eliminate impacts and how the state of the art is changing.

It is critical to keep in mind that the combination of horizontal drilling, hydraulic fracturing, and shale gas production is less than 20 years old. Even with that short history, practitioners are finding new methods of operation that can reduce water demand, cut chemicals use, and generally reduce the environmental footprint of shale gas operations. Nevertheless, certain interactions with the natural environment are inevitable and mitigation measures will need to be integrated into normal operations.

In the United States the regulation of most aspects of shale gas operations is handled by individual states. Key issues, including water use and treatment and land use, are resolved at a state level not at the national one (see Appendix 4 for an example of U.S. state level shale gas regulatory initiatives). A major exception to this rule is the case of drilling on federal lands, at this time a relatively small element in overall shale gas activities. The result of this technological progress in drilling technology is a continuing minimization of overall environmental impacts.[5] A visual example is given in Figure 2, showing how shale gas development can be compatible with agriculture and natural areas.

**Table 1. Key Issues and Control Measures Related to Water Use and Quality**

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Isolation of fresh water zones | Drilling/Completion | Achieve isolation of fresh water zones prior to deepening of the well. Ensure that cementing/surface casing operations are adequate. |
| Surface water contamination | All | Add monitoring stations to accommodate specific areas of concern |
| Surface water contamination | All | Use adequate setbacks from streams and sources. |
| Surface water contamination | Drilling/Completion | Apply closed mud system to alleviate water accumulation in pits. |

[5] 1. "Stepping Lightly: Reducing the Environmental Footprint of Oil and Gas Production," Interstate Oil and Gas Compact Commission, 2008. Available at: http://iogcc.publishpath.com/Websites/iogcc/pdfs/2008_IOGCC_12pg_bleed_web.pdf

2. "Record of Decision: West Tavaputs Plateau, Natural Gas Full Field Development Plan," July 2010. Bureau of Land Management/Price Field Office. (The BLM states: The ROD reflects a historic agreement between the project proponent, Bill Barrett Corporation (BBC), and the Southern Utah Wilderness Alliance (SUWA) that will substantially reduce the project's environmental impacts while continuing to allow for vigorous new oil and gas production. See: http://www.blm.gov/ut/st/en/fo/price/energy/Oil_Gas.html)

3. Molvar, Eric M.: "Drilling Smarter: Using Directional Drilling to Reduce Oil and Gas Impacts in the Intermountain West," Prepared by: Biodiversity Conservation Alliance. February 18, 2003. Available at: www.voiceforthewild.org.

4. Pierce, David E.: "Minimizing the Environmental Impact of Oil and Gas Development by Maximizing Production Conservation," North Dakota Law Review, Vol. 85:759. 2009. pp. 760-779.

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Ground water contamination | Drilling/Completion, Production/Processing | Survey all nearby water wells prior to operations, during operations and afterwards. |
| Flood Plains – contamination of surface waters from release of chemical pollutants in a flood event | All | No well pads or access roads for high-volume hydraulic fracturing permitted within 100-year floodplains |
| Potential leaks | Production/Processing | All production facilities with the potential to leak should be placed within appropriate containment. |
| Use of hazardous materials | All | All proposed actions should be analyzed for their potential to release hazardous materials into the environment. |
| Disruption of natural hydrology | All | Develop and implement a Storm Water Management Plan |
| Volume of water used | Drilling/Completion | Develop and implement a Water Management plan that includes water sourcing/use/discharge that can minimize the volume of water used.. |
| Composition of reclaimed water | Drilling/Completion, Production/Processing | Reclaimed water may not be clean enough for potable water uses within the community; however, there may be a use for the water within the operations thereby reducing the overall water needs of the region. |
| Contamination of freshwater wetlands from accidental release of hydraulic fracturing fluids, chemicals or fuel | Drilling/Completion | Specify setbacks between fuel tanks and wetlands at a mandatory 500 ft. (150 m). Require secondary containment for any fuel tank. Require site-specific analysis of the plan when project is within 100 feet (30 m) of a freshwater wetland > 12.4 acre (5 h) in size or of unique local significance. Authorize location and timing of activities/facilities on site-specific basis. Require replacement of lost wetland acreage. |

Similar tables have been provided in Section 4.3 of this report for air emissions, hydraulic fracturing chemicals,[6] land use, and transportation of equipment and gas. However, the coverage of water supply and water quality impacts is, as appropriate, the largest segment of this part of the report.

[6] Note that hydraulic fracturing chemicals, most of which are in common use in households and industry across the world, comprise about 0.5% of the total volume of hydraulic fracturing fluid. See Figure 42 for a representation of composite hydraulic fracturing fluid components in the U.S. In Austria it is likely that shale gas drilling and production will take place without chemical use. It is expected that, though feasible, this restriction will increase costs and reduce overall productivity in shale gas operations.

**Figure 2. Fort Beeler Facility Next to a Drilling Location (from www.marellus-shale.us/MARCELLUS)**

One area that should also be addressed as a high priority is air emissions from shale gas drilling and production operations. It has been found in the U.S. that a greatly increased tempo of operations can result in a significant rise in air emissions (see Figure 28 and Figure 29). The IRG Team's environmental specialists have recommended that this issue receive early attention on account of (i) the poor existing air quality in the Dnieper-Donets Basin; and (ii) the desire to leave the Western Ukraine region without significant deterioration from shale gas operations. In Section 4.3.7 of the paper there is a detailed discussion of air emissions, best practices to mitigate impacts and a catalogue of potential additional mitigation and control measures.

### 1.3.3 LEGAL AND REGULATORY ISSUES

Three lawyers, two from the U.S. and one from Ukraine worked on the collection, translation, interpretation, and assessment of the current state of the legal and regulatory framework affecting shale gas in Ukraine. In Volume II of this report[7] the legal Team has described the relevant laws, and the relationships and distribution of authority with regard to shale gas activities. Ukraine has enacted no laws specific to shale gas development but several laws and codes apply. Furthermore, laws in Ukraine governing environment and oil and gas are general, leaving much of the implementation to regulations. In many cases, such regulations have not yet been produced or have been overridden by various Cabinet of Ministers resolutions. Many relevant regulations were not available to the Team for preparation of this document.

[7] USAID. 2012. Ukraine Shale Gas: Volume II - Regulatory Analysis of Ukraine Law Regarding Shale Gas Development (hereinafter, Regulatory Analysis).

While the laws cover the necessary ground in general form, they do not have enough specificity to be clear or to establish clear lines of authority for implementation and enforcement. Repeatedly, the IRG Team has observed that numerous officials at equivalent levels in different organizations have legal authority over one article or another of environmental or oil and gas law while other officials on a similar level, residing elsewhere in the government, control other aspects of the legislation. This dispersion of authority creates a situation where many individuals or offices can reject or stall a drilling or production application, while few officials can approve such activities without extensive intra-governmental coordination.

A typical oil and gas development must comply with the Law on Oil and Gas. Pursuant to that law, an entity interested in developing a resource must first go through a tender process to receive a special permit to develop the resource. The holder of the successful tender would have to negotiate a lease that would define additional conditions for the development. The local government would also have to approve the exact siting of the wells and associated facilities. The proposed oil and gas operation would go through an environmental analysis (Expertiza) process and have to comply with all relevant environmental laws (including laws on air protection, water protection, waste management, species protections, and natural lands). The complexity of these procedures and the need to navigate many different layers and organs of government created a situation whereby approvals had become extremely difficult to obtain, discouraging the inflow of investment and technology in the oil and gas sector.

In an attempt to streamline some of this complexity the Parliament of Ukraine passed a Law on Production Sharing Agreements. This law explicitly provides for exemption from ordinary environmental and natural resources laws, reduces the role of local governmental units, centralizes signing authority in one ministry and provides for internal specification of tax, arbitration and other provisions; circumventing some of the more tortuous elements of the older Oil and Gas Law. Recent amendments to the PSA Law have resulted in the addition of a stability clause that protects investors from arbitrary or unforeseen changes in contractual and operational conditions.

After a great deal of internal discussion the Government of Ukraine has issued a tender for production sharing in the Oleska and Uzivska regions (Western Ukraine, see Appendix 3 for the official tender). Although investors are eager to propose for blocks in this region there remain significant concerns about the ability of the current PSA tender to proceed to a successful award and implementation. In particular, the following issues remain problematic in the current PSA régime in Ukraine:

- The definition of "work program", including activities from exploration to closure is neither clear nor broad enough to encompass the full investment cycle;
- There is uncertainty about who can act as the bidding entity for an international oil company;
- The role of the state-owned company in the development (financial, technical);
- The law is unclear about international arbitration requirements;
- Clarification is needed regarding who holds the special permit – the investor company or the state-owned company;
    - The Law needs additional transparency with regard to the criteria for award and the weighting of those criteria; and
    - There must be some method of addressing local impacts of shale gas development or such issues can eventually lead to political problems for shale gas contractors.

It was generally observed that the tendering procedure could benefit from additional transparency with regard to the criteria for award and the weighting of those criteria. Other PSA issues noted by the IRG Team include generally inadequate environmental laws and regulations specific to shale gas activities in the PSA Law and other relevant laws of Ukraine.

One proposal, to incorporate the "code of conduct" of an international oil company into the PSA should be viewed as a last resort. Such an approach is not easy to implement in a legally satisfactory manner in Ukraine, but it is possible. Moreover, it does not provide an adequate basis for monitoring, enforcement and arbitration in the case of environmental damages.

The distribution of the government's share of profits from the PSA remains problematic and is an issue that the country needs to address to head off potentially difficult political conflict. The Government of Ukraine will receive PSA profits in two ways: (i) the Government's own share of the profit gas; and (ii) the dividends from the government company that will be a 50% partner in the shale gas PSA venture.

Local governments will bear most of the responsibility for dealing with infrastructure, emissions, water supply and quality and other impacts. However, under current PSA and other laws, there is no direct mechanism to defray additional costs borne by the governments of the areas in production to compensate for environmental damages or additional infrastructure investments – roads, schools, water supply, etc. Current Ukraine Law does not allow a local self-government to levy either a severance tax or user fees on investors or production of gas. As a result, the only recourse for local governments is to petition the national government (Council of Ministers) for compensatory funds. Decisions for undertaking and funding needed upgrades and additions to infrastructure will need to be taken at the state level even if such matters are normally within the purview of local governments. In other countries this distribution of benefits from oil and gas production has also proved to be a reliable source of political and fiscal conflict. In federal states one way around the problem is the enactment of a severance tax on production, rendering the flow of income essentially automatic.[8]

Air and water quality conditions and regulations may be the biggest barrier to environmentally sustainable shale gas development in Ukraine. Some regions in Ukraine already have poor air and water quality. Assuming large-scale shale gas development goes forward over the next 20-30 years, the current air and water quality regulations and standards should be amended and monitoring and enforcement programs should be strengthened. There is very little baseline data for water quality, air quality, or biodiversity in the shale gas basins. Understanding the current conditions in the shale gas basins should be a top priority for Ukraine to provide an appropriate basis for impacts assessment as large-scale shale development moves forward.

### 1.3.4 RECOMMENDATIONS FOR FURTHER ACTIVITIES

The IRG Team has noted a number of areas where the state of the art in technology, law, regulation, environmental assessment and local government could benefit from further interaction with U.S. and international shale gas experts. The recommendations made in this report for further short-term U.S.-Ukraine cooperation are through31st December 2012. Longer-term recommendations for follow-on activities are discussed in Section 5 of this report.

The short-term follow-on activities of the USAID-funded team and its Ukrainian counterparts must be focused and achievable by 31st December.. The recommended activities listed below fit within

[8] It should be noted that even in federal systems, where most upstream production decisions are taken by the *state* government, such governments have usually ensured that *local* governments cannot unduly delay or regulate investments and production permits approved at the state level.

those constraints and also represent specific follow-up activities mentioned by one or more counterparts or other Ukrainian stakeholders.

### Improve Baseline Environmental Data and Analysis

As noted in the main text, Ukraine lacks a well-specified and credible environmental assessment methodology for shale gas. The Team has proposed a short-term activity to assist the country in designing an appropriate longer-term implementation of environmental assessment methodology to generate baseline and monitoring data.

> **Environmental Assessment:** Ukraine is in need of a modernized EA methodology, especially given the potential tempo of shale gas investments in the country. The country needs a method of developing predrilling baseline information. Implementation of a full methodology is beyond the time frame and scope of the current calendar year. However, it is possible for the Team's environmental specialist to provide the current guidelines in the U.S. for generic pre-drilling assessments and to work with a team from the MENR to draw up EA methodology specifically relevant to Ukraine's needs based on those guidelines.

### Improve Public Understanding and Acceptance of Shale Gas and Its Production Methods

The Environmental Friendly Drilling Systems team, which includes several members of the IRG Team, has worked with the Groundwater Protection Council (GWPC) and others to develop training modules related to the GWPC successful FracFocus (www.fracfocus.org) effort. These training modules can be employed in Ukraine to assist in improving the public's understanding of and perceptions of shale gas and the associated production technologies. Such short-term activities include the following three:

1. **Landowner, Community, and Local Government Outreach:** Short-term Activity is based on the observed problems with local government capabilities. This activity would seek to work with bodies of local self-government, NGOs, and citizens in the areas of potential shale development to educate them and engage them in the development process for the industry. Short-term activities may include:

   - Presenting factual information about shale gas development, including experience with hydraulic fracturing
   - Discussing ways to allow meaningful local input in the PSA process
   - Designing feasible solutions to funding concerns of local governments

   In the longer term it would be useful to engage a local NGO to develop and implement a public engagement campaign to both inform the public and solicit information and opinions from the public.

2. **Prepare a Guide to Citizen and NGO Participation in Environmental Protection:** The body of Ukraine law that provides for citizen and NGO participation in environmental protection is complex. A better understanding of the role of citizens and NGOs in the shale gas development process could lead to enhancement of public understanding of shale gas development, public participation in decision making, environmental protection, and, perhaps, public acceptance of shale gas development.

3. **Workshop on Regulatory Reform:** Sponsor a workshop for all stakeholders to discuss creation of a new shale gas law and/or revision of the PSA Law and individual environmental laws applicable to shale gas development

- Such a workshop should be cosponsored by USAID, the American Chamber of Commerce in Ukraine, MENR, individual international companies, Environment-People-Law, Precarpathian Law Institute
- The cosponsors should support participation of NGOs and citizens;
- Topics of discussion might include:
  - Access to Information
  - The Model Framework for Drilling and Completion (see Appendix 4 for Table of Contents)
  - Inspection and fines
  - Bonding

### Improve the Regulatory Environment and Provide Assistance to the MENR in its PSA Deliberations.

**Expand the Regulatory Review Document:** Many suggested changes to a variety of Ukrainian Laws were suggested in Section 4.3 (see also Table 6). It would be very helpful to organize a multi-party review of the existing Regulatory Analysis document and expand it to include additional laws, regulations, and standards as deemed appropriate by the multi-party group. Prepare an expanded report for the benefit of multiple stakeholders. Appendix 4 provides a suggested outline for such an activity.

**Prepare a Guide to Citizen and NGO Participation in Environmental Protection:** The body of Ukraine law that provides for citizen and NGO participation in environmental protection is complex. A better understanding of the role of citizens and NGOs in the shale gas development process could lead to enhancement of public understanding of shale gas development, public participation in decision making, environmental protection, and, perhaps, public acceptance of shale gas development.

**Provide an Expert Resource for the Interministerial Commission:** Serve as a resource to the Interministerial Commission that may have questions about the Regulatory Analysis report and how to implement some of its recommendations into the regulatory framework for PSAs they will be negotiating over the next few months.

# 2. INTRODUCTION

## 2.1. INTRODUCTION

This Environmental Assessment (EA) represents the efforts of a multi-disciplinary team of oil and gas and environmental specialists with regard to proposed development of shale gas resources in Ukraine. The work of the project team, under the direction of International Resources Group (IRG) is reflected in this EA that covers key areas of environmental concern for shale gas exploration, development and use. The Government of Ukraine, through its Ministry of Ecology and Natural Resources (MENR), has been involved at each step of the project and this report reflects their cooperation and inputs.

The IRG Team is comprised of specialists in the following areas: environmentally sound drilling technology, legal analysis of oil and gas related environmental and commercial laws and regulations, economic analysis of shale gas and regulation and modeling analysis and assessment of the potential impacts of shale gas on the overall energy balance of the country.

## 2.2. BACKGROUND

### 2.2.1. SUMMARY OF 22 CFR 216 REQUIREMENTS

The requirements for environmental assessment are contained in the following notice from USAID: http://www.usaid.gov/our_work/environment/compliance/22cfr216.htm. This notice lists four broad areas that call for environmental assessment of proposed projects:

- Ensure that the environmental consequences of A.I.D.-financed activities are identified and considered by A.I.D. and the host country prior to a final decision to proceed and that appropriate environmental safeguards are adopted;
- Assist developing countries to strengthen their capabilities to appreciate and effectively evaluate the potential environmental effects of proposed development strategies and projects, and to select, implement and manage effective environmental programs;
- Identify impacts resulting from A.I.D.'s actions upon the environment, including those aspects of the biosphere which are the common and cultural heritage of all mankind; and
- Define environmental limiting factors that constrain development and identify and carry out activities that assist in restoring the renewable resource base on which sustained development depends.

### 2.2.2. ENVIRONMENTAL THRESHOLD FINDING PROPOSED ACTION

The need for an environmental assessment of proposed assistance activities leading to the development of shale gas resources in Ukraine is based on the likely range of impacts from even the most environmentally conscious gas development projects. At the same time a full review is considered appropriate given that environmental concerns have grown in the US over the drilling and chemical injection processes known as hydraulic fracturing associated with shale gas exploitation. Hydraulic fracturing is a 50-year old petroleum production technique that has been newly applied to

gas production. In some instances wells subjected to hydraulic fracturing have been associated with gas well blowouts, air emissions, fluid spills, and some contamination of drinking water.[9]

A positive determination is recommended for this activity given the need to (i) develop new lands for shale gas production in Western Ukraine (22 CFR 216 216.2(d)(vi); (ii) build new power plants to use the output of the shale gas production (22 CFR 216.2(d)(ix);[10] (iii) possible threats to endangered species (22 CFR 216.5); and (iv) prevention of biodiversity loss (Foreign Assistance Act 119). Based on this positive determination a programmatic environmental assessment (PEA) must be completed in accordance with 22 CFR 216.6, with an environmental scoping statement (ESS) to be completed pursuant to 22 CFR 216.3(4).

## 2.3. SUMMARY OF PROJECT ACTIVITIES

Part of the IRG team was initially mobilized in December 2010 for a short trip to Ukraine to set out the overall design of the project. Once the project description was accepted by USAID IRG assembled the rest of the team in the second and third quarters of 2011.

Team members traveled to Ukraine in May, October, November 2011 and January 2012. These trips were intended to familiarize the Team with the Ukrainian priorities and issues, liaise with counterpart officials in Ukraine and work with local contract staff. A detailed description of project activities can be found in Section 2.2.

## 2.4. PURPOSE OF THE PROGRAMMATIC ENVIRONMENTAL ASSESSMENT

The purpose of the environmental scoping process is to identify the significant issues relating to shale gas development and to determine the scope of the issues to be addressed in the Programmatic Environmental Assessment. The task consisted of the following activities:

a. Comparison of shale gas to other energy alternatives
b. Coordination with energy and environmental stakeholders
c. Identification of technical, economic, legal and regulatory issues
d. Scoping assessment of the environmental impacts of shale gas development

[9] EPA is now conducting a Congressionally-mandated study of the environmental impact of this process on drinking water quality. Once the results of the study are finalized, EPA plans to identify regulatory needs to addressing adverse environmental impacts. The industry's position is that their environmental record has been good and that contamination of water resources is unlikely since the depth at which shale gas is drilled (>10,000 ft) effectively precludes interaction of the hydraulic fracturing fluids with groundwater (<250 ft).

[10] Given the expected pace of production of shale gas and the need to substitute for gas that is currently imported from Russia it is not likely that new power plants based on shale gas will be built before 2025 or later.

# 3. PROJECT DESCRIPTION

## 3.1. UNCONVENTIONAL GAS TECHNICAL ENGAGEMENT PROGRAM[11]

### 3.1.1. OVERVIEW

The U.S. Department of State (DOS) launched the Unconventional Gas Technical Engagement Program (UGTEP), formerly known as the Global Shale Gas Initiative (GSGI) in April 2010. Its purpose was to help countries identify and develop their unconventional natural gas resources economically and in an environmentally sound manner. US experience with shale gas has shown that this unconventional energy source can be produced and used in a manner that is attractive to investors and benign environmentally, especially in comparison to coal, its chief competitor.

In the US, shale gas production has risen from almost nothing to more than 20% of total supplies in 2011. Production of U.S. shale gas now exceeds 5 trillion cubic feet (tcf) annually (~140 bcm/y). Unlike conventional hydrocarbons, shale formations are found in many countries around the world. Consequently, the UGTEP holds promise not just for the U.S. but also for its other member countries: India, China, Argentina, Poland, Jordan, and Ukraine, among others.

Shale, along with other unconventional hydrocarbons, is one of the key energy developments of this century and holds the potential to be one of the most rapidly expanding trends in world energy supplies over the next 20-30 years. By 2030 the U.S. Energy Information Administration (EIA), projects that shale gas will represent 14% of total global gas supplies, providing sufficient reserves for expanded consumption of natural gas. As a lower-carbon "bridge fuel" to reduce $CO_2$ emissions unconventional gas provides an economic path to the future, without destabilizing electric power grids or creating difficult waste disposal and treatment problems.[12]

The U.S. shale gas experience depended heavily on the existence of a robust oilfield services sector and is unlikely to be precisely duplicated in other countries. However, many important lessons were learned about the geology, technology and environmental management aspects of shale gas. As a result the application of these lessons through UGTEP can be instrumental in helping governments understand the complexities of shale gas development. Governments often have limited capability to assess their own country's shale resource potential or are unclear about how to develop shale gas in a safe and environmentally sustainable manner through establishing the right regulatory policy and fiscal structures. The ultimate goals of UGTEP are to achieve greater energy security, meet environmental objectives and further U.S. economic and commercial interests.

### 3.1.2. ACTIVITIES OF THE UGTEP

The UGTEP uses government-to-government policy engagement to bring the U.S. federal and state governments' technical expertise, regulatory experience and diplomatic capabilities to help selected

[11] This section is based on the US Department of State description of the GSGI, but the language and statistics have been shortened, updated and modified.

[12] The other main form of unconventional gas is coalbed methane (called coal seam gas in some countries). Technology for production of CBM is simpler than for shale gas and production has moved ahead in a number of countries.

countries understand their shale gas potential. U.S. government agencies that partner with the Department of State under UGTEP include: the U.S. Agency for International Development (USAID); the Department of Interior's U.S. Geological Survey (USGS); Department of Interior's Bureau of Ocean Energy Management, Regulation, and Enforcement (BOEMRE); the Department of Commerce's Commercial Law Development Program (CLDP); the Environmental Protection Agency (EPA), and the Department of Energy's Office of Fossil Energy (DOE/FE).

UGTEP activities are tailored to each country's specific needs and availability of funding. Examples of UGTEP activities include: shale gas resource assessments; technical guidance to evaluate the production capability, economics and investment potential of shale gas resources; and workshops and seminars on technical, environmental, business and regulatory challenges related to shale gas development. Other activities may focus on regulatory policies and fiscal structures challenges. At the request of member countries, DOS organizes conferences, meetings, training and public-private sector events in the United States. They are also invited to participate in select multilateral UGTEP events.

## 3.2. ACTIVITIES IN UKRAINE

An initial trip to Ukraine was conducted in December 2010 to assess the need and work scope for a cooperative program in Ukraine for GSGI. The trip included Robert Ichord from USAID, two representatives of the GSGI at the Department of State (Rebecca Neff and Alex Greenstein), Brenda Pierce from the US Geological Survey and Donald Hertzmark, consultant. The group met with officials of the Ministry of Fuel and Energy, Ministry of Ecology and Natural Resources (MENR), the Rada (Parliament), State Geological Survey and others.

The outgrowth of this mission was a memorandum signed by the US Government and the Government Ukraine in February 2011 outlining the areas of cooperative activity regarding shale gas in Ukraine. An initial scope of work for an assistance project in Ukraine under the aegis of the GSGI and funded by USAID-Washington was completed during the third quarter of 2011. A contract was awarded to International Resources Group (IRG) under the 2007 USAID Energy IQC. MENR was chosen as the counterpart agency in Ukraine because (i) MENR has signing authority with regard to production sharing agreements (PSAs), the chosen contract form for shale gas; and (ii) USAID had determined that its initial assistance must be in the form of an assessment of environmental issues, law and regulation in Ukraine as they pertain to shale gas exploration, development and production.

The institutions and individuals engaged to implement this environmental assessment were:

- Houston Advanced Research Center (HARC, cooperating with *Environmentally Friendly Drilling-EFD*) – Richard Haut;
- University of Leoben, Austria, Department of Petroleum Engineering (*EFD*) – Gerhard Thonhauser;
- University of Colorado, Natural Resources Law Center – Kathryn Mutz and Matthew Sura;
- International Resources Group – Pat DeLaquil and Donald Hertzmark (consultant).

In May 2011 a 3-person IRG team led by Robert Ichord and Barbara Britten of USAID plus Pat DeLaquil, then project manager, Richard Haut and Gerhard Thonhauser visited Kyiv to discuss the project with MENR and others in the country. An initial detailed Scope of Work was produced by IRG and finalized in September 2011. This Scope of Work called for an initial Environmental Scoping Statement followed by and Environmental Assessment, each of these documents following standard USAID outlines and practice.

In October 2011 Hertzmark and Thonhauser visited Kyiv to meet with the Department of State liaison, Jacquelyn Henderson, other US Embassy-Kyiv officials, MENR officials, the American Chamber of Commerce (AmCham) staff and other key parties in the oil industry and legal community. The result of the trip was the Environmental Scoping Statement, completed in December 2011.

On the completion of the Scoping Statement the Team was provided with an outline and a roadmap for its activities to complete the environmental assessment phase of the project. Each member of the Team was provided with specific assignments in this outline that further directed their focus and activities in law, drilling technology, environmental impacts, and analysis of alternatives and assessment of regulatory environment. Work was started on the modeling of alternative production scenarios for shale gas and how that energy source fits into Ukraine's energy future.

In October and November 2011, Ms. Mutz and Mr. Sura traveled to Ukraine, met with local legal entities and participated in a shale gas workshop that was conducted in Lviv, Western Ukraine. Mr. Sura also contacted a law institute in Western Ukraine that will be providing analysis of local and provincial legal issues for the Team.

In the wake of those trips Ms. Mutz and Mr. Sura were able to obtain information that helped to focus their efforts on matters specific to the Environmental Assessment.

In January-February 2012 Dr. Hertzmark traveled to Kyiv to meet with counterparts at MENR and to discuss PSA activities with members of the legal and oil communities. Hertzmark presented preliminary findings on selected environmental assessment issues to the MENR counterparts.

During February 2012 the Ukrainian Academy of Sciences was able to complete the simulation modeling of shale gas production profiles within the context of selected energy production and consumption scenarios for the country.

In February 2012 Mr. Prohaska of Dr. Thonhauser's staff worked with industry representatives, including both Ukrainian and international companies. Discussions were held with representatives of international oil companies present in Ukraine, including ExxonMobil, Chevron, Shell, TNK-BP, among others. The chief subjects of discussion centered on rig count, technical capabilities and hydraulic fracturing infrastructure in the country, if any.

In February 2012 Dr. Hertzmark presented preliminary findings to Ambassador Richard Morningstar and others in the Department of State Energy Bureau.

In April 2012 the full Team will return to Kyiv to present its findings.

## 3.3. OBJECTIVES OF THIS ACTIVITY

As stated in the Scope of Work the objectives of this activity can be summarized as follows:

- This project is intended to begin the process of helping the government of Ukraine to develop an environmentally sound framework for pursuing shale gas development.
- This assessment will compare a range of feasible energy alternatives to shale gas development and identify the relevant environmental, economic, legal and regulatory issues associated with shale gas development.
- USAID and the IRG technical team will coordinate with the Ministry of Ecology and Natural Resources, the Shale Gas Working Group and technical experts designated by that group to ensure that other interested agencies and organizations in Ukraine will be involved in the process and to ensure an environmental assessment that is conducted in an open, transparent and collaborative manner.

# 4. ANALYSIS AND ALTERNATIVES

This is the main analytical section of the report. It starts with an analysis of the potential role of shale gas in the country's energy future. The remainder of this section consists of a description of the environment of the two basins analyzed, a listing of potential environmental impacts of shale gas production for air, water, land, natural environments, an assessment of current technology for gas production in Ukraine and a catalogue of possible adverse impacts and mitigation/best practices by environmental sink and type of impact.

## 4.1. COMPARISON OF SHALE GAS TO OTHER ENERGY ALTERNATIVES

### 4.1.1. DEFINITION OF ALTERNATIVES TO SHALE GAS DEVELOPMENT IN UKRAINE

In order to assess the costs and benefits of developing shale gas relative to other energy alternatives in Ukraine, the national TIMES[13]-Ukraine energy system planning model[14], developed under the USAID Regional Energy Security and Market Development project in conjunction with the Hellenic Aid SYNENERGY Strategic Planning activity, was be utilized to compare shale gas and alternative scenarios to a Reference (or business-as-usual) scenario.

The following scenarios were identified to ensure consideration of the full range of alternatives to shale gas development are analyzed to provide a comparison of the relative impacts of in terms of changes in the energy system cost, environmental emissions (particularly $CO_2$), energy imports, technology investment requirements, and other measures.

1. Energy Efficiency Incentives
2. Renewable Energy Mandates
3. Coal Technology Advances
4. Coal Bed Methane Development
5. Increased Gas Imports

Of these scenarios, Coal Bed Methane (CBM) development was dropped because only Coal Mine Methane capture is currently underway in Ukraine, and the local and international experts agreed that CBM development can only proceed on a schedule that is at or behind shale gas, and its development issues are similar in many ways to shale gas development.

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[13] See www.iea-etsap.org.

[14] The model describes the energy system of Ukraine starting with resource extraction, process that convert primary energy carriers into electricity, pipeline quality natural gas, liquid fuels, etc., end use devices that deliver energy services such as lighting, space heat, industrial motor drive, etc., to meet future energy demands that are driven by GDP growth, population growth, and other factors.

Each of the scenarios to be evaluated is briefly described below.

**Reference scenario**: This represents a business-as-usual development of the energy system with no new policy or technology developments beyond those already planned by the government.

**Energy Efficiency Incentives**: Demand-side management and energy efficiency programs, which generate a 1% reduction in final energy consumption per year through 2030. This scenario is in line with various announcements of the State Agency on Energy Efficiency and Energy Saving of Ukraine, which is responsible for renewable energy and energy efficiency policy.

**Renewable Energy Mandates**: Programs and incentives to meet a target of 20% of electricity produced from renewable sources in 2020 and 30% by 2030. This scenario is in line with various announcements of Ukraine's National Association for Renewable Energy NAER.

**Coal Technology Advances**: This scenario assumes that high-efficiency technologies for electricity generation from coal, such as circulating fluidized-bed firing, supercritical and ultra-supercritical generating units are incentivized. However, clean coal technologies with $CO_2$ capture and sequestration were not included given that Ukraine has no policy that promotes reducing greenhouse gas emissions.

**Contractual Gas Imports**: According to existing take-or-pay contract Ukraine has to buy approximately 33 billion cubic meters (1.17 tcf) of natural gas from Russia per year. The last of these contracts will expire in 2018, and although Ukrainian official have announced the intention to reduce this volume, this scenario examines the effects of such contracts being extended to 2030.

### 4.1.2. POTENTIAL RESOURCE LEVELS FOR SHALE GAS DEVELOPMENT IN UKRAINE

This analysis examined low, medium and high levels for the shale gas resource in Ukraine based on estimates developed by the technical team. Each of the shale gas resource levels is based on the following set of assumptions:

1. Rig building capacity does not vary in each of the resource options. Capacity is 2 new rigs per year in the first year and 5 new rigs per year in subsequent years;
2. ROP (rate of penetration) is the primary variable impacting the resource levels – as it is strongly dependent on technology and drilling practices, and it varies from 80 m (260 ft.) per day to 160 m (520 ft.) per day;
3. Hydraulic fracturing costs are assumed to be proportional to drilling costs – rather than constant;
4. Average shale gas production per well is assumed to be constant at 113 million $m^3$ (~4 bcf) per year;
5. Number of wells per pad (12) is also a constant, and
6. Start of shale gas production is 2015.

The change in ROP primarily affects the number of wells drilled each year, which is shown in Figure 3.

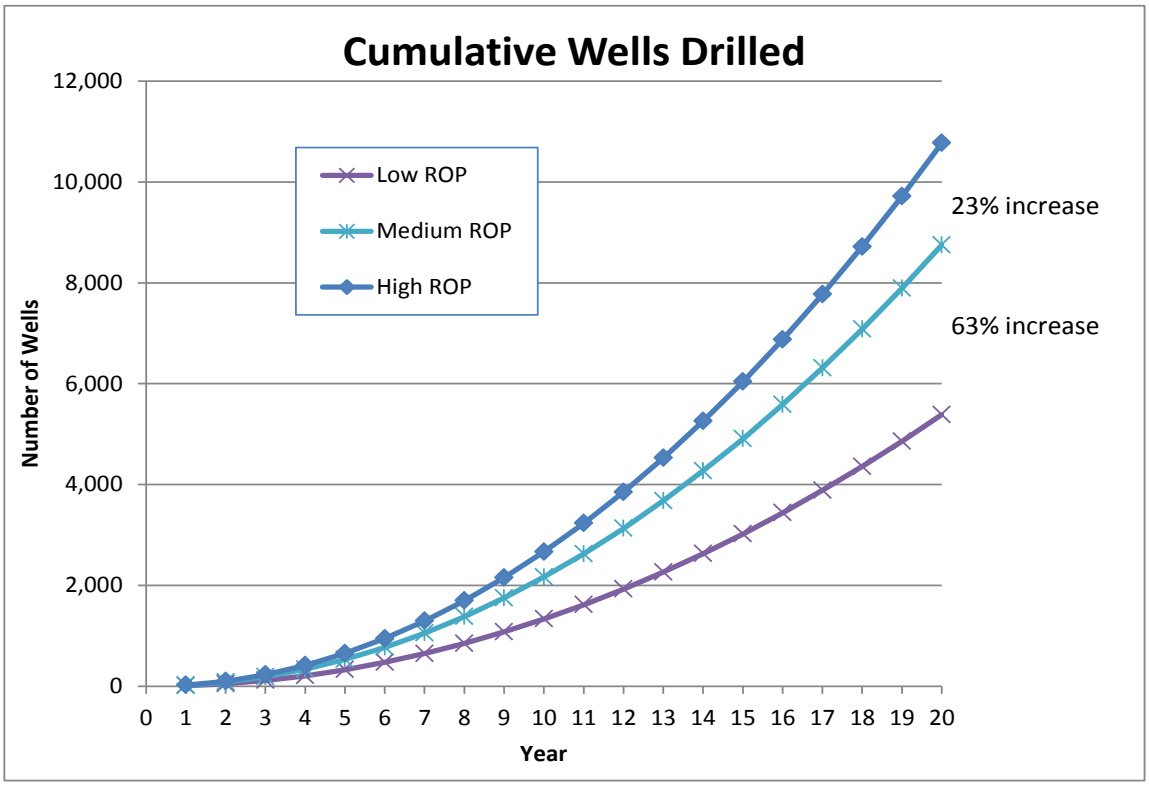


**Figure 3: Cumulative number of shale gas wells drilled for each production scenario**

Total potential shale gas production is shown in Figure 4 for the three resource cases, and these values are compared to the current domestic production and imports of conventional gas resources in the Reference scenario. Note that the developable shale gas resource in all three cases has the potential to exceed projected natural gas consumption levels in Ukraine. The high ROP case has the potential to achieve this by 2024, the medium ROP case by 2028, and the low ROP case after 2035.

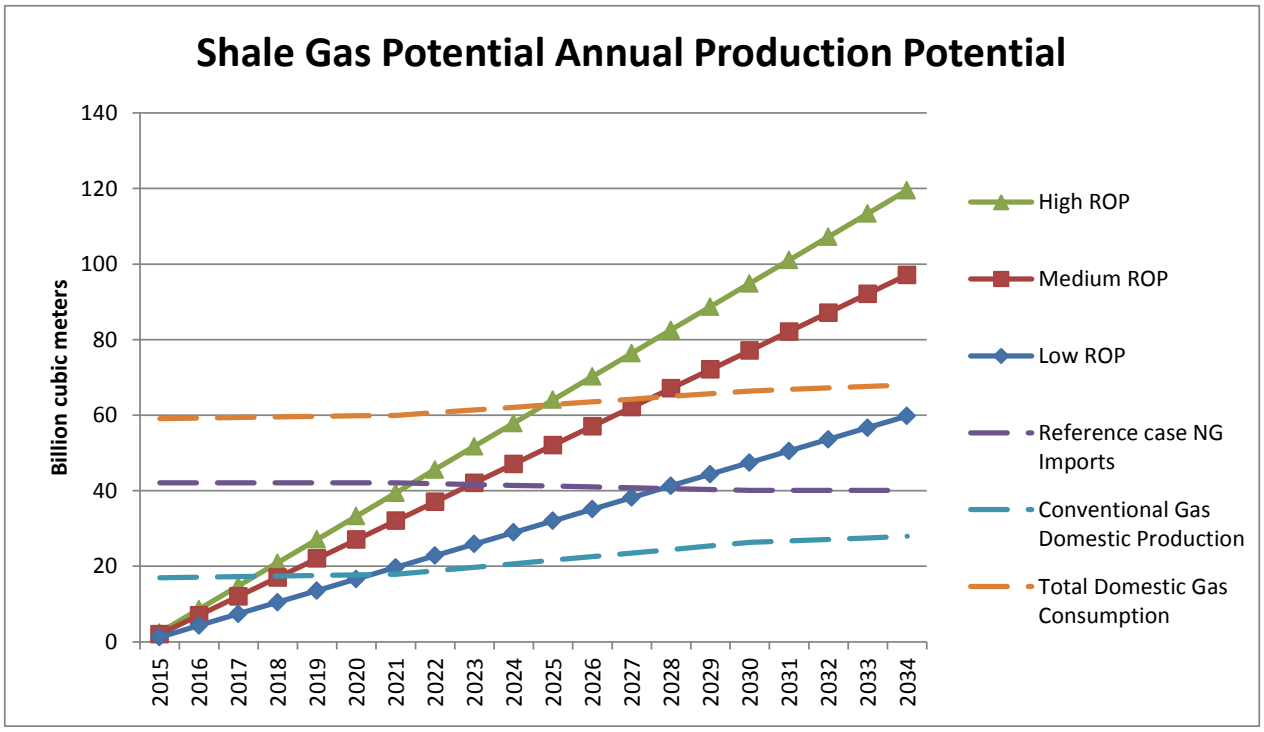


**Figure 4: Annual shale gas production potential compared to reference scenario consumption**

Data from the technical team indicates that the shale gas production costs are constant over time and vary significantly from 331 € per 1000 $m^3$ in the low ROP case to 272 € per 1000 $m^3$ in the medium ROP case to 165 € per 1000 $m^3$ in the high ROP case (US$9.37, $7.70, and $4.67 per mmbtu, respectively).

Table 2 defines the set of model runs and the labels used to identify the 9 scenarios that comprise the analysis of alternatives to shale gas development in Ukraine.

**Table 2: Run Matrix With Scenario Designations for Alternatives Analysis Ukraine Shale Gas**

| Scenario | Low ROP | Medium ROP | High ROP |
|---|---|---|---|
| Reference | 1 (UA-SGS-L-REF) | 2 (UA-SGS-M-REF) | 3 (UA-SGS-H-REF) |
| Energy Efficiency Incentives | | 4 (UA-SGS-M-EE) | 5 (UA-SGS-H-EE) |
| Renewable Energy Mandates | | 6 (UA-SGS-M-RE) | 7 (UA-SGS-H-RE) |
| Coal Technology Advances | | 8 (UA-SGS-M-CT) | |
| Contractual Gas Imports | | 9 (UA-SGS-M-GI) | |

### 4.1.3. REFERENCE SCENARIO ASSUMPTIONS

The Reference scenario represents a business-as-usual development of the energy system and takes into account current trends and government policy. Key premises include no radical change in the technology mix of the energy system, with the main focus main being extending the operating lifetime of existing facilities (with performance improvement), and continued restructuring of the economy away from energy intensive industry and toward commercial services. More specific details include:

- Natural gas recovery: Moderate investments providing output of 23.5 billion $m^3$ in 2020 and 25.7 billion $m^3$ in 2030 (830 and 908 bcf, respectively);
- Oil extraction: Moderate investments preserving output of 4.1-4.5 million tons (~85,000-90,000 b/d);
- Nuclear power: From 2006-2030 not more than 48% of total electricity production may come from nuclear plants. Existing plants won't be closed, and new capacity of up to 2 GW can be added by 2030;
- Thermal power plants (TPP) and combined heat and power (CHP): New capacity additions may not contribute more than 10% of total production in 2020 and 15% in 2030;
- Hydropower: Maximum installed capacity 13 GW in 2020 and 15 GW in 2030;
- Wind: Maximum installed capacity 18 GW in 2020 and 24 GW in 2030;
- Solar: Maximum installed capacity 6 GW in 2020 and 8 GW in 2030;
- Electricity exports: Capped at current levels;
- Heat production by municipal boiler houses: Not less than 40% in total heat production by 2013 and 32% by 2030, with not less than 95% from natural gas by 2015 and 80% by 2030;
- Steel Industry: Moderate growth rates reaching full load of existing capacities after 2020;
- Coke production by metallurgical companies: Will remain stable at the level of 15%;
- Advanced industrial technologies: New technologies in non-ferrous metallurgy, cement production, paper industry will not exceed 5% share by 2030;
- Advanced technologies in households, public and commercial sectors: New technologies for space heating, water heating and air-conditioning will not exceed 2% in 2020 and 5% in 2030;
- Rehabilitation of residential and commercial buildings and buildings: Share of buildings undergoing rehabilitation not to exceed 2% in 2020 and 5% in 2030, and
- Subsidies on energy resources by type of consumers will stop by 2020, and tariffs will be economically justified.

### 4.1.4. ANALYSIS OF SHALE GAS SCENARIOS

Over the study horizon (2010 to 2030), shale gas is economically attractive under the Reference scenario assumptions, as shown in Figure 5. However, economic viability in the low ROP case does not occur until 2027.

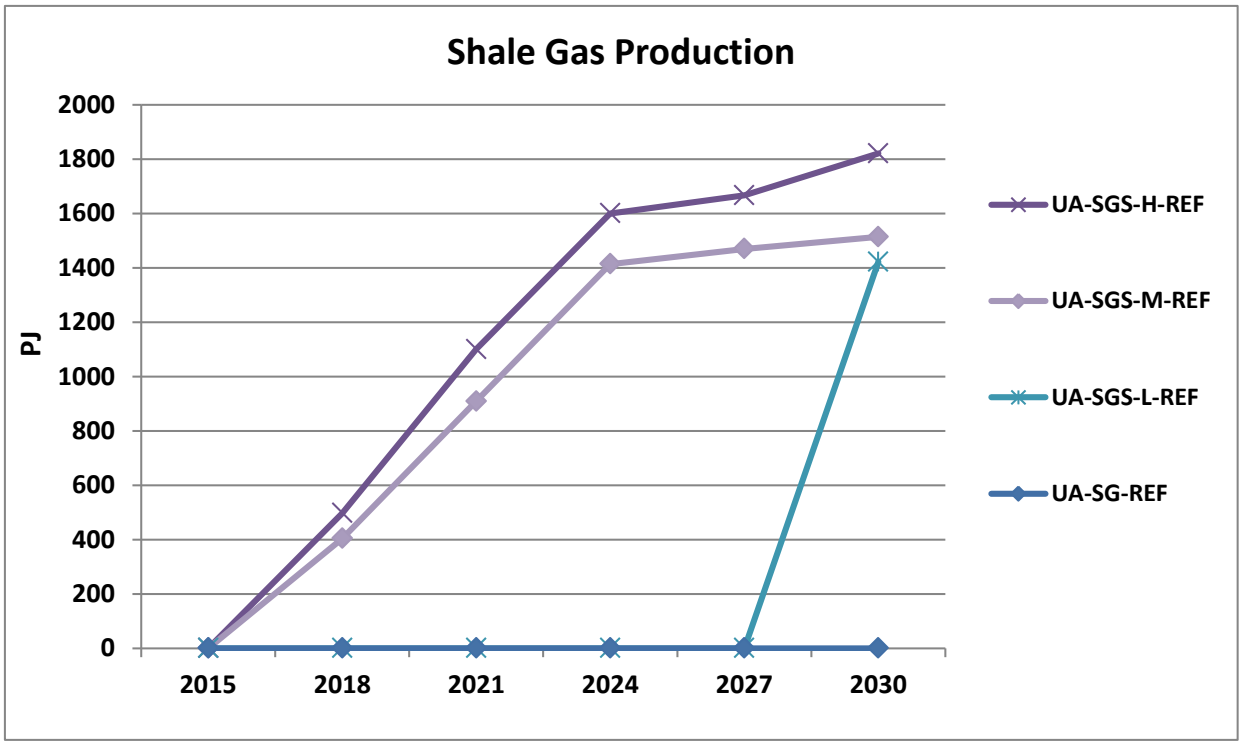


**Figure 5: Shale gas production with Reference scenario assumptions**

The various alternatives to shale gas were examined in more detail for the medium ROP case, and their impacts on shale gas production are shown in Figure 6. Energy efficiency has the greatest impact on economic production of shale gas starting in 2020, leveling off production at about 44% below the levels shale gas production would reach without energy efficiency promotion (the "M-Ref" case in Figure 6). However, annual shale gas production during this period remains quite significant at about 900 PJ (26.8 billion $m^3$, or 946 bcf).

The advanced coal technology scenario also shows an impact on shale gas production starting in 2020, but the impact is only a reduction of 8 to 10% in overall production. The renewable energy scenario and the import contract extension scenario both have a minimal economic impact on shale gas production.

The policy scenario where the current gas import contracts are maintained has the most significant impact on shale gas production, not due to economics, but because it leave little market room for shale gas to develop. Under this policy, shale gas production levels out at about 7.5 billion $m^3$ (265 bcf/y).

In the high ROP scenarios, energy efficiency has a similar impact of reducing shale gas production by about 38% after 2020, but from a higher production level (33.4 billion $m^3$, 1.17 tcf), and the renewable energy scenario has minimal impact.

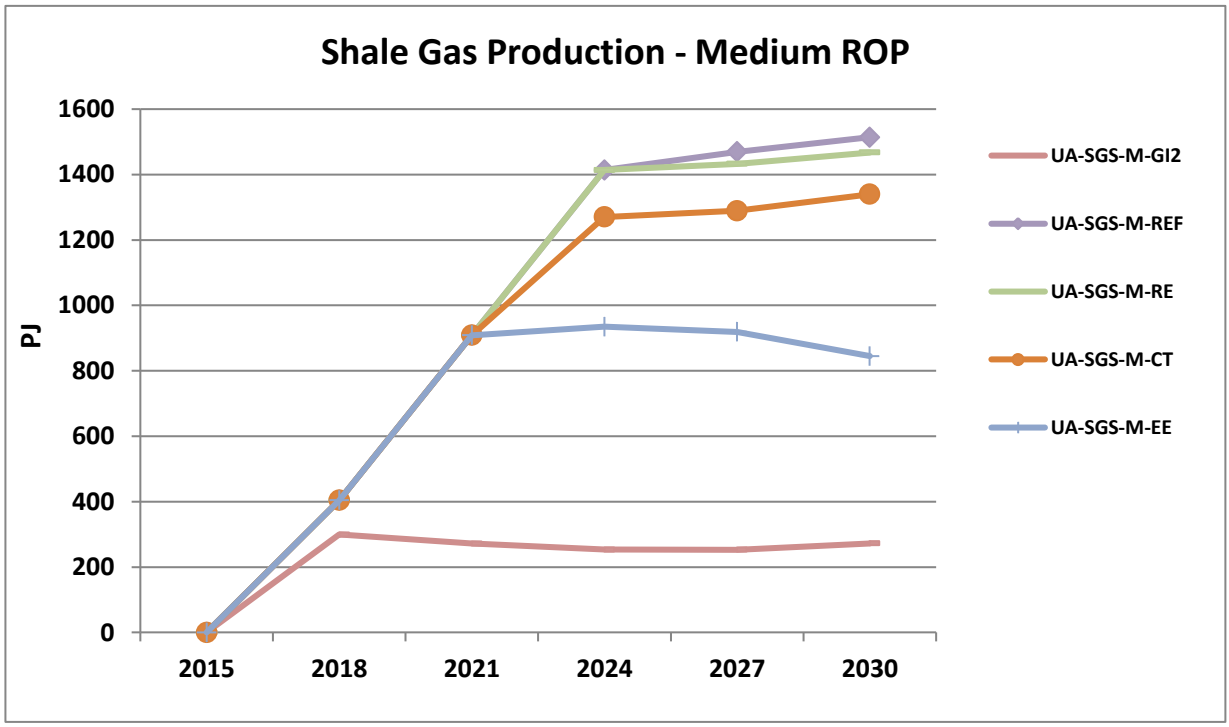


**Figure 6: Shale Gas Production in the Medium ROP Cases**

In the Reference scenario, natural gas imports by Ukraine decrease only slightly between 2012 and 2030. However, in the medium and high ROP cases, shale gas development drops natural gas imports to almost zero by 2024, as shown in Figure 7. In the low ROP case, natural gas imports undergo a similar drop starting in 2027.

Figure 8 shows that the alternatives to shale gas development have a small impact on the reduction in natural gas imports with energy efficiency and advanced coal technologies speeding up the decrease. The policy of continuing the gas import contracts maintains imports at about 85% of 2012 levels. The economic impact of this scenario is an increase in the annual energy system cost of €2.4 (US$ 3.2) billion in 2030 relative to the medium ROP case.

In the high ROP case with energy efficiency, gas imports decline to almost zero by 2021.

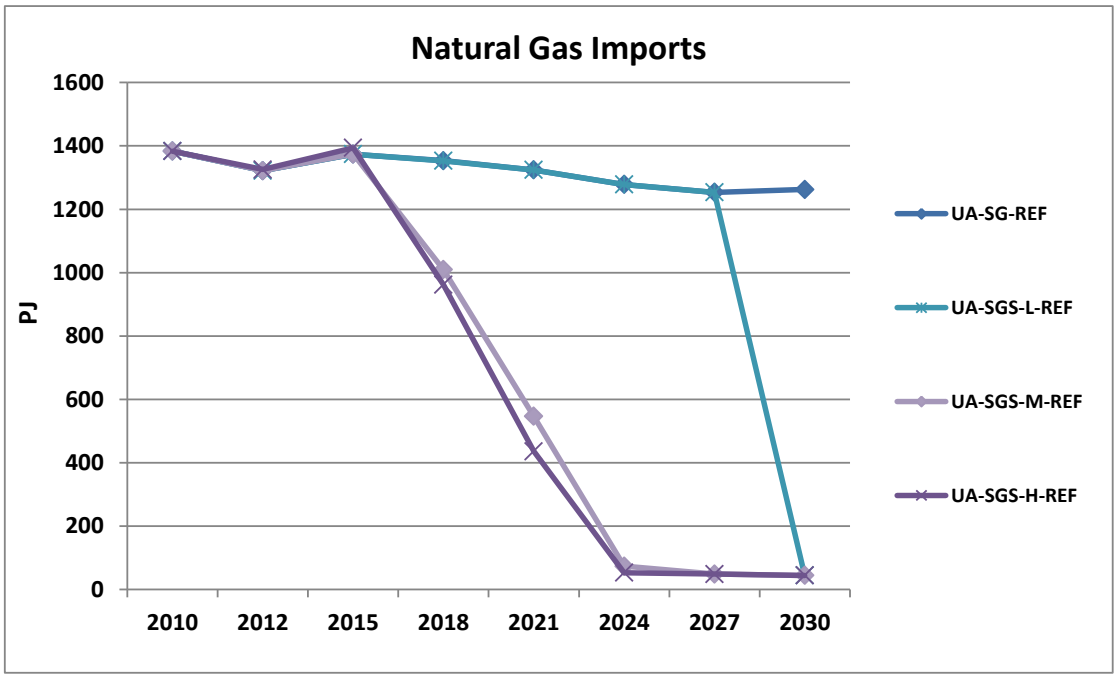


**Figure 7: Natural Gas Imports with Reference Scenario Assumptions**

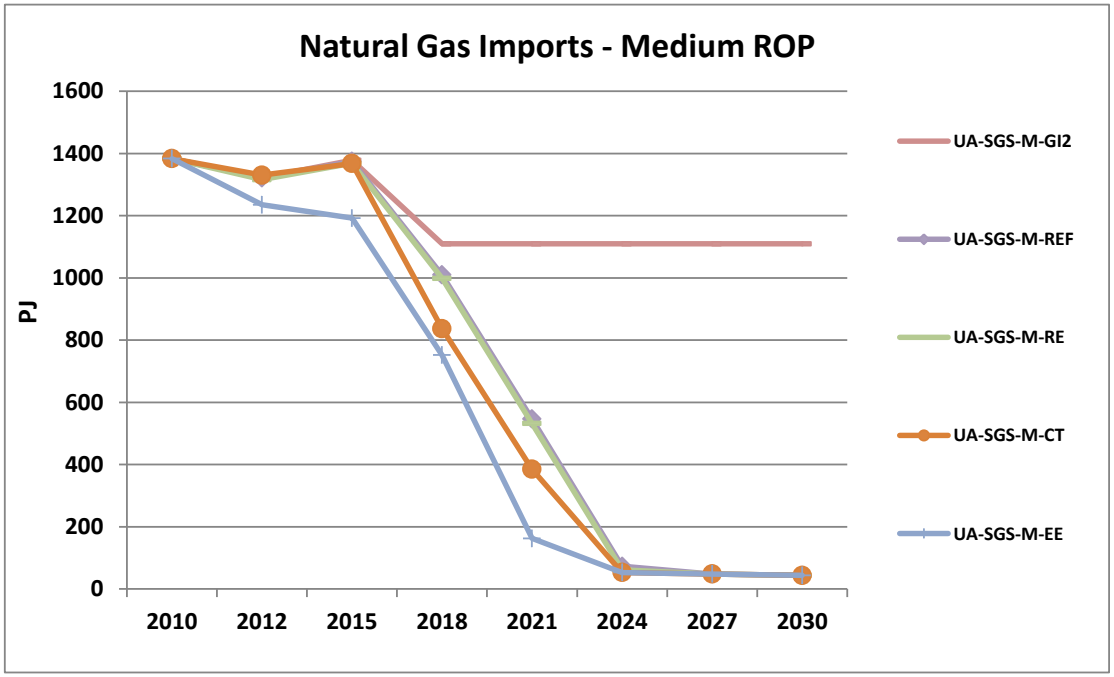


**Figure 8: Natural Gas Imports in the Medium ROP Cases**

As shown in Figure 9, energy sector related $CO_2$ emissions increase 20% in the Reference scenario between 2012 and 2030, with the shale gas case adding another 3% by 2030. This arises because the shale gas displaces not just coal and oil, but also $CO_2$-free imported electricity and some renewables. This is shown in Figure 10.

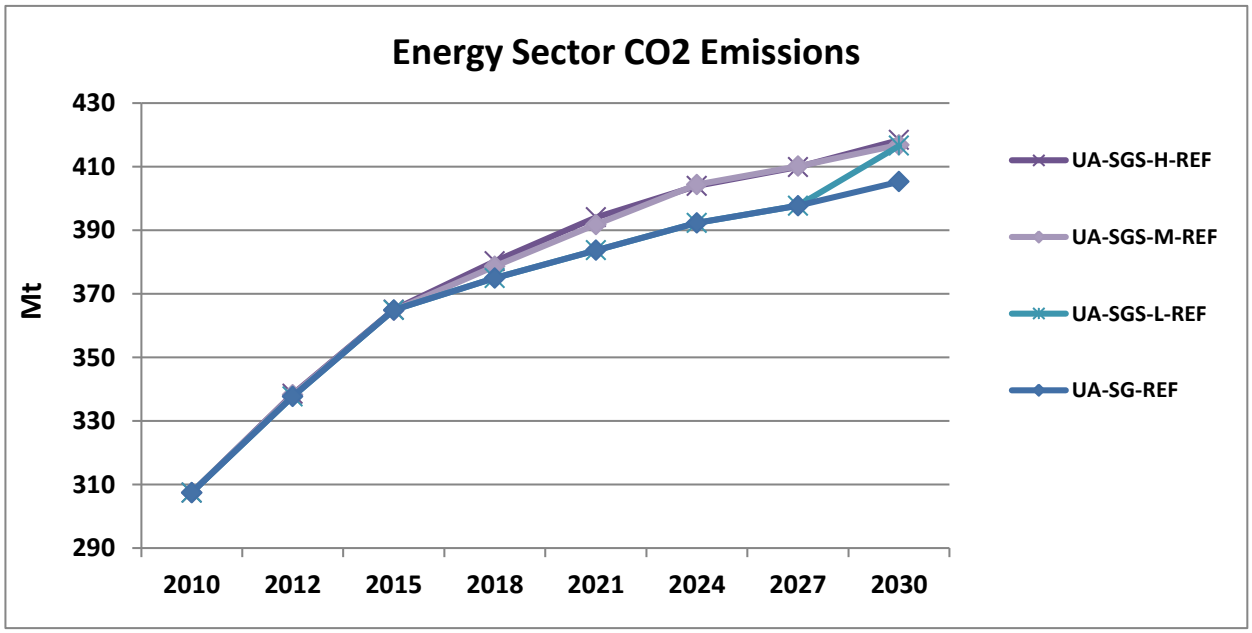


**Figure 9: Energy Sector $CO_2$ Emissions with Reference Scenario Assumptions**

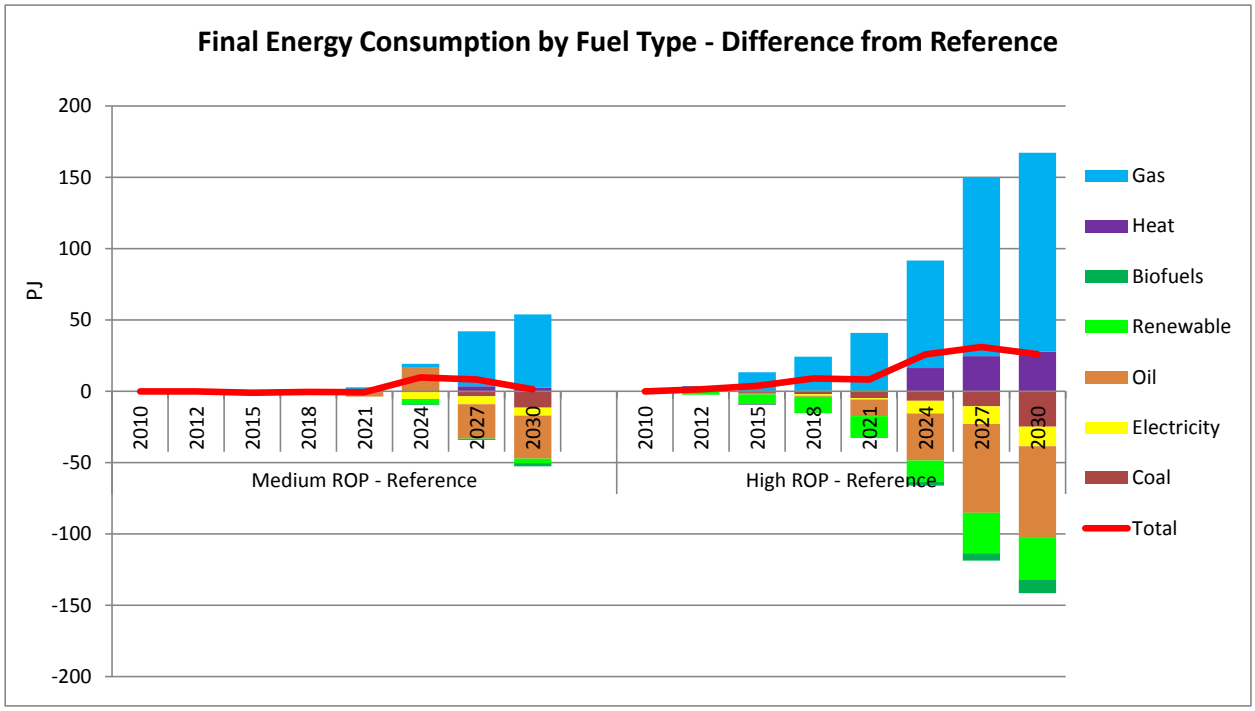


**Figure 10: Final Energy Consumption: Difference from Reference for Medium and High ROP Cases**

Figure 11 shows that in the medium ROP cases, reductions in energy sector $CO_2$ emissions can be achieved when the shale gas scenario is examined in conjunction with renewable energy (7% in 2030) and energy efficiency (16% in 2030) scenarios.

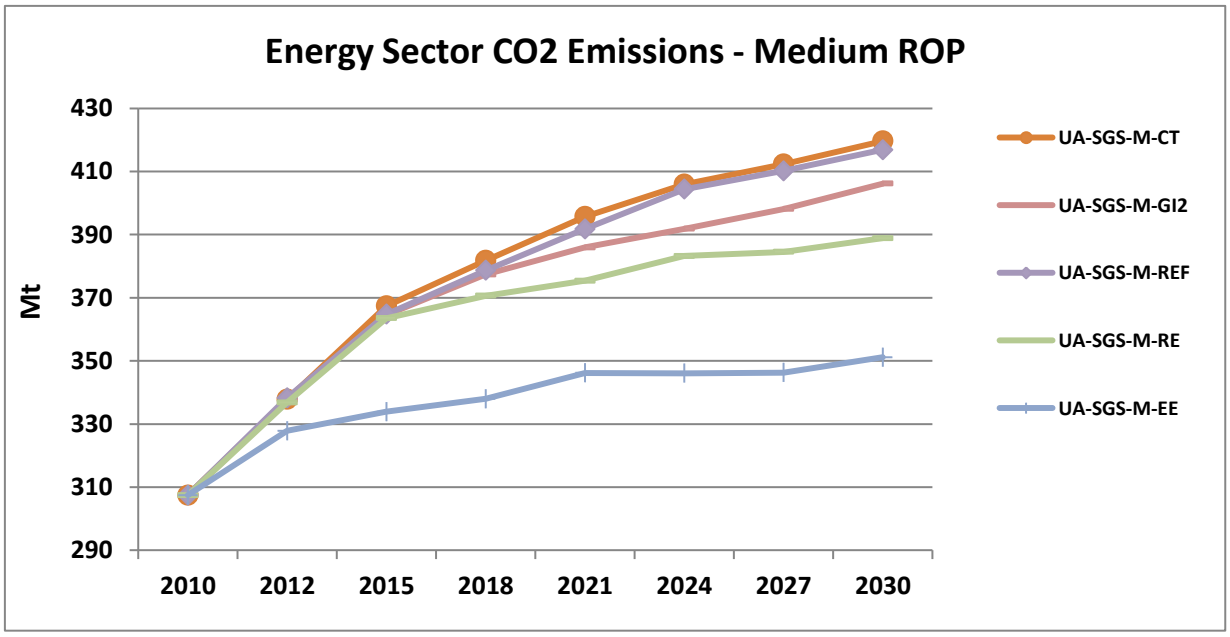


Figure 11: Energy Sector $CO_2$ Emissions in the Medium ROP Cases

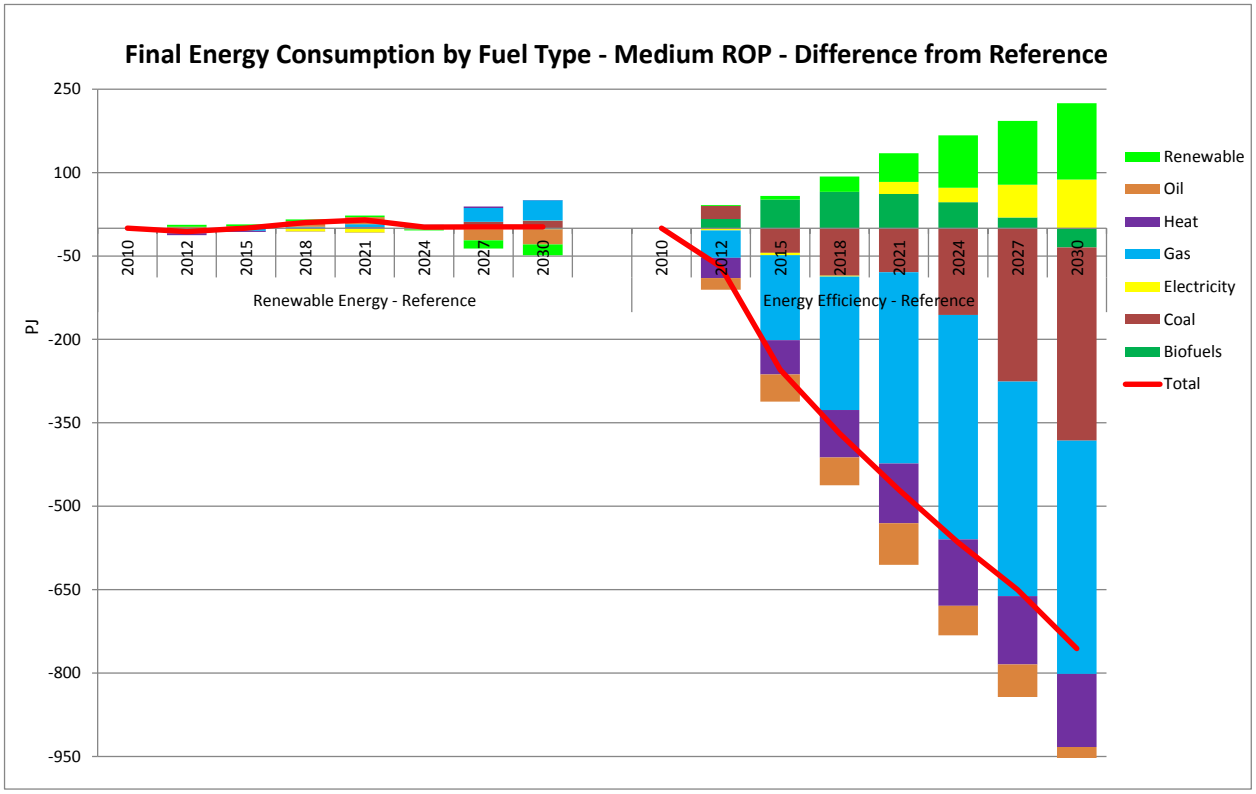


Figure 12: Final Energy Consumption: Difference from Reference for the Medium ROP Cases

Figure 12 shows that in medium ROP cases, the renewable energy scenario features a small increase in natural gas use, while in the energy efficiency scenario, only renewables and electricity show increases. All other primary energy sources decline.

Figure 13 shows the savings in energy system costs that result from shale gas production, particularly in the medium and high ROP cases. Potential savings reach almost €2.8 billion annually in the medium ROP case by 2030. In the high ROP case, the potential savings reach almost €7.8 billion annually by 2030. Almost all of these savings are in fuel costs, because more expensive imported gas is being displaced by domestic shale gas.

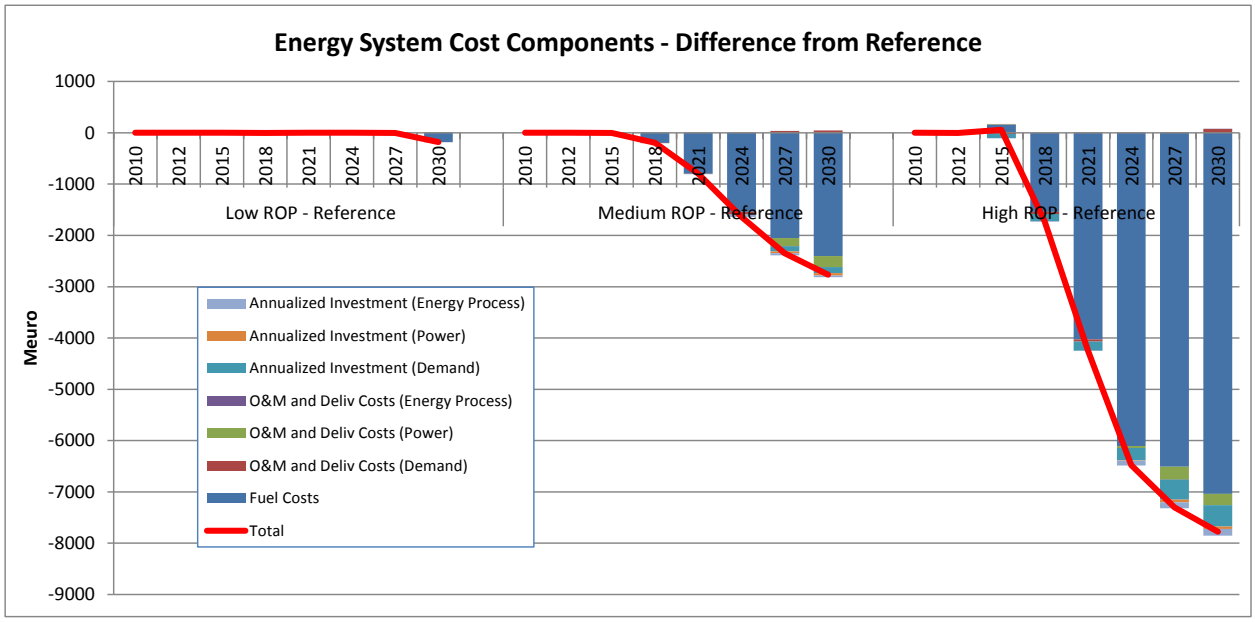


**Figure 13: Energy System Cost: Difference from Reference for Medium and High ROP Cases**

Figure 14 shows the impact of the alternative scenarios on the energy system cost savings in the medium ROP cases. Incentives for advanced coal technologies increase the fuel cost savings given the higher efficiency of the new coal plants. The coal technology scenario also assumes that supply side policies for coal will lower the cost of coal to users.

The high cost of the renewable energy mandates counterbalances the savings from shale gas development and results in an increase in the energy system cost. The energy efficiency incentives are cost-effective relative to shale gas and increase the savings in energy system costs to almost €3.6 billion (US$4.8 billion) by 2030.

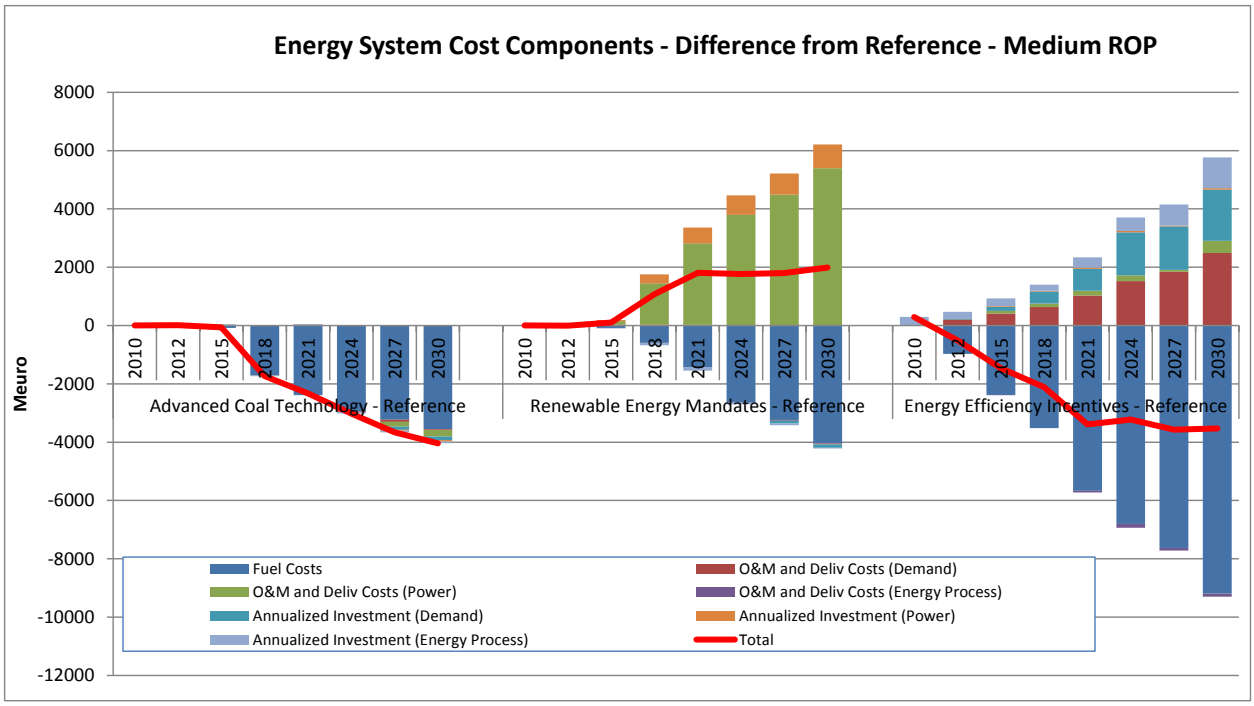


**Figure 14: Energy System Costs: Difference from Reference for Medium ROP Cases**

## 4.2. AFFECTED ENVIRONMENT

Two basins (East: Dnieper-Donets Basin, West: Carpathian Basin) were studied in order to analyze the environmental effect of the shale gas development in terms of water, environmentally sensitive areas, and agricultural regions (Figure 15). A third potential basin, the Kuban, runs from the North Caucasus region of Russia through the Crimea and was not included in this assessment.

- The Dnieper-Donets Basin, located in the east of the Ukraine with the important provinces Kharkov Oblast, Chernihiv Oblast, Poltava Oblast, Donetsk Oblast, and Sumy Oblast: The Dnieper-Donets Economic Area has rich mineral deposits. It has major industrial plant, including a great deal of heavy industry. Leading industries include mining, metallurgy, chemical and machine building. The basin contains a cluster of plants producing zinc, mercury, fertilizers, etc. The development of the coke and chemical industry is closely allied with metallurgical and coal industry. The area has the greatest concentration of thermal and hydroelectric power stations in Ukraine.
- Alongside with the high level of industrialization, the area is one of the main food suppliers for the country.[15]
- The Carpathian Basin, located in the west of the Ukraine with the important provinces Lviv Oblast, Ivano-Frankivsk Oblast and Chernitsi Oblast: The Southwestern Economic Area has a high population density, a dense network of roads and railways. This places the area in a favorable position with supplies of metals and fuel, machine-building plants and the shipping of products to consumers. The largest reserves of minerals and the valuable wood of the

[15] Ukraineatpresent. Online source: http://ukraineatpresent.com/Economic_Areas_p_76. (accessed on 17.02.2012).

Carpathian forests is used in the chemical, gas, mining, timber, paper, porcelain, and other industries.

- Local agriculture forms the basis of the food industry, such as sugar, grain-milling, etc. industries.[16]
- The evaluation of the southern Azov-Kuban Basin was not part of this study.[17]

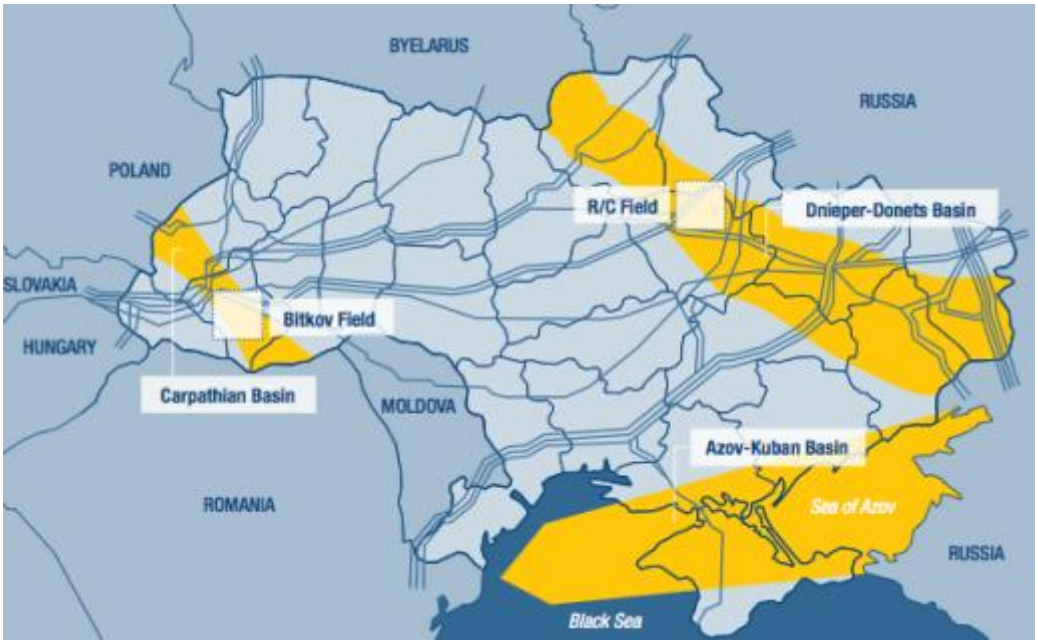


**Figure 15: Hydrocarbon Basins in Ukraine**

**Source:** Zarko Stefanovski "Ukraine Oil and Gas Sector Overview", December 2005.

### 4.2.1. CONVENTIONAL OIL & GAS IN THE DNIEPER-DONETS AND CARPATHIAN BASINS

Today the Dnieper-Donets Basin is a major producing region of Ukraine accounting for 90% of Ukrainian production from over 120 gas fields. Over 3000 wells have been drilled in the basin to date (Figure 16).

The Carpathian basin (Figure 17) is a mature oil and gas basin with a long history of exploration and production. The first exploration works and oil extraction were recorded at the end of the 18th century. A number of large oil field discoveries were made during the mid-19th century and large gas fields were discovered in the mid-20th century. The cumulative output from the Ukrainian part of the basin is relatively large – it was reported in 1996 by Oil and Gas Journal as over 700 mmbbl of oil and 8 tcf of natural gas (111 million cubic meters of oil and 0.227 trillion cubic meters of natural gas).[18]

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[16] Ukraineatpresent. Online source: http://ukraineatpresent.com/Economic_Areas_p_76. (accessed on 17.02.2012).

[17] Stig Arne Kristoffersen, Partner at UkraNova Ltd., "Gas Shale Potential in Ukraine: An Assessment of a Large Opportunity", Bahrain 2010.

[18] Oil and Gas Journal, 1996, Volume 94, Issue 2.

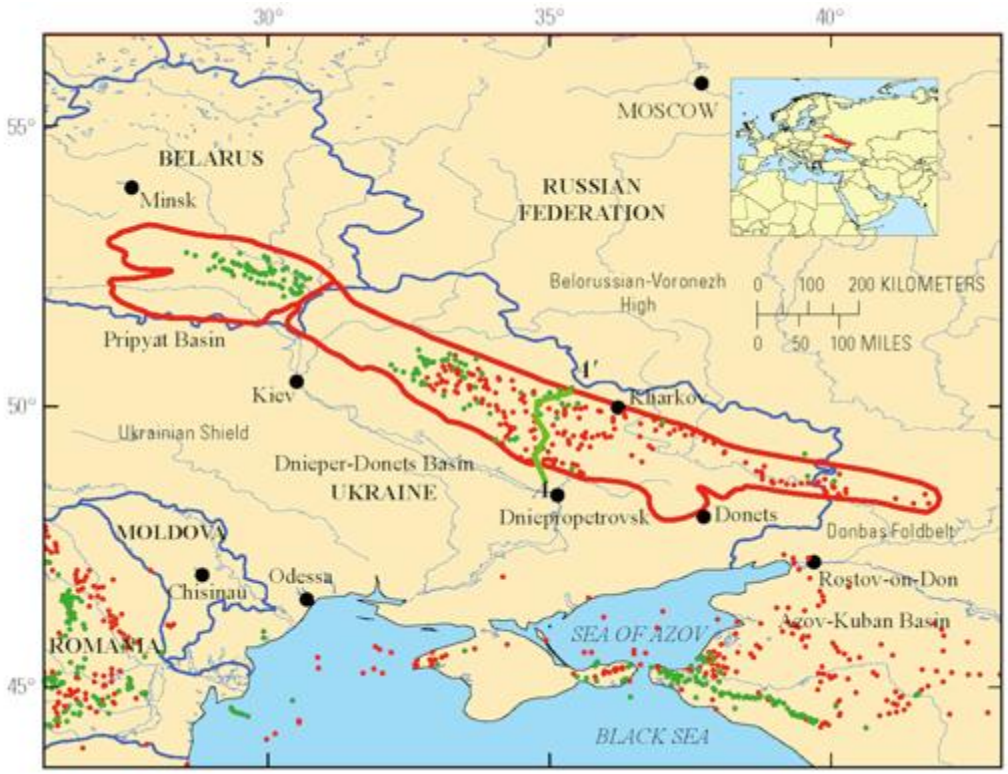


**Figure 16: Dnieper-Donets Basin**

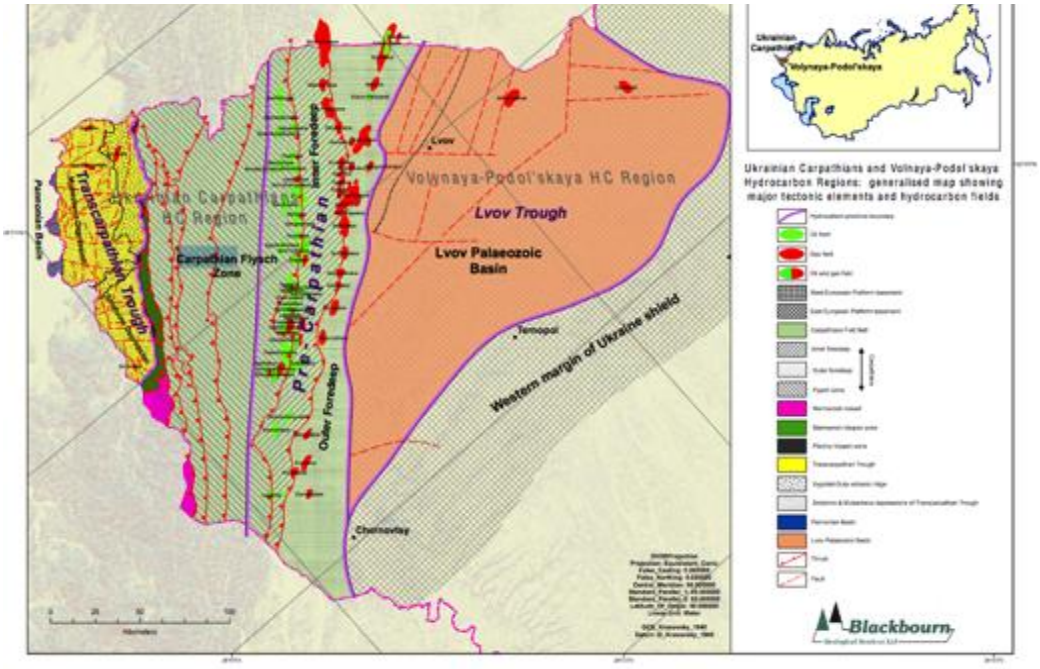


**Figure 17: Carpathian Basin**

### 4.2.2. NATURAL LANDSCAPES, BIODIVERSITY, AND THREATENED AND ENDANGERED SPECIES

The terrestrial ecosystems of Ukraine can be generally classified into six biogeographic provinces, plus additional freshwater, coastal, and marine ecosystems (Figure 18).[19] Ukraine's biodiversity includes many unique (endemic) species, and unique assemblages or communities of plants and animals, although most of the natural systems of Ukraine have been altered. About 70 percent of the natural vegetation of Ukraine has been converted to agricultural systems. The main vegetation provinces of the Carpathian Basin are Western Forest zone and Carpathian Mountain zone. The main provinces of the Dnieper-Donets Basin are Polissya, Forest-Steppe and Steppe. A 2004 analysis by the Biodiversity Indicators for National Use project listed both forest-steppe and steppe ecosystems as the most threatened in Ukraine.[20]

The known species of plants and fungi (mushrooms and lichens) of Ukraine number around 18,000 species.[21] The ecosystems of Ukraine provide habitats that support about 45,000 known species of invertebrate and vertebrate animals.[22] Ukraine has approximately 440 endemic and sub-endemic species. Twelve species of vertebrates are endemic to Ukraine. Nine percent of Ukraine's vascular plant species are endemic. Mountains have especially high endemism: in the Ukrainian Carpathians there are 133 endemic species of a total of 2050 species.[23]

Forests were the natural vegetation of the western and northern parts of Ukraine. Forests of western Ukraine are generally deciduous; forests of the north and northwest Polissya zone are mixed conifer and deciduous. In the forest zone, about 50 percent of remaining forests are plantations, usually even-aged monocultures, and not natural or naturally regenerating forests. This situation is a challenge for biodiversity as many endemic plants and animals need "old growth" forest habitats with a significant component of dead and decaying trees and dead wood on the ground. The Forest-Steppe biogeographic zone is the ecological transition zone between forest and grassland ecosystems. Forests, meadow-steppe, wet-meadow and wetland landscapes in river valleys exist together in this area. In the forest-steppe zone, soils are mostly fertile, humus-rich chernozem ("black earth") soils, and therefore, large areas of forest were cleared, and the majority of steppe grasslands in this zone were plowed for annual crops. Because few natural landscapes remain in this zone, protected areas are also few in number and small in area.

Steppe is a dry temperate grassland ecosystem with precipitation ranging from 300-450 mm per year. Steppe vegetation is dominated by drought-tolerant grasses and forbs. Conversion of native vegetation

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[19] ECODIT. 2011 Ukraine FAA119 Biodiversity Analysis: Actions Needed for Conservation. Prosperity, Livelihoods and Conserving Ecosystems (PLACE) IQC Task Order # AID-121-TO-11-00001 (hereinafter ECODIT). The text on biodiversity in this report has been excerpted liberally from this report. The map is from Figure 2.1 and is derived from the National Atlas of Ukraine. 2008. Paton, B.E., A.P. Shpak, and L.G. Rudenko, Eds. National Academy of Sciences of Ukraine. http://wdc.org.ua/atlas/en/4120100.html

[20] Prydatko, Vasyl, Yulia Apetova, and Stefanie Aschmann. 2004. Biodiversity and Agriculture in Ukraine (BINU) Project, Ukrainian Land and Resource Management Center. http://www.ulrmc.org.ua/services/binu/prmaterials/Biodiversity_Agriculture.pdfrydatko,

[21] This includes 5,227 mushrooms, 1,322 lichens, 4,908 algae, 763 bryophytes (mosses and clubmosses), and 6,086 vascular plants. (National Atlas of Ukraine, 2008). http://wdc.org.ua/atlas/en/4110100.html and http://www.biomon.org/en/.

[22] About 35,000 of these are insect species. The vertebrates in Ukraine include 117 species of mammals, almost 400 species of birds, 21 species of reptiles, 17 species of amphibians, and 182 species and subspecies of fish. http://www.biomon.org/en/

[23] See, Planta Europa at http://www.plantaeuropa.org/eip/country_profiles/assets/pt web site_dreamweav er/pt website country pages/country/ukraine.html

to agricultural fields was most extreme in the steppe region, mainly because of its highly fertile chernozem soils.

The Ukrainian Carpathian Mountain zone is characterized by altitudinal zones of vegetation: foothill forests, lower and upper elevation mountain forests, and subalpine and alpine zones. Above treeline, the vegetation consists of low growing shrubs and grasslands, and the highest elevations support mountain grasslands. Lower forest zones are subject to logging pressures as in other forest zones.

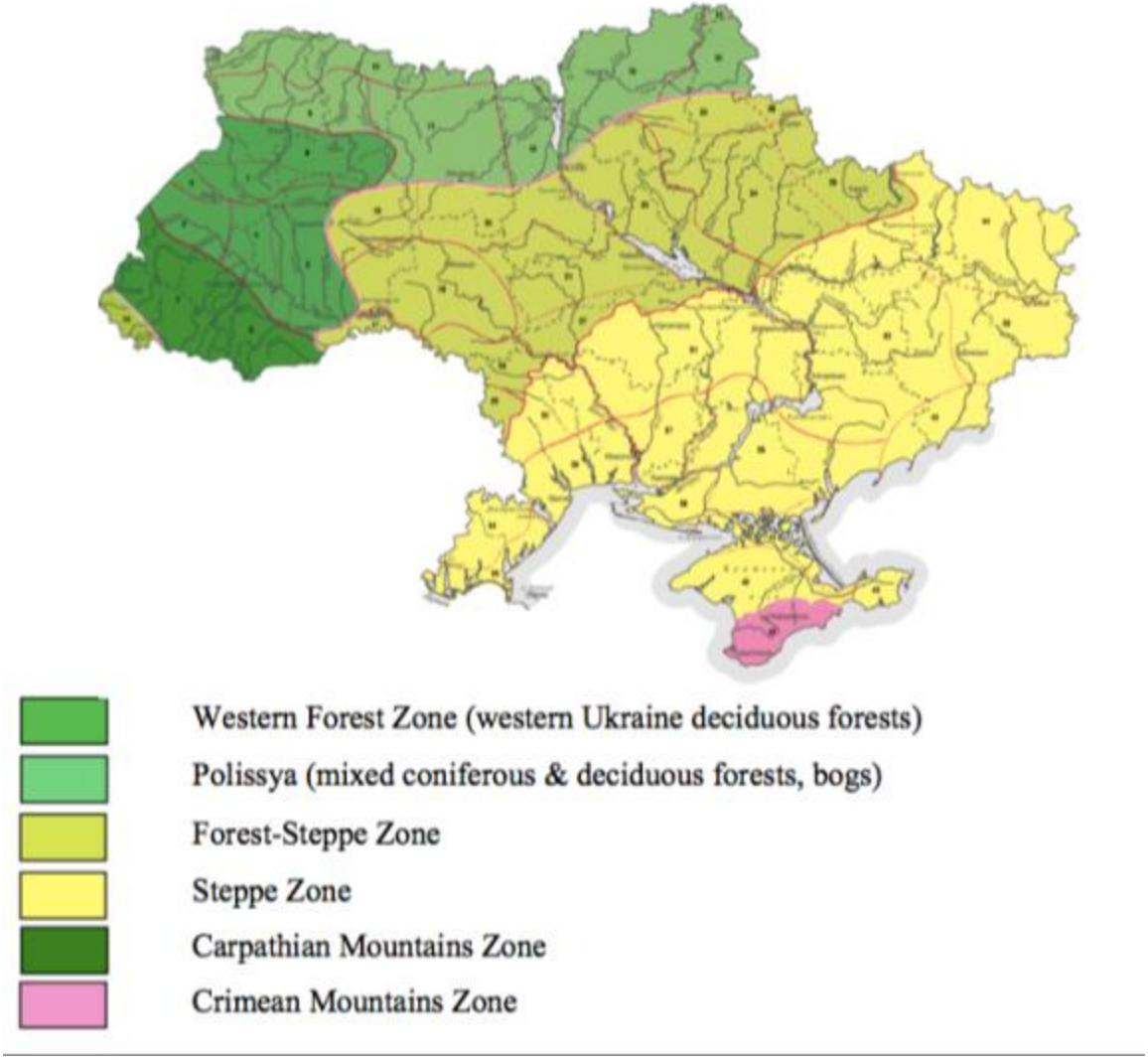


**Figure 18: Biogeographic Provinces of Ukraine**

The forests of Ukraine fulfill important ecological and economic functions, including soils and water protection, recreation, and forest products production. All forests are marked green on Figure 19. National forest lands also have an important role in conserving biodiversity in the forested biogeographic regions of Ukraine occurring in both the eastern and western shale areas. The total area of Ukrainian forest lands in the "Forest Fund," managed by the State Agency of Forest Resources

(SAFR) is around 7.5 million hectares. This represents about 70 percent of Ukraine's forest lands, with the remainder under the control of other agencies. [24]

The State "Ukraine's Forests for 2002-15"[25] Program defines optimal forestation for Ukraine as 19-20 percent. To reach this, forest area must be increased by at least by 2-2.5 million hectares. Some researchers, meanwhile, believe optimal forestation should be around 25 percent. Almost all Ukraine's forest masses suffer from intensive technogenic and anthropogenic impact. Their sanitary-hygienic and protective functions are decreasing as a result of industrial emissions. The Chernobyl disaster dealt Ukraine's forests a huge blow. Excessive cutting of stands of middle-aged trees and trees that are near ready is another reason for the weakening of the forest phytocenosis. Most of the western part of Carpathian Basin is covered with forests.

### 4.2.3. PROTECTED AREAS

Ukraine has begun the process of inventorying and protecting special species and habitats through the Ukraine Nature Reserve system (Figure 20, Figure 21), but the lands of Ukraine have not been well mapped or characterized. The protected area system was established in 1992 by the Law of Ukraine on the Natural Reserve Fund of Ukraine, No. 2456-XII, 16.06.1992 (hereinafter, "Protected Areas Law"), which defined a national system of protected areas for an independent Ukraine.[26] This law defines eleven categories of protected areas (PAs), five of which form the core of the protected area system (Table 3).[27] The national system of protected areas is currently composed of more than 7,000 protected areas covering around 2.8 million hectares, somewhat more than 5 percent of the national territory. Within the forests managed by SAFR, about 1.2 million hectares are set aside as forest protected areas, or about 15.4 percent of the Forest Fund lands as of January, 2011.[28] These protected forest areas are part of the protected area system summarized in Table 3.

Since independence, Ukraine's natural protected land fund has increased more than twice in area, or by 1303.1 thousand hectares. There is a plan for a further rapid increase to 10.4 percent by 2015. Ukraine has many protected areas registered through its participation in international agreements. The Primeval Beech Forests of the Carpathians is a UNESCO Nature World Heritage Site; there are six UNESCO Man and the Biosphere Program Biosphere Reserves; and 33 Wetlands of International Importance registered under the Ramsar Convention.[29]

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[24] ECODIT at 30.

[25] National Environmental Policy of Ukraine: General assessments and key recommendations", Kyiv 2007.

[26] ECODIT citing Protected Areas of Ukraine, http://en.wikipedia.org/wiki/Protected_areas_of_Ukraine viewed 19 April 2011); Law on the Ukraine Nature Reserve Fund, June 16, 1992, No. 2456-12.

[27] ECODIT, Table 5.1. Sources for this table are: State Agency for Protected Areas, April 2011 GEF-UNDP, 2008; Categories of Protected Areas of Ukraine: http://en.wikipedia.org/wiki/Categories_of_protected_areas_of_Ukraine IUCN Protected

[28] ECODIT at 30.

[29] ECODIT at 32.

**Table 3. Protected Areas of Ukraine**

| PA Category Name (Eng/Ukr) | # of Areas | Size in acres (hectares) | % of PA Network | Principle Purposes | IUCN Category |
|---|---|---|---|---|---|
| National Nature Preserve/ Natsionalny Pryrodnyy Zapovednik | 19 | 506,350 (205,000) | 5.5 | Strict protection, scientific research, education | I |
| Biosphere Preserve/ Biosphernyy Zapovednik | 4 | 619,970 (251,000) | 6.7 | Strict protection, scientific research, education | I |
| National Nature Park/ Natsionalnyy Pryrodny Park | 47 | 3,003,520 (1,216,000) | 32.6 | Conservation, nature recreation, science, education | II |
| Regional Landscape Park/ Regionalny Landshaftny Park | 58 | 1,600,560 (648,000) | 17.3 | Conservation, nature recreation, education | V |
| Nature Reserve/ Zakaznik | 2922 | 3,166,540 (1,282,000) | 34.2 | Conservation restoration of natural habitats & species | IV, VI |
| Protected Site/ Zapovidne Urochyshe | 803 | 239,590 (97,000) | 2.6 | Protect specific natural feature | IIII |
| Nature Monument/ Pamyatnyk Pryrody | 3245 | 69,160 (28,000) | 0.7 | Protect specific natural feature | III |
| Other categories, not natural | 641 | 44,460 (18,000) | 0.4 | Zoos, botanic, gardens | Not Applicable |
| **Total** | 7739 | 9,250,150 (3,745,000) | 100.0 | | |

There are four Nature Reserves and National Parks in the territory of Carpathian Basin and six in the territory of Dnieper-Donets Basin (Figure 19). Ukraine Nature Reserves and National Parks in the shale gas development areas include:

- 10, 11, 12, 13 – Ukrainian steppe Nature Reserve
- 14, 15, 16 – Luganskiy nature Reserve
- 21 - Rostochya Nature Reserve
- 26 - Horgan Nature Reserve

- 30 - Karpatskiy National Park
- 32 - Senevyr National Park
- 34 - Vygneckiy National Park
- 36 - Svyaty Gory National Park
- 37 - Yavorivskiy National Park
- 39 - Skolivskiy National Park

Many other protected areas in the western and eastern shale gas areas are shown in gold on Figure 20 and Figure 21. A listing of potential biodiversity impacts in Ukraine is provided in Appendix 5.

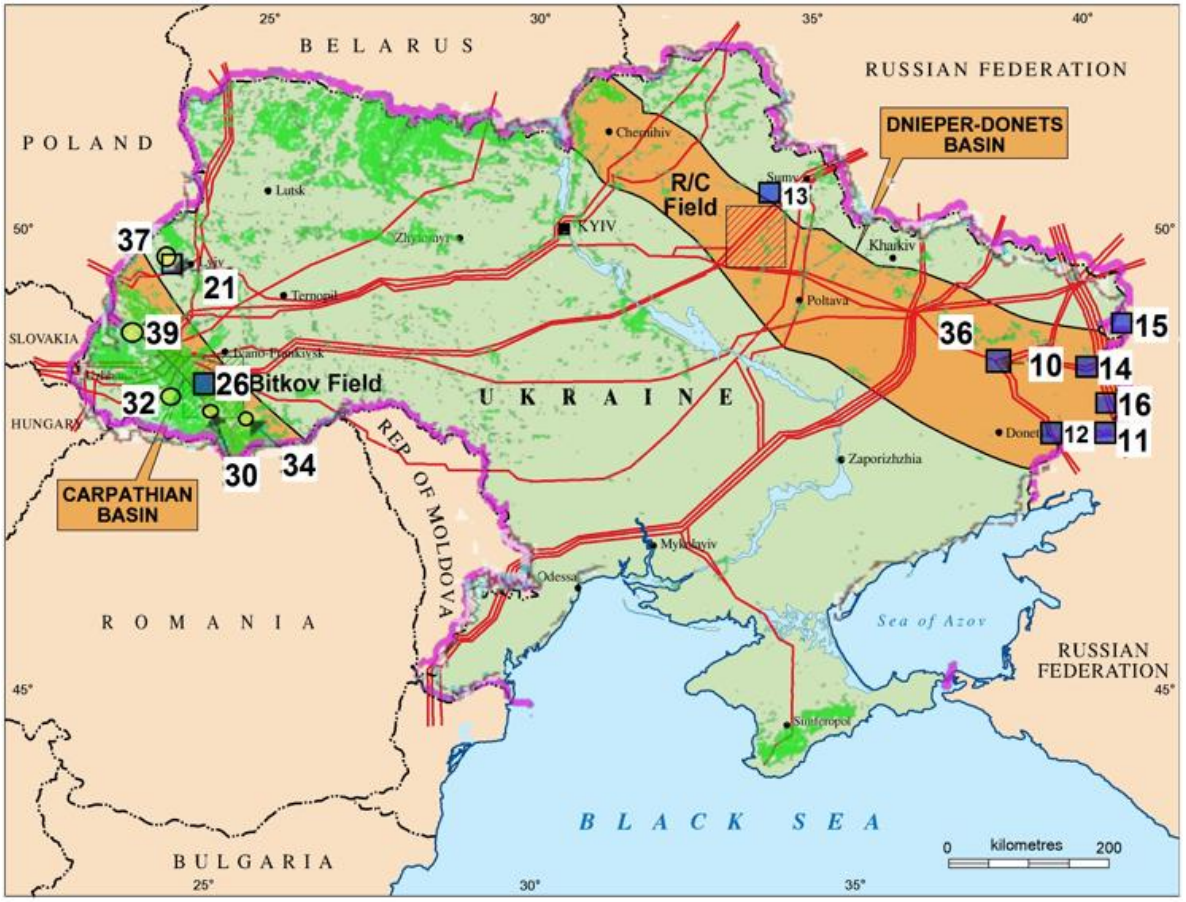


**Figure 19: Nature Reserves and National Parks. (Source National Environmental Policy of Ukraine: General assessments and key recommendations", Kyiv 2007. Modified by University of Leoben)**

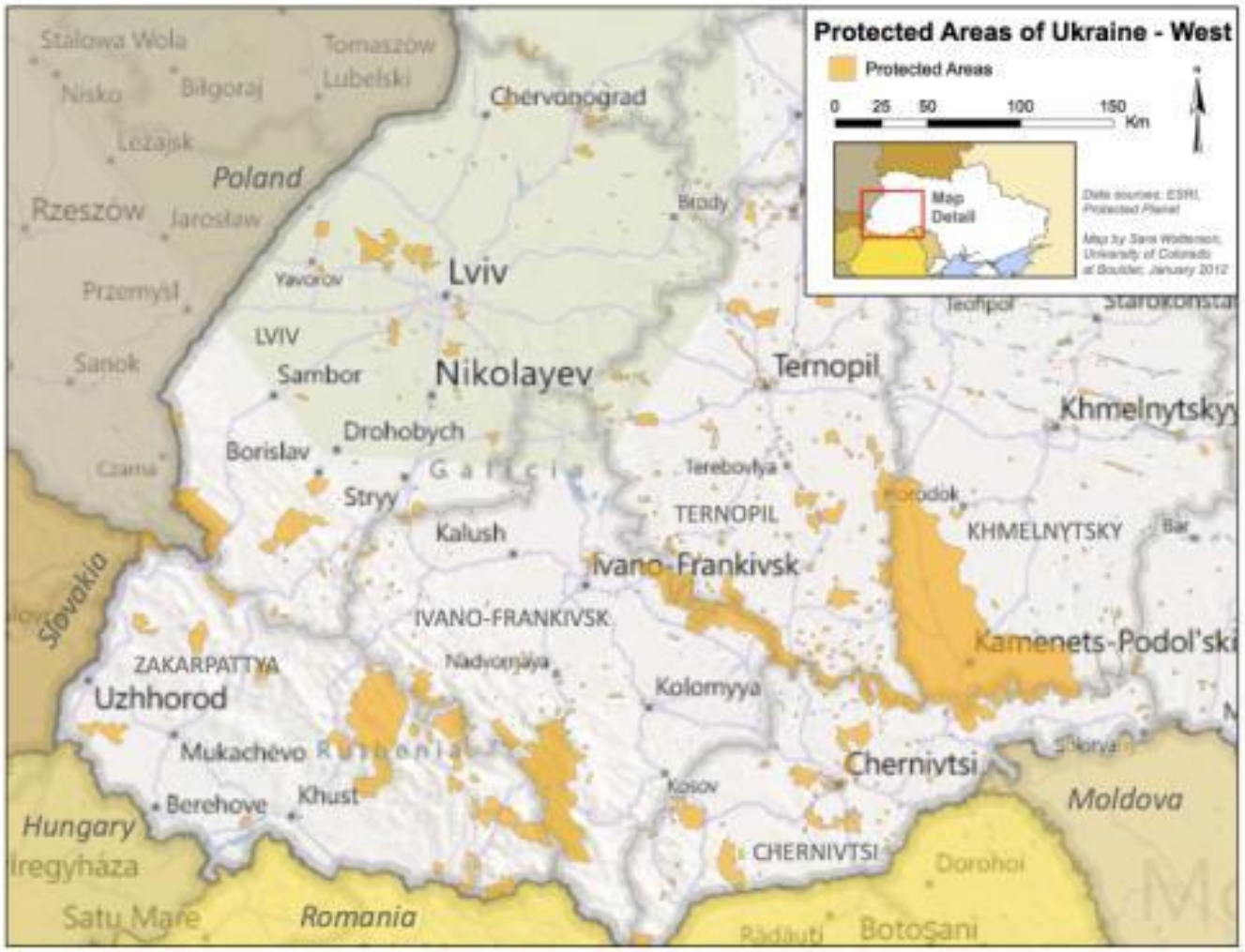


**Figure 20: Protected Areas of Ukraine - West**


**Figure 21: Protected Areas of Ukraine - East**

### 4.2.4. LOCATION OF AGRICULTURAL AREAS IN UKRAINE

The structure of the country's land usage is as follows: agricultural lands cover 71.3% of Ukraine's territory, with agricultural production land covering 69.3%. The structure of agricultural lands, just like the structure of Ukraine's land fund, is characterized by a very high index of agricultural development (0.72 unit). Ukraine has a very high level of cultivated land, significantly exceeding the ecologically justified limit according to the National Environmental Policy of Ukraine, published in 2007 (see Section 4.2.2). A meaningful percentage of Ukraine's land resources have unprecedented economical-ecological parameters. Among these is black soil, which accounts for 60% of cultivated soil. Humus consistency is traditionally considered an integral soil fertility indicator. According to a recent soil-agrochemical monitoring cycle, the average humus content in Ukrainian soil amounted to 3.2% and, compared to a prior monitoring cycle, it decreased by an average of 0.07%. Harvesting of agricultural cultures has significantly decreased, and therefore the input of post-harvest and root leftovers. As a result, there is an acute deficit balance of organic elements in all of Ukraine's natural zones, with losses exceeding newly created humus by an average of 800 kilograms per hectare.

Agricultural land in Ukraine includes cultivated land (grains, technical crops, forages, potatoes and vegetables, and fallow), gardens, orchards, vineyards, and permanent meadows and pastures. Winter wheat, spring barley, and corn are the country's main grain crops. Sunflowers and sugar beets the main technical, or industrial, crops. The production of grain and oilseed crops is dominated by large agricultural enterprises that were established when Ukraine's agricultural sector was restructured in April, 2000. In contrast, nearly 90 percent of the country's vegetables and virtually all of the potatoes are grown on private household plots.[30]

The Agricultural map (Figure 22) shows structure of especially valuable soils and their content in dependents on radius of pie chart. The color code in the right bottom corner illustrates the content of valuable soil in percentage. As it can be seen in Figure 22, less valuable soil is located in most of the Carpathian basin. Here, farming conditions vary and are relatively marginal in the mountains and in wide areas of the plains where poor soils dominate (e.g., gleysols, podzols), or ground- water levels are high (e.g., in the Dnister floodplains). In such areas, dairy, beef, oat, and potatoes are the main agricultural products. Where farming conditions are more favorable, major agricultural products include grain (e.g., winter wheat, buck-wheat), corn, oil crops (e.g., rape, sunflowers), and dairy, and meat.[31] Higher valuable soils are occupying around one fifth of territory of the Dnieper-Donets basin. In this general area, the main specialization of agricultural production is the cultivation of cereals, sugar beets and sunflowers. Potatoes and vegetables are grown in suburban areas of the large cities. In the animal husbandry sector, dairy and meat cattle breeding and pig breeding dominate. Apiculture and sericulture enterprises are also developing. Part of the area is known for the diverse plant cultivation and animal breeding. People cultivate winter wheat, barley, maize, sugar beet, sunflower, hemp, and coriander. The leading sectors are milk production and cattle breading. Enterprises specializing in breeding pigs, sheep, rabbit, and poultry are also popular and pond fish breeding is developing.[32]

Ukraine agriculture has been evolving since the country achieved independence in 1991, following the breakup of the Soviet Union. State and collective farms were officially dismantled in 2000.

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[30] U. S. Department of Agriculture, Production Estimates and Crop Assessment Division, Foreign Agricultural Service. 2004. Ukraine: Agricultural Overview. (hereinafter, USDA FAS) http://www.fas.usda.gov/pecad/highlights/2004/12/ukraine_ag_overview/index.htm

[31] Kuemmerle, Tobias, et al. 2010. Post-Soviet farmland abandonment, forest recovery, and carbon sequestration in western Ukraine. Global Change Biology (2010), doi:10.1111/j.1365-2486.2010.23333.x. at 3. http://www.whrc.org/resources/publications/pdf/KuemmerleetalGCB.11.pdf.

[32] 4 Travel Ukraine. No date. Agriculture in Ukraine. http://www.4-travel-ukraine.com/agricultural_tours/agricultural_in_ukraine.

Farm property was divided among the farm workers in the form of land shares and most new shareholders leased their land back to newly-formed private agricultural associations. The sudden loss of State agricultural subsidies had an enormous effect on every aspect of Ukrainian agriculture. The contraction in livestock inventories that had begun in the late 1980s continued and intensified. Fertilizer use fell by 85 percent over a ten-year period, and grain production by 50 percent. Farms were forced to cope with fleets of aging, inefficient machinery because no funds were available for capital investment. At the same time, however, the emergence from the Soviet-style command economy enabled farmers to make increasingly market-based decisions regarding crop selection and management, which contributed to increased efficiency in both the livestock and crop-production sectors. Difficulty in obtaining credit, especially large, long-term loans, remains a significant problem for many farms. Ukraine agriculture is going through a winnowing process whereby unprofitable, usually smaller farms will either collapse or join more successful farms.[33]

### 4.2.5. WATER RESOURCES IN UKRAINE

Ukraine has seven major river basins, all discharging into the Black Sea except the Northern Bug, which flows through the northern part of the western shale area towards the Baltic Sea. The Dnipro River basin drains about 65 percent of the country, the Dnister basin 12 percent, and the Danube basin 7 percent. The ecosystems of most Ukraine rivers, both small and large, have been dramatically altered by human activities.

Ukraine's average multi-year water resources amount to 87.1 $km^3$ (without the flow of the Danube on the Kiliyskiy branch, they amount to 123 $km^3$/year in volume). Local water resources - those that are formed within Ukraine - amount to 52.4 $km^3$ in an average water-volume year. Water resources are distributed very unequally within the country's territory. There are more of them in the North and less in the South, where the bigger water-consumers are located. As a result of limited water resources and the way they are distributed, river flow is widely regulated by means of dams and impoundments, leading to lower volume discharges of fresh water. Reservoirs and ponds, in aggregate, hold close to 58 billion cubic meters, which exceeds the local river flow of all the country's rivers. Regulating the flow of the majority of rivers has reached and even exceeded the top-end economic- and ecology-based permissible limits. Such regulation has drastically decreased and often completely destroyed rivers' capacity of self-regeneration. In addition, many reservoirs (over 1100) and ponds (around 28 thousand) have caused increases in underground water levels in large areas, and changes in underground water systems.

[33] USDA FAS (excerpt from the website).

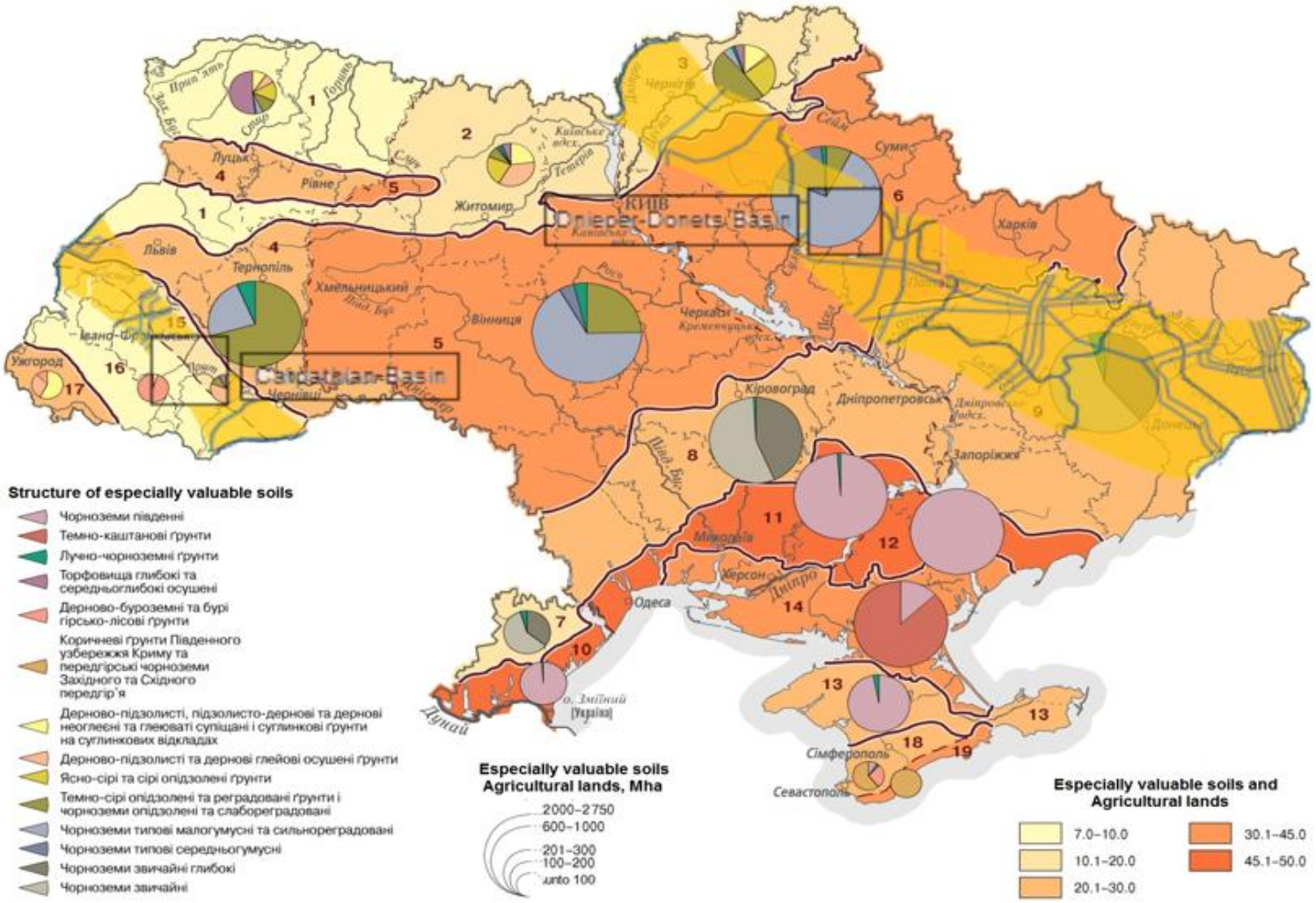


**Figure 22: Agricultural Areas of Ukraine**

The water consumption structure complies in neither quantity nor quality with the particularities of how water resources are created and distributed temporally and territorially in the country. Figure 23 illustrates the environmental situation and state of drinking water in Ukraine. As it can be seen, about 65-70% of Dnieper-Donets basin water is conditionally clean. About 15% of the Dnieper-Donets basin territory in the East-South suffers from contamination of ground waters, approximately 20% of the basin's ground water in the South is heavily contaminated, and about 10% in the West has lower contamination level. Also, about 5% of Dnieper-Donets basin territory has groundwater contamination in the Northwest and approximately 2% of groundwater in the Northern part of the Basin is contaminated with radioactivity. The Carpathian basin is located on the territory with conditionally clean water. However, about 2% of water in the Southeast and 2-3% of groundwater in the Northeast is recognized to be contaminated with radioactivity.[34]

**Definition of water quality level:**

Conditionally clean water – water quality index (WQI) 70-90%
Contaminated water – WQI 50-70%
Heavily contaminated water – WQI 25-50%
Extremely contaminated water – WQI 0-25%
**Source:** http://www.water-research.net/watrqualindex/index.htm

For shale gas developments, ground and surface water sources most proximal to the well sites are the most desirable. Natural gas operators will work to minimize costs associated with transporting water by securing withdrawals as close as possible to their planned development areas. Operators with large lease holdings may need to evaluate and secure several water sourcing take points in order to minimize the environmental footprint while still meeting the water needs of their development plans. Operators may elect to make withdrawals during periods when water is more abundant and then store the water for later use. Overland piping from distant sources may also be considered to minimize truck traffic. The evaluation of water adequacy will require both a means for measuring water availability and recognition that this availability may sometimes be reduced by seasonally low water or drought. Water management planning may include an assessment of the location of the need, the seasonal timing of the need, the location of available water and the regulations governing the water withdrawals. Shale gas withdrawals may be small on a regional level, however, withdrawals at any given point must be managed to ensure the ecological health of the water body and to provide for other industrial, agricultural, recreational or residential uses.

[34] National Environmental Policy of Ukraine: General assessments and key recommendations", Kyiv 2007.

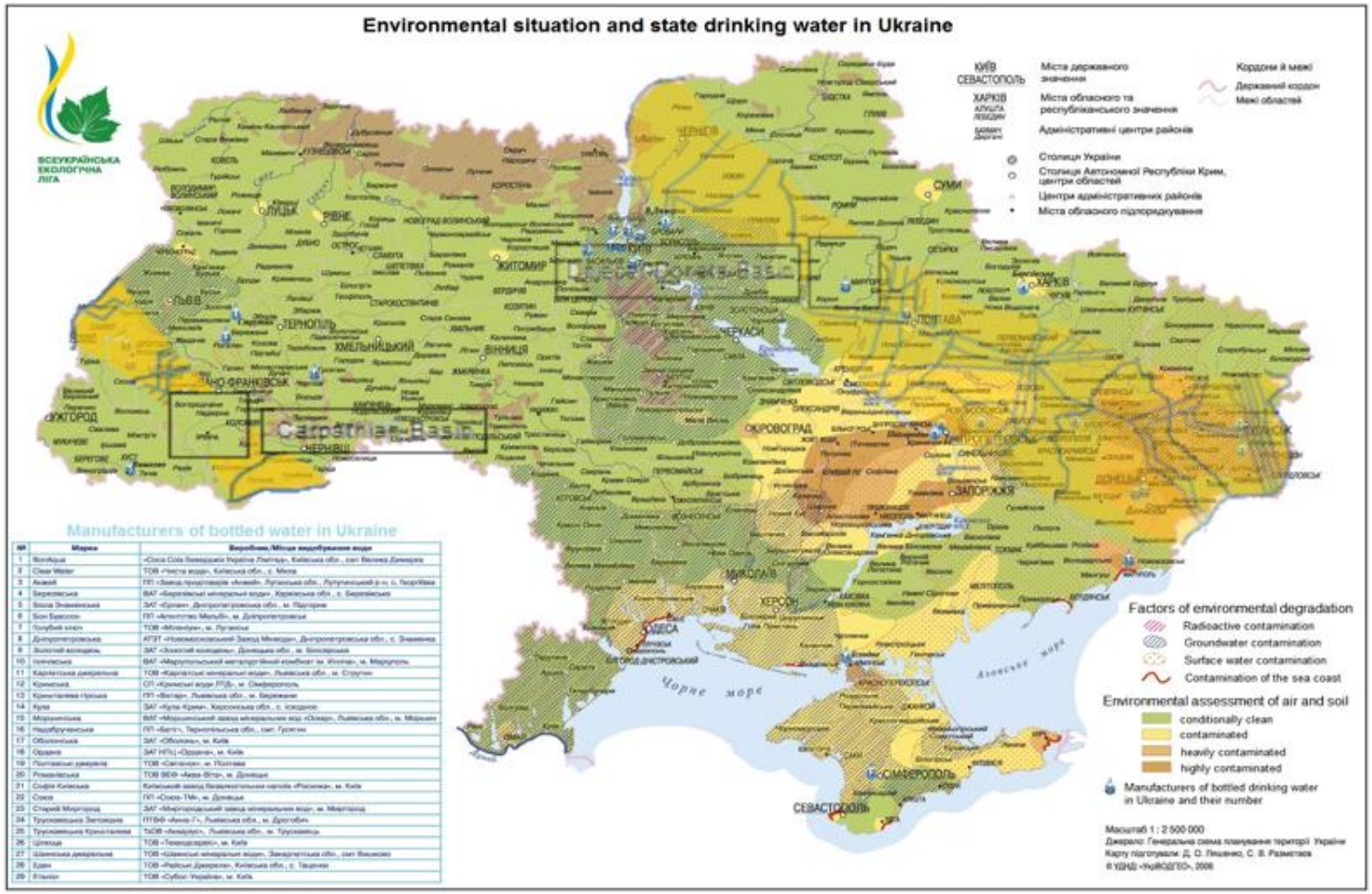


**Figure 23: Environmental Situation and State Drinking Water in Ukraine**

## 4.3. IDENTIFICATION OF ENVIRONMENTAL, TECHNICAL, ECONOMIC AND REGULATORY ISSUES AND CONSEQUENCES

### 4.3.1. LEGISLATIVE FRAMEWORK

Oil and gas, environmental, health and safety, and labor legal requirements in Ukraine are implemented through the following legal hierarchy:

- Constitution (1996);
- International treaties approved by the Parliament (Supreme Council of Ukraine or Verkhovna Rada);
- Laws and codes;
- Decrees and Directives of the President;
- Resolutions by Parliament;
- Decrees and Directives of the Cabinet of Ministers of Ukraine (Cabinet or Cabinet of Ministers);
- Orders of a ministry;
- Decisions and Directives of local self-government bodies; and
- Technical regulations adopted by law (Parliament) or by resolution (Cabinet of Ministers) and standards.

Under the Constitution, subsurface resources in Ukraine are property of the people of Ukraine, and state and local authorities exercise the ownership right on behalf of the people.[35] Modern laws have been adopted in the main sectors of environmental and social protection; most of them were originally adopted under the previous constitution, replaced with a new constitution in 1996 and amended in recent years.

Currently the main governmental body of Ukraine that is responsible for protection and administration of the environment is the Ministry of Ecology and Natural Resources (MENR). The MENR performs its duties directly and through special authorized executive bodies. The Ministry supervises inspectorates, including the State Ecological Inspectorate, state services, research institutes and state enterprises.[36] In addition to the units at the national level, environmental policy is implemented at a sub-national level by the state departments for environmental protection in oblasts and select cities. These departments are subordinate to the MENR but are also coordinated with the regional administrations.

In addition there are a number of other Ministries and Committees, including ministries responsible for health protection, industrial safety and industrial policy, labor and social policy, and energy development and distribution. These other ministries have authority over certain aspects of environmental laws. Typically permits issued by certain ministries are required to obtain approvals from other entities before issue. Local self-governments may also have some

[35] Constitution of Ukraine, available at http://www.rada.gov.ua/const/conengl.htm .

[36] See, United Nations Economic Commission for Europe Committee on Environmental Policy. 2007. Environmental Performance Reviews: Ukraine, Second Review, Environmental Performance Reviews Series No. 24, ECE/CEP/133 at 25 (summary of administration). (hereinafter EC Review)

responsibility for administration of environmental laws, depending upon the nature of the project under consideration. See Figure 24.

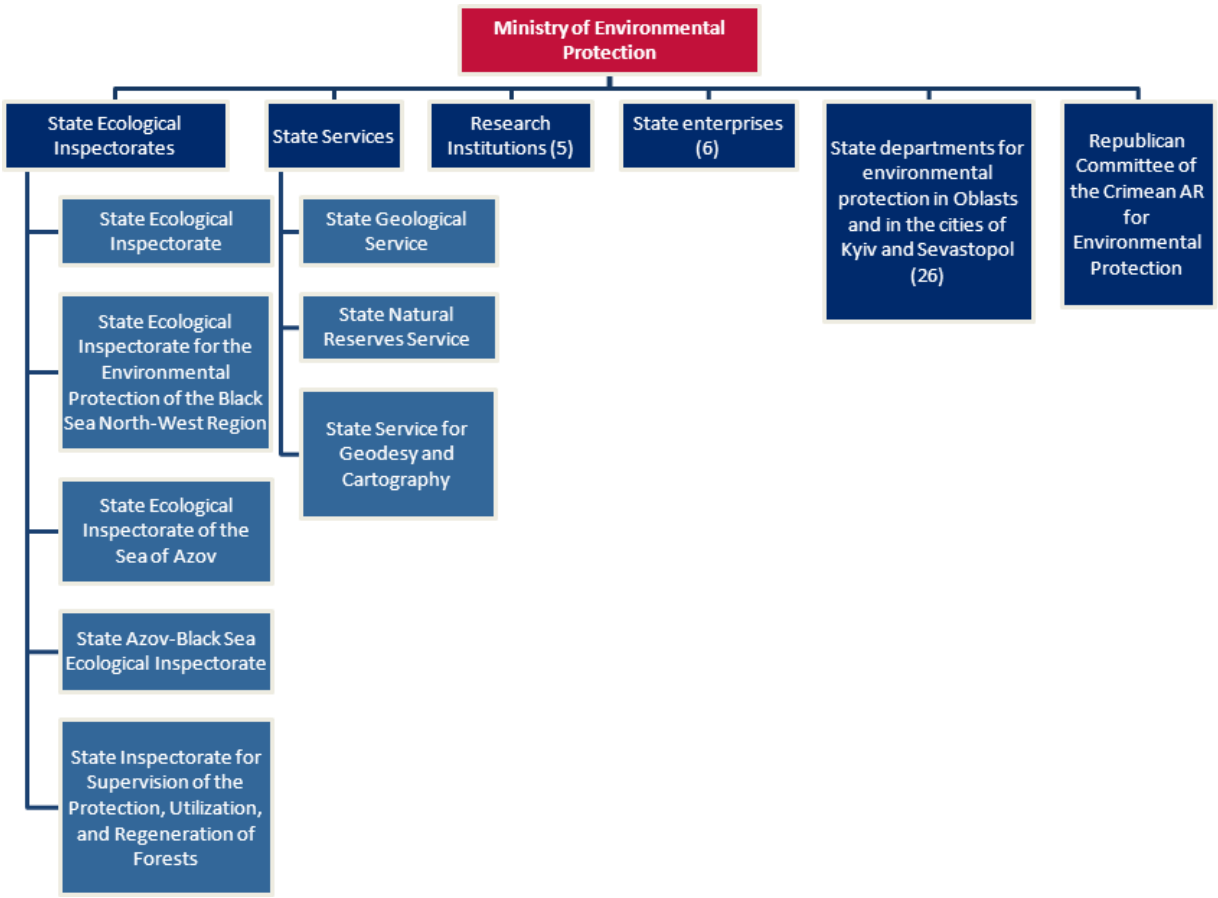


**Figure 24: Environment and Energy Government Bodies**

### 4.3.2. OIL AND GAS ADMINISTRATION

All oil and gas beneath Ukraine soil, or under Ukrainian territorial waters, is the property of the people of Ukraine (Law of Ukraine on Oil and Gas, No. 2665-III, 12.01.2001, hereinafter "Oil and Gas Law"). The Oil and Gas Law is the primary law regulating oil and gas development, as well as oil and gas transportation, storage, refining, and sales. The purpose of the Oil and Gas Law is to provide for higher efficiency of the oil and gas industry, encouraging energy saving technologies, standardization of rules throughout Ukraine, protection of the environment, worker safety, fostering competition, and providing stable financial conditions for the industry. The Verkhovna Rada of Ukraine defines the guidelines for national oil and gas policy. The Cabinet of Ministers and the administrative agencies implement the policy through rules and guidelines as well as providing industry oversight. Many of the provisions in the Oil and Gas Law could be applied to shale gas development.

The main entities for permitting of oil and gas developments are:

- State Service of Geology and Subsoil of Ukraine
- Oblast councils
- The respective region, city, town and village councils

- MENR
- Derzhhirpromnahliad (National Oil and Gas Department)

Under the Oil and Gas Law, an entity interested in developing a resource must first go through a tender process to receive a "special permit" to develop the resource. The holder of the successful tender would have to negotiate a lease that would define additional conditions for the development.

The local government would also have to approve the exact siting of the wells and associated facilities. Local self-governments do not permit gas pipelines. An enterprise owned by the central government operates the Unified Gas Transportation System of Ukraine (UTGSU) through a centralized control system. No other entities, including local governments, may exercise jurisdiction over the operations of the UGTSU.

Another form of administration of shale gas development would be through production sharing agreements (PSAs). Since the 1960s, many countries that lacked domestic capital or technological expertise to develop oil and gas have come to rely on PSAs, also known as Production Sharing Contracts, or Profit Sharing Agreements.[37] In a typical PSA, the country will grant an international energy company (investor) a contractual right to develop resources within a specified area in the country. The investor accepts all of the financial risks inherent in exploration and production. If oil and gas are found in producible quantities, the investor gets title to the product and can sell it until it has paid its costs. This is generally referred to as "cost oil". Once the investor's costs have been paid for, additional oil or gas is split between the country and the investor based on percentage stated in the contract. This is generally referred to "profit oil".

Ukraine's Law on Production Sharing Agreements, No. 1039-XIV, 14.09.1999 (hereinafter "PSA Law"), provides the framework for the PSA contracts the Ukraine government enters into with investors to extract natural resources. Ukraine's PSA Law has the components common in PSA laws in other countries. The Oil and Gas Law does not apply to a PSA. (Oil and Gas Law, Article 2).

The PSA process begins with a government tender for specific areas. The areas offered through a resolution passed by the Cabinet of Ministers. The tenders are then considered by a standing Interministerial Commission made up of local government authorities, representatives of bodies of the state, and People's Deputies of Ukraine. The investor awarded the tender offer must then draft the PSA (contract) that will propose a work program as well as a detailed plan for meeting the terms of the tender. The PSA and its terms can also be specified by the Interministerial Commission. Once the PSA is approved, the authorization of a special permit is guaranteed.

The PSA Law explicitly allows for exemption from ordinary environmental and natural resource laws and provides for internal specification of tax, arbitration and other provisions that may be at variance with the older Oil and Gas Law. Recent amendments to the PSA Law have resulted in the addition of a stability clause that protects investors from unforeseen changes in contractual and operational conditions and have limited the role of local self-governments in permitting PSA operations. Other recent amendments to the PSA Law have also allowed the government to require that a state-owned oil and gas company be brought on as a partner in the oil and gas development.

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[37] Bruce Kramer, et al, *Concessions, Production Sharing, Participation Agreements*, in INTERNATIONAL PETROLEUM TRANSACTIONS, THIRD EDITION, pg. 463 (Rocky Mountain Mineral Law Foundation 2010). The two countries pioneering PSAs were Algeria and Indonesia in the 1970s.

After a great deal of internal discussion the Government of Ukraine has issued a tender for production sharing in the Oleska and Uzivska regions (see Appendix 3 for the official tender). Although investors are eager to propose for blocks in this region there remain significant concerns about the ability of the current PSA tender to proceed to a successful award and implementation. In particular, the following issues remain problematic in the current PSA régime in Ukraine:

- There needs to be a clear and broad definition of "work program", including activities from exploration to closure;
- Uncertainty about who can act as the bidding entity for an international oil company.
- Clarify the role of the state-owned company in the development (financial, technical)
- International arbitration requirements
- Clarification of who holds the special permit – the investor company or the state-owned company;
- Additional transparency with regard to the criteria for award and the weighting of those criteria; and
- There needs to be some method of addressing local impacts of shale gas development.

For a more detailed discussion of these laws, see the Volume II, Sections 2.2 – 2.3.[38] See also Table 4 for a summary of major Ukraine, U.S. and EU oil and gas administrative laws applicable to shale gas development.

**Table 4: Summary of Major Oil and Gas Administrative Laws Applicable to Shale Gas Development**

| Issue | Law of Ukraine<br>Code of Ukraine | European Union Law | United States Law |
|---|---|---|---|
| Oil and Gas Administration | Subsoil Resources Code of Ukraine (Code of Ukraine on Mineral Resources), No. 132/94-VR, 27.07.94 (Subsoil Law) | Directive 94/22/EC of the European Parliament and the Council of 30 May 1994 on the conditions for granting and using authorizations for the prospection, exploration and production of hydrocarbons, OJ L 164, 30.06.1994. | Mineral Leasing Act and the Federal Onshore Oil and Gas Leasing Reform Act, 30 USC §181-287 |
| | Law of Ukraine on Oil and Gas, No. 2665-III, 12.01.2001<br><br>Law on Production Sharing Agreements, No. 1039-XIV, 14.09.1999<br><br>Law of Ukraine on Gas (Methane) of Coal Deposits, No. 1392-VI, 21.05.2009 | | Bureau of Land Management Oil and Gas Regulations 43 CFR §3000 et seq.<br><br>U.S Forest Service Oil and Gas Regulations 36 CFR §228 et seq.<br><br>State and local laws |

[38] USAID. Draft. Regulatory Analysis of Ukraine Law Regarding Shale Gas Development.

### 4.3.3. REVIEW OF UKRAINIAN ENVIRONMENTAL LAWS RELATED TO GAS SHALE DEVELOPMENT

The Law on Environmental Protection, No. 1264-XII, 25.06.1991 (hereinafter "Environmental Protection Law") establishes Ukraine's framework for environmental protection. It includes general provisions that set the tone for environmental protection in Ukraine and establishes the authority for implementation of the laws in all levels of government as well as in the public. This law includes the essential elements of law for environmental protection, focusing first on the rights and duties of citizens:

- Establishing ownership in the lands and natural resources of the country and identifying the objects of the environment to be protected;
- Establishing and guaranteeing the ecological rights and establishing duties of citizens for environmental protection;
- Collecting and recording environmental information and guaranteeing free access to information on environmental issues;
- Providing for public participation regarding legislation, planned activities, and other matters affecting the environment; and
- Creating a framework for assessing the potential environmental impacts of projects.

The law also addresses the activities of development that can impact the environment:

- Requiring that enterprises and other entities protect the environment while designing, constructing, and operating certain structures and facilities;
- Providing economic incentives to encourage environmental protection;
- Developing standards and rates for regulating the use of natural resources and controlling pollution;
- Requiring planning and implementation of measures to prevent and mitigate accidents; and
- Providing the means to ensure compliance with environmental laws, resolve disputes, and bring ecological offenses and crimes to justice.

While the Environmental Protection Law establishes the framework, individual process and substantive laws establish the regulatory framework for development and provide more detailed requirements for environmental protection:

- The Law of Ukraine on Ecological Expert Examination, No. 46/95-VR, 09.02.1995 (hereinafter "Expertiza Law") requires project proponents to analyze the impacts of development (prepare environmental assessments) and requires or allows the state, public organizations, and other interested legal entities and individuals to evaluate those assessments in expert ecological examinations. The following elements would be addressed in the documentation for a shale gas development:
    - Evaluation of three alternative locations
    - Environmental and sanitary impacts
    - Technical solutions for deducing impact and related costs
    - Design and costs of the infrastructure needed

- Transport and availability of energy for the planned activity.[39]

- The Water Code of Ukraine, No 213/95-VR, 06.06.1995 (hereinafter "Water Code"), is intended to ensure conservation, scientific study, and rational use of water for the needs of the population and industries. The code is the principal legislation for protecting and improving both the quantity and quality of surface and ground water while also facilitating its use. The Water Code, along with the Oil and Gas Law, regulates disposal of wastewater in subsoil zones.
- The Law of Ukraine on Wastes, No. 187/98-VR, 05.03.1998 (hereinafter "Law on Wastes"), is the principal law for minimizing production of waste and regulating the safe handling of waste, use of waste as a secondary material, and disposal of both hazardous and non-hazardous waste. The law does not regulate substances discharged in wastewater or air.
- The Law of Ukraine on Air Protection, No. 2 707-XII, 16.10.1992, (hereinafter "Law on Air Protection"), is the principal law for protecting and improving the quality of air in Ukraine. The Law on Air Protection uses three approaches to regulate air quality: 1) Set regional air pollution limits and restrict pollution based on those thresholds; 2) Require polluters to obtain permits to emit certain chemicals; and 3) Require the polluters to use systems or technologies that reduce pollution.
- Several laws of Ukraine function to protect natural lands and their biodiversity. These include the Law of Ukraine on the Natural Reserve Fund of Ukraine, No. 2456-XII, 16.06.1992 (hereinafter "Protected Areas Law"), the Forest Code of Ukraine, No. 3852-XII, 21.01.1994 (hereinafter "Forest Code"), Law of Ukraine on Fauna, No. 2894-III, 13.12.2001 (hereinafter "Law on Fauna"), Law of Ukraine on Flora, No. 591-XIV, 09.04.1999 (hereinafter "Law on Flora"), and the Law of Ukraine on Plant Protection, No. 180-XIV, 14.10.2004 (hereinafter "Plant Protection Law"). Biodiversity and natural landscapes and species are protected in part through limitation of the activities that can occur in protected areas and by requiring protection of individual species.
- Property Rights laws: Relevant property laws include the Land Code of Ukraine, No. 2768-III, 25.10.2001 (hereinafter "Land Code") and the Law of Ukraine on Expropriation of Privately Owned Land Plots and Other Real Estate Objects Located Thereon for Public Needs or on the Grounds of the Public Necessity, No. 1559-VI, 17.11.2009 (hereinafter "Public Necessity Law"). Rather than allowing surface use agreements with private owners, Ukraine requires the oil and gas operator or the government to own the land where the drilling and production equipment are located. Transfer of ownership can occur either through voluntary sale or exchange or through condemnation proceedings through the courts.
- The Law of Ukraine on Ecological Audits, No. 1862-IV, 24.06.2004 (hereinafter "Ecological Audit Law"), is the principal law for evaluating and ensuring compliance with the legislation of Ukraine on environmental protection. Through this law, independent auditors conduct voluntary and mandatory audits of compliance with substantive environmental laws. The law provides for both voluntary and mandatory audits. Voluntary audits are used as a tool in the process to obtain ISO 14000 certification.

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[39] United Nations Economic Commission for Europe, Committee on Environmental Policy: *Environmental Performance Reviews – Ukraine, Second Review*, 2007.

The Environmental Protection Law and individual substantive laws and codes require collection of baseline data on the environment and monitoring of the impacts of development activities. These laws establish limited authority of the government to limit the activities of entities violating the laws and to impose disciplinary, administrative, civil, and criminal penalties for violations.

For a more detailed discussion of these laws, see Volume II, Sections 2.4 – 2.11, Overview of Legal/Regulatory Recommendations. See also Table 5 for a summary of the major Ukraine, U.S. and EU environmental laws affecting shale gas development.

**Table 5: Summary of Major Environmental Laws Applicable to Shale Gas Development**

| Issue | Law of Ukraine<br>Code of Ukraine | European Union Law and<br>United Nations Conventions | United States Law |
|---|---|---|---|
| Integrated Pollution Control | | Directive 2008/1/EC of the European Parliament and of the Council of 15 January 2008 concerning integrated pollution prevention and control (replaced by Directive 2010/75/EU on industrial emissions in January 2014) | |
| Environmental Assessment Process | Environmental Protection, No. 1264-XII, 25.06.1991 (Environmental Protection)<br>Expert Ecological Examination, No. 46/95-VR, 1995 (Expertiza)<br>Regulation of Town Planning Activity, No. 3038, 17.02.2011 | Council Directive 85/337/EEC of 27 June 1985 on the assessment of the effects of certain public and private projects on the environment, OJ L 175, 7.5.1985 (Directive 85/337/EEC)<br>Convention on Environmental Impact Assessment in a Transboundary Context (Espoo Convention)<br>Convention on Access to Information, Public Participation in Decision-making and Access to Justice in Environmental Matters (Aarhus Convention) | National Environmental Policy Act, 42 USC §§ 4321-4347 (NEPA) |
| Assuring Compliance with Laws | Ecological Audit, No. 1862-IV, 24.06.2004<br>Citizen Appeals, No. 393/96-BP, 02.10.1996 | | Individual federal laws |
| Public Information on Environmental Issues | Public Access to Information, No. 2939-VI, 13.01.2011 | Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC, OJ L 41, 14.02.2003<br>Aarhus Convention<br>Directive 85/337/EEC | Freedom of Information Act, 5 USC §552<br>Emergency Planning and Community Right to Know Act, 42 USC 11000<br>NEPA |
| Air quality Protection | Atmospheric Air Protection, No. 2707-XII, 16.10.1992 (Air Protection) | Ozone precursors - Directive 2001/81/EC of the European Parliament and of the Council of 23 October 2001 on national emission ceilings for certain atmospheric pollutants, OJ L 309, 27.11.2001. | Clean Air Act, as amended, 42 USC §§7401 - 7671 |
| | | Directive 2005/55/EC of the European Parliament and of the Council of 28 September 2005 on approximation of the | |

| Issue | Law of Ukraine Code of Ukraine | European Union Law and United Nations Conventions | United States Law |
|---|---|---|---|
| | | laws of the Member State relating to the measures to be taken against the emission of gaseous and particulate pollutants from compressing-ignition engines for use of vehicles, and the emission of gaseous pollutants from positive-ignition engines fuelled with natural gas or liquefied petroleum gas for use in vehicles, OJ L 275, 20.10.2005;<br>Commission Regulation 2001/582/EU of 25 May 2011 implementing and amending Regulation 2009/595/EC of the European Parliament and of the Council with respect to emission from heavy duty vehicles (Euro VI) and amending Annexes I and III to Directive 2007/46/EC of the European Parliament and of the Council, OJ L 167, 25.6.2011. | |
| Noise | Air Protection | Directive 2009/42/EC of the European Parliament and of the Council of 6 May 2009 on statistical returns in respect of carriage of goods and passengers by sea, OJ L 141, 6.6.2009.<br>Directive 2000/14/EC of the European Parliament and of the Council of 8 May 2000 on the approximation of the laws of the Member States relating to the noise emission in the environment by equipment for use outdoors, OJ L 162, 3.7.2000. | Noise Control Act of 1972, 42 U.S.C. § 4901 - 4918. |
| Solid Waste Management | Wastes, No. 187/98-VR, 05.03.1998. | Directive on the Management of Waste from Extractive Industries 2006/21/EC, OJ L 102, 11.4.2006, | Resource Conservation and Recovery Act, 42 USC §6901 et seq. |
| | National Program of Toxic Wastes Management, No. 1947-III, 14.09.2000 | Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives, OJ L 312, 22.11.2008. | |
| Waste Water Management | Water Code, No 213/95-VR, 06.06.1995,<br>Oil and Gas Law;<br>Subsoil Law | Council Directive<br>91/271/EEC of 21 May 1991 concerning urban waste-water treatment, OJ L 135, 30.5.1991 | Safe Drinking Water Act, 42 USC §300 (SDWA) |
| Surface Water Quality Protection | Water Code, No. 213/95-VR, 06.06.1995 (Water Code) | Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ L 327, 22.12.2000 (Directive 2000/60/EC) | Clean Water Act, 33 USC §§1251 - 1387 |
| Groundwater | Water Code | Directive 2006/118/EC of the European Parliament and of the Council of 12 December 2006 on the protection of | SDWA |

| Issue | Law of Ukraine<br>Code of Ukraine | European Union Law and<br>United Nations Conventions | United States Law |
|---|---|---|---|
| | | groundwater against pollution and deterioration, OJ L 372, 27.12.2006 | |
| Water Quantity Protection | Water Code | Directive 2000/60/EC | State water laws |
| Land Ownership and Management | Land Code of Ukraine, No. 2768-III, 25.10.2001 | | Federal Land Policy and Management, 43 USC §§1701 - 1785<br>National Forest Management Act, 16 USC §1600 et seq.<br>State and County law |
| | Expropriation of Privately Owned Land Plots and Other Real Estate Objects Located Thereon for Public Needs or on the Grounds of the Public Necessity, No. 1559-VI, 17.11.2009 | | |
| Biodiversity | Natural Reserve Fund of Ukraine, No. 2456-XII, 16.06.1992<br>Flora, No. 591-XIV, 09.04.1999<br>Fauna, No. 2894-III, 13.12.2001<br>Red Book of Ukraine, No. 3055-III, 07.02.2002<br>Forest Code, No. 3852-XII, 21.01.1994 | Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora, OJ L 206, 22.7.1992<br>Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on conservation of wild birds, OJ L 20, 26.1.2010 | Endangered Species Act, 16 USC §§1531-1544 (ESA)<br>Migratory Bird Treaty Act, 16 USC §§703-712 |
| | Plant Protection, No. 180-XIV, 14.10.2004 (weeds) | | State and Local government |
| | Ecological Network of Ukraine, No. 1864-IV, 24.06.2004 | Natura 2000 | |

The Regulatory Analysis report (Volume II) that was prepared in conjunction with this PEA includes recommendations for changes in law, regulation and practice. See Table 6 and Volume II, Sections 2.2 – 2.11) for a more detailed discussion of those recommendations. Many of the recommendations address issues already recognized as important by Ukraine in its National Action Plan for Environmental Protection in Ukraine for 2011- 2015. The IRG Team recommendations address the following issues:

- **Planning for Shale Gas Development:** Preparing a plan for industrial development, including shale gas development, is a requirement of several laws, including the Environmental Protection Law and PSA Law. The plan should be comprehensive, addressing development from exploration activities to well closure, reclamation, and

follow-up monitoring. To facilitate verification and enforcement provisions the Plan should include verifiable implementation activities with regard to retirement of facilities and should include bonding provisions.

- **Baseline Data Collection:** Without sufficient baseline data, it will be impossible to site shale gas facilities in order to minimize impacts. It would also be extremely difficult to assess the impacts of development, to revise plans and operations to further minimize development, and to compensate for unavoidable impacts. Baseline data on water (location, quantity and quality), air quality, and the location and abundance of special plant and animal species and communities are of utmost importance. Baseline data collection to support the monitoring and verification needed throughout the development process must be the responsibility of the private sector developers, but should be compatible with and integrated into national and regional environmental monitoring programs and databases.
- **Transparency and Participation:** Acceptance by the public of shale gas development and the ability of the pubic to participate in decision making and environmental protection require increased transparency and opportunities for participation. These require both more specificity in the regulations, more dialogue among government, industry and the public, and creation of an atmosphere that welcomes and encourages public participation.
- **Administration of Gas Development:** The current approach to shale gas development in Ukraine calls for the majority of the relevant legal provisions to be either included in the PSA or subsidiary to it. Such an approach may be sensible to get the shale gas program off the ground. However, in the longer term such an approach establishes two different standards of legal and regulatory status for essentially similar commercial products, conventional and unconventional natural gas. Ukraine needs to move towards adoption of a law that would provide the legal framework for the regulation of shale gas development. One way to achieve this would be to amend the current Oil and Gas Law to be applicable to shale gas development.[40] The general provisions of that Law might also require some modification to reflect the country's recent experience with upstream activity based on that Law.

  Conversely, the PSA Law could be used as the primary vehicle for oil and gas exploration and production activities. If the latter path is chosen that that Law will probably require a thorough examination to improve its generality to oil and conventional gas and to reduce conflicts with existing law that have been identified in this report.
- **Protection of Water:** Protection of water may be the most controversial and critical issue in shale gas development. Recommendations include evaluating and implementing a model framework for drilling and completing wells that involve hydraulic fracturing; revising Ukraine law on withdrawal and disposal of water used and produced during development; clarifying the law regarding use of process water basins and retention ponds; and ensuring that drainage waters from oil and gas construction and operations is treated to reduce the level of pollutants before discharging into water bodies.
- **Protection of Air:** Current air quality problems and poor air quality laws and enforcement may pose limits to responsible shale gas development in Ukraine. Air quality

[40] Such a series of amendments of the Oil and Gas Law would also require amendments as to the permitted business arrangements for exploitation of oil and gas resources.

monitoring stations are needed in Dnieper-Donets and Carpathian basins. These monitoring stations need better baselines for all the pollutants associated with the oil and gas sector (including ozone). Ukraine should also adopt U.S.-type new source performance standards for oil and gas equipment. Areas that are out of compliance with regional air quality standards (such as Donetska Oblast and Ivano-Frankivsk Oblast) must have regional plans to bring air quality into compliance before any new pollution sources are permitted in those areas.

- **Protection of Biodiversity:** The principal barriers to protection of biodiversity during shale gas development are insufficient law regarding non-native species and inadequate funding allocated to identify existing resources (baseline data) and protect them. To protect biodiversity, Ukraine should develop a comprehensive law on non-native species and provide the resources to collect adequate baseline information and to monitor populations and enforce existing biodiversity protection laws. Plans for shale gas development should require and insurance or bonding to guarantee successful interim and final reclamation that supports a restoration of native communities where appropriate. Funding of off-site mitigation to protect adjacent high-biodiversity areas should also be considered.
- **Protection of Land Ownership/Use Rights:** In order to minimize disruption of the local population during shale gas development, the Land Code and Public Necessity Law should be amended to protect both landowners and those that do not have clear title to lands. Amendments should:
  - Give landowners a choice in selling or leasing their land and allow for some gas development operations under negotiated surface use agreements.
  - If private lands are sold to the state, compensation should be based on a market assessment.
  - Neither buyout nor condemnation should be allowed without clear title; the state or developers should be required to pay for the title work to settle ownership.
- **Local Government Concerns:** The Oil and Gas Law gives land use permitting authority for oil and gas development to local self-governments. However, in the case of a PSA, the local government has no authority to limit the areas allowed for PSAs and thus no permitting authority; it is a national decision. Allowing for a meaningful local self-government participation in review of the terms of the PSA would help to address some concerns about both direct impacts on local areas and the distribution of various costs of oil and gas development.[41]
- **Addressing Localized Impacts:** The impacts of shale gas development will be most acute in the areas where it is extracted and produced. There must be a mechanism whereby local self-governments can have appropriate funding to pay for damages caused by shale gas development and for necessary infrastructure improvements.
- **Monitoring and Enforcement:** Regardless of the quality of the regulatory regime, adequate monitoring and enforcement is essential for prudent, sustainable shale gas

[41] State governments in the US typically do allow local governments some ability to permit oil and gas facilities, so long as those permit requirements do not materially impede the state's interest. We are advocating a limited role for local governments, but a role that will allow the local government, and the industry, to be more responsive to the needs of the local citizenry and environment.

development. Without transparency, stakeholder participation and even-handed enforcement, selective application of environmental regulations would likely result in unacceptable negative impacts on the environment and people of Ukraine as well as a failure to develop an open, fair, and competitive business environment. To avoid these problems, Ukraine law should provide for appropriate roles for the national government, industry (self-monitoring) in monitoring and (self) enforcement. The implementation provisions of the law should be written with the understanding that the initial emphasis on staffing and funding is appropriately at the national level. Once the national monitoring and enforcement staffing and training has been completed then the efforts to implement in the affected regions should be initiated. Funding will need to accompany such a role, one that is in accordance with the authority of local governments under the current Oil and Gas Law. Recommendations include:

- Increasing transparency regarding plans and compliance, including making results and supporting materials of ecological audits accessible to the public;
- Increasing stakeholder involvement through both industry self-monitoring and NGO/community participation in planning for and verification of compliance;
- Providing a role for the MENR and local self-governments in limiting activities of entities in violation of environmental laws (including when development occurs under a PSA); and
- Providing training for MENR staff and eventually local government staff in these activities (see Section 5).

A comprehensive catalogue of suggested changes in Ukrainian Laws to update them for new energy development is shown in Table 6. These suggested changes will take a number of years to discuss, draft and implement. In the end the country will have updated and upgraded its legal framework for oil and gas development as well as the protection of the environment.

**Table 6: Summary of Recommended Changes to Ukraine Law and Practice**

| Issue | Law Change or Action Recommended | Section # | Category |
|---|---|---|---|
| PSA Law: Authority | Expand participation of local government in transfer of land for mineral use and provide specific guarantees for the community | 2.11.9 | Local Government Concerns |
| PSA Law: Authority | The Interministerial Commission should include representatives of regional councils affected by the PSA. | 2.11.9 | Local Government Concerns |
| PSA Law: Compliance | Require a comprehensive examination of compliance at least every five years | 2.11.9 | Monitoring and Enforcement |
| PSA Law: Compliance | Require mandatory sanctions on investors responsible for their failure to fulfill environmental obligations associated with the reclamation of disturbed land, compliance with environmental regulations, etc. | 2.11.9 | Monitoring and Enforcement |
| PSA Law: Content | There needs to be a clear definition of "work program" | 2.3.6 | Administration of Gas Development |

| Issue | Law Change or Action Recommended | Section # | Category |
|---|---|---|---|
| PSA Law: Content | Include international arbitration requirements | 2.3.6 | Administration of Gas Development |
| PSA Law: Local impacts | Need some method of addressing local impacts of shale gas development (addressed in detail regarding local government) | 2.3.6 | Local Government Concerns |
| PSA Law: Parties | Clarify who can act as the bidding entity for an international oil company | 2.3.6 | Administration of Gas Development |
| PSA Law: Parties | Clarify the role of the state-owned company in the development (financial, technical) | 2.3.6 | Administration of Gas Development |
| PSA Law: Parties | Clarify who holds the special permit – the investor company or the state-owned company | 2.3.6 | Administration of Gas Development |
| PSA Law: Process | Need additional transparency with regard to the criteria for award and the weighting of those criteria | 2.3.6 | Transparency and Participation |
| PSA Law: Socio-economic obligations | Require that investors conclude an agreement on social partnership with affected communities | 2.11.9 | Local Government Concerns |
| PSA Law: Socio-economic obligations | Require mandatory liability insurance for environmental damage for the benefit of that level of government with the remediation or repair obligations | 2.11.9 | Local Government Concerns |
| Budget Code: Distribution of profits | Investing companies should make their targeted contributions to the local budget and require a publicly-released accounting on how the money was spent. | 2.11.9 | Local Government Concerns |
| Tax Law | Redirect monetary penalties for damages from general distribution to targeted fund for distribution to governments in the affected areas | 2.11.9 | Local Government Concerns |
| Tax Law: Distribution of profits and compensation for damage | Consider a new (national) severance tax that would go to the local governments where the minerals are located. A targeted national severance tax could act in lieu of a user fee or a local/provincial tax. | 2.11.9 | Local Government Concerns |
| Land Code and PSA Law: Fairness to land owners | Owners of land needed for mineral extraction should have a choice as to whether they sell their land to the central | 2.10.4<br>2.11.9 | Protection of Land Ownership/Use |

| Issue | Law Change or Action Recommended | Section # | Category |
|---|---|---|---|
| | government or lease it. | | Rights |
| Land Code and PSA Law: Fairness to land owners | Some development activities should be allowed to proceed under negotiated surface use agreements. | 2.10.4 | Administration of Gas Development; Protection of Land Ownership/Use Rights |
| Law on Public Necessity: Fairness to land owners | Allow for a market assessment to be the basis for compensation. | 2.10.4 | Protection of Land Ownership/Use Rights |
| Law on Public Necessity: Fairness to land owners | Avoid displacing landowners without clear title; require that the state pay for the costs of the title work prior to a buyout or condemnation proceeding or, alternatively, that these proceedings may not be initiated for property with unknown ownership. | 2.10.4 | Protection of Land Ownership/Use Rights |
| Environmental Protection Act, PSA Law, Oil and Gas Law: Effective regulations | Reevaluate requirements of laws and regulations to assure preparation of a comprehensive (from exploration to closure), transparent, and enforceable plan for shale gas development. Plan fulfillment should be secured by insurance/bonding. Provide for appropriate notification and public participation provisions. | 4.3.2<br>4.3.3 | Planning and Development |
| Environmental Protection Act: Role of various levels of government, regulated entities, and the public | Build capacity of state and local government, NGOs, and citizens to fulfill their roles | 2.4.2 | Local Government Concerns; Transparency and Participation |
| Environmental Protection Law: Role of various levels of government, regulated entities, and the public | Clarify role for the MENR and local governments in assuring compliance with environmental laws regardless of whether development occurs under a subsoil permit or a PSA | 2.4.2 | Monitoring and Enforcement; Administration of Gas Development |
| Expertiza Law: Improve compliance | Develop enforcement measures to ensure compliance with EIA procedures | 2.9.4 | Monitoring and Enforcement |
| Expertiza Law: Improve environmental analysis | Improve alternatives analysis with comprehensive consideration of alternatives including the “no action” alternative | 2.9.4 | Planning for Development |
| Expertiza Law: | Clarify the applicability of the Expertiza | 2.9.4 | Transparency |

| Issue | Law Change or Action Recommended | Section # | Category |
|---|---|---|---|
| Improve environmental analysis regarding construction projects | Law and Town Planning Law for evaluation of construction projects | | and Participation |
| Expertiza Law: Increase public participation | Improve process and timing of scoping | 2.9.4 | Transparency and Participation |
| Expertiza Law: Increase public participation and information access | Provide additional detail to law and regulations to allow early and meaningful public participation | 2.9.4 | Transparency and Participation |
| Ecological Audit Law: Improve compliance with environmental legislation | When the customer is a government body performing either a voluntary or mandatory audit, confidentiality should be provided only to protect the sources of information of an audit. | 2.4.2 | Transparency and Participation |
| Ecological Audit Law: Improve compliance with environmental legislation | The final audit report, including the evidence and conclusion of the audit, should generally be available to the public. | 2.4.2 | Transparency and Participation |
| Water Code: Protect surface and ground water during all phases of development | Require a special water permit for extraction, use and disposal of more than a (to be) specified volume of water from the subsurface, regardless of the quality of water, the zone of withdrawal/injection, or the entity involved (lessee or enterprise). | 2.5.8 | Protection of Water |
| Water Code: Protect surface and ground water during all phases of development | Require tracking and disclosure of water withdrawals and injections, including the chemicals included in fracking fluids | 2.5.8 | Protection of Water |
| Water Code: Protect surface and ground water during all phases of development | Clarify law regarding use of process water basins and retention ponds. | 2.5.8 | Protection of Water |
| Water Code: Protect surface and ground water during all phases of development | Ensure that drainage waters from oil and gas construction and operations are treated to reduce the level of pollutants before discharging into water bodies. | 2.5.8 | Protection of Water |
| Water Code: Protect surface and ground | Evaluate and institute measures comparable to the model regulatory | 2.5.9 | Protection of Water; Protection |

| Issue | Law Change or Action Recommended | Section # | Category |
|---|---|---|---|
| water during drilling and completion | framework law for drilling and completion | | of Biodiversity |
| Law on Wastes: Improve implementation | Determine which gas exploration and production waste is classified as "hazardous". | 2.6.4 | Protection of Water; Protection of Biodiversity |
| Law on Wastes: Improve implementation | Require enterprises to adhere to EU/U.S. waste hierarchy | 2.6.4 | Protection of Water; Protection of Biodiversity |
| Law on Wastes: Improve implementation | Ensure adequate locations for waste disposal | 2.6.4 | Protection of Water; Protection of Biodiversity |
| Air Quality: Equipment | Consider requiring through regulation or the PSA, reduced emissions completions, low-bleed pneumatic devices, compressor leak prevention practices, tank controls, LDAR at gas processing plants, $SO_2$ controls at gas processing plants, dehydrator controls, and tank controls. | 2.7.10 | Protection of Air |
| Air Quality: Improve quality | Create and enforce meaningful sanctions for violation of air quality laws | 2.7.10 | Protection of Air; Monitoring and Enforcement |
| Air Quality: Improve quality | Develop an effective self-monitoring system for permit holders | 2.7.10 | Protection of Air; Monitoring and Enforcement |
| Air Quality: Improve quality | Regions that are currently out of compliance with regional air quality standards should be required to implement a plan to bring regional air pollution levels to within safe limits. | 2.7.10 | Protection of Air |
| Air Quality: Standards | Review the list of major air pollutants, to improve the system of norms of pollutant emissions, to shift to international standards and norms of air quality. | 2.7.10 | Protection of Air |
| Air Quality: Standards and equipment | Establish new emission standards for all oil and gas equipment. As interim measure, PSA contracts should require use of equipment that meets standards implemented elsewhere, e.g., U.S. | 2.7.10 | Protection of Air |
| Air Quality: Understand existing air quality and improve quality | Understand the extent of existing problems through better air quality monitoring; establish a baseline and monitoring systems for the air pollutants likely to be exacerbated by shale gas | 2.7.10 | Protection of Air; Monitoring and Enforcement; Baseline Data Collection |

| Issue | Law Change or Action Recommended | Section # | Category |
|---|---|---|---|
| | development. If the baseline air quality is not understood prior to a PSA, it should be a condition set in the agreement. | | |
| Biodiversity protection measures: Baseline data | Complete a survey and mapping of vegetation communities to provide a baseline for evaluating shale gas development impacts. | 2.8.6 | Protection of Biodiversity; Baseline Data |
| Biodiversity protection measures: Compensating for impacts | Include off-site mitigation projects including protection of high-biodiversity areas adjacent to shale gas development | 2.8.6 | Protection of Biodiversity |
| Biodiversity protection measures: Improve monitoring and enforcement | Provide adequate staff and resources to MENR agencies, and the Academy of Sciences, to effectively carry out the responsibilities for biodiversity | 2.8.6 | Protection of Biodiversity |
| Biodiversity protection measures: Reduce Impacts | Develop and implement a comprehensive policy and legislation regarding non-native invasive species. | 2.8.6 | Protection of Biodiversity |
| Biodiversity protection measures: Reduce impacts | Develop and implement programs of economic incentives and disincentives for conservation of steppe vegetation; require participation of shale gas developers | 2.8.6 | Protection of Biodiversity |
| Biodiversity protection measures: Reduce impacts | Explore payments for ecosystem services mechanisms in steppe regions, especially for water and soil (may be accomplished under severance tax-type mechanism suggested above) | 2.8.6 | Protection of Biodiversity |
| Biodiversity protection measures: Restoration | Require a pre-development reclamation plan and successful interim and final reclamation | 2.8.6 | Protection of Biodiversity |
| Biodiversity protection measures: Restoration | Any environmental insurance or bonding required should include well and/or field closures, successful completion of interim and final reclamation, and follow-up monitoring. | 2.8.6 | Protection of Biodiversity |

### 4.3.4. CAPACITY FOR ADMINISTRATION, MONITORING AND ENFORCEMENT

An appropriate national framework of substantive law and procedural safeguards is essential to meet the goals of sustainable shale gas development process. Adequate implementation of those laws, however, is equally critical to development that meets these goals. Adequate implementation requires effective and efficient permitting, monitoring/inspection, reporting, and enforcement.

Whether there will be effective administration, monitoring, and enforcement of laws depends on:

- Sufficient authority and requirements in the law to permit activities, monitor compliance, and take action when laws are violated;
- Political will to fully and fairly implement the law;
- Efficient and effective organization of administrative bodies;
- Baseline data against which monitoring results can be compared;
- Access to the development location and its processes; and
- Adequate personnel with expertise, training, equipment and protocols to implement it.

As discussed in more detail regarding specific laws (see Volume II, Section 2.2 – 2.10), administration of the systems that would regulate shale gas development are primarily at the state level (various ministries, including the MENR), their local councils, and, to a lesser extent, in bodies of local self-government. Individual laws specify the authorities of various levels of government and their appointees. For example, the Law on Wastes[42] establishes the authorities of the Cabinet of Ministers (Article 18), local state administrations (Article 20), bodies of local self-government (Article 21), specially appointed bodies of executive authority (Articles 22), and the jurisdiction of other Ministries (Article 23). Depending on the law, state or local bodies may be responsible for issuing permits for construction or operation of facilities, monitoring activities, collecting data or reports, and enforcing compliance with the law and its regulations.

In their National Action Plan, Ukraine has identified several needs related to improvements in administration, monitoring, and enforcement of environmental protections.

- Institutional development and strengthening the capacity of public administration in environmental industry (Item 4.2)
- Developing a national environmental information system and database (Item 1.1)
- Improving monitoring and data management systems (Item 3.11)
- Improving air quality monitoring (Item 3.1)
- Developing mechanisms for improving public input into enforcement (Item 1.12)
- Implementing a program for environmental education of government employees working on environmental issues (Item 1.6) and continuing professional education (Item 3.9)
- Improving enforcement regarding water quality (Items 3.2 – 3.3)

The most recent evaluation of environmental performance of Ukraine expressed considerable concern as to the administration of the Ukraine system. The Economic Commission concluded:

> The need to protect the environment and use natural resources more efficiently has been declared a priority in a number of official documents. However, with economic growth

[42] Law of Ukraine on Wastes, No. 187/98-VR, 05.03.1998.

becoming the Government's primary goal, environmental issues have in practice been considered an obstacle to achieving this goal. The emphasis on economic growth "at any cost" has resulted in the weakening of environmental policies and institutions, whether by stalling the development of effective and efficient policy and regulations, by relaxing enforcement of environmental requirements or by pursuing frequent and incomplete institutional changes. All these factors have contributed to significantly decreasing the effectiveness of the environmental regulatory framework.

. . .

In the absence of an effective environmental management system, and in the context of slower than- anticipated structural reform and modernization of technological processes, economic expansion is bringing back high pollution levels and maintaining the inefficient approaches of the past to the use of energy and natural resources.[43]

Over the last five years [between 1999 – 2007], a number of steps have been taken to build and strengthen the institutional system for environmental management in Ukraine. However, these actions may not have achieved the expected results because of the too frequent reorganizations of environmental authorities. These frequent changes of the Ministry of Environmental Protection (MENR] leadership have led to the dilution of the strategic vision and its coherence and have resulted in weakening the efficiency of staff's work, scattering of technical and human resources and inefficient use of financial resources.

Furthermore, fragmentation and an unclear division of responsibilities between agencies responsible for environmental protection and their subnational structures have led to overlaps in objectives, responsibilities, functions and operations. They have also contributed to inefficient use of financial, material and human resources. The decentralization of environmental management to elected government structures has not been accompanied by a clear division of responsibilities and has not resulted in the expected better use of resources.

Therefore, there is a need to strengthen the capacities of environmental administration in Ukraine and to review the institutional setting and the division of responsibilities. As a matter of priority, the [MENR] should review its staff, assess its capabilities, and allocate responsibilities according to objectives so that priority issues are addressed more effectively. This may mean that the Ministry and the Oblast Administrations concentrate their efforts on "core" public functions and a smaller number of priority issues and focus on solvable problems. The changes would also require adjusting the salaries of staff according to their responsibilities and introducing incentive-based structures to enhance employees' performance. All these steps can help ensure a fair, effective and transparent framework of policy-making and enhance the institutional capacity for implementation.[44]

While the concerns expressed by the Economic Commission are several years old and were not specific to oil and gas development, they are echoed in recent public concerns about shale gas development. While many of the concerns about shale gas focus on implementation of new,

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[43] United Nations Economic Commission for Europe Committee on Environmental Policy. 2007. Environmental Performance Reviews: Ukraine, Second Review, Environmental Performance Reviews Series No. 24, ECE/CEP/133 (hereinafter EC Review) at 21.

[44] EC Review at 31.

unproven (in Ukraine) technologies, others are based in a lack of confidence that the government will fairly and effectively implement existing laws. These concerns are exacerbated by recent changes in the PSA law that reduce the authority of local governments in the process and even limit the authority of the MENR to take action when national environmental laws are being violated under a PSA agreement.

Monitoring of basic environmental parameters, e.g., water and air quality, and environmental performance of enterprises has several functions that can benefit all stakeholders:

- Gauging the condition of the environment relative to established norms or to the quality of the environment in other countries;
- Directing/redirecting industry resources during development; and
- Ensuring compliance/enforcement of laws and agreements.

Some of Ukraine's laws include specific provisions to facilitate monitoring and enforcement, for example, requiring users of oil and gas strata to provide information to officials and to allow those officials access to facilities (Oil and Gas Law, Article 37).[45] Self-monitoring of emissions and discharges is required of large polluting installations with the specific requirements for monitoring (e.g., frequency) decided on a case-by-case basis. This self-monitoring is sporadically checked by independent laboratories and quarterly or annual reports of data are used to calculate emissions charges. Smaller industries are normally not required to monitor their emissions and generally report their emissions based on emission factors calculations. Industry monitoring of ambient environmental parameters is voluntary and uncommon.[46]

Some of the environmental protection statutes have explicit authorizations for monitoring or to require monitoring:

- The Environmental Protection Law tasks the MENR with organization of monitoring of the environment, establishment and functioning of the network of national automated ecological information, and analytical system of providing access to ecological information (Article 20 §c);
- The Environmental Protection Law requires state bodies of supervision over the safe performance of work in industry and in the nuclear energy sector, jointly with specially authorized state bodies of administration in the sphere of environmental protection and use of natural resources, systematically conduct inspections of the condition of ecologically dangerous facilities (Article 66);
- The Oil and Gas Law requires that a mining lease agreement include procedures for monitoring the implementation of the special authorization for use of oil and gas strata (Article 28).

The Economic Commission for Europe environmental performance review provides a summary of the air, surface water, ground water, soil, biodiversity and radioactivity monitoring program and data management system of Ukraine.[47] The review noted that, environmental monitoring in Ukraine is "seriously underfinanced"[48] and:

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[45] Law of Ukraine on Oil and Gas, No. 2665-III, 12.07.2001.

[46] EC Review at 37 (detailed description of monitoring in Ukraine).

[47] EC Review at 41-47.

[48] EC Review at 51 (data collected in 2005).

> Overall, the results of environmental monitoring are not efficiently used to assess environmental conditions, the driving forces behind changes in the environment, the effectiveness of environmental protection measures, nor are they used effectively for making decisions, elaborating policy or enhancing public awareness of the issues in Ukraine.[49]

Environmental enforcement authority is mainly lodged in the State Ecological Inspectorate (SEI) of the MENR. Among its responsibilities are organization and implementation of state control over compliance with:

- Environmental legislation and rational use of natural resources;
- Requirements of the state ecological expert examination;
- Environmentally related permits and licenses; and
- Requirements for environmental safety.

The territorial inspectors support the SEI, but also work independently in the oblast. In addition to the SEI, Ukraine uses public inspectors. These are appointed by the national or oblast environmental authorities and work on a voluntary, unpaid basis. NGOs can also participate in monitoring in special situations. Under the Environmental Protection Law, NGOs have authority to participate with the specially authorized state bodies on environmental protection in verifying the fulfillment of nature protection plans and measures by enterprises, institutions and organizations (Article 21 §c).

Inspectors use special reporting forms and must report the environmental problems noted as well as the level of sanction that results. Where evidence (from inspection or otherwise) indicates that the law has been violated, some laws explicitly authorize various government bodies to take action. For example, state officials may suspend or revoke an authorization under the Oil and Gas Law,[50] and the MENR and its local bodies can limit or suspend (temporarily) the activities of enterprises and facilities for a variety of reasons regardless of their jurisdiction and forms of ownership, except that this power may not be applied to businesses (investors) performing their activities under products distribution agreements (PSAs).[51] For PSAs, the Cabinet of Ministers must initiate any required suspension of activities. Use of economic sanctions is also possible, although fines are generally thought to be too low to act as meaningful deterrents.[52]

Citizens of Ukraine may also participate in enforcement, bringing actions against the government, enterprises and others for compensation for damages to health and property (Article 9 §i); and bringing court actions regarding actions, inaction or decisions of state and local governments and their officials regarding violations of ecological rights (Article 9 §j).

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[49] EC Review at 47.

[50] Oil and Gas Law, Articles 26-27: specifically authorized central executive agency for the geological exploration and sustainable mineral resource utilization may suspend a special authorization to use oil and gas bearing strata under various scenarios and at their discretion; or may annul the special authorization if the holder of the special authorization fails to correct the deficiencies (there are also other, stated reasons for annulment or suspension of the special authorization).

[51] Environmental Protection Law, Article 20 §h (if their operation is carried out in violation of the legislation on environmental protection and the requirements of the permits for the use of natural resources and exceeds the limits of emission of pollutants, impact of physical and biological factors and limits of emission of pollutants.)

[52] EC Review at 39 (see text for a detailed description of economic sanctions); Personal communications, Kyiv, November 2011 (Comments on the lack of deterrence of fines); see also EC Review at Chapter 5.

Regardless of the legal requirements and authorities for administration, effective administration, monitoring and enforcement depend on personnel that, in turn, depend largely on national priorities as they are manifest in government budgets. This study was not able to collect data on enforcement, but the Economic Commission 2007 evaluation of Ukraine's monitoring system and environmental performance concluded that overall enforcement in Ukraine is weak.[53] Review of Ukraine enforcement activities noted continuing problems with fragmentation and overlapping of different inspectorates' inspection activities. Joint inspections by different inspection services are one way to coordinate activities.[54] The review committee also recommended clarifying the responsibilities of various levels of government and providing regular training to inspection staff to improve their skills. A recent USAID report on biodiversity in Ukraine notes continued problems with enforcement, at least in administration of the special protected areas (PAs) in Ukraine (see Section 4.3.6). The authors of that report note recent government restructuring resulting in decreased number and authority of staff to carry out mandated responsibilities relevant to biodiversity conservation,[55] a severely underfinanced PA system,[56] and effective management of the PA system compromised by deficiencies in the skills set of staff.[57]

The quality of environmental self-monitoring is also low with few companies monitoring their emissions properly and even fewer using continuous, online monitoring. Improved monitoring can improve process performance, production, and environmental protection and pay off in economic terms.[58]

### 4.3.5. NATURAL AREAS, WILDLIFE, AND ENDANGERED SPECIES

Biological diversity provides social and economic benefits of three distinct kinds: ecosystem products, ecosystem services, and non-material benefits.[59] Conservation biologists recognize both primary (direct) and secondary (indirect) threats to biodiversity. Primary impacts result from

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[53] EC Review at 38.

[54] EC Review at 34.

[55] ECODIT at 22; GEF-UNDP, 2008. Strengthening Governance and Financial Sustainability of the National Protected Area System in Ukraine (hereinafter GEF-UNDP) ("The State Service [Department of Protected Areas, formerly called the State Service for Protected Areas], which is the main institution vested with the responsibility of managing the PA system, has 25 staff. These staff must fulfill a level and scope of responsibility comparable to that of a fully staffed ministry with a central unit and local branches. The State Service relies on regional branches of the Ministry of Environment to implement its mandate. Further, the reporting line between the central-level State Service and oblast level departments of the Ministry of Ecology is blurred. As a result, even though the MENR has delegated PA management at the central level to State Service, it has no real authority to supervise oblast departments, greatly inhibiting its ability to enforce protected area policies at the oblast level.")

[56] ECODIT at 23 (There is a chronic shortage of resources for active habitat management, scientific research, awareness-raising, capital items needed to support enforcement, and rewarding salary scales for PA teams. The Ukrainian Protected Areas Act allows PAs to establish entry fees and impose user charges on resource-users, and retain 100% of the revenues raised from charges on these activities. Legal provisions are not put to good use because PA management planning has not been underpinned by business planning. There is a lack of capacity and experience within the Ukrainian institutions responsible for PA management to systematically tap alternatives to government funding." Current financing flows to PAs cover only up to 60% of what has been projected as needed to properly implement PA management plans.)

[57] GEF-UNDP

[58] EC Review at 40.

[59] USAID. 2005a. Biodiversity Conservation: A Guide for USAID Staff and Partners. Sept. 2005. http://pdf.usaid.gov/pdf_docs/PNADE258.pdf ; Byers, Bruce A. 2008. Ecosystem Services: What Do We Know and Where Should We Go? ARD, Inc. http://ncseonline.org/Conference/Biodiversity/Resources/Breakout%2029/Ecosystem_Services_Jan._2008_update.pdf. Values of each of these types of benefits of Ukraine's biodiversity are summarized in the ECODIT report at 13.[59] Zarko Stefanovski "Ukraine Oil and Gas Sector Overview", December 2005

operational decisions and the activities of project personnel. Secondary impacts occur because of the presence of the project and tend to result from government decisions and the actions and practices of nearby communities or immigrants.[60] Of the five main types of threats to biodiversity,[61] shale gas development can help reduce one threat, but may contribute to biodiversity loss through the other four. Looking first at the benefits of long-term use of shale gas, development can help decrease the threat to biodiversity by decreasing the potential or severity of macro-environmental change, such as climate change. (See Section 4.1) However, shale gas development could contribute to loss of biodiversity through the other four mechanisms:

- **Conversion, loss, degradation, and fragmentation** of natural habitats could occur with all land disturbances connected with construction of exploration and production facilities.
- **Overharvesting or overexploitation** of particular species may be an indirect impact of increased employment in the area leading to increased legal and illegal exploitation of species through hunting and gathering.
- **Non-native species (weeds) introduction** can harm native habitats and species and can be exacerbated with construction activities for well pads, roads, pipelines, and other facilities. [62]
- **Pollution and contamination** (air, land and water) that harms natural habitats or species may be increased in the short-term with construction and drilling and in the long-term with production activities, including the transport of materials to and away from the project sites.

The potential shale gas development areas of Ukraine could impact biodiversity in parts of most of its biogeographical areas and the freshwater ecosystems, especially the Western Forest and Carpathian Mountain zones in the Carpathian Basin and the Polissya, Forest-Steppe and Steppe zones in the Dnieper-Donets Basin. Freshwater ecosystems could be impacted in both potential development regions. Most of the threats to biodiversity from shale gas development are similar to those from conventional oil and gas development with the exception of an increased time of potential disturbing activities related to the well completion process, more long-term impacts of noise from compressors (disturbance of wildlife), and potential increase in truck traffic due to increased use of water for hydraulic fracturing (short-term impacts) and disposal of increased flowback and produced water volumes (long-term impacts). Most of these threats can be minimized through careful siting of facilities, minimizing the area disturbed by construction, and use of advanced technologies and best management practices to control the extent and intensity of impacts during exploration, field development, production and abandonment. These practices are generally described in other sections of this document related to resource protection (e.g., air,

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[60] The Energy and Biodiversity Initiative. No date. Negative Secondary Impacts from Oil and Gas Development. http://www.theebi.org/pdfs/impacts.pdf ("secondary" does not imply less important or significant, but rather recognize timing and scope issues. (EBI Secondary)

[61] ECODIT at 18

[62] EBI Secondary at 2 ("Non-native soil, seeds, insects and other animals may be directly introduced to an area through the transportation of equipment, materials and supplies for the project and its associated services, or through revegetation programs. Similarly, people who move into a project area, either for employment related to the project or to pursue their own economic activities, may bring with them non-native plants and animals. In addition, the problem of "edge effects" can arise when land-clearing allows plant species to spread into and colonize areas that were previously inaccessible to them. Weeds, grasses and other aggressive species, even if native to the region, can begin to crowd out other plant species that had been previously protected by forest cover, bringing with them certain native insect and animal species that could not thrive in the forested area.")

water). Designing mitigation measures for specific elements of the ecosystem will be important when the proposed location of development is known.

Key issues and control measures concerning wildlife and endangered species are listed in

Table 7. An extensive table of good practices to be used during exploration (seismic and drilling), drilling/completion, production, transmission, and decommissioning (reclamation) are outlined in Appendix 4.[63]

[63] The Energy and Biodiversity Initiative. No date. Good Practice in the Prevention and Mitigation of Primary and Secondary Biodiversity Impacts.

**Table 7. Key Issues and Control Measures concerning Wildlife and Endangered Species**

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Lack of information about existing wildlife | All | Develop and implement a Wildlife Monitoring/Protection Plan. |
| | | Develop and implement an Environmental Awareness training program for all workers. |
| | | Perform wildlife surveys on annual basis. |
| Wildlife Fragmentation | All | Avoid activities that create barriers to big game and livestock seasonal movements. |
| | | Adhere to restrictions during critical wildlife periods (such as nesting or fawning). |
| | | Require operator to develop and employ Best Management Practices for surface disturbance to reduce habitat impacts. |
| | | Restrict operations during mating and migration seasons in certain habitats. |
| | | Require interim and final reclamation of well pads and other facility locations. |
| Wildlife mortality | All | Advise personnel regarding speed limits and reclaim roads. |
| | Drilling/Completion | Fence and cover all pits with netting. Document mortality observed in pits and adjust practices to eliminate impacts. |
| Wildlife Disturbance | All | Avoid disturbance in sensitive habitats. Select well locations, roads and pipeline routes to avoid disturbances of high wildlife value. |
| | Drilling/Completion | Avoid drilling and completion activities during periods of intensive wildlife usage. |

While these practices can reduce the impacts of shale gas development on biodiversity, baseline data are essential. Additional science-based characterization of important landscapes, habitats and corridors are necessary, first, to declare unique and/or sensitive areas off limits to drilling and support infrastructure and, secondly, to provide a baseline of data against which to evaluate the impacts of development. Follow-up monitoring and reevaluation of impacts are necessary to assure that the best technologies and management practices are minimizing primary impacts and to identify the secondary impacts that may not begin to occur until after development is initiated.

Ukraine has begun the process of inventorying and protecting special species and habitats through the Ukraine Nature Reserve system (Figure 20 and Figure 21), but the lands of Ukraine have not been well mapped or characterized. The protected area system was established in 1992 by the Law on the Ukraine Nature Reserve Fund, which defined a

national system of protected areas for an independent Ukraine.[64] This law defines eleven categories of protected areas (PAs), only five of which form the core of the protected area system (Table 3).[65] The national system of protected areas is currently composed of more than 7,000 protected areas covering around 2.8 million hectares, somewhat more than 5% of the national territory. There is a plan for a further rapid increase to 10.4% by 2015. Ukraine has many protected areas registered through its participation in international agreements. The Primeval Beech Forests of the Carpathians is a UNESCO Nature World Heritage Site; there are six UNESCO Man and the Biosphere (MAB) Program Biosphere Reserves; and 33 Wetlands of International Importance registered under the Ramsar Convention.[66]

National forest lands have an important role in conserving biodiversity in the forested biogeographic regions of Ukraine occurring in both the eastern and western shale areas. The total area of Ukrainian forest lands in the "Forest Fund," managed by the State Agency of Forest Resources (SAFR) – formerly called the State Forestry Committee (SFC) – is around 7.5 million hectares. This represents about 70% of Ukraine's forest lands, with the remainder under the control of other agencies, such as the Ministry of Agrarian Policy of Ukraine, Ministry of Defense, and Ministry of Emergencies and Affairs of Population Protection from the Consequences of Chernobyl Catastrophe, and MENR. Within the forests managed by SAFR, about 1.2 million hectares are set aside as forest protected areas, or about 15.4% of the Forest Fund lands as of January, 2011. These forest protected areas are part of the protected area system that was summarized in Table 3.

The infrastructure for monitoring impacts on biodiversity is limited as information is limited. Land use maps are not publicly available in Ukraine at this time. Such maps are needed for assessing the status of biodiversity at the ecosystem level and effective biodiversity conservation planning, because they allow actual land use and cover to be compared with potential natural vegetation. Accurate maps showing the distributions and ranges of rare plant and animal species do not exist. Furthermore, there is no national system of biodiversity monitoring in Ukraine.[67] A new public initiative has been recently started on biodiversity monitoring http://www.biomon.org/en/. Ukrainian laws (e.g., the Law on Flora, Law on Fauna) state that species should be monitored, but there is no statement that data should be provided to a database of species. An electronic database of animal species is being developed by the Institute of Zoology; an electronic database of plant species has not yet been started.[68]

### 4.3.6. LAND USE AND POTENTIAL IMPACTS IN PROSPECTIVE BASINS

Estimating the impact of shale gas development on agriculture is difficult since the precise area of development has not been determined. Based on the type of agriculture in the two areas,

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[64] ECODIT citing Protected Areas of Ukraine, http://en.wikipedia.org/wiki/Protected_areas_of_Ukraine viewed 19 April 2011); Law on the Ukraine Nature Reserve Fund, June 16, 1992, No. 2456-12.

[65] ECODIT, Table 5.1. Sources for this table are: State Agency for Protected Areas, April 2011 GEF-UNDP, 2008; Categories of Protected Areas of Ukraine: http://en.wikipedia.org/wiki/Categories_of_protected_areas_of_Ukraine IUCN Protected

[66] ECODIT at 32.

[67] Gasso V. Y. No date. Ukraine National Review: World Biodiversity and European Taxonomy. http://www.biostrat.org/NR-T&B_Ukraine.pdf

[68] ECODIT at 4; See also, Biostrat: Developing the EU Biodiversity Research Strategy at http://www.biostrat.org/

however, it is likely that shale gas development will have more impact on commercial agriculture in the Dnieper-Donets Basin and more impact on small family farms in the Carpathian Basin. Impacts to agriculture will be similar to some of the physical impacts to natural areas described in Section 3.3.6 (conversion/degradation/fragmentation of lands, introduction of weeds, and pollution or contamination of soils) and to the community impacts described in Section 3.3.8 (dust, noise, traffic, road damage, etc.) Whether shale gas development will impact water used for agriculture will depend on the source and quality of the water used for well completions and how flowback and produced water are disposed of during development and production activities.

Impact in both areas will depend on the extent of land disturbance and the speed and quality of reclamation. If shale gas development in the Dnieper-Donets Basin is confined to those areas already impacted by conventional oil and gas development, impacts to commercial agriculture will be minimized.

### 4.3.7. LOCAL GOVERNMENT AND COMMUNITY IMPACTS

A listing of impacts to local government and communities is, at this point, speculative. No-one knows for sure how productive the resource will be, precisely where the most productive areas will be located, and what terms the production sharing agreement (PSA) will contain. The PSA is required to detail the areas to be developed and a work plan that will provide a schedule when the areas will be developed. The PSA will also include clauses referencing the laws and conditions that will apply to the industry. Until the PSA is finalized, local governments may not know what role they are expected to play in monitoring and regulating the development of shale gas within its jurisdiction.

Because so much of this is speculative at this point, we can only present some of the most common impacts of shale gas development in the US. The impacts to local governments and communities in the US that are dealing with shale gas development can be broken down into the following categories: 1) Transportation, 2) Environmental Impacts, 3) Social and Economic Impacts, and 4) Local Government Staff and Service Requirements.

This section is also going to assume that exploratory wells in Ukraine will be successful and lead to full well field development. Full well field development means that individual well locations are accessed and pads are created. One or more wells may be drilled from an individual well pad then the rig is moved to another nearby location where the process is repeated. Once several wells are drilled, they can be put into production by connecting them to refining equipment, gathering lines, compressor stations, and ultimately, a main pipeline to transport the gas to market.

Some of these impacts may be mitigated, depending on the conditions placed on the industry by the PSA. Many of the impacts detailed below can also be mitigated through appropriate planning and the use of best management practices.

Many of the impacts brought about by rampant oil and gas development in the US will be reduced if the PSA requires staged development of the well field. Staged development would restrict the industry to developing the gas resource in one or two areas at a time rather than allowing many areas to be developed at once. Staged development is more likely in Ukraine because PSAs will likely give one company development rights to a large area rather than allowing several companies to rush to develop the resource. Staged development will also be a natural consequence of a shortage of drilling rigs in Ukraine.

#### TRANSPORTATION IMPACTS

Key issues and control measures concerning transportation impacts are listed in Table 8.

**Table 8. Key Issues and Control Measures related to Transportation Impacts**

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Road usage – truck traffic | Drilling/Completion, Production/processing | Use pipelines for transport of water whenever possible. |
| Municipality traffic | All | When feasible, heavy equipment and trucks should use bypass routes to avoid municipalities. |
| Disturbance and visual impact of roads | All | Combine infrastructure planning with roadway planning to avoid separate utility corridors. Complete transportation plans that minimize disturbance and visual impact. Consider topographic contours when constructing new roads. |
| Dust | All | Control transportation-related dust throughout the duration of the project. Develop and implement a dust abatement program. |
| Road Maintenance | All | Ensure all roads are adequately maintained for the projected increase in use. |
| Safety awareness | All | Establish and adhere to speed limits, other road safety rules/regulations. |

The effect shale gas development has on local transportation infrastructure will likely be one of the greatest impacts to local governments and communities in the shale-producing regions of Ukraine. The development of shale gas is expected to occur in rural areas that are accessed by roads that were not designed for the volume of traffic, or the weight of the heavy trucks, needed to drill and complete a well. Many of these impacts can be mitigated through planning and increased road maintenance and road reconstruction.

Many roads in Ukraine are not designed for the heavy volumes of traffic needed to construct a well, in particular secondary roads in rural areas. Based on the experience in the US, shale gas development in Ukraine is likely to take 2-4 million gallons of water for the hydraulic fracture of a well.[69] Most of this water will be trucked onsite. An average water truck carries 5,000 gallons of water[70] so an average well may need 800 truck trips for delivering water. The additional trips for bringing in sand, chemicals, and setting up and removing the drilling rig will total well over a thousand heavy truck trips and over 800 light truck trips.[71] The transport of sand, chemicals and water will take place over the course of the 4-5 weeks that it takes to drill the horizontal well, at a rate of up to 50 truck trips per day.

[69] EPA, Office of Research and Development, Plan to Study the Potential Impacts of Hydraulic Fracturing on Drinking Water Resources, November 2011, Page 22. *Available at:* http://www.epa.gov/hfstudy/HF_Study__Plan_110211_FINAL_508.pdf

[70] Radisav D. Vidic, Ph.D., PE, Marcellus Shale Natural Gas Stewardship: Understanding the Environmental Impact, A Temple University Summit, March 18, 2010. *Available at:* http://www.temple.edu/environment/NRDP_pics/shale/presentations_TUsummit/Vidic-Temple-2010.pdf

[71] New York State Department of Environmental Conservation, Revised Draft - Supplemental Generic Environmental Impact Statement 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, September 7, 2011, Pg. 6-302. *Available at:* http://www.dec.ny.gov/energy/75370.html

Many of the roads in the region of shale gas development were not designed for heavy trucks and are already in poor condition. The weight of the heavy trucks needed to haul water, materials, and drilling equipment is likely to cause even more damage to those roads. Heavy trucks generally cause more damage to roads and bridges than cars or light trucks due to the weight of the vehicle. A general rule is that a single large truck is equivalent to the passing of 9,000 automobiles.[72]

The impacts to the local community from the increase in traffic congestion can be mitigated through choosing appropriate locations for the gas wells and facilities and through thoughtful planning of transportation haul routes. Local governments will want to make sure that truck traffic is routed away from residential areas. Other mitigations for reducing traffic congestion are more expensive, requiring the construction of passing lanes, acceleration and deceleration lanes, and intersection signalization or reconfiguration.

The condition of the roads will also likely have to be addressed. Some roads and bridges may have to be maintained more often, or even replaced, to accommodate the weight of the heavy trucks used by the industry. There are many instances in the US where the industry has negotiated to compensate local governments for road damage that occurs as a result of their activities. Alternatively, the industry may elect to negotiate road maintenance and repair agreements to ensure that damage to roadways are repaired and that the cost is absorbed by the drilling enterprise rather than the local government.[73]

Best management practices also can play a role in reducing impacts of shale gas development. Truck traffic can be greatly reduced by recycling and reusing water on a multi-well pad, or by piping water to the location rather than using water trucks. Once the well goes into production, remote monitoring technologies can replace the need for regular trips to visit well pads.

In addition to the impacts described above, there may be additional trucks on Ukraine roads carrying hazardous materials, such as hydraulic fracturing water or chemicals used for hydraulic fracturing or drilling. Local governments and communities may be impacted by traffic accidents that lead to accidental human exposure, spills, contamination of ground water sources, and increased costs to local governments in coordinating emergency response.

### ENVIRONMENTAL IMPACTS

This section is not meant to be a reiteration of environmental impacts that are likely as a result of shale gas development. Rather, it will discuss how changes to the environment brought about by shale gas development may affect communities and local governments.

Short-term impacts to water quality and quantity, air quality, and the land are inevitable parts of shale gas development. The amount of deterioration of the environment, and the longevity of these environmental impacts, will depend on how much shale gas development is allowed, where it is allowed, and if environmental safeguards and best management practices are required in the PSA or by the appropriate oversight agency.

## Water Quality and Quantity

Key issues and control measures concerning water issues are listed in Table 9.

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[72] *Id.* at 6-311 (citing Alaska Department of Transportation and Public Facilities 2004).

[73] U.S. Department of Energy, Modern Shale Gas Development in the United States: A Primer, April 2009, Pg. 50. *Available at:* http://www.netl.doe.gov/technologies/oil-gas/publications/epreports/shale_gas_primer_2009.pdf

**Table 9. Key Issues and Control Measures Related to Water Use and Quality**

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Isolation of fresh water zones | Drilling/Completion | Achieve isolation of fresh water zones prior to deepening of the well. Ensure that cementing/surface casing operations are adequate. |
| Surface water contamination | All | Add monitoring stations to accommodate specific areas of concern |
| Surface water contamination | All | Use adequate setbacks from streams and sources. |
| Surface water contamination | Drilling/Completion | Apply closed mud system to alleviate water accumulation in pits. |
| Ground water contamination | Drilling/Completion, Production/Processing | Survey all nearby water wells prior to operations, during operations and afterwards. |
| Flood Plains – contamination of surface waters from release of chemical pollutants in a flood event | All | No well pads or access roads for high-volume hydraulic fracturing permitted within 100-year floodplains |
| Potential leaks | Production/Processing | All production facilities with the potential to leak should be placed within appropriate containment. |
| Use of hazardous materials | All | All proposed actions should be analyzed for their potential to release hazardous materials into the environment. |
| Disruption of natural hydrology | All | Develop and implement a Stormwater Management Plan |
| Volume of water used | Drilling/Completion | Develop and implement a Water Management plan that includes water sourcing/use/discharge to minimize the volume of water used. |
| Composition of reclaimed water | Drilling/Completion, Production/Processing | Reclaimed water may not be clean enough for potable water uses within the community; however, there may be a use for the water within the operations thereby reducing the overall water needs of the region. |

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Contamination of freshwater wetlands from accidental release of hydraulic fracturing fluids, chemicals or fuel | Drilling/Completion | Specify setbacks between fuel tanks and wetlands at a mandatory 500 ft. (150 m). Require secondary containment for any fuel tank. Require site specific analysis of the plan when project is within 100 feet (30 m) of a freshwater wetland > 12.4 acre (5 h) in size or of unique local significance. Authorize location and timing of activities/facilities on site-specific basis. Require replacement of lost wetland acreage. |

A major concern of most communities faced with shale gas development is what effect, if any, it will have on their water quality. As described in "Water Use and Acquisition" (below), the majority of Ukraine's clean drinking water comes from underground aquifers rather than from surface water.[74] Some of the shallow water tables have been contaminated due to pollution entering through abandoned wells, agricultural practices, activities of mining companies, and past oil and gas activities.[75]

Additionally, natural gas is largely methane, a naturally occurring compound of carbon and hydrogen. When burned, these elements recombine with oxygen to create carbon dioxide and water. The amount of water that is produced from combustion of natural gas can be calculated and compared to the amount of water used to produce it. A typical natural gas well requires five million gallons (19,000 kilolitres) of water. If the assumption is made that 80 percent of it stays underground, there is a total of four million gallons (15,200 kilolitres) removed from the water cycle. That same well can be expected to produce as much as two billion cubic feet of gas over 10 years. For every one billion cubic feet of gas, 11 million gallons (41,800 kilolitres) of water is added to the atmosphere from combustion. So, over the 10 years a net increase of 18 million gallons (68,400 kilolitres) of water is added to the water cycle.

Because of the state of its water supplies, Ukraine is likely to require the oil and gas industry to obtain water needed for drilling and hydraulic fracturing from surface water sources. While the amount of water required to drill and hydraulically fracture an individual well seems great, the amount of water required for gas development is quite small relative to such other uses as agriculture. The depletion of surface water is not likely to pose a threat to other surface water uses, particularly if the industry is required to recycle its water, rather than disposing of the produced water and flowback water after each well.

As described in the "Water Use and Acquisition" (see below), as long as the well is properly sited, constructed, tested, and monitored, there is very little threat to ground water contamination from the drilling and hydraulic fracturing process. Spills and leaking pits are also a threat to shallow

[74] The Regional Report on the State of the Environment in Lviv Region in 2008, §4.2.

[75] *Id.* at §4.1

ground water but these threats can be reduced through the use of closed-loop systems, establishing a water quality baseline, and testing for impacts to ground water prior to drilling. Produced wastewater from oil and gas production must be either treated or disposed of properly. Appropriate regulations need to be in place and enforced.

Surface water quality could also be adversely affected by increased sediment that is released from the creation of well pads and new roads used to access the resource. These impacts are also easily remedied, and can even be eliminated, through siting well and road locations away from surface water and the application of simple best management practices for storm water protection.

### Water Use and Acquisition

Drilling and hydraulic fracturing of a deep, horizontal shale gas well may require between two to five million gallons (7,600 to 19,000 kilolitres) of water.[76] The volume of drilling water required per well is dependent upon the drilling practices a well as the location. The volume of water may vary substantially between wells. In addition, as technologies and methods improve over time, the volume required may decrease. In the United States the volume of drilling water per well varies from approximately 60,000 gallons (228 kilolitres) for the Fayetteville Shale in Arkansas to about 1,000,000 gallons (3,800 kilolitres) for the Haynesville Shale in Louisiana. Hydraulic fracturing requires an average of about 4.5 million gallons (17,100 kilolitres) of water.

The five million gallons (19,000 kilolitres) of water needed to drill and fracture a typical deep shale gas well is equivalent to the amount of water consumed by:[77]

- New York City (with a population of over 8 million, equivalent to nearly 1/5 of Ukraine's population) in approximately seven minutes
- A one Gigawatt coal fired power plant in 12 hours
- 7.5 acres (0.03 km$^2$) of maize in a season

In the Lviv oblast, the main source of water supply for households and industry is from underground sources. Surface water use is limited, mostly for fishery, technical water supply enterprises and in mountain areas, for drinking water. The main sources of surface water pollution are untreated/undertreated wastewater and lack of protected coastal areas.[78]


**Figure 25: Dniester River Basin**

[76] Satterfield, J., M. Mantell, D. Kathol, F. Hiebert, K. Patterson, and R. Lee. 2008 Chesapeake Energy Corp. *Managing Water Resource's Challenges in Select Natural Gas Shale Plays*. Presented at the GWPC Annual Meeting, September 2008.

[77] Hydraulic Fracturing Facts. http://www.hydraulicfracturing.com/Water-Usage/Pages/Information.aspx

[78] Bodnarchuk, T.: *Baseline Assessment of Water Contamination in Ukrainian Part of Western Bug Basin.* 2009. http://europeicid2009.org/media/trudy/Bodnarchuk_Ukraine.pdf

The Dniester river basin, which includes 7 oblasts, is vitally important for Ukraine. The Dniester is a transboundary river, which starts in the Ukrainian Carpathians, flows through Moldova and reaches Ukraine again near the Black Sea. The upper and lower reaches of the Dniester flow within Ukraine. Over 5 million people in the Ukraine live in the Dniester River basin. The Dniester is currently facing environmental problems due to pollution and the current water flow regime.[79]


**Figure: 26 Dnipro River Basin**

The Dnieper is an important navigable waterway for the economy of Ukraine,[80,81] having several dams and hydroelectric power plants that generate approximate 10 percent of the electricity for the Ukraine. The drainage basin is large, covering about the middle two-thirds of the country as seen in Figure: 26.

Water withdrawals during periods of low stream flow could affect aquatic life, fishing, recreational activities, municipal water supplies and other industries such as power plants and need to be appropriately planned. For example, operators may make use of seasonal changes in river flow to capture water when surface water flows are the greatest. Operators will need to plan for their water withdrawals from surface waterways so as to not affect adversely other competing uses for the water or minimal flow requirements for navigation, wildlife, etc. Such water use planning is expected to be included in the comprehensive plan filed by each operator for drilling and production sites.

Water for shale gas development is needed over a relatively short period of time, when the gas wells are being drilled and stimulated. It should take approximately 3 to 4 weeks to prepare the well site (the pad), about two weeks to drill the vertical section of the wellbore, roughly 4 to 5 weeks for the horizontal drilling, a week for the hydraulic fracturing process and another week or so to hook up the pipeline and well site equipment. Water is occasionally used for dust suppression during site preparation. Water is used during the drilling of the vertical section of the wellbore, however, on occasion some of this section may be drilled just with pressurized air. The horizontal drilling is often done with a synthetic oil based mud, so, little water is used during that time period.

For the hydraulic fracturing process, water is brought to site ahead of the treatment. Often it is stored in a pond that will supply water for several different wells.

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[79] OSCE/UNECE Project: Transboundary Co-operation and Sustainable Management of the Dniester River: Transboundary Diagnostic Study for the Dniester River Basin, November 2005. http://www.osce.org/eea/38320

[80] GEF Project Brief: *Belarus, Russia, Ukraine: Preparation of a Strategic Action Programme (SAP) for the Dnieper River Basin and Development of SAP Implementation Mechanism*, http://iwlearn.net/iw-projects/460/project_doc/dnieper-river-basin-environment-programme-project-brief-45p-328k.pdf

[81] Canadian Association on Water Quality Monograph Series No. 6: *Conservation of Biological and Landscape Diversity in the Dnipro (Dnieper) River Basin,* 2005. http://idl-bnc.idrc.ca/dspace/bitstream/10625/28928/1/121462.pdf

Water may be recycled from the flow-back and produced water from existing wells with either surface water, public water or well water being used for making up the difference. Water for the drilling and hydraulic fracturing activities may come from surface water bodies such as rivers, creeks and lakes, from municipal water plants or industrial discharge water, ground water or re-used produced water. It is possible that the water required for the operation may be non-potable, provided sufficient testing concerning compatibility issues are addressed.

### Waste-Water Well Injection

Shale gas reservoirs contain saltwater along with the natural gas. This saltwater, which accompanies the gas to the surface, may be disposed by injecting it into underground porous rock formations not productive of oil or gas, and sealed above and below by unbroken, impermeable strata. Additional resources may be needed to monitor and regulate waste-disposal injection wells.

Construction design for water injection wells must adequately confine injected fluids to the authorized zone as well as prevent the migration of fluids into underground sources of drinking water (USDWs). Injection wells are drilled into geologic rock formations that will accept the injected fluids. The fluid pressure, fracture pressure, and geological characteristics of the injection zone must be considered when evaluating a zone that may be suitable for injection. Confining zones generally overlie the injection zones. Confining zones are non-permeable zones that add to the environmental security of the well by restricting the upward movement of the injected fluids.

New injection wells are drilled and cased with steel pipe. The pipe is cemented in place to prevent the migration of fluids into USDWs. The surface casing is commonly set below the base of the lowermost USDW and cemented back to the surface, preventing the movement of fluids into USDWs. The cement is placed behind the long string casing for several hundred feet above the injection zone to prevent injected fluids from migrating upward into the USDW. The long string casing and cement sheath are perforated in the injection zone to allow for fluid emplacement. A typical injection well also has an interior string of pipe called tubing through which injection takes place. A packer is used to isolate the injection zone from the casing above the packer, and also helps to facilitate the detection of any leakage. A typical water disposal injection well is illustrated in Figure 27.[82]

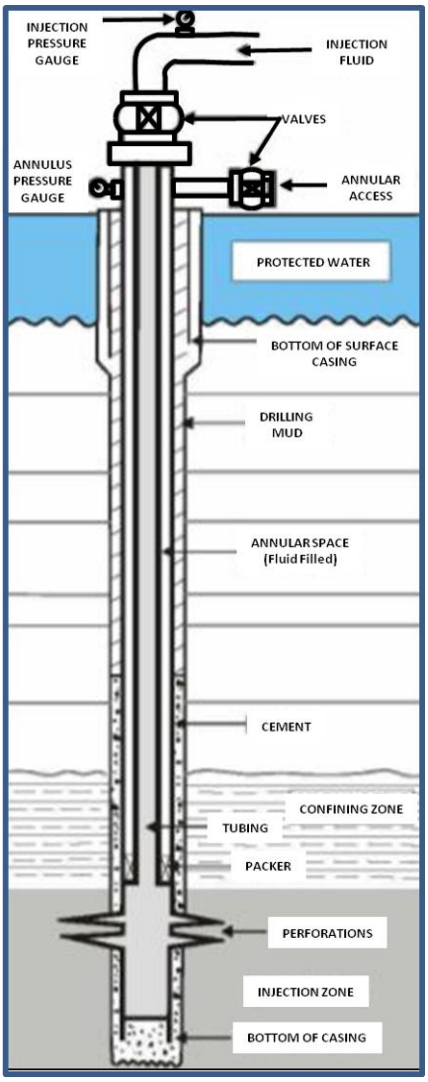


**Figure 27: Typical Water Disposal Injection Well**

Injection well operations must be directed in such a manner as to prevent the contamination of USDWs and to ensure fluid emplacement and confinement within the

[82] *Illustration Source: New Mexico Oil Conservation Division, Energy, Minerals and Natural Resources Department, New Mexico's Underground Injection Control (UIC) Program, Class II Well Facts*

authorized injection zone. Typically, the oil, gas and salt water are separated at the oil and gas production facility. The salt water is then either piped or trucked to the injection site for disposal. There, the salt water is transferred to holding tanks and pumped down the injection well.

Continuous ground water protection is accomplished by testing and monitoring the injection wells after placing them in service. Injection pressures and volumes are monitored as a valuable indicator of well performance. Downhole problems normally can be recognized through the monitoring of injection well pressures. Effective monitoring is important so that corrective action can be taken quickly to prevent endangerment of USDWs.

In the United States, the federal Underground Injection Control (UIC) program is designed to prevent contamination of underground sources of drinking water. Most injection wells associated with oil and gas production are used to inject water and other fluids (for example, liquid $CO_2$) into oil- and gas-bearing zones to enhance recovery, or they may be used to dispose of produced water. The regulation specifically prevents the disposal of waste fluids into USDWs by limiting injection only to formations that are not "underground sources of drinking water." The injected fluids must not endanger, or have the potential to endanger, a current or future public water supply. The UIC requirements that affect the siting, construction, operation, maintenance, monitoring, testing, and, finally, closure of injection wells have been established to address these concepts. All injection wells require authorization under general rules or specific permits. In the 30 years of the Safe Drinking Water Act (SDWA), nearly 720 billion barrels (114.5 billion kilolitres) of brine have been successfully disposed of by injection.[83]

According to Article 72 of the Oil and Gas Law of Ukraine, enterprises, institutions and organizations that produce oil and gas shall return oil field waters to subsurface horizons. Enterprises constructing and operating disposal wells require a subsoil use permit, but not necessarily a special water permit if the injection zone is of mineralized water unfit for household needs. See Volume II, Section 2.5.4 for more detail.

## Flow-Back and Water Produced from Wells

Produced water and flow-back water are produced with the natural gas. The flow-back water refers to the water used during the hydraulic fracturing process that returns to the surface. Produced water refers to the water that exists in the formation containing the gas that is produced over the life of the well.

### *Produced Water*

Produced water is produced during the lifespan of a well and the quality and quantity may vary significantly by region. Produced water quality may also vary tremendously from brackish (not fresh, but less saline than seawater) to saline (similar salinity to seawater) to brine (having salinity levels several times higher than seawater). Depending on the formation being developed, produced water quality can vary tremendously even from the same formation.

There are two sources of produced water that is brought to the surface during hydrocarbon production.

1. Some proportion of water used during the hydraulic fracturing process will be produced back as flow-back water.
2. Formation water contained in the shale reservoir will also be produced.

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[83] Groundwater Protection Council: *Ground Water Report to the Nation: A Call to Action,* http://www.gwpc.org/calltoaction/.

The produced water, the combination of flow-back water and formation water, can be one of the largest waste products, by volume, that will need to be managed and disposed of by the industry. These produced waters will contain a complex mixture of inorganic (dissolved salts, trace metals, suspended particles) and organic (dispersed and dissolved hydrocarbons, organic acids) compounds, and in many cases, residual chemical additives (scale and corrosion inhibitors) that are added during the hydrocarbon production process.

### *Flow-back Water*

The use of water for hydraulic fracturing is a necessary step to complete shale wells and initiate production. Typically, an average of about 4.5 million gallons (17,100 kilolitres) of water may be used to hydraulic fracture a well. Sand, used as the proppant, and chemicals are added to the water that is pumped downhole during the hydraulic fracturing treatment. The flow-back water will contain salts and constituents that must be managed in an environmentally responsible manner. Not all fracturing fluids injected into the geologic formation during hydraulic fracturing are recovered. Estimates of the fluids recovered range from 5-50% of the volume injected depending on the site. The amount of water recovered will not be known until the shale has been put on production. For comparison, in the United States, the recovery in the Marcellus is 10 to 20%, in the Haynesville it is 5%, and in the Barnett it is 50%.[84]

### *Produced Water Treatment*

Treatment technologies and processes depend on final disposal and particular field conditions. Techniques may include combinations of gravity separation, mechanical separation and chemical treatment. Processes may require a multistage system containing various technologies in series to meet injection or discharge requirements.

### *Environmental Considerations*

To minimize environmental risks associated with residual chemical additives in the produced water stream, production chemicals should be selected carefully by taking into account their volume, toxicity, bioavailability and bioaccumulation potential. If evaporation ponds for produced waters are used, they should be constructed and managed to minimize risks to the environment.

### *Reuse of Produced Water*

Produced water may be reused in other hydraulic fracturing treatments. Due to the water loss during the hydraulic fracturing process, large amounts of makeup water may be required for the development of each new shale well. Obtaining the makeup water needed may be an issue as the amount of water needed is often not available at the desired time due to stream flow limitations and regulatory restrictions. One solution to the water supply problem is to chemically treat abandoned mine drainage (AMD) to a quality suitable for use as makeup water. AMD often has a pH below 5.0, which leaches heavy metals from surrounding rocks and kills fish and other aquatic species in its path. For makeup water use, the AMD water may be treated to remove anything that would cause plugging of the shale factures; constituents such as suspended solids, aluminum, barium, calcium, iron, magnesium, manganese, and strontium must be removed.

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[84] Arthur, J.D., Bohme, B., Layne, M.: *Hydraulic Fracturing Considerations for Natural Gas Wells of the Marcellus Shale,* Presented at the Groundwater Protection Council 2008 Annual Forum, Cincinnati, Ohio, September 21-24, 2008. http://www.dec.ny.gov/docs/materials_minerals_pdf/GWPCMarcellus.pdf

### *Water Treatment and Waste Disposal*

Produced water is an inescapable fact of life for oil and gas production that offers both challenges and opportunities. Common methods for produced water management have been disposal by injection into the producing reservoir to maintain pressure or enhance recovery, or via underground injection into a salt water disposal well. Approximately 98% of the produced water is disposed of into salt water disposal wells or injection wells in the U.S.[85]

Treatment technologies can be divided into two general categories, dependent upon the type of pollutant to be removed. Table 10 lists treatment technologies designed to remove salt content. Table 11 lists treatment technologies to remove oil, grease and other organic materials.[86]

**Table 10. Treatment Technologies to Remove Salt Content**

| Technology | Subcategory | Pros | Cons |
|---|---|---|---|
| Membrane processes | Microfiltration, ultrafiltration, and nanofiltration | Good pretreatment steps for more advanced processes like reverse osmosis (RO). Technologies operate at lower pressure and lower cost than RO. | These levels of filtration cannot remove most salinity.<br>Potential for membrane fouling.<br>Sensitivity to fluctuating water quality. |
| | Reverse Osmosis (RO) | RO can remove salinity (up to about 50,000 mg/L TDS). | Requires pretreatment and regular membrane cleaning. Not suitable for high-salinity flowback water. Potential for membrane fouling. Sensitivity to fluctuating water quality. |
| | Other (e.g., electrodialysis, forward osmosis) | May offer future treatment opportunities. | Have not been used in full-scale treatment systems yet.<br>Potential for membrane fouling.<br>Sensitivity to fluctuating water quality. |
| Thermal Treatment | Distillation | Can process high-salinity waters like flowback.<br>Generate very clean water as one product (can be re-used). | High energy usage and cost.<br>Generates concentrated brine stream that requires separate disposal.<br>Potential for scaling. |

[85] *ibid.*

[86] *Management of Produced Water from Oil and Gas Wells*, Paper #2-17, Working Document of the NPC North American Resource Development Study. September 15, 2011.

| Technology | Subcategory | Pros | Cons |
|---|---|---|---|
| | Evaporation/Crystallization | Can treat to a zero liquid discharge standard. | High energy usage and cost.<br>Limited usage in oilfield applications.<br>Potential for scaling.<br>Challenges in disposing of salt residue. |
| Ion exchange | N/a | Successfully treat low to medium salinity water. | Large acid usage.<br>Resins can foul.<br>Challenges in disposing of rinse water and spent media (resin).<br>Also ineffective on high salinity produced waters. |
| Capacitive Deionization | N/A | Low energy cost. | Limited to treating low salinity waters.<br>Limited usage in oilfield applications. |

**Table 11. Treatment Technologies for Removing Oil and Grease Content**

| Technology | Subcategory | Pros | Cons |
|---|---|---|---|
| Physical separation | Advanced Separators (e.g., inclided plate, corrugated plate) | Provide enhanced oil capture compared to basic oil/water separators. | Works well for free oil, but not as effective on dispersed and soluble oil.<br>Performance can be improved by adding flocculants. |
| | Hydrocyclone | No moving parts results in good reliability.<br>Separates free oil very well. | Does not work well on dispersed and soluble oil. |
| | Filtration | Different types of filter media and filter operations provide a good range of oil and grease removal. | Requires regular back-flushing.<br>Does not treat soluble oil. |
| | Centrifuge | Provides good separation of free and dispersed oil. | More expensive than other technologies in this group. |
| Coalescence | N/A | Collects small oil droplets and forms larger droplets than can be more easily removed by the other technologies. | Limited value for dispersed or soluble oil. |
| Floatation | Dissolved air flotation, induced gas flotation | Removes free and dispersed oil. | Does not remove soluble oil. |

| Technology | Subcategory | Pros | Cons |
|---|---|---|---|
| Combined Physical and Extraction Processes | EPCON, C-Tour | Can treat to very low oil and grease levels. | Very costly. |
| Solvent Extraction | Macro-porous polymer extraction | Can treat to low oil and grease levels. | Very costly. |
| Adsorption | Organoclay, activated carbon, zeolites. | Does a good job at removing oil and grease. Used primarily for polishing. | Media cannot be re-used or regenerated – resulting in large volume of solid waste. |

The feasibility of re-using shale gas produced water depends on the volume and quality of the flowback and produced water generated. There are four primary methods of recycling produced/flowback water:

1. Distillation/Thermal Evaporation
2. Reverse Osmosis
3. Electro-Coagulation
4. Chemical Coagulation

### *Distillation/Thermal Evaporation*

In this process a heat source is used to bring water to its boiling point. As water evaporates off, any chemicals or organic matter with a higher boiling point than water is left behind as an effluent. These include bacteria, minerals, metals and salts. The vapor is then collected, cooled and recovered as water. The process is a physical separation, not a chemical reaction. The process results in condensed water that is very low in total dissolved solids (TDS). It will reliably remove bacteria, soluble minerals like calcium, magnesium and phosphates and has a long history of effectiveness. The process, however, typically requires a large fixed facility for significant treatment rate and is not very effective on high TDS water. In addition, water recovery rate can be limited.

### *Reverse Osmosis (RO)*

In this process membranes are used that contain small pores that block compounds that are larger than water, such as minerals, salt and bacteria. The primary requirements are pressure and an appropriate membrane. The RO process can treat water that is very low in TDS, is less expensive than distillation and low volume mobile units are available. The RO process, however, requires large, fixed facilities for significant treatment rates. In addition, high operating pressure is required. When the source water is over 30,000 ppm TDS, low water recovery may occur. Also, membrane fouling may occur by scale or when even small amounts of hydrocarbon are prevalent.

### *Coagulation*

This process uses electrical or chemical means to destabilize contaminants out of solution and ten aggregate them into larger particles for removal. The larger particles are removed by sedimentation, flotation or filtration. Electro-coagulation is performed by passing an electrical current through the water. Chemical coagulation is similar to electro-coagulation except specific chemicals are added to destabilize and flocculate the contaminants. Mobile units are available; however, the process does not remove bacteria and may require secondary filtration.

### Air Quality and Greenhouse Gas Emissions

Key issues and control measures concerning air quality are listed in Table 12.

**Table 12. Key Issues and Control Measures related to Air Quality**

| Issue/problem | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Exhaust emissions | All | All equipment should be maintained to minimize exhaust emissions. |
| Ground level ozone and Hazardous Air Pollutants | All | All immobile equipment that emits nitrogen oxides (NOx), volatile organic compounds (VOCs) or other Hazardous Air Pollutants (HAPs), should be regulated as a single source and for its cumulative effect. |
| Mobile sources of emissions | All | Ensure that all diesel engines have appropriate controls for NOx, PM and VOC emissions. |
| Dust suppression | All | Develop and implement a Dust Control Plan to keep dust in place on roads, material stockpiles, sites, etc. |
| Methane Emissions | Drilling/Completion, Production/Processing | Use portable equipment (sand traps, separators, dehydrators) if permanent installation is not completed or is out of service for maintenance. |

Air pollution can cause harm or discomfort to humans and other living organisms. It can also cause damage to the natural environment or built environment. Air pollution is caused by the introduction of chemicals, particulate matter or biological materials into the atmosphere. The quality of air relies on many factors concerning chemistry and motions of the atmosphere as well as the emissions of a variety of pollutants from both natural and anthropogenic sources.

The greatest air quality threat shale gas development poses to local governments and communities is increased levels of ozone ($O_3$).[87] Ozone is formed by the chemical conversion in the atmosphere of other atmospheric species or 'precursors'. The ozone precursors are the nitrogen oxides ("$NO_x$", from the burning of fossil fuel, lightning, and other sources) and volatile organic compounds ("VOCs," from fuel burning, natural emissions of vegetation, and other sources). In the presence of sunlight, a series of chemical reactions in the atmosphere creates ozone. Meteorology plays an important role in the conditions that are ripe for making high amounts of ozone; hot, stagnant days result in more ozone being produced from the $NO_x$ and VOC precursors.

Motor vehicle exhaust and industrial emissions, gasoline vapors, natural gas production, as well as natural sources emit NOx and VOC that help form ozone. Ground-level ozone is the primary constituent of smog. Sunlight and hot weather cause ground-level ozone to form in harmful concentrations in the air. Many urban areas tend to have high levels of ozone, but even rural areas may be subject to increased ozone levels if there is a high concentration of gas wells, or if they are downwind from a source of ozone pollution.

According to the U.S. EPA, ground-level ozone and the smog it helps produce is responsible for human health problems such as emphysema, asthma, bronchitis, congestion, chest pain, premature heart attacks, and overall, reduced lung function. It also affects the environment by

[87] There is a more detailed discussion of ozone generation and mitigation in Section 3.3.24.

reducing forest growth and crop yields, impacting species diversity, damaging tree leaves, and interfering with the ability of plants to produce and store food.[88]

In the U.S., ozone is regulated under the federal Clean Air Act ("CAA"), 42 U.S.C.§§ 7401 *et seq*. Currently, the CAA limits ozone concentrations to no more than 0.075 parts per million ("ppm") over an eight-hour period. An exceedance of the standard occurs whenever ambient ozone concentrations reach 0.076 ppm or higher and a violation of the CAA occurs whenever the three year average of the fourth-highest annual eight-hour ozone concentrations is 0.076 ppm or higher. Information about whether either western or eastern Ukraine is near these levels remains to be determined.

Immediately near a well site there may be some odors that nearby residents will find objectionable. Because these odors are typically from waste pits, most odors will be controlled through the requirement of closed-loop drilling.

Other localized air impacts may be increased dust from the use of unpaved roads to access well sites. This impact can be mitigated through well site planning as well as requiring the oil and gas industry to employ some method of dust suppression.

Another aspect of air quality is the presence of fine particles, or "particulate matter" (PM). Fine particles can be either directly emitted ("primary") pollutants or they can be formed within the atmosphere. For example, particles that are directly emitted into the atmosphere include soot particles from burning vegetation (which can be both a natural and a human-caused source), sea-salt spray, blowing dust, and volcanic ash. Other particles can be generated within the atmosphere, such as those arising from chemical conversion of the nitrogen oxides, volatile organic compounds, or sulfur-containing gases emitted from fuel burning, volcanic eruptions, or other sources.

Other components important in air quality include carbon monoxide, sulfur dioxide, NOx and VOCs (ozone precursors, mentioned above), and air toxics such as benzene, mercury and other hazardous air pollutants.

There are five basic categories of air emissions from natural gas production, processing and transmission:

1. Dust (particulate matter, PM) from vehicular traffic
2. Combustion emissions
3. Glycol dehydrators
4. Methane and volatile organic compounds (VOCs) from fugitive and point sources
5. Acid gas emissions from sour gas sweetening processes.

Pollutants of concern include nitrogen oxides ($NO_x$), carbon monoxide (CO), particulate matter (PM), hazardous air pollutants (HAP) such as benzene, toluene, ethyl benzene and xylenes (BTEX), as well as other volatile organic compounds (VOC). Formaldehyde is emitted from the compressor engines burning natural gas. (Typically engines are controlled by oxidizers to minimize organic emissions including formaldehyde.) Small quantity of ethylene glycol is emitted from gas dehydration operations at compressor stations. Emissions may be substantially

[88] 73 Fed. Reg. 16,436, 16,443-46 (March 27, 2008).

controlled by the use of current technologies, best management practices and application of emission control technologies.

Table 13 lists various technologies for controlling emissions associated with natural gas operations.[89]

**Table 13. Air Emission Control Technologies**

| Technology | Description |
|---|---|
| ***Dust from Road Traffic*** | |
| Surface Treatment | Surface treatment includes the use of water or chemical dust suppressants to control dust emissions generated by vehicular traffic on unpaved roads. |
| Reduction of vehicle miles traveled | Reduction strategies include consolidation of wells to avoid road construction and minimize traffic, management of projects to minimize traffic, and three-phase gathering systems to avoid the need for truck traffic. |
| ***Emissions from Combustion Units*** | |
| Selective Catalytic Reduction (SCR) | For lean-burn, gas-fired engines and diesel engines. Add-on $NO_x$ control placed in the exhaust stream following the engine and involves injecting ammonia ($NH_3$) into the flue gas. The $NH_3$ reacts with $NO_x$ in the presence of a catalyst to form water and nitrogen. |
| Selective Catalytic Reduction (SCR) with particulate matter (PM) filters | For diesel engines. SCR with PM filter technology simultaneously reduces particulate matter and $NO_x$ content of the exhaust gas. The technology combines SCR and diesel particulate filter (DPF). |
| Non-Selective Catalytic Reduction (NSCR) | For rich-burn, gas-fired engines. A three-way conversion catalyst system that simultaneously reduces $NO_x$, carbon monoxide (CO), and hydrocarbons (HC) and involves placing a catalyst in the exhaust stream of the engine. |
| Flue Gas Recirculation (FGR) | A portion of the flue gas is recycled from the stack to the burner windbox. Primarily, the recirculated gas acts as a diluent to reduce combustion temperatures, thus suppressing the thermal $NO_x$ mechanism. To a lesser extent, FGR also reduces $NO_x$ formation by lowering the oxygen concentration in the primary flame zone. |
| Low- $NO_x$ Burners (LNB) | $NO_x$ emissions are reduced by accomplishing the combustion process in stages. Staging partially delays the combustion process, resulting in a cooler flame, which suppresses thermal $NO_x$ formation. |
| Low- $NO_x$ Turbines | Low- $NO_x$ turbines are gas turbines using staged combustion. Fuel and air are thoroughly mixed in an initial stage resulting in a uniform, lean, unburned fuel-air mixture that is delivered to a secondary stage where the combustion reaction takes place. |
| Flare | Flaring is a high-temperature oxidation process used to burn combustible components, mostly hydrocarbons, of waste gases from industrial operations. In combustion, gaseous hydrocarbons react with atmospheric oxygen to form carbon dioxide ($CO_2$) and water. |

[89] *Air Emissions Management*, Paper #2-15, Working Document of the NPC North American Resource Development Study, September 15, 2011.

| Technology | Description |
|---|---|
| Alternative Energy Combustion Source | Elimination of the need for combustion from traditional sources through the use of adequately sized alternative or renewable energy sources, such as fuel cells. |
| ***Emissions from Glycol Dehydrators*** | |
| Flash Tank Separator | Reduces emissions from glycol still vent by flashing off most of the absorbed lighter hydrocarbons, especially methane, in a low-pressure separator prior to glycol regeneration in the still. Emissions are reduced if the flash tank vent is routed either to a nearby fuel system or by control device such as a flare or vapor condenser. It allows much more efficient use of a condenser on the glycol still vent. |
| Still Vent Condenser | A condenser, typically an air-fin design, is used to remove and collect condensable hydrocarbons from the glycol still vent. |
| Still Vent Combustion in Reboiler Firebox | Uncondensed hydrocarbons are mixed with fuel for combustion in the glycol still reboiler firebox. Typical destruction rates of 50% to 90% dependent on cyclic nature of glycol still reboiler firing. Modern patented firing systems can increase destruction efficiency and reliability. |
| Add-on Still Vent Combustion | Combustion of still vent vapors in a flare or thermal oxidizer. Destruction efficiencies up to 99%. |
| Alternative to Dehydrators | Development of a process to dehydrate gas using an alternative technology to glycol dehydrators that includes a closed-loop system. For example, a desiccant dehydrator can replace a glycol dehydrator reducing methane, VOC and hazardous air pollutant (HAP) emissions by 99 percent. |
| ***Emissions from Tanks and Loading, Vents, Pumps, Valves, Connectors, Seals, and Sampling Connections*** | |
| Vapor Recovery Systems | Vapor recovery systems require a compressor to collect emissions from storage vessels and return the gas to sales line or the suction line of another facility compressor. |
| Combustion Systems | In a typical thermal oxidation system, the air/vapor mixture is injected through a burner manifold into the combustion area of an incinerator. |
| Low-bleed Pneumatic Controls | New, technically advanced low-bleed devices and retrofit kits reduce methane emissions considerably. |
| Leak Detection and Repair (LDAR) | An LDAR program is designed to identify pieces of equipment that are emitting sufficient amounts of material to warrant reduction of the emissions through repair. These programs are best applied to equipment types that can be repaired on-line, resulting in immediate emissions reduction, and/or to equipment types for which equipment modifications are not feasible. |
| Extended DI&M Programs | A more extensive LDAR program, which can include the use of infrared technology to discover leaks. |
| ***Acid Gas Emissions from Amine Units*** | |
| Vent gas flaring | Acid gas from amine units is routed to an elevated, open flare for combustion. The burner tip (flare tip) is located at the top of the flare stack. A continuously lit pilot or electronic auto ignition system ensures that vent gases are combusted at the flare tip. |

| Technology | Description |
|---|---|
| Sulfur recovery plants | Acid gases from the amine unit are processed in a sulfur recovery plant, which uses the Claus process in the vast majority of cases. Generally, this option is employed at gas processing plants where the gas is sour enough to justify its use. |
| Underground injection | In cases where it is not economically feasible for companies to recover elemental sulfur for sale, acid gas is now being dissolved in oilfield produced water at the surface and injected into subsurface formations or injected directly with a high pressure compressor into a permitted disposal well. |
| Alternative to Amine Units | Technology that performs the same function but avoids any air emissions. |

### *NOx, VOCs and Ozone*

Ground level ozone can be dangerous since ozone will react with living tissue. In plants, ozone can hamper photosynthesis and lower crop yield. In people, ozone can inflame delicate tissues in the lungs, leaving them open to asthma and infections. Children and elderly people are especially at risk from ozone exposure.

Ground level ozone occurs as the result of a reaction between naturally occurring nitrogen oxides ($NO_x$) and oxygen in the air. Human created $NO_x$ and volatile organic compounds (VOC's) accelerate the ozone formation process, resulting in excessive amounts of ground level ozone.

Controlling $NO_x$ and VOCs are the best ways to limit ground level ozone.

A study was performed in the United States to create a comprehensive criteria pollutant emissions inventory for all activities associated with oil and gas field operations.[90] Although performed specifically for the Powder River Basin in Wyoming, the results can serve as an overview of emissions that are a result of typical operations.

Overall, as seen in Figure 28, compressor engines accounted for approximately 44% of $NO_x$ emissions basin-wide, including primarily lateral and centralized compressor engines, and drilling rigs accounted for approximately 27% of $NO_x$ emissions basin-wide. Venting from well workovers and recompletions, well fugitive emissions, and exhaust VOC emissions from compressor engines accounted for approximately 65% of VOC emissions, as shown in Figure 29.

[90] *Development of Baseline 2006 Emissions from Oil and Gas Activity in the Powder River Basin*, Prepared by ENVIRON International Corporation, June 10, 2011.

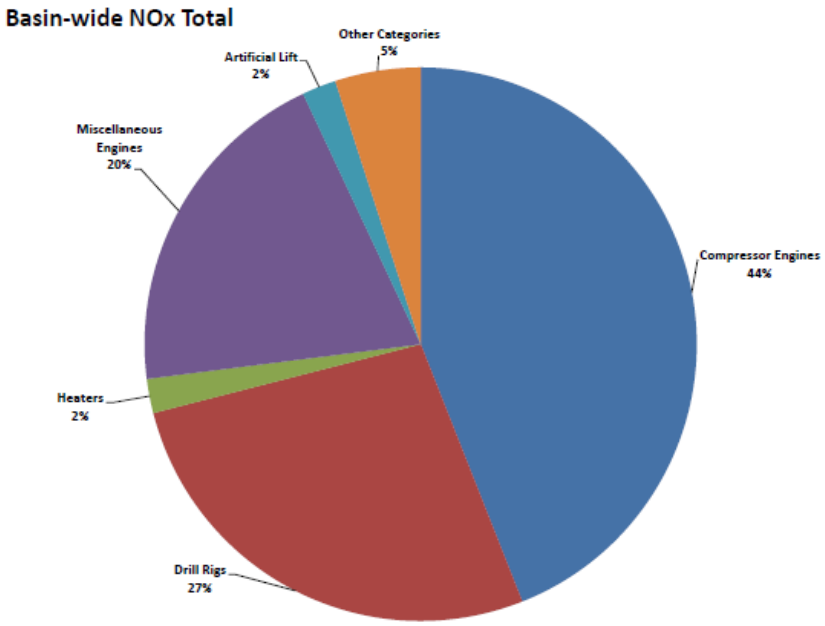


**Figure 28: $NO_x$ Emissions from Powder River Basin Study**

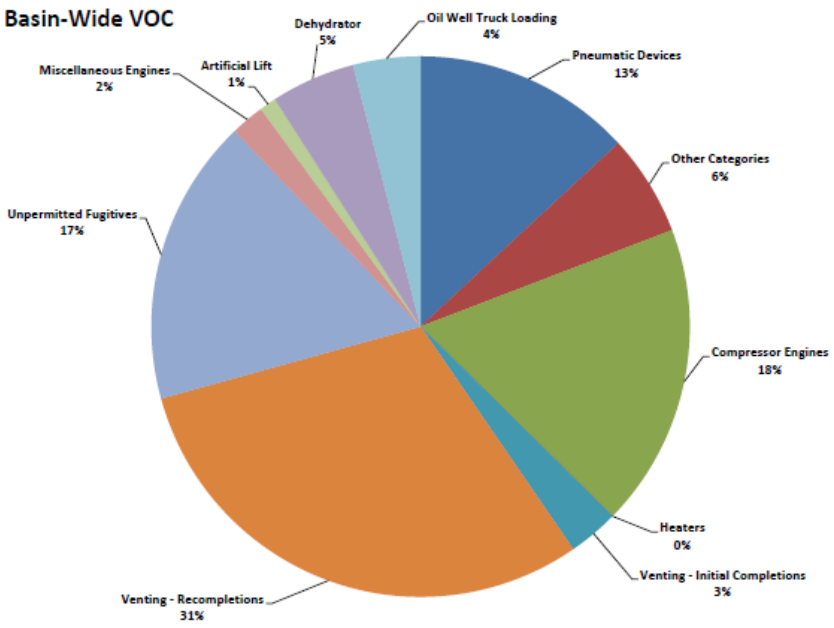


**Figure 29: Powder River Basin 2006 Baseline Results: VOC Emissions by Source Category**

### *Greenhouse Gases*

The main greenhouse gases include water vapor, carbon dioxide, methane, nitrogen oxides, and some engineered chemicals such as chlorofluorocarbons. One of the main greenhouse gases is carbon dioxide. Although carbon dioxide does not trap heat as effectively as other greenhouse gases (making it a less potent greenhouse gas), the sheer volume of carbon dioxide emissions into the atmosphere can be very high, particularly from the burning of fossil fuels. Because carbon dioxide makes up such a high proportion of greenhouse gas emissions, reducing carbon dioxide emissions can play a pivotal role in combating the greenhouse effect and global warming. The combustion of natural gas emits almost 30 percent less carbon dioxide than oil, and just under 45 percent less carbon dioxide than coal.

In the Ukraine, the energy sector is the main source of carbon dioxide ($CO_2$) and methane ($CH_4$) emissions, representing 69% of total greenhouse gas emissions (electricity and heat plants alone are responsible for 24% of total $CO_2$ emissions). The combustion of fossil fuels, particularly coal, is the largest contributor to $CO_2$ emissions. In Ukraine, fuel combustion is responsible for 57% of total greenhouse gas emissions. Fugitive $CH_4$ emissions contribute 12% of total domestic greenhouse gas emissions. Globally, Ukraine ranks 20th in the emissions of $CO_2$ from fuel combustion and 8th in energy-related $CH_4$ emissions. [91, 92]

Greenhouse gas emissions in Ukraine decreased through the 1990s, mostly due to the sharp economic decline. Emissions in 2000 (the lowest point in the last 15 years) were about 60% lower than in 1990. Since 2001, greenhouse gas emissions have grown: they were 399 Mt of $CO_2$-equivalent in 2001 and 413 Mt of $CO_2$-equivalent in 2004. In 2004, Ukraine's total greenhouse gas emissions were 45% of their 1990 level. The energy sector greenhouse gas emissions in 2004 represented 41% of their 1990 level. Both the $CO_2$ emissions from fuel combustion and fugitive $CH_4$ emissions from coal have fallen significantly since 1990. However, fugitive $CH_4$ emissions from oil and gas have dropped by only 25% in the same time period.[93]

In the last decade, the $CO_2$ emissions from the electricity and heat sectors have also dropped because of changes in the energy balance and efforts to improve energy efficiency. The share of natural gas in Ukraine's total primary energy supply increased from 43% in 1993 to 47% in 2004 and the share of nuclear grew from 10.5% to 16% (and is set to increase still more). Coal and oil decreased, respectively, from 30 to 24% and from 16 to 13% over the same period. Without additional policy measures and technological innovations, the country's greenhouse gas emissions will continue to grow with economic recovery. The Energy Strategy to 2030 envisions a significant increase in coal consumption for electricity and heat production, which will lead to increased greenhouse gas emissions. Changes in Ukraine's energy intensity will also have a strong, potentially mitigating, influence on emissions.[94]

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[91] Austrian Energy Agency, http://www.enercee.net/ukraine/environment.html

[92] IEA Statistics, $CO_2$ Emissions from Fuel Combustion Highlights, 2011 Edition. www.iea.org/co2highlights/co2highlights.pdf

[93] *ibid*.

[94] Austrian Energy Agency. http://www.enercee.net/ukraine/environment.html

### *Methane Emissions*

Methane, the principal component of natural gas, is a potent greenhouse gas with an ability to trap heat almost 21 times more effectively than carbon dioxide.[95] Sources of methane emissions include waste management and operations, agriculture and animal husbandry, as well as leaks and emissions from the oil and gas production, transport and transformation.

In 1993, the natural gas industry joined with US Environmental Protection Agency (USEPA) in launching the Natural Gas STAR Program to reduce methane emissions. Natural Gas STAR has provided a framework to encourage partner companies to implement methane emissions reducing technologies and practices and document their voluntary emission reduction activities. Through this work, the oil and natural gas industry, in conjunction with Natural Gas STAR, has pioneered some of the most widely–used, innovative technologies and practices that reduce methane emissions. There is now a Natural Gas STAR International program that builds on the successful program in the USA. Through the Gas STAR program, information about best management practices to reduce greenhouse gas emissions is shared, including:

- Reduced Emission Completions (often referred to as "green completions")
- Low-bleed pneumatic controllers
- Flash gas compression
- Enhanced compressor blow-down procedures
- Vapor recovery units
- Dehydrator flash tanks
- Fugitive leak detection and repair

### *Summary of Air Emissions From Natural Gas Operations*

In summary, air emissions from natural gas operations occur as follows.

***Drilling/Hydraulic Fracturing***: these operations are typically accomplished with the use of diesel engines. Emissions would be regulated by same standards that regulate emissions from cars and trucks. Figure 30 shows a drilling location near a gas processing facility in the United States.

[95] http://www.epa.gov/outreach/scientific.html

**Figure 30: Drilling and Gas Processing in Marcellus Shale**

***Completion/Production Activities***: Flowback period can last for hours or for several days during which time some natural gas flows back with the fracturing fluid and is either flared or disperses into the atmosphere.

***Gas Treatment/Compression***: Tri-ethylene glycol dehydrator is used at many wellsites, in particular small wellhead gas compressors.

***Gas Gathering***: Compressor station consists of one or more large compressors that boost the pressure of the natural gas so that it can flow to a user or a local distribution company. Dehydration units may be located at compressor stations. Figure 31 shows a gas compression facility in the United States.

***Gas Processing***: Natural gas may be processed to condense and remove heavier hydrocarbons known as natural gas liquids (NGL). These include ethane, propane, butanes, pentanes and natural gasoline that are typically stored on-site in pressurized tanks and then shipped via pipeline or tanker truck. VOCs may be emitted from pumps, fittings flanges and other connectors. Gas processing plant may also have natural gas-fired engines that drive refrigeration compressors, inlet gas compressors or outlet gas compressors. Figure 32 shows a gas processing plant in the United States.

The most common control methodology for air emissions, by activity, may be summarized as in Table 14.

**Figure 31: Gas compressor station in the Marcellus. (from www.marcellus-shale.us/MARCELLUS)**

**Table 14. Control Methodologies**

| Activity | Goal | Control Methodology |
|---|---|---|
| Drilling | Limit emissions of $NO_x$, PM and $SO_2$ | Manufacturer's technology/diesel fuel sulfur standards |
| Hydraulic Fracturing | Limit emissions of $NO_x$, PM and $SO_2$ | Manufacturer's technology/diesel fuel sulfur standards |
| Completion/Production Activities | Limit emissions of VOCs | Limit venting, use of flares, green completion practices |
| Gas Treatment | Limit emissions of HAP | Condensers, flares, VRUs |
| Gas Compression | Limit emissions of $NO_x$, VOCs and HAP | Low emission engine technologies, catalysts on engine exhaust |
| Gas Processing | Limit emissions of VOC's | Leak detection and repair program |

**Figure 32: Example of a cryogenic processing facility recently constructed in the Marcellus. This is Caiman Energy's Fort Beeler facility. Processes 'wet' Marcellus gas by cryogenic process removes profitable liquids such as ethane, butane and propane leaving 'dry' methane gas. (from www.marcellus-shale.us/MARCELLUS)**

### Effects on Land

Key issues and control technologies associated with land disturbances are listed in Table 15.

**Table 15. Key Issues and Control Measures related to Land Disturbances**

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Minimizing disturbances | All | Develop and implement a Surface Use Plan that considers the construction and reclamation operations for a broad area. |
| | | Co-locate/consolidate roads, structures, power lines and other features/equipment. |
| | | Develop and implement an Erosion Control, Revegetation and Restoration Plan. |
| Road Usage | All | Adhere to seasonal road restrictions. Adopt regular road maintenance programs. |
| Contamination due to flooding | All | Avoid areas prone to flooding. Take topography, natural drainage and site run-off into account. Avoid areas subject to erosion and soil movement. |

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Protecting wetland/riparian areas | All | Avoid crossings of wetland/riparian areas by linear features, such as pipelines, roads and power lines, to the extent practicable. |
| Land Degradation | All | Avoid land-use practices that reduce soil moisture effectiveness, increase erosion, cause invasion of exotic plants and reduce abundance and diversity of native plants. |
| Erosion issues | All | Avoid locating well pads, roads and pipelines on steep slopes. Avoid loops in roads. |

Local governments and communities may be adversely affected by shale gas development through the change in ownership in land needed for shale gas development, and from the visual impacts that occur as a result of the development.

The Law of Ukraine On Expropriation of Privately Owned Land Plots and Other Real Estate Objects Located Thereon for Public Needs or on the Grounds of the Public Necessity ("Public Necessity Law", Nov. 17, 2009 No 1559-VI) allows for land needed for shale gas development to be either purchased or condemned. This practice is likely to have some local impacts on the community through the displacement of some of the population unless another property in the area is made available for exchange. There is likely going to be local resentment of the shale gas industry if community members are forced to leave their homes and land through a condemnation proceeding.

Some percentage of the population of Ukraine still does not have clear title to the land they have been living on or farming since Ukraine gained independence in 1991. Without clear title, the law allows the government to take the property without giving the resident any compensation. If land is taken in this manner, there are sure to be negative political and social ramifications.

Shale gas development will also create visual impacts. As drilling increases, pumping stations, access roads, well pads, storage tanks, power lines, pipelines and other material and machines are added to the landscape. For some, this creates an adverse visual impact because it disrupts previously undisturbed natural settings. At night drill rigs and well flaring may light up what was once dark sky.

The visual effects of shale gas development may be mitigated through directing the lighting to the well pad, requiring green completions that would eliminate the need for flaring, and the use of paint to camouflage the well head and other production equipment left on the surface.

### Noise

Key issues and control measures associated with noise disturbances are listed in Table 16.

**Table 16. Key Issues and Control Measures related to Noise Disturbances**

| Issue | Stage of Operation (Exploration, Drilling/Completion, Production/Processing, Transmission) | Best Practices / Mitigation Measures |
|---|---|---|
| Noise disturbances | Production/Processing | All noise-producing facilities should be tested to determine noise levels. Apply noise mitigation measures at well locations as deemed necessary. Select sites for compressor facilities at sufficient distances from sensitive wildlife locations and residences. Enclose compressor stations. |
| Noise disturbances | Drilling/Completion | Construct noise barriers and use noise dampening/control measures. Do not use horns, bells, or other noise-making devices to delineate shift changes. |

The noise impacts associated with shale gas exploration and development are, in general, similar to those already experienced in Ukraine with traditional gas development.

The drilling phase of any gas development is when many of the problems associated with noise occur. The difference in shale gas development is that the drilling takes longer and there is increased noise during hydraulic fracturing of the well.

A shale gas well takes four to five weeks of drilling at 24 hours per day to complete. The primary sources of noise during the drilling of the horizontal well are: [96]

- **Drill Rigs**. Drill rigs are typically powered by diesel engines, which generate noise emissions primarily from the air intake, crankcase, and exhaust. These levels fluctuate depending on the engine speed and load.
- **Air Compressors**. Air compressors are typically powered by diesel engines and generate the highest level of noise over the course of drilling operations. Air compressors would be in operation virtually throughout the drilling of a well, but the actual number of operating compressors would vary. However, more compressed air capacity is required as the drilling advances.
- **Tubular Preparation and Cleaning**. Tubular preparation and cleaning is an operation that is conducted as drill pipe is placed into the wellbore. As tubulars are raised onto the drill floor, workers physically hammer the outside of the pipe to displace internal debris. This process, when conducted during the evening hours, seems to generate the most concern from adjacent landowners. While the decibel level is comparatively low, the acute nature of the noise is noticeable.
- **Drill Pipe Connections**. As the depth of the well increases, the operator must connect additional pipe to the drill string. Some operators in the US use a method known as air-drilling. As the drill bit penetrates the rock the cuttings must be removed from the wellbore. Cuttings are removed by displacing pressurized air (from the air compressors discussed above) into the well bore. As the air is circulated back to the surface, it carries with it the rock cuttings. To connect additional pipe to the drill string, the operator will

[96] New York State Department of Environmental Conservation, pg. 6-293.

release the air pressure. It is the release of air pressure that creates a higher frequency noise impact.

The cumulative noise created during drilling is 76 dBA at the source, dissipating to 44 dBA at 200 feet.[97]

Hydraulic fracturing takes two to five days to complete. The primary noise of the hydraulic fracturing process is from pumper trucks. During the hydraulic fracturing process, water, sand, and other additives are pumped under high pressure into the formation to create fractures. To inject the required water volume and achieve the necessary pressure, up to 20 diesel-pumper trucks operating simultaneously are necessary. The cumulative noise of the 20 pumper trucks operating is 128 dBA dissipating to 72 dBA at 2,000 feet.[98]

A study was performed to investigate how noise from production operations affects wildlife. A 500 kW diesel electric generator was installed at a gas well to power a downhole pump. Noise measurements for the operation of the diesel generator were recorded and wildlife activity was recorded before, during and after the installation of the generator. The noise level of the generator was 81 dBA at a distance of 5 ft. (1.6 meters) from the generator, 68 – 70 dBA at 25 ft. (8 meters) and 61 – 64 dBA at 50 ft. (16 meters). There was no observed disturbance to wildlife movement.[99]

Once a well has been put into production, the gas will need to be compressed to be transported. Large compressor engines can be the cause of a lot of disturbance and, unlike the noise from drilling and completing a well, the noise from a compressor station will be there for as long as the well is productive. Compressor engine noise varies from the size and type of engine used. The US Bureau of Land Management estimates that an average compressor is 89 dBA if measured 50 feet (16 meters) away from the source.[100]

The U.S. EPA has set 70 decibels as the maximum level of environmental noise, which will prevent any measurable hearing loss over a lifetime.[101] Levels of 55 decibels outdoors and 45 decibels indoors are identified as preventing activity interference and annoyance.

The best way to eliminate noise concerns is through the appropriate siting of wells and compressor engines away from homes and businesses. Noise created by drilling and hydraulic fracturing operations can be mitigated through the use of berms or natural topography. Compressor noise can be reduced through the use of mufflers, sound-insulated buildings, or electric motors.

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97 *Id.*

98 *Id.*

99 Haut, R.C., Bergan, J.F. and Price, L.: *Living in Harmony – Gas Production and the Attwater's Prairie Chicken*, SPE-133652-PP, presented at the SPE Annual Technical Conference and Exhibition, Florence, Italy, 19-22 September 2010.

100 Bureau of Land Management, *Draft RMPA/EIS for Federal Fluid Minerals Leasing and Development in Sierra and Otero Counties*, Oct.2000, Page 4-29.

101 Information on Levels of Environmental Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety," EPA/ONAC 550/9-74-004, March, 1974.

## SOCIAL AND ECONOMIC IMPACTS

### Impacts on Employment

The impacts on local employment are likely to be seen as a positive for local governments and communities. Oil and gas jobs generally pay better than many other jobs that can be found in rural areas and the presence of those high-paying jobs can raise the average salaries for the entire area.[102]

While it is impossible to predict how many jobs shale gas development may create in Ukraine, there are some legal requirements that the jobs that area created should benefit Ukrainian workers. The PSA is likely to contain a requirement that the oil and gas operator demonstrate a preference for hiring Ukraine workers, services and purchasing Ukraine products (Ukraine Law on Production Sharing Agreements, Art 8§5). In November, 2011, Chevron announced that they typically hire at least 80% of their workers from the country where they are operating.[103]

In addition to jobs in the gas industry, shale gas development is likely to lead to hiring in other employment sectors as well. In Colorado, it was estimated that every oil and gas job creates an additional 2.7 jobs outside the oil and gas industry.[104]

There is a natural cycle to employment in the oil and gas industry. The industry's need for employees is highest during the drilling and exploration phase of gas development. Once the field has been put into production, there is no longer a need for drilling and exploration crews. In the US, the natural cyclical nature of the industry is exacerbated by drastic swings in employment due to market conditions. A downturn in gas prices may cause the industry to drastically reduce its activities, creating a corresponding loss of jobs in the area and high unemployment.[105] The precipitous boom and bust cycles are not as likely in Ukraine because of the requirement for the industry to commit to a work plan in the PSA, the lack of drilling rigs, and the relative lack of competition in the Ukraine shale gas industry.

### Localized Population Increases

If the PSA does require preferences to be given to Ukrainian workers, there is likely to be some influx in population moving from other parts of Ukraine to the regions with shale gas development. Most of the new population will be working age and their dependents.

In the US, rapid oil and gas development has caused severe labor and housing shortages in some areas.[106] There are many cases where the local schools also had to be expanded, or new schools built, to accommodate the influx of new students. Meeting the needs of the influx in population is complicated by the fact that some of the increase in population is likely to be temporary – based entirely on the needs of the industry.

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[102] Fossil Fuel Extraction and Western Economies, Headwaters Economics, p. 50, April 2011. Available at: http://headwaterseconomics.org/energy/western/maximizing-benefits

[103] Ken Nelson, General Manager of Chevron Europe, Eurasia and Middle East E&P, speaking at a Chevron Shale Gas Workshop, L'viv, Ukraine, Nov 3, 2011.

[104] Colorado Energy Resource Institute, *Oil and Gas Economic Impact Analysis*, CERI Report 2007-1, at 6, *Available at:* http://www.ceri-mines.org/publications.htm (estimating an employment multiplier of 2.67).

[105] Fossil Fuel Extraction and Western Economies, at

[106] Ryan Holeywell, "North Dakota's Oil Boom is a Blessing and a Curse", Governing the State and Localities (website), Aug. 2011. Available at: http://www.governing.com/topics/energy-env/north-dakotas-oil-boom-blessing-curse.html

### Increased Crime

As population in areas increases due to growth in the oil and gas industry, local governments in the US have seen an increase in local crime rates.[107] In some areas, the rapid increase of oil and gas development has strained county jails and available law enforcement staff. The national government will need to put some additional law enforcement resources into the affected areas in order to prevent possible increases in the crime rate, especially for crimes involving public order, petty theft and similar misdemeanors and light felonies.

#### LOCAL GOVERNMENT STAFF IMPACTS AND SERVICE REQUIREMENTS

If shale gas development is successful, the affected local governments will likely see a dramatic increase in their staffing and resource needs. The challenges of local governments can be broken down into two categories: (i) the challenges in regulating a new or expanded industry; and (ii) the change in the composition of the community itself.

The expansion of the oil and gas industry into shale gas development will require local government to shift its attention to new areas and to new programs. Rural roads that saw little traffic and maintenance needs may suddenly require upgrading and increased maintenance. Local governments may have to learn new environmental inspection and enforcement requirements that will apply to an industry that is widely dispersed over the countryside (see Section 4.4). Local governments will also need to have new emergency response plans and additional capacity to meet their increased responsibilities.

The increase in population will also increase demands for government services. Further complicating matters, the increase in population will not be stable but changing with the needs of the industry. During the development phase of shale gas operations, some elements of the new population will be very transient. Examples include specialized pipefitters and electricians that may only be on site only for a few months. Drilling crews typically work long hours, but have long periods of time off, and may essentially commute to the area. As the industry matures, a higher percentage of employees will be permanent with full time jobs and are more likely to become long-term residents with families. [108] [109]

As this employment curve shifts, so will the demand on a variety of services. Law enforcement and criminal justice institutions will likely see an increased but shifting caseload over time as the population shifts from being transient to becoming more stable. To the extent that the area becomes known as a likely employment center, social services and charitable organizations may encounter an increase in the number of people arriving to seek work with little means of support. Schools may encounter a high student turnover rate and difficulty recruiting teachers and staff. Mental health, drug and alcohol service providers will likely see caseloads increase both from the new population and the historic residents if the transition is dramatic in a given community.

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[107] Gerald Dahl, et al., Oil and Gas Regulation: A Guide for Local Governments, Colorado Dept. of Local Affairs (2010), pg. 9.

[108] *Id.* at 9-10.

[109] See Section 4.3.18 for a discussion of employment created for drilling one modern horizontal hydro-fractured well. For each well drilled (there are about 6-8 on each pad) the exploration phase requires about 1 Full time equivalent worker, from a variety of occupations and skills; drilling calls for 9 FTEs, and production 0.2 FTEs. With a moderate program in Ukraine likely resulting in 40-45 pads by the fifth year this would mean at least 1500-2000 FTEs in a variety of skills and occupations, not including construction and civil works (see Table 21).

Emergency rooms and clinics will likely see a rise in workplace related accidents, traffic accidents, and substance abuse.

A local government faced with shale gas development may have difficulty planning for the changes that will occur. Dramatic swings in industry activity can create rapid changes to the demographics of a community, making long-term planning difficult. Even a major decline in employment levels can trigger increased needs for law enforcement, social services, and non-profit charities.

Local governments in Ukraine will benefit from working with the national government and the industry in designing the PSA work plan. Staged development of the resource will provide for more stability in community and allow the local governments to more effectively meet the changing needs of their constituencies.

### 4.3.8. CHEMICALS USED IN THE DRILLING PROCESS

Chemicals of various types are used in the various stages of drilling, completion and production operations of gas wells. These chemicals include inorganic salts, transition metal compounds, common organic chemicals, solvents, water/oil soluble polymers and surfactants. The chemicals used in the various operations for completion of any well can be grouped into the following categories.

- Drilling fluid/Mud chemicals and Mud additives
- Cement and cement additives
- Production chemicals
- Water Injection Chemicals
- Well Stimulation Chemicals
- Process Chemicals

Drilling fluids or liquids perform a variety of functions that influence the drilling rate, the cost, efficiency and safety of drilling operations. There are many types of drilling fluid systems available like water base muds, oil base muds, stable foam muds, air or gas base muds from which the right system may be chosen. Main drilling mud additives include viscosifying agents, fluid loss control agents, drilling fluid dispersants and corrosion inhibitors.

Cement and cement additives are considered to be critical inputs in the completion of any oil and gas well. Portland cement is the primary cementing material in use for cementing of oil and gas wells, zonal isolation, casing protection and borehole support. The increase in demand for cement suitable for oil and gas wells led to the establishment of API codes by the American Petroleum Institute and nine classes of cements for the oil industry have been classified. Two of the nine classes of cements, the classes G and H, are called basic oil well cements. Main cement additives are retarders, turbulence inducers and fluid loss controlling agents.

Production chemicals are used to keep the produced fluid mobile after shut down or under cold conditions, remove emulsified water and prevent corrosion of the pipeline.

There are a large number of chemicals that are used in the oil field. The required use of these chemicals varies, depending on the formation, produced fluids, temperatures and desired properties of drilling fluids, cement compositions and other uses. The most essential and important oil-field chemicals are summarized in Table 17.

**Table 17. Summary of Oil Field Chemicals and Their Use**

| Chemicals | Primary Use |
|---|---|
| Chrome lignite | High temperature drilling fluid conditioning agent |
| Chrome lignosulphonate | Drilling fluid dispersant/thinner |
| Diaseal M or equivalent | Drilling fluid loss control agent |
| Drilling detergent | Drilling fluid surfactant |
| Polyanionic cellulose | Fluid loss control agent |
| Resinated lignite | High temperature fluid loss reducing agent/ shale stabilizing agent |
| Guar gum | Viscosity additive |
| Sulphonated asphalt | Shale stabilizer |
| Gilsonite | Shale stabilizer |
| XC- polymer | Viscosity additive |
| Carboxy methyl starch | Fluid loss control |
| Barite/Hematite | Weighting agents |
| Class "G" cement | Cementing casing |
| CMHEC (carboxy methyl hydroxyl ethyl cellulose) | Cement retarder, fluid loss reduction |
| Catalyzed ammonium bisulphate/amines | Corrosion inhibition |
| Triethylene glycol | Gas dehydration |
| Calcium chloride | Cement accelerator |
| Gilsonite | Lost circulation control |

Shale gas wells require hydraulic fracturing in order to enable the wells to produce the natural gas cost effectively. Water and sand can make up to over 98-99+ percent of the fluid used in hydraulic fracturing. The other 0.5 – 2 percent are chemicals with the exact formulation dependent upon the well conditions. A typical treatment will use between 3 and 12 chemical additives with each component serving a specific, engineered purpose. For example, the addition of friction reducers allow fracturing fluids and sand to be pumped at a higher rate and reduced pressure than if water alone was used. Biocides prevent microorganism growth and reduce biofouling of the fractures. Oxygen scavengers and other stabilizers prevent corrosion of metal pipes.

Fluids are used to create the fractures and to carry the proppant (sand) that is deposited in the fractures to prevent them from closing. Figure 33 shows the percentages of additives used for a hydraulic fracturing treatment of a Fayetteville Shale horizontal well in Arkansas.[110] The additives represent less than 0.5% of the total fluid volume.

Table 18 provides a summary of hydraulic fracturing additives, their main compounds, the reason the additive is used, and other common uses for the compound.

[110] **Modern Shale Gas Development in the United States: A Primer**. Work Performed Under DE-FG26-04NT15455. April 2009.

**Table 18. Hydraulic Fracturing Fluid Additives, Main Compounds and Common Uses[111]**

| Additive Type | Main Compound(s) | Purpose | Common Use of Main Compound |
|---|---|---|---|
| Diluted Acid (15%) | Hydrochloric acid or muriatic acid | Help dissolve minerals and initiate cracks in the rock | Swimming pool chemical and cleaner |
| Biocide | Glutaraldehyde | Eliminates bacteria in the water that produce corrosive byproducts | Disinfectant; sterilize medical and dental equipment |
| Breaker | Ammonium persulfate | Allows a delayed break down of the gel polymer chains | Bleaching agent in detergent and hair cosmetics, manufacture of household plastics |
| Corrosion Inhibitor | N,n-dimethyl formamide | Prevents the corrosion of the pipe | Used in pharmaceuticals, acrylic fibers, plastics |
| Crosslinker | Borate salts | Maintains fluid viscosity as temperature increases | Laundry detergents, hand soaps, and cosmetics |
| Friction Reducer | Polyacrylamide | Minimizes friction between the fluid and the pipe | Water treatment, soil conditioner |
| | Mineral oil | | Make-up remover, laxatives, and candy |
| Gel | Guar gum or hydroxyethyl cellulose | Thickens the water in order to suspend the sand | Cosmetics, toothpaste, sauces, baked goods, ice cream |
| Iron Control | Citric acid | Prevents precipitation of metal oxides | Food additive, flavoring in food and beverages; Lemon Juice ~7% Citric Acid |
| KCl | Potassium chloride | Creates a brine carrier fluid | Low sodium table salt substitute |
| Oxygen Scavenger | Ammonium bisulfate | Removes oxygen from the water to protect the pipe from corrosion | Cosmetics, food and beverage processing, water treatment |
| pH Adjusting Agent | Sodium or potassium carbonate | Maintains the effectiveness of other components, such as crosslinkers | Washing soda, detergents, soap, water softener, glass and ceramics |
| Proppant | Silica, quartz sand | Allows the fractures to remain open so the gas can escape | Drinking water filtration, play sand, concrete, brick mortar |
| Scale Inhibitor | Ethylene glycol | Prevents scale deposits in the pipe | Automotive antifreeze, household cleansers, and deicing agent |
| Surfactant | Isopropanol | Used to increase the viscosity of the fracture fluid | Glass cleaner, antiperspirant, and hair color |
| Note: The specific compounds used in a given fracturing operation will vary depending on company preference, source water quality and site-specific characteristics of the target formation. The compounds shown above are representative of the major compounds used in hydraulic fracturing of gas shales. | | | |

[111] Modified from: Arthur, J.D., Bohm, B. and Layne, M. *Hydraulic Fracturing Considerations for Natural Gas Wells of the Marcellus Shale.* Presented at the GWPC Annual Forum, Cincinnati, OH. September 2008.

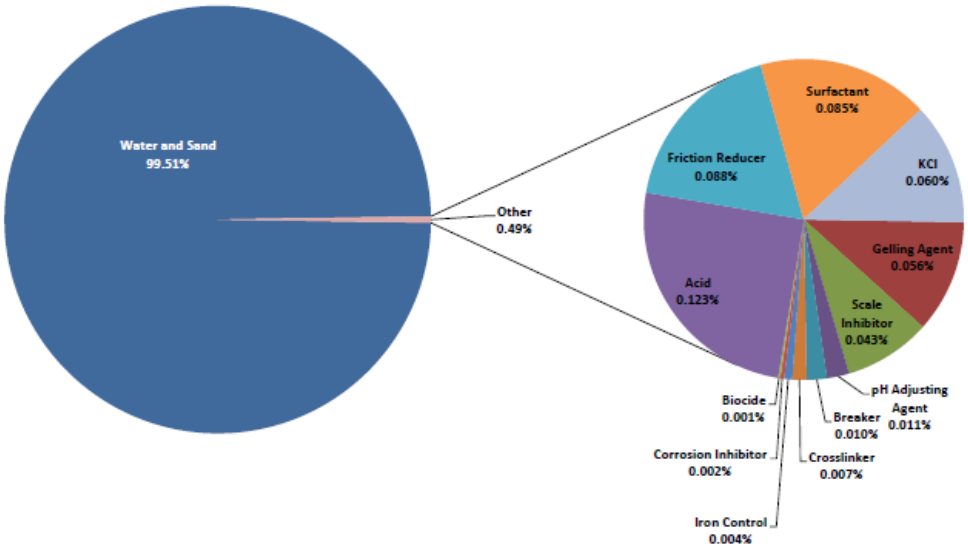


**Figure 33: Composition of Hydraulic Fracturing Fluid**

### 4.3.9. DRILLING INFRASTRUCTURE

There is not much information available about the drilling rig count in Ukraine. However, some information about wells that have been drilled during the last years have been collected and summarized. The following companies are present in Ukraine:

- Naftogas of Ukraine NJSC. Drilling activities are carried out by its subsidiaries Ukrgazvydobuvannia SC, Ukrnafta OJSC and Chornomornaftogaz SJSC. Figure 34 illustrates the exploratory drilling volumes in Ukraine. In 2010, the Company's enterprises drilled 151,900 meters of exploratory wells and 142,900 meters of production wells. See Figure 35. Ukrgazvydobuvannia SC carries out more than 80% of drilling activity. The company has experience in operating at depths above 6000 meters, pressures up to 1000 bars, and bottomhole temperatures up to 200 °C. In 2004-2005, Ukrgazvydobuvannia SC drilled two horizontal production wells in Poltava Oblast. About 20% of the wells are drilled with directional equipment. Ukrgazvydobuvannia SC currently has 83 rigs[112] and planning to buy seven new ones. Aleksey Nesterenko, Deputy Director of Ukrgazvydobuvannia SC, stated that it typically takes the company around three years to complete a 5000-6000 meters deep well.[113] Other sources, particularly Regal Petroleum, schedule their wells to 350-400 days to reach the total depth of 5000-5500 meters.[114]

[112] UAEnergy (http://www.uaenergy.com.ua/c225758200614cc9/0/ac5689ecc804abbec225796500480b5d, Translated into English, Website).

[113] UAEnergy (http://www.uaenergy.com.ua/c225758200614cc9/0/ac5689ecc804abbec225796500480b5d, Translated into English, Website).

[114] Energy-pedia news (http://www.energy-pedia.com/news/ukraine/new-148580, accessed on 24.01.2012)

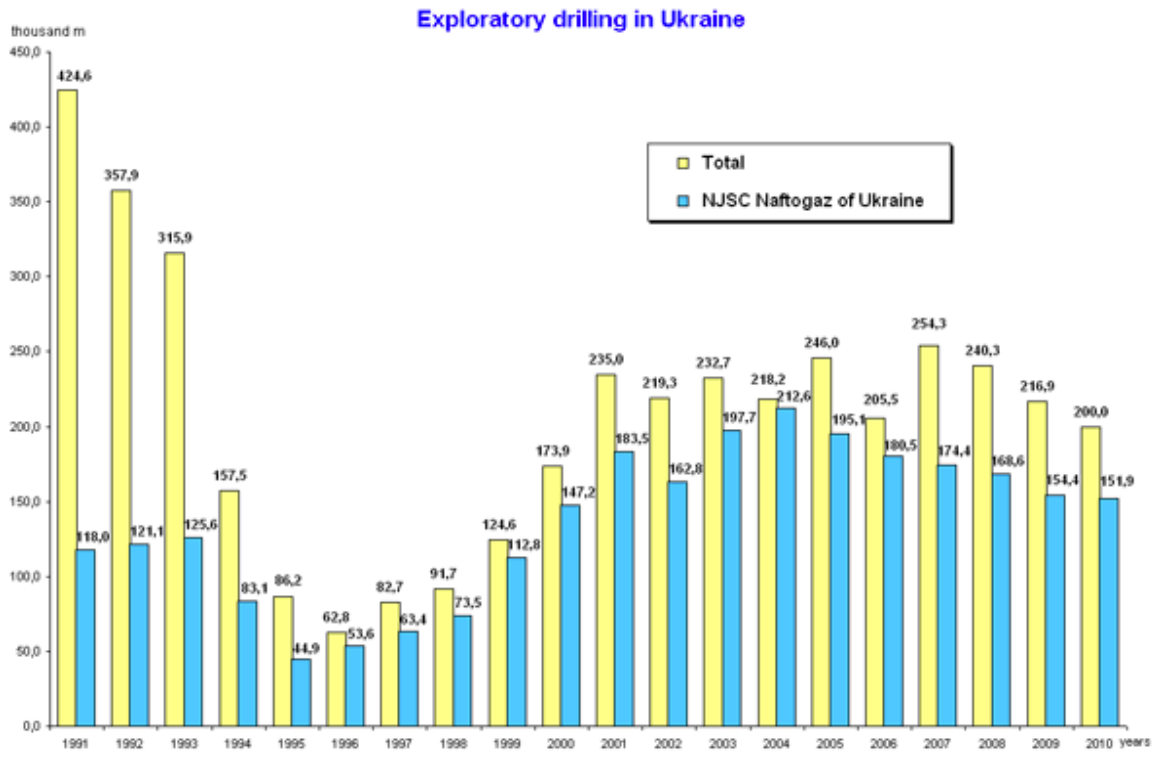


**Figure 34: Exploratory Drilling in Ukraine**

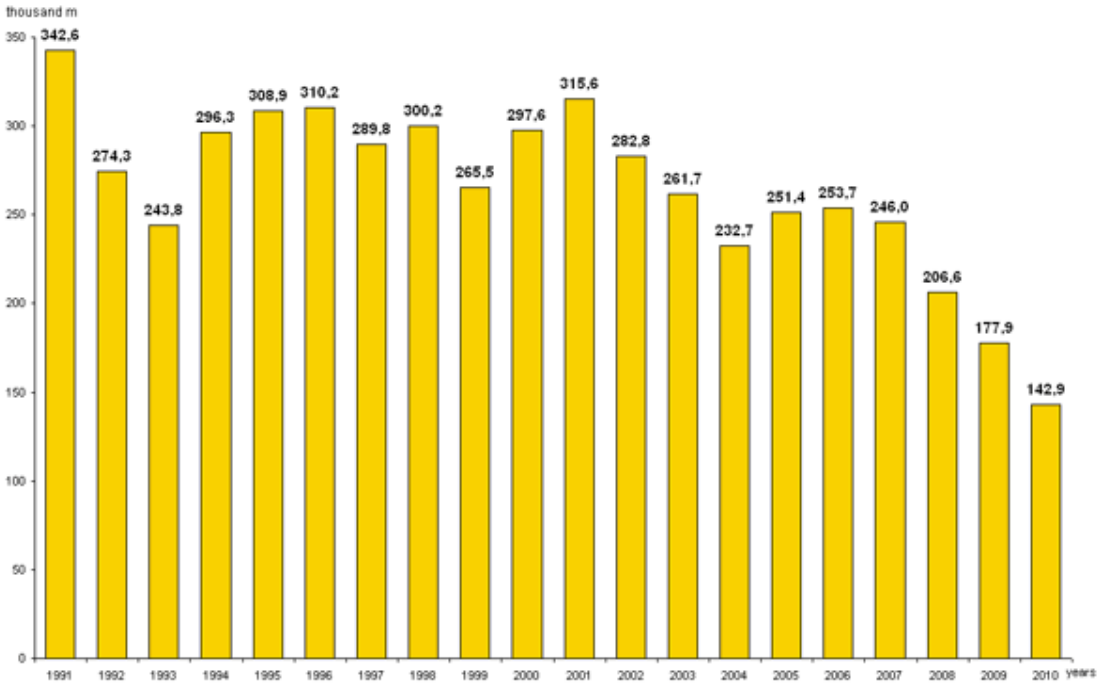


**Figure 35: Development Drilling in Ukraine[1]**

- DISCOVERY drilling equipment.[115] It is a Canadian engineering & Ukrainian manufacturing company. Their design includes rigs that range from 350 HP to 3000 HP, and models include carrier trailer swing lift, and pad skidding rigs.
- Kulczyk Oil Ventures owns at least one 1000 HP rig in Ukraine. In the first week of November Kulczyk Oil Ventures successfully stimulated two wells (Olgovskoe-6 and Olgovskoe-8) using the modern hydraulic fracture stimulation. The operation was undertaken by KUB-Gas LLC (partially-owned indirect subsidiary of KOV) that employed a cross-linked gel water frack fluid with 40 tonnes of ceramic proppant. Target zone was 13 meters thick at a depth of approximately 2300 meters. Source (Ukraine Energy (Homepage) http://ua-energy.org/en/post/13633).
- Dnieperpolymermash is a Ukrainian rig manufacturer that could contribute to the building of required equipment. The company is capable of manufacturing various types of drilling rigs.[116]

### 4.3.10. HYDRAULIC FRACTURING INFRASTRUCTURE

There is a lack of massive hydraulic fracturing equipment in Ukraine, even though there are companies that provide stimulation services for conventional wells (such as Region Company[117]).

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[115] Discovery (Homepage).

[116] Dnieperpolymermash (Homepage).

[117] Region (Homepage).

Therefore the most likely solution for the future will be to rely on international service providers (e.g. Weatherford, with a base in Kyiv, planning to open a new base in Poltava Oblast).[118]

## 4.3.11. PIPELINE INTERCONNECTIONS – GATHERING SYSTEMS, PIPELINES AND COMPRESSOR STATIONS

### THE UKRAINIAN GAS TRANSMISSION SYSTEM

The gas transmission system (GTS) of Ukraine (Figure 36 and Figure 37), operated by Naftogaz of Ukraine NJSC (Ukrtransgaz AC), is closely connected with gas transportation systems of Russia, Belarus, Poland, Slovakia, Hungary, Romania and Moldova, and integrated into the Europe-wide gas network. Owning to its favorable geographical position, the system acts as a "gas bridge" between gas production regions of Russia, Central Asia and European consumers.

- Input capacity of the GTS is 290 bcm of natural gas, while its output capacity is 178,5 bcm including 142,5 bcm of natural gas transported to West and Central European countries.
- About 70% of Russian natural gas is transited to European countries through the territory of Ukraine.
- Ukrainian GTS consists of 39,800 km of pipelines, including 14,000 km with a diameter ranging from 1,020 to 1,420 mm and varying working pressures, 74 compressor stations (green circles in Figure 37) and 112 compressor shops, providing a total capacity of 5,450 MW, and 13 underground gas storage facilities. Overall, the GTS consists of 22.16 thousand km regional pipeline and 16.39 thousand km gas pipeline taps. The number of gas distribution stations (GDS) has increased to 1,449[119]

Ukraine receives natural gas via 22 main pipelines. The gas flow is measured at 10 border Gas Metering Stations (GMS) and 3 Gas Consumption Measurement Points (GCMP). Two GMSs are located in the Republic of Belarus, one in the Republic of Moldova, and the remaining points are located in the Russian Federation.

Natural gas, transported outside Ukraine via 15 main pipelines, is measured at 9 border GMSs and one GCMP. Seven GMSs are located in Ukraine (one at the border with Poland, one – with Slovakia, one – with Hungary, two – with Romania, and two – with Moldova), and GMS in the Russian Federation. Transportation of natural gas on the territory of Ukraine includes transitional measurement of its consumption at 18 GMSs installed along main pipelines on the borders of jurisdiction zones of SC Ukrtransgaz departments.

The territories of 6 Regional Pipeline Divisions (RPD) of Ukrtransgaz AC can be observed as red squares on Figure 37. Their KPI's are summarized in Table 19.

Repair and maintenance of regional pipelines, supervision over construction of new and overhaul of existing gas pipelines are managed by the 6 RPD's, including 41 line production regional pipeline divisions and 9 production departments for underground gas storage.

Protection of underground lines of gas transportation objects against soil and stray-current corrosion in gas transportation system of Ukrtransgaz AC is carried out by 4658 cathodic

[118] Weatherford (Homepage).

[119] NAFTOGAZ OF UKRAINE (Homepage).

protection units, 120 drainage protection units, 3084 protectors which significantly contribute to longer operation life time.[120]

**Table 19: Ukrtransgaz Division Information**

| Main Data | Divisions | | | | | |
|---|---|---|---|---|---|---|
| | 1.Lvivtransgas | 2.Kyivtransgas | 3.Kharkivtransgas | 4.Prycarpattransgas | 5.Donbastransgas | 6.Cherkassytransgas |
| **Length of gas mains including taps** | 6458.4 km | 9233.03 km | 6748.4 km | 5100 km | 5094.4 km | 5259.565 km |
| **Number of gas distribution stations** | 213 | 415 | 254 | 196 | 181 | 196 |
| **Number of compressor plants (shops)** | 12 (22) | 22 | 9 (15) | 18 | 6 (7) | 23 |
| **Number of gas pumping units** | 150 | 152 | 83 | 127 | 60 | 133 |
| **Overall capacity of compressor plants** | 854.4 MW | 1070.8 MW | 407.1 MW | 1121.9 MW | 376.82 MW | 1668.5 MW |
| **Number of underground gas storages** | 4 | 3 | 2 | 1 | 2 | 1 |
| **Number of employees** | 3311 | 3960 | 2978 | 3356 | 2561 | 2710 |

[120] Ukrtransgaz AC (Homepage).

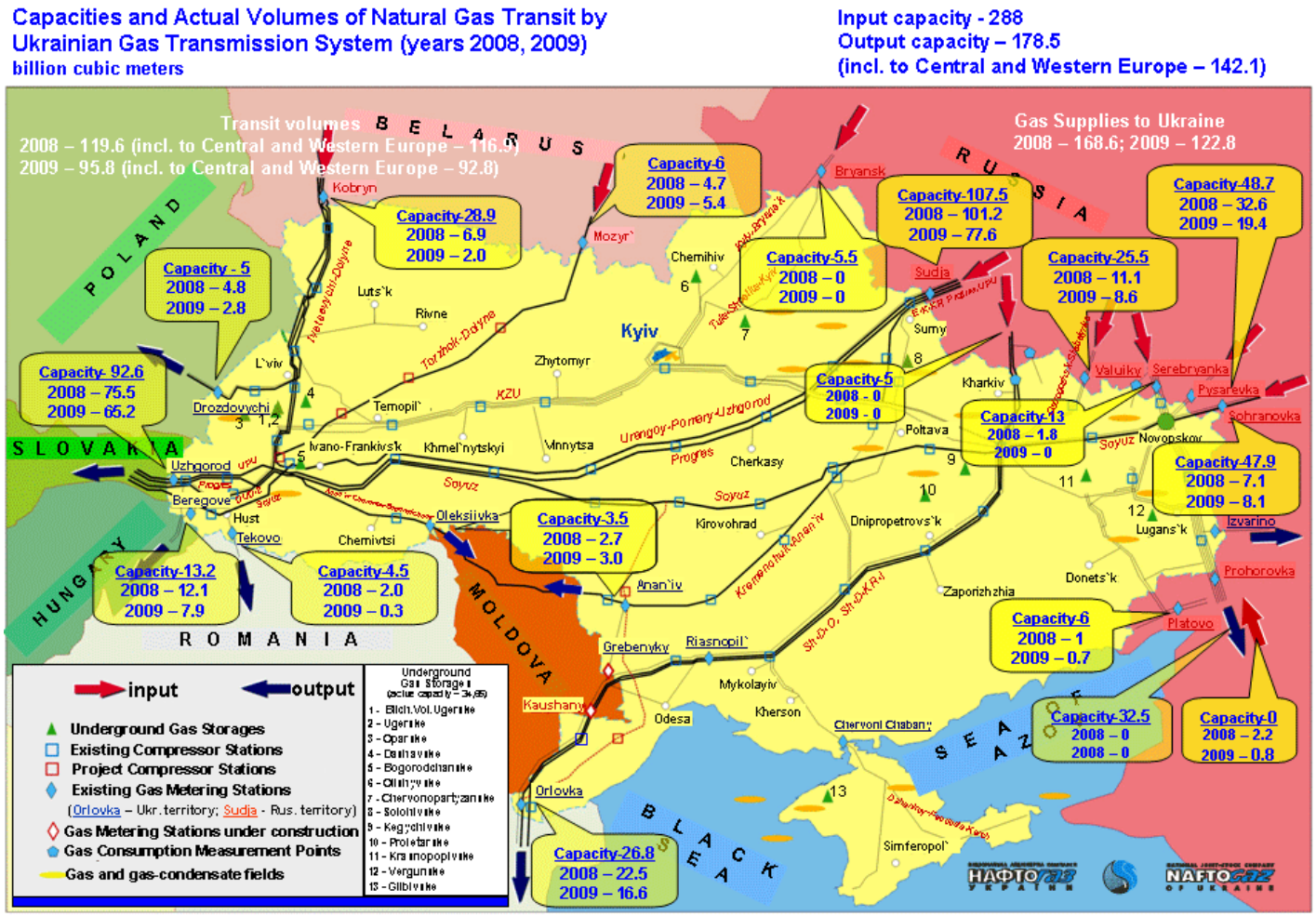


Figure 36: Capacities and Actual Volumes of Natural Gas Transit by Ukrainian GTS (2008, 2009)

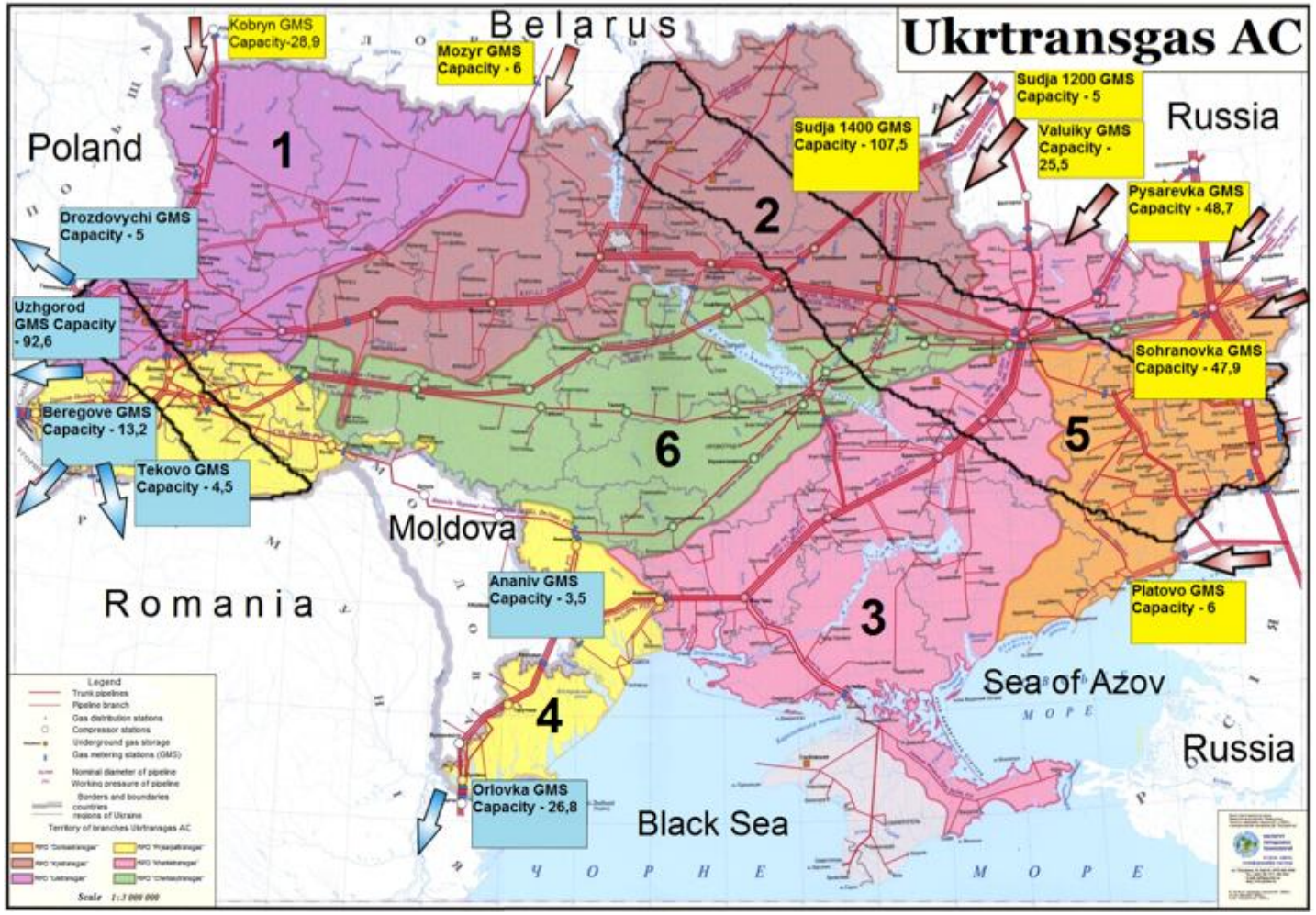


**Figure 37: Ukrainian Gas Transmission System**

### 4.3.12. COMPRESSOR STATIONS

The Ukrainian gas pumping capacity consists of 702 units including 448 gas turbine units of 20 different types (63%), 158 electric motor driven units of 4 types (23%) and 96 gas motor driven units of 3 types (14%). Their total capacity is 5450 MW. They are located at 74 compressor plants including 112 compressor shops.

To ensure reliable gas transportation, reconstruction of compressor plants is undertaken by replacing gas pumping units whose service life is finished with high-efficiency (36%) engines having capacity of 6, 10, 16 or 25 MW.[121]

Ukrtransgaz AC started to integrate very actively electric motor driven gas-pumping units to the production process in 2010, after change of the company's management. That change allowed the company to conserve 335 million cubic meters of natural gas since the beginning of the year 2011 with total cost about UAH 1,1 billion at the expense of less use of fuel gas for gas pumping units (GPU) owing to use of electric motor driven GPUs.

The biggest number of electric motor driven gas compressor units is concentrated on the Transnational gas pipeline system. This system supplies gas to Kharkivtransgas (main Gas Pipeline Department), Lvivtransgas (main Gas Pipeline Department) and Kyivtransgas (main Gas Pipeline Department). Electric motor driven gas compressor units have higher efficiency (up to 89%) account for 23% of the total stock of Ukrtransgaz AC gas compressor units and may produce up to 15% of the gas compressor units total output.[122]

### 4.3.13. UNDERGROUND GAS STORAGE

Ukrtransgaz AC has one of the largest underground gas storage facilities (GSF) networks in Europe. It is an integral technological constituent of the Ukrainian gas transportation system. Today the company operates 13 underground gas storage facilities, two of which are created on the basis of aquifer storages and the rest on the basis of depleted gas reservoirs. The total active volume of underground gas storage facilities is 34.5 billion m³, about 21.3% of European gas storage capacity.

The underground gas storage network includes four systems: the West-Ukrainian, Kyiv, Donetsk and South-Ukrainian complexes. At maximum storage and output rates, Ukraine's storage facilities can withdraw 250 million cubic meters of natural gas a day. The Company sells underground gas storage services both to gas suppliers and consumers.[123]

From the beginning of the period of 2011 pumping period, as of September 18.97 billion m³ of gas has been pumped into the underground storages. Hence, by December 2011 19.7 billion m³ of gas had been stored.[124]

### 4.3.14. LPG TRANSPORTATION

Ukrspetstransgaz SJSC, owned by Naftogaz of Ukraine NJSC, provides services for transportation of liquefied petroleum gas (propane - butane) in special gas tank cars from its producers to consumers within

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[121] Ukrtransgaz AC (Homepage).

[122] Pipeline Transport Magazine (Ukrtransgas AC Official Magazine).

[123] Ukrtransgas AC (Homepage).

[124] Pipeline Transport Magazine (Ukrtransgas AC Official Magazine).

Ukraine and abroad (Romania, Hungary, Moldova, Slovakia, Poland, Bulgaria). The enterprise has on its balance 1.860 rail tank cars. The enterprise annually carries hundreds of thousand tons of liquefied gas.[125]

### 4.3.15. GAS PIPELINE OPERATIONAL RESULTS

Ukraine input capacity is close to 290 bcm. According to data from 2006 to 2010 period the maximum capacity has never been reached (only 58% of total capacity of GTS). In 2011 the total volume of gas transited through Ukraine equaled 104.2 bcm including 101.1 bcm of gas transited to Western European countries.[126]

As it can be seen on Figure 38 the pipeline length increases steadily, however the throughput volume decreased (Figure 39).

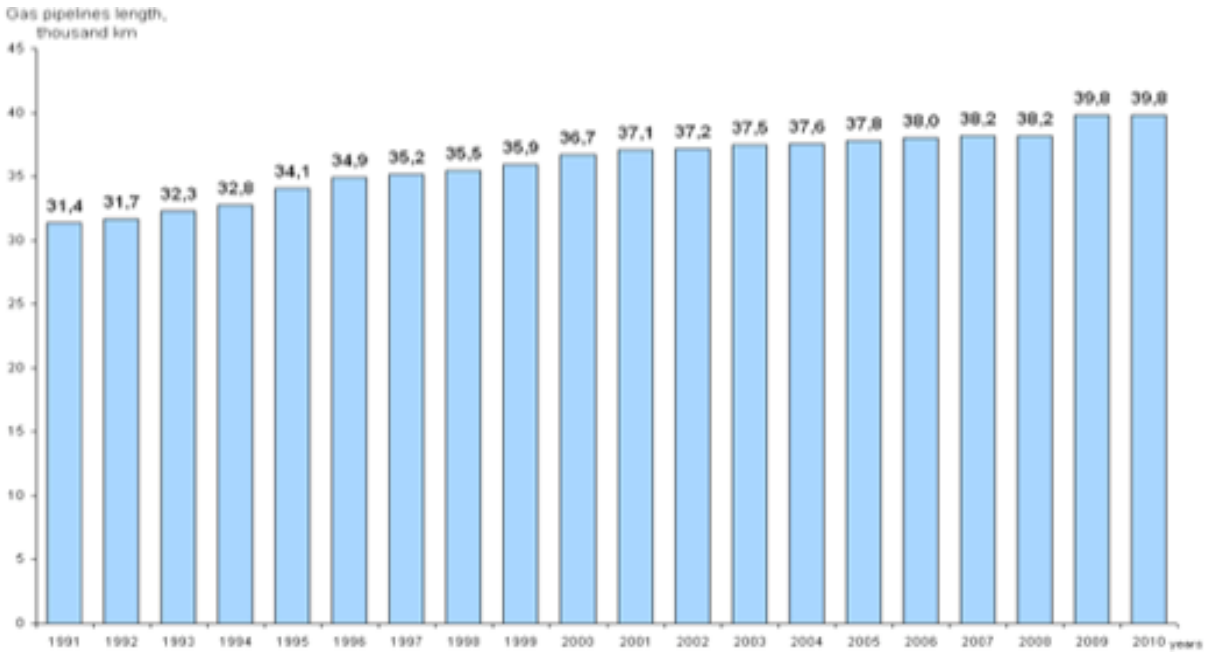


**Figure 38: Development of Gas Transmission System of Ukraine**

[125] NAFTOGAZ OF UKRAINE (Homepage).

[126] Pipeline Transport Magazine (Ukrtransgas AC Official Magazine).

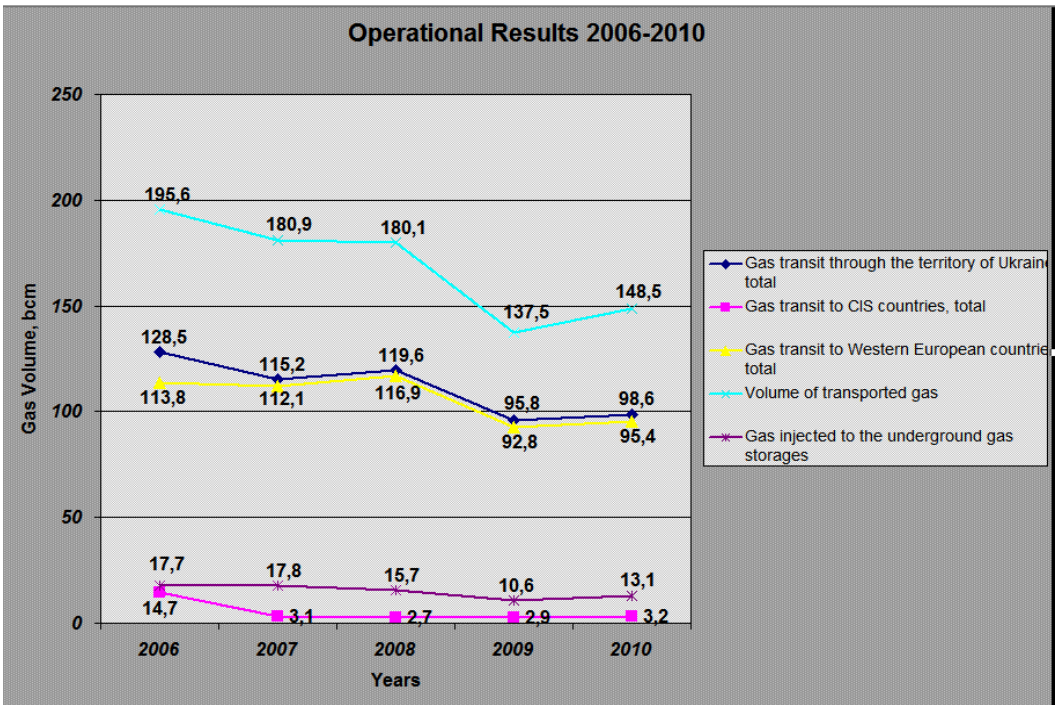


**Figure 39: Operational Results**

According to a chief engineer of Ukrtransgaz Affiliated Company, Igor Lohman„[127] the company still needs about US $5.3 billion investments for priority objects in a period of 7 years, 37.9% (US $2.014 billion) of which will go to pipelines modernization and repairing, 52.3% (US $2.781 billion) for the modernization and repairing of compressor stations, 8.5% (US $455.3 million) for underground gas storages and 1.19% (US $63.6 million) for output gas metering stations.[128]

## 4.3.16. INSTITUTIONAL CAPACITY AT NATIONAL AND LOCAL LEVELS

The following technical universities in Ukraine have been identified:

- National Technical University of Ukraine 'Kyiv Polytechnic Institute'
- Kyiv Taras Shevchenko National University
- Donetsk National Technical University
- National Mining University
- National Technical University 'Kharkiv Polytechnic Institute'
- V.N. Karazin Kharkiv National University
- National Aerospace University 'Kharkiv Aviation Institute'

[127] Personal communication with Ukrtransgaz by Gerhard Thonhauser.

[128] Ukrtransgaz AC (Homepage, Interview with chief Engineer, Translated into English).

- Lviv Polytechnic National University
- Ivano-Frankivsk National Technical University of Oil and Gas.

### IVANO-FRANKIVSK NATIONAL TECHNICAL UNIVERSITY OF OIL AND GAS (IFNTUOG)[129]

Founded in 1960s it is the only higher education establishment specializing in oil and gas training in the country.

Currently there are around 10 thousand students studying at 28 specialties and 14 departments. 682 are the number of university teaching staff (56 Doctors of Sciences and 239 Candidates of Science). High-quality long-term teaching is ensured by technical and support staff. Over 600 people are employed in university research and development institutes. The University also trains students from other countries, such as, Bulgaria, Belarus, Vietnam, India, Iran, Jordan, Moldova, Mongolia, Russia, Pakistan and Turkmenistan.

Bachelor's Degree Program duration is 4 years. Upon graduation students are awarded the Diploma of Bachelor of Sciences translated into Ukrainian and English languages. Master's Degree Program duration is plus 1 year after completing the Bachelor's program. Upon graduation students are awarded the Diploma of Master of Sciences translated into Ukrainian and English languages. The University prepares well-trained and qualified specialists of 22 specialties through post-graduate and doctorate study. Four specialized Scientific Councils are directed towards defending of theses for Doctor's degree on following majors:

- Drilling of Wells
- Development of Oil and Gas Fields
- Machinery of Oil and Gas Industry
- Oil and Gas Pipelines, Petroleum Depots and Storage Facilities Specialization
- Methods and Inspection Tools of Quality and Production Certification
- Geology of Oil and Gas
- Geophysics

### TECHNICAL SUPPORT ORGANIZATIONS

- Marathon (MRO)
- Naftogas Ukrainy (NAK)
- JKX Oil & Gas (JKX)
- Regal Petroleum (RPT)
- Cadogan Petroleum (CAD)
- Transeuro (TSU)

MRO and NAK signed an agreement in June 2007 to explore the Dnieper-Donets Basin. Other companies mentioned have interests in the basin or the vicinity.[130]

Total S.A. signed a contract on a feasibility assessment and possible acquisition of rights and deposits of non-conventional fuel in Western Ukraine together with Eurogas. Royal Dutch Shell has also joined the research for shale gas deposits.[131]

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[129] Ivano-Frankivsk National Technical University of Oil and Gas (IFNTUOG) Homepage.

[130] Maximilian Kuhn, Frank Umbach King's College of London „Strategic Perspectives of Unconventional Gas", May 2011.

### 4.3.17. TECHNICAL CAPACITY

There are five larger gas-processing plants (GPPs) in Ukraine. Three of them (Hnydytsevsky, Kachanivskiy, and Dolynsky) are incorporated into Ukrnafta; and two of them (Shebelinsky and Selechenskiy) are in the Ukrgazvydobuvannia/Naftogas structure. Together, Ukrainian GPPs and privately owned small gas processing units produce about 1.2 million tons per year.[132]

Ukrgasvydobuvannia AC includes Ukrburgas Drilling Department, which is the largest drilling enterprise in Ukraine. UkrgasvydobuvanniaAC drilled 240 thousand meters (141 miles) of headway in 2010, and constructed 78 wells.[133] Using this information, we calculated that the average well depth was approximately 3000 meters (10,000 feet). Drilling for shale gas will take place at considerably greater depths and more wells will be required to maintain economic production levels (based on U.S. experience and Stig Arne Kristoffersen 2010). Consequently, additional investments in technical and manpower capacity will have to be made to develop successfully Ukraine's shale gas fields. This gap between the drilling and technical requirements of shale gas and local capabilities is likely to be filled by international service providers and international E&P companies.

### 4.3.18. REQUIRED TRAINING AND HUMAN RESOURCES DEVELOPMENT

An example of the Marcellus basin in the US is presented in the following text. This example could provide a basis for understanding the skilled manpower needs for shale gas development in Ukraine.

To bring a single Marcellus shale well on line requires about 420 individuals across 150 different occupations. Utilizing 260 eight hour days or 2080 work hours per year, the first Marcellus well drilled on a well pad will require the total hours worked by these individuals equivalent to 13.1 FTE (Full-time equivalent) direct jobs over a course of the year for dry gas wells. Of these FTEs, 12.9 are required during the pre-drilling and drilling phase, while 0.19 are required during the production phase. For additional wells drilled on a previously constructed well pad, the total FTEs required drops to 9.64. Of the 9.64 FTEs, 0.65 are required during pre-drilling, 8.81 during drilling, and 0.19 during production phase.

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[131] Energy Security Challenges in Ukraine, 2010.

[132] Anna Tsarenko „Overview of Gas Market in Ukraine", 2007, Naftogaz.

[133] Ukrgasvydobuvannia AC Homepage (http://ugv.com.ua/en/activities/drilling, accessed on 17.02.2012).

**Table 20: FTE by Phase and Type of Well**

| FTE by Phase and Type of Well | | |
|---|---|---|
| Phase | Single Well | Additional Wells on Pad |
| Pre-drilling[1, 2] | 2.41 | 0.65 |
| Drilling[1, 2, 3] | 10.49 | 8.81 |
| Production[1, 2] | 0.19 | 0.19 |
| Natural Gas Processing[2] | 0.20 | 0.20 |
| Dry Gas Total | 13.09 | 9.65 |
| High-BTU Gas Total | 13.29 | 9.85 |

[1]Dry Gas Calculation
[2]High-BTU Gas Calculation
[3]Includes Pipeline Construction

It is important to note that pre-drilling and drilling phase jobs for each job do not compound year after year. These workers are required only while wells are being drilled and are a function of the number of wells being drilled each year.

The workforce model estimates that 0.19 of these long-term, full-time jobs are created for each dry gas well drilled in a given field (approximately one worker for every five wells drilled). Approximately 0.2 processing jobs are created per high-BTU gas well for the first five years of production from a well.[134]

$$\frac{(\text{Workers Per Well}) \times (\text{Work Days Per Well})}{260} \times (\text{Drilling Rigs} \times 12) = \text{Workforce Full Time Equivalent (FTE)}$$

*The average number of workdays for one FTE worker is equal to 260. A Marcellus Shale drilling rig will drill 12 wells per year on average, which has increased from 10 wells per year in previous models.*

**Figure 40: General Equation Behind Workforce Model**

[134] Marcellus shale education and training center, "Pennsylvania Marcellus Shale Economic Impact Study", 2011.

**Table 21: Historical and Projected Activity & Median Estimated Workforce Requirements, 2008-2014**[135]

| Historical and Projected Drilling Activity & Median Estimated Workforce Requirements, 2008-2014 | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Southwest | | | Northeast | | | Northwest | | | Pennsylvania | | |
| | Wells | Rigs | FTEs | Wells | Rigs | FTEs | Wells | Rigs | FTEs | Wells | Rigs | FTEs |
| 2008 | 103 | 10 | 1,333 | 76 | 8 | 956 | 19 | 2 | 239 | 198 | 20 | 2,528 |
| 2009 | 370 | 37 | 4,319 | 332 | 33 | 3,745 | 61 | 6 | 689 | 763 | 76 | 8,753 |
| 2010 | 358 | 36 | 4,032 | 909 | 91 | 9,664 | 101 | 10 | 1,080 | 1,368 | 137 | 14,777 |
| 2011 | 449 | 37 | 5,095 | 1,020 | 85 | 10,971 | 130 | 11 | 1,401 | 1,599 | 133 | 17,467 |
| 2012 | 620 | 52 | 7,062 | 1,089 | 91 | 11,889 | 179 | 15 | 1,940 | 1,888 | 157 | 20,891 |
| 2013 | 760 | 63 | 8,734 | 1,069 | 89 | 11,884 | 180 | 15 | 1,985 | 2,009 | 167 | 22,603 |
| 2014 | 892 | 74 | 10,350 | 1,088 | 91 | 12,285 | 179 | 15 | 2,008 | 2,159 | 180 | 24,644 |

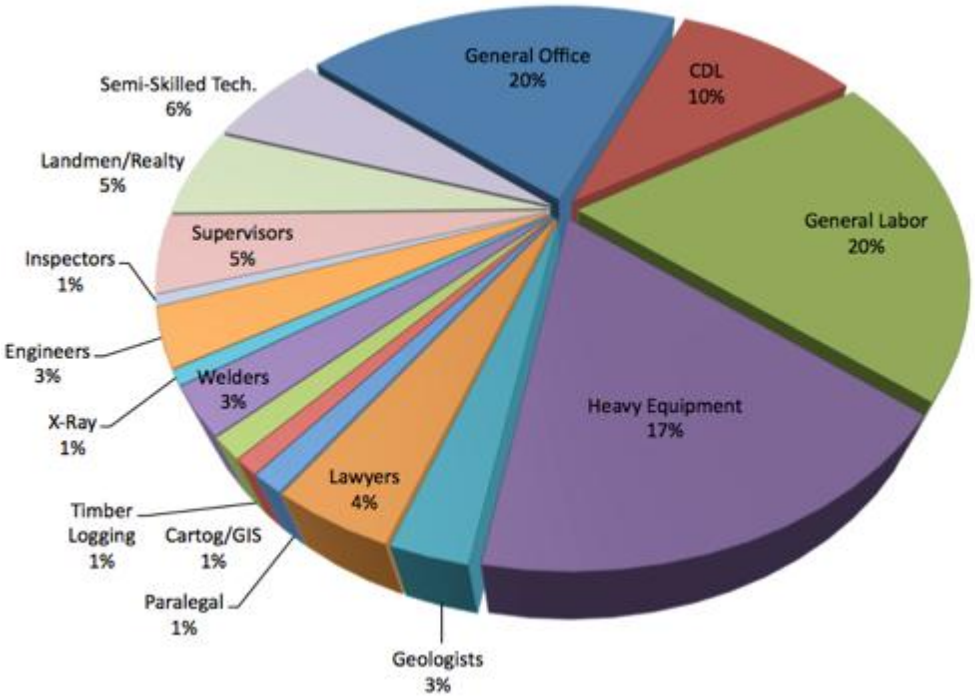


**Figure 41: Occupational Composition of Natural Gas Workforces**

## 4.3.19. ESTIMATING THE NUMBER OF WELLS FOR DEVELOPMENT

This sections aims to define the number of wells required to develop the Dnieper-Donets Basin, as well as the equipment required such as drilling rigs and fracturing units.

The model is based on data available for the Dnieper-Donets Basin.

[135] Marcellus shale education and training center, "Pennsylvania Marcellus Shale Economic Impact Study", 2011.

The Dnieper-Donets Basin consists out of 31 sub-basins. Nine of the sub-basins are assumed to be potential shale gas prospects, however two of them are close to major cities and therefore are not considered. Total areal extension of 22,500 km² of probable shale gas prospects was selected.[136]

### SCENARIO I

For this scenarios, the accessible area was set to be 10%,[137] resulting in a total areal extension of 2,250 km². The well spacing was assumed to be 3.0/2.4/1.5 wells per km².[138,139] Taking these numbers into account, about 6,860/5,490/3,430 wells have to be drilled in the Dnieper-Donets Basin, as illustrated in Figure 42.

The timeframe for the development period was assumed to be 20 years.

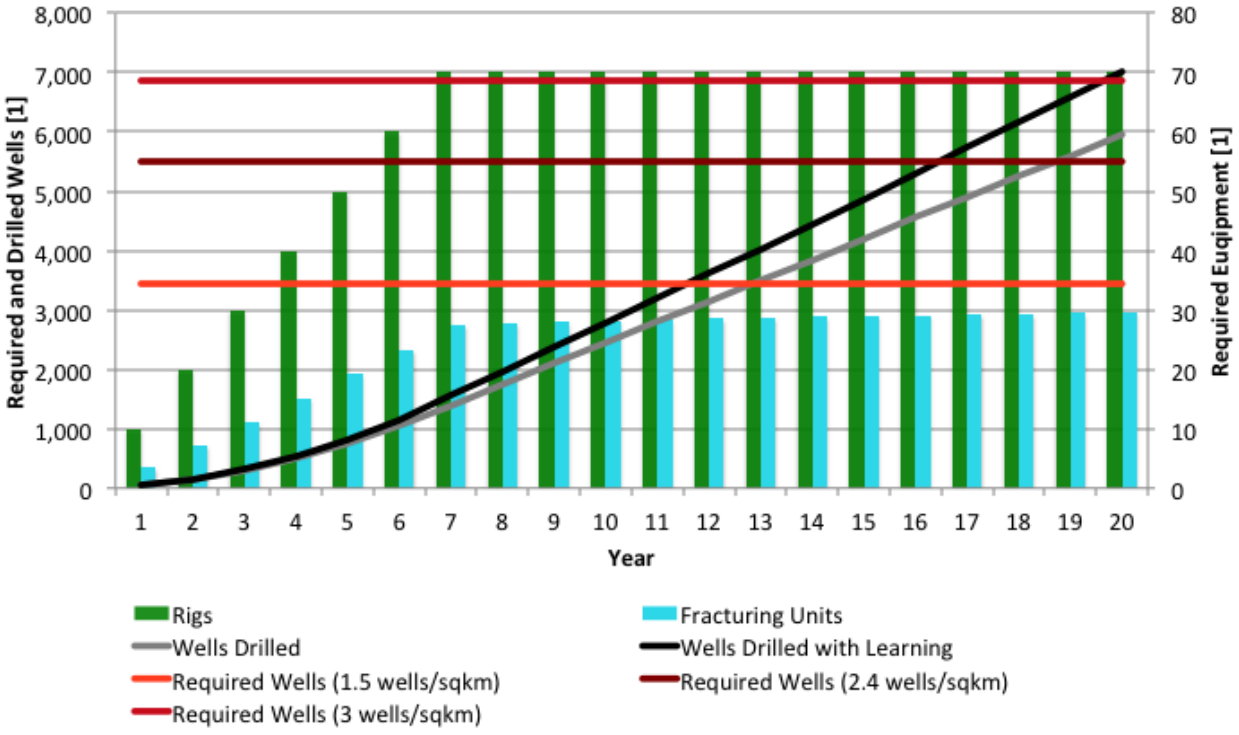


**Figure 42: Drilling Requirements for Production Scenario 1**

The initial number of rigs, which can be used for shale gas drilling, was presumed to be 10. Adding 10 new rigs for 6 subsequent years, then 70 rigs drilling are for the 13 remaining years. Wells are drilled within weeks up to one month[140] in the US. However, there are data stating that it takes much longer to drill wells

[136] Stig Arne Kristoffersen "Gas Shale Potential in Ukraine", Bahrain 2010.

[137] Hans Jürgen Handler: „Unconventional Energy Strategy", presented at Siemens Oil and Gas CEE Days, 11th Jan 2012.

[138] "Impact of the Marcellus Shale Gas Play on Current and Future CCS Activities", US DOE, NETL, August 2010.

[139] Norvell P.E.: " Prelude to the Future of Shale Gas Development: Well Spacing and Integration for the Fayetteville Shale in Arkansas".

[140] Billa R., et a.: „Drilling Performance Improvement in the Haynesville Shale Play", SPE/IADC 139842, Shell Upstream Americas, 2011.

in Ukraine. Taking this into account we assume that one rig drills 5 wells per year. This scenario illustrates that 5,950 wells should be drilled in 20 years development period. Taking into account a learning curve, about 7,000 wells are likely to be drilled in the same timeframe. All further calculations include the learning curve effect.

One fracturing job is assumed to last 5 days. According to the scenario described above, 30 fracturing units would be required.

Under the given assumptions of Scenario 1 it is possible to develop the field even with the 3.0 wells per km$^2$ well spacing.

### SCENARIO 2

Assuming a core area of 20% (4,500 km$^2$) and the same well spacing as in Scenario 1 13,720/11,980/6,860 wells have to be drilled in the 20 years period. Starting with 10 rigs and adding 10 rigs in each of the four subsequent years and then adding 15 rigs each year until the 13$^{th}$ year, the Ukraine requires 170 rigs, resulting that 13,600 wells can be drilled. The number of fracturing units would increase to 72.

### EFFECT ON NEIGHBORING COUNTRIES

Ukraine is important to Europe because it is a transit country for 80% of Russia-EU gas exports, supplying one-quarter of EU gas demand. Ukraine is also the easternmost border of the EU, comprising a population of 46 million people who, generally speaking, hope to see themselves as part of the Union in the future.

As a former constituent of the Soviet Union, Ukraine still maintains persistent ties, both economic and psychological, to Russia. Russia has been able to exert continued influence in Ukraine due in part to that country's dependence on Russian gas. At the same time, Russia sees Ukraine as vital because the gas transit pipelines through Ukraine are vital to Russia's economic health and political influence in Europe.

It is doubtless the case that robust development of Ukrainian shale gas would impact Russia's financial and political influence with Ukraine and with the EU customers for Russia's gas. Production cost estimates compiled for this report indicate that shale gas produced in Ukraine could be sold at prices well below oil parity, breaking the Russian price bar, just as shale gas has done in the Atlantic Basin to oil-linked LNG prices. With Russian influence in Ukraine curtailed by Ukraine's gas dependence, Russia's energy leverage over the EU would be weakened.[141] Were Ukraine to be able to raise shale gas output to the point of exporting gas to the EU then an important element of Russia's financial and political leverage in that sphere would attenuate.

Successful production of unconventional gas in Ukraine and Poland could become exemplary for other EU members with potential reserves, including France, Netherlands, United Kingdom, among others. [142] Were that to happen, then, just as U.S. shale gas development provided technology, capital and a positive example for Canada and Australia, Ukraine and Poland could provide the EU with a technological path out of dependence on Russian gas. At a minimum prices throughout the EU would likely soften considerably.

As regards the impacts of emissions from shale gas production and use, it is likely that emissions from shale gas use in the power and CHP sectors will reduce overall emissions from current levels. Emissions from

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[141] Gordon Little, 2012. University of New York. How would the Development of Shale Gas Resources in Ukraine Impact Europe's (energy) Security? Online source: http://www.iaee.org/en/publications/newsletterdl.aspx?id=162

[142] Frank Meißner, Dmytro Naumenko German Advisory Group, Institute for Economic Research: "Non-Conventional Gas Regulation in Europe: Implications for Ukraine", April 2011.

the production of shale gas, mostly in surface waters, can be expected to be minimal provided appropriate mitigation methods are used and best practices are adopted for both technology and regulation.

### 4.3.20. WORKER SAFETY STANDARDS

The new rules, which were adopted on 6 June 2008 by the State Committee for Industrial Safety, Labor Protection and Mining Supervision:

- Will apply to everyone involved in design, construction, extraction, repair or reconstruction aspects of oil and gas production, as well as specialist organizations involved in geophysical surveys, R&D, projects and construction, engineering, balancing, commissioning and emergency response.
- Contain detailed and comprehensive technical requirements and incorporate key technical standards previously spread across many documents.
- Require all organizations intending to engage in oil and gas production or research to obtain a permit from the Committee before doing so.
- Require each project for exploration, production and equipping the oil and gas fields to be properly evaluated, examined and approved before a permit is granted.
- Set out detailed requirements relating to staff, equipment, machinery, tools and working conditions, particularly for those working in confined spaces such as wells.
- Prescribe safety standards for preparation works, drilling and repairing the wells, and for the work program used for constructing wells.
- Set out a list of necessary technical and safety characteristics for mining equipment including the emergency response process.
- Include requirements for procedures such as using sucker-rod pumps, coiled tubing installations, the cycling process, water flooding, flowing wells and gas lift operations, as well as for the intensification process, repairs, oil and gas gathering and transportation.
- Specify that geophysical works may only be conducted by specialist geophysical companies under agreements with drilling and production companies.
- Stipulate that all geophysical research must be carried out in the presence of representatives of the drilling team and well owner and sets out requirements for drilling and extraction activities and for geophysical equipment.[143]

## 4.4. REVIEW CAPABILITIES FOR MONITORING, REPORTING AND VERIFICATION (MRV) AND THEIR RELEVANCE TO SHALE GAS DEVELOPMENT

### 4.4.1. MONITORING, REVIEW AND VERIFICATION ACTIVITIES NECESSARY TO SUPPORT ENVIRONMENTAL REGULATION OF SHALE GAS DEVELOPMENT

The Bali Action Plan initiated a new round of negotiations under the United Nations Framework Convention on Climate Change (UNFCCC). In framing these negotiations, the Bali plan requires that certain actions be "measurable, reportable and verifiable." Specifically, in paragraphs 1(b)(i) and (ii), addressing mitigation, the plan appears to anticipate that a new climate agreement will provide

[143] Mondaq (Website).

for the measurement, reporting, and verification (MRV) of three categories of action: developed country mitigation commitments or actions, developing country mitigation actions, and the provision of support for developing country mitigation actions.[144] According to the Pew Center on Global Climate Change:

MRV can serve a wide range of purposes in a new climate agreement. It can provide an important means of tracking parties' progress individually and collectively toward the Convention's ultimate objective. The very process of measurement can facilitate parties' actions by establishing baselines and helping to identify mitigation potentials. The reporting of actions can allow for their recognition internationally. The review or verification of parties' actions can enhance action through expert advice on opportunities for improvement. MRV could play a particular role in the linkage between developing countries' action and support for those actions. Finally, credible MRV can strengthen mutual confidence in countries' actions and in the regime, thereby enabling a stronger collective effort. [145]

### 4.4.2. SUMMARY OF MRV PROVISIONS IN UKRAINE LAW

The Supreme Council (Parliament) of Ukraine ratified the UNFCCC on 29 October 1996, and in accordance with UN rules, Ukraine became a Party to the Convention on 11 August 1997. The Kyoto Protocol to UNFCCC was ratified by Ukraine on 4 February 2004. The national regulatory and legislative base, related to the climate change issues is constantly developing and improving with over 30 regulatory and legislative documents, dealing with the execution of the requirements of UNFCCC and its Kyoto Protocol, which regulates activity in Ukraine related to climate change issues.

The [MENR] ensures active participation of Ukraine in the negotiation process initiated by the Bali Action Plan in order to prepare drafts of decisions that should in the best way reflect the national interests of the country.[146] In 2009, the Cabinet of Ministries of Ukraine, taking into account aspects of the international negotiation process, introduced changes to the National Plan of actions on performance of the Kyoto protocol.[147] This National Plan stipulated the drafting, during 2010, of a national plan of actions for adaptation for climate change, and for later drafting of correspondent regional plans for each oblast in order to take into account their peculiarities. This national plan has yet to be adopted (January 2012).

The Fundamentals (Strategy) of State Ecological Policy of Ukraine until 2020[148] envisaged that during the period from adoption until 2015, the main principles of state policy on climate change should be defined, a National Plan of actions on mitigation of climate change consequences and prevention of anthropogenic influence on climate change until 2030 should be worked out, and the plan of action should be performed in stages. While the National Plan is still being developed, it is considered an issue of national security. On November 17 2010, the National Council of Security and Defense of Ukraine issued a decision on challenges and threats to the national security of Ukraine in 2011. In this decision, it stated that the Cabinet

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[144] Breidenich, Clare and Daniel Bodansky. 2009. Measurement, Reporting and Verification in a Post-2012 Climate Agreement, Pew Center on Global Climate Change at 1. http://www.c2es.org/docUploads/mrv-report.pdf

[145] Breidenich, Clare and Daniel Bodansky. 2009. Measurement, Reporting and Verification in a Post-2012 Climate Agreement, Pew Center on Global Climate Change at 1. http://www.c2es.org/docUploads/mrv-report.pdf

[146] Fifth national notification of Ukraine on climate change prepared in accordance with articles 4 and 12 UNO convention on climate change and article 7 of Kyoto Protocol (dated 2009).

[147] Adopted by Directive of Cabinet of Ministry of Ukraine March 5 2009, N 272-p.

[148] Adopted by Law dated December 21 2010, N 2818-VI.

of Ministers of Ukraine should in three months work out and adopt a National Plan of adaptation for climate changes and should define the sources for financing actions.

To our knowledge, there is no national plan for monitoring, reporting and verification of greenhouse gas emissions reductions, but there is evidence that Ukraine is taking actions to reduce the country's contribution to climate change and to mitigate its impacts. See for example, a pilot project on Energy Efficiency in Municipal District Heating[149] and Reducing Vulnerability to extreme floods and climate change in the Dniester river basin.[150]

### 4.4.3. CURRENT CAPABILITIES OF UKRAINE GOVERNMENT AND TECHNICAL GROUPS FOR MRV IMPLEMENTATION AND SUPPORT

From the OECD/IEA analyses for COP 15:

> The 2007 Bali Action Plan refers to "measurable, reportable and verifiable" (MRV) as an important part of the international process intended to deliver concrete national actions to address climate change. Gaps and weaknesses in current provisions to measure, report and verify greenhouse gas (GHG) emissions, mitigation actions and support have led to proposals for an enhanced framework for MRV in a post-2012 agreement. Such a framework could facilitate strategic and cost-effective decision-making; the implementation of mitigation actions; and the generation of transparent and comparable information.
>
> There is much uncertainty as to what exactly M, R and V will comprise post-2012, and to what it will be applied. The scope and scale of provisions to measure, report and verify GHG mitigation actions, commitments and support are still being negotiated. Key issues are to what extent MRV provisions are common for developed and developing countries; and whether these provisions are to vary within developing countries, depending for example on whether actions are supported by international finance. What a post-2012 framework for MRV focuses on – e.g. emission levels, mitigation actions and/or emission reductions from mitigation actions – will also have significant impacts, both in terms of what countries will need to do to satisfy MRV requirements as well as on whether new international guidance is needed to achieve a transparent system that generates comparable information. . . .
>
> ... but new institutional structures, guidance and processes are also likely to be needed. Strengthening reporting and measurement provisions for information on mitigation actions, to include more countries, as well as GHG impacts, is likely to entail new institutional structures, guidance and/or processes at the national and international level. For qualitative reporting, a national "focal point" or leading body may be needed to collect and submit information on mitigation actions (and possibly support received and provided), whether the submission is a national-level action plan or strategy, or whether it comprises sector-level and individual mitigation actions. Institutional provisions for national- level measurement and verification activities could also be needed if

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[149] Climate Change Mitigation in Ukraine Through Energy Efficiency in Municipal District Heating (Pilot Project in Rivne) http://europeandcis.undp.org/environment/show/3D2AA100-F203-1EE9-B4A6E9B2C225F652

Lessons learned or additional resources: http://gefonline.org/projectDetails.cfm?projID=934

[150] Reducing vulnerability to extreme floods and climate change in the Dniester river basin (The project aims to reduce risks from climate change - and specifically flooding - for security by improving the adaptive capacity of Ukraine and the Republic of Moldova. More specifically, the project aims to expand and further strengthen cooperative management in the Dniester River basin to address cross-border management of floods, taking into account both current climate variability and long-term impacts of climate change on flood risks.) http://www1.unece.org/ehlm/platform/display/ClimateChange/Dniester

quantitative reporting is included, particularly if actions and/or commitments are recorded in an appendix to a post-2012 agreement.[151]

Within Ukraine, the national "focal point" or leading body for collecting and submitting information on mitigation activities could be the MENR, with the assistance of its local bodies and NGOs and industry associations. The National Ecological Centre of Ukraine (NECU) currently works to monitor activity of the Ukrainian government and impact its decisions for implementation of the climate protection programs. The NECU participates in activities of the NGO Working Group (NGO WG) on Climate. NECU also takes active part in international negotiations on the reduction of greenhouse gas emissions, monitors the implementation of Kyoto protocol mechanisms in Ukraine, works with media and general public.[152]

## 4.5. COLLABORATION WITH UKRAINE ON PREPARATION

The IRG Team has worked closely with a variety of Ukrainian institutions since the project definitional mission in December 2010. Team members have met with representatives from the key Ukrainian government institutions involved with shale gas and alternative energy.

The project definitional trip established the general parameters of USAID collaboration with the Government of Ukraine. During this trip team members met with key Ukrainian and international institutions, including:

- Ministry of Fuel and Energy
- Naftogaz
- MENR
- Poltava Geophysical Works Authority
- National Agency for Effective Use of Energy
- EU
- Shell Ukraine
- US Embassy (Ambassador Tefft and staff)
- EU Twinning Project at NERC

In an initial trip in May 2011, prior to the finalization of the scope of work, a team from IRG and Environmentally Friendly Drilling (EFD) joined Dr. Robert Ichord in Kyiv to flesh out the needs of the Ukrainian counterparts. At this point it was established that the counterpart institution for this project would be the MENR. The MENR has authority over production sharing agreements for shale gas and was the natural locus for this activity.

### 4.5.1. ESTABLISHMENT OF COUNTERPART TEAM

In October 2012 the IRG Team returned to Kyiv and held two meetings at the MENR. The first was to (re)introduce the Team to the Dr. Ignashenko and his key staff on shale gas matters.

His team consists of experts on water resources, water law, land use, PSAs and environmental impacts generally. Dr. Ignashenko laid out his goals for the project, focusing on those activities that can lead to the execution of production sharing agreements in the Western Part of the country.

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[151] Measurable, Reportable and Verifiable Mitigation Actions and Support: A summary of OECD/IEA analyses for COP 15. http://www.oecd.org/dataoecd/32/15/44228245.pdf

[152] National Ecological Centre of Ukraine - Національний екологічний. http://www.necu.org.ua/about/

Key issues included the issuance of land permits by the Lviv Oblast for the Olesky PSA area, protection of potable water resources, underdevelopment of local water resources.

The MENR team noted that they would like to refine their EIA methodology to conform it more to both international practice and local needs. (Note, this is one of the key short and long term recommended activities for follow-up with MENR).

There was significant discussion of Ukrainian water law, which appears to be very detailed and complex as regards water strata and types. Dr. Ignashenko also expressed interest in the alternatives work stream (Markal modeling) and the timeline and nature of that analysis was discussed.

The IRG Team discussed these water issues and we are likely to take an approach to water regulation that focuses on water consumption, and treatment outcomes, rather than specific strata of water types. As regards PSAs Dr. Ignashenko noted that the current PSA law, though not perfect, is probably workable with appropriate safeguards through a Council of Ministers process regarding tax code, customs code and gas sales. Modifications to the PSA law to remedy its current deficiencies is a long process, 2-3 years, and is not guaranteed to yield improved outcomes in the near term.

It was agreed that the IRG Team would meet with a subgroup to establish some of the roles and responsibilities of the counterpart team later in the week (meeting held on Wednesday October 5 to that end). At this subgroup meeting it was further agreed that:

- Hertzmark would provide Oksana Kyshko-Yerli with some samples of best international practices in PSA tendering;
- Kathryn Mutz to work with Ministry lawyers as regards best international practices for environmental assessments and regulatory environment;
- Both sides to provide lists of key team members and contact details.

The IRG Team liaised with MENR through visits by Kathryn Mutz and Matthew Sura. In between visits there was steady contact through, Ms. Kyshko-Yerli, the IRG Team's Kyiv-based attorney.

Hertzmark returned to Kyiv in early February 2012 and held an extended meeting with MENR staff, led by Mr. Ivan Ivanets. The draft report was discussed with the MENR, including a summary of environmental and legal activities and findings. In particular, the discussion focused on findings with respect to water use, water pollution and treatment of produced and wastewater streams. These remain areas that are poorly articulated in Ukrainian law and will require additional environmental studies to establish a baseline. A positive example for mitigation of environmental degradation caused by shale gas activities was provided on the subject of air pollution from road building, transportation, drilling and gas compression. Examples of best practices, regulation and other mitigation measures discussed in the draft report were presented orally to the MENR counterparts. Mr. Ivanets requested that the IRG Tem provide a review copy of the draft report at the end of this month. The IRG Team agreed to provide the MENR staff with extended consultations and a translation of the Final Report when they return in May 2012.

At that time the IRG Team will be able to focus on activities that are specifically to the benefit of the MENR staff assigned to shale gas oversight. These activities will include the recommended follow-up activities listed in Section 5 of this report.

While it has been difficult to establish a regular rhythm of collaboration during this phase of the work the IRG Team is confident that a set of follow-on activities focused specifically on the needs of MENR rather than the requirements of U.S. law will permit closer contact and collegial collaboration.

# 5. RECOMMENDATIONS FOR FOLLOW-ON ACTIVITIES

## 5.1. INTRODUCTION: ENHANCING UKRAINE'S CAPACITY TO DEVELOP AN ENVIRONMENTALLY SOUND STRATEGIC APPROACH TO SHALE GAS DEVELOPMENT

In early 2011, the U.S. Government and Government of Ukraine signed a Memorandum on Shale Gas Development. Within this framework, USAID began assisting Ukraine in addressing the environmental and regulatory aspects of shale gas development and production. This cooperation is intended to increase Ukraine capabilities to address environmental concerns in shale gas development and create a framework for monitoring and mitigating possible negative impacts and facilitating sound investments by international and Ukrainian companies. As part of that effort, the IRG Team, in cooperation with Ukraine's MENR has prepared this PEA (Volume I) and a Regulatory Analysis (Volume II). The team has also cooperated with government officials, NGOs, international and Ukrainian companies, and academics to identify follow-on activities that, beyond the scope of this PEA and the Regulatory Analysis, can further this mission. The following sections briefly describe potential activities that can be carried out in the short-term (before December 31, 2012) and in the long-term with willing Ukrainian counterparts.

The objectives of these follow-on activities are three-fold: (i) provide essential near-term advisory services for ongoing contractual and project development activities; (ii) provide a framework for the design and development of longer term solutions; and (iii) implement changes in law, regulatory procedures, measurement of environmental conditions and impacts and analysis of local impacts prior to large scale development of the country's shale gas resources. The following sections describe the goals of specific activities, outline the necessary tasks, and identify stakeholder groups and colleagues that would be needed to participate in the activities. The descriptions do not, however, identify specific entities (e.g., NGOs) or individuals, nor has availability of any individuals to participate been determined.

## 5.2. ESTABLISHING BASELINE ENVIRONMENTAL INFORMATION AND DEVELOPING MONITORING AND MITIGATION PLANS

The Government of Ukraine has identified a need to develop better information on natural resources and pollution in Ukraine. Action items in Ukraine's National Action Plan (see Appendix 6) include developing a national environmental information system and database (Item 1.1), further development of the national system of inventories of natural resources, state statistical reporting on the use of natural resources and environmental pollution (Item 6.2), and addressing various air quality issues (Items 2.2 – 2.5 and 3.1). Baseline information is important for evaluating the potential impacts of development as well as gauging actual impacts and determining responsibility for impacts and accidents.

Most studies of the environmental impacts of shale gas development (including horizontal drilling and hydraulic fracturing) suffer from the lack of baseline monitoring to determine conditions prior to gas development. Two full years of monitoring of a development site prior to any operation are the minimum necessary to provide sufficient information to establish a baseline. Then monitoring of environmental

parameters can continue through pad and access road construction, drilling, completion and into early production.

### 5.2.1. SHORT-TERM ACTIVITIES: BASELINE ENVIRONMENTAL INFORMATION PLANNING AND ASSESSMENT

A short-term activity is recommended to scope out the work plan for the three items discussed further below: (i) the two year baseline study, including identification of best management practices needed to protect air and water quality; (ii) the assessment of the impact on the economy and the community and (iii) plans to address produced water issues. This short-term activity would be a joint undertaking by the Houston Advanced Research Center (HARC) and the University of Leoben. Assistance would come from various members of the Environmentally Friendly Drilling Systems program team located in the United States, including Texas A&M University, West Virginia University and potentially additional consultants. This short-term activity should involve approximately 400 hours of effort over four to six weeks. The project would result in a document that provides an initial outline of the three investigations that are discussed further below, along with potential other long-term studies that may be identified during the short-term activity. The Environmentally Friendly Drilling Systems team has a representative on the U.S. Environmental Protection Agency's Science Advisory Board concerning their multi-year study on the impact of hydraulic fracturing on fresh water resources. The proposed effort will include consultation with this Board to help establish the focus and methodology for any study conducted on the same issue in the Ukraine. The short-term activity would consist of the following elements:

- University of Leoben personnel will establish the state of the art in baseline studies through contact with leading institutions in the United States that have performed or have ongoing baseline studies; develop summary report.

- University of Leoben personnel will travel to Kyiv and meet with MENR and other appropriate government agencies and environmental organizations in Kyiv to determine important environmental parameters that should be baselined; develop summary report of meetings.

- Write a summary report assessing data needs and providing plans for baseline studies:
    - Outline of information that can be obtained by visiting potential shale development site(s) in the Ukraine to determine appropriateness of baseline monitoring parameters.
    - Outline plans for the three investigations:
        - One-year baseline study
        - Assessment of the Impact on Economy and Community
        - Produced Water Issues.

### 5.2.2. LONGER TERM ACTIVITIES: DEVELOPMENT OF PRE-DRILLING BASELINE INFORMATION, LOCAL IMPACT ASSESSMENTS AND PRODUCED WATER ANALYSIS

#### DEVELOPING PRE-DRILLING BASELINE INFORMATION

A longer-term activity would be needed to develop the detail baseline study plans and perform both the predrilling baseline study and the assessment of the impact on the economy and the community.

The Marcellus Shale Coalition in the United States has established useful guidelines for pre-drilling assessments designed to protect oil and gas producers from unwarranted damage claims. The guidelines include recommended approaches, sampling methodologies, and lists of analyses, such as metals and dissolved gases, as well as laboratory methods. Typical pre-drilling baseline assessments usually consist of

documenting nearby water-supply wells and springs, developing a sampling approach, contacting local residents to request access for sampling, and then sampling, analyzing, and reporting.[153]

Baseline studies would include:

- Regional water quantity, including both surface and ground water, including recharge rates for groundwater
- Regional air quality
- Specific surface water time series and cross sectional data
- Mapping and survey data
- Seismic activity
- Study of best management practices

An economic and resource impact study determining existing water quality and quantity and air quality within the area prior to the commencement of gas extraction from the formation is critical. Data produced from future monitoring of streams and wells and air quality in the region will be compared to the baseline data to identify impacts that may be associated with gas development activities including drilling, hydraulic fracturing, trucking, etc. Baseline ground water and stream data and air quality measurements for at least two years are needed to capture the variability caused by different weather and seasonal events. The baseline study will include identification of best management practices required to maintain and improve air and water quality.

### IMPACT ASSESSMENT ON ECONOMY AND COMMUNITY

Other, non-site specific baseline data, are also needed. The first is development of best practices for all aspects of gas production and exploration. The second is a study to predict the impacts, both positive and negative, of gas exploration and production on the economy and the community. Data should be assembled on housing, transportation, recreation/tourism, local land use patterns, rural character, habitat, and wildlife. The study should identify ways to maximize the positive impacts and avoid or minimize negative impacts on the economy and community.

Understanding the dynamics of ground and surface water use and ground water recharge is important for protecting both the quantity and quality of drinking water supplies in the region. Data are also needed to understand the influence of drought and the seasonal impacts of ground water withdrawal on the water resource and on the health of stream biota.

Sampling of surface streams and the living organisms in them is key to establishing a baseline against which to assess the potential impacts of increased gas drilling, hydraulic fracturing, and production activity.[154]

### PRODUCED WATER

Technical issues concerning produced water will require further study. In particular, the following, will require further, long-term study. Plans should be developed for investigating these issues and these plans should be discussed with the MENR.

1. Produced water composition – need to measure the chemical make-up of the produced water in order to select appropriate treatment technologies.

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[153] Environmental Standards (Homepage), http://www.envstd.com/news_standard-2011-issue3-pg2.html.

[154] Maryland Department of the Environment, Maryland Department of Natural Resources "Marcellus Shale Safe Drilling Initiative Study", December 2011.

2. Make-up water volumes – need to determine the amount of produced water that will be available for reuse. Will also need to determine other sources of make-up water that can be available for hydraulic fracturing processes. This study should include a projection of the number of wells that will be drilled/completed along with the timing of the operations. This study is dependent upon field development plans that are developed by the operators.
3. Analysis of treatment options – once the produced water composition and the amount that is available for reuse is known, the various treatment and disposal options may be investigated.

## 5.3. DEVELOPING MITIGATION AND MONITORING PLANS

### 5.3.1. LANDOWNER, COMMUNITY, AND LOCAL GOVERNMENT OUTREACH – SHORT- AND LONG-TERM ACTIVITY

The Government of Ukraine has identified the need for improving access to information and education on ecological issues. Ukraine's National Action Plan (see Appendix 6) includes several action items on public education, including training programs, education centers, websites, etc. (see items 1.2 – 1.10).

During shale gas development, bodies of local self-government, NGOs, and citizens in the areas of potential shale development will experience local impacts of shale gas development. The U.S. experience in unconventional gas development has indicated that early engagement of these groups is important for facilitating development and benefiting the local community. A short-term activity supervised by the University of Colorado members of the IRG Team would initiate outreach to the landowners, communities, and local governments that will be affected by the two PSA processes initiated by the government in early 2012 (see Appendix 3) and develop a plan for future public engagement activities to be coordinated by a local NGO in cooperation with industry and the MENR.

The Environmentally Friendly Drilling Systems team has worked with the Groundwater Protection Council (GWPC) and others to develop training modules related to the GWPC successful FracFocus (www.fracfocus.org) effort. The proposed activities will include a review of private-public partnerships, such as the FracFocus initiative, including GWPC's plans to replicate the effort in Europe..

**Short-term Activities:**
In the short-term, the University of Colorado members of the IRG Team would work with the MENR, Pre-Carpathian University, and at least one local NGO in the affected PSA areas. In at least one city in both the eastern and western PSA areas, the team would:

- Develop outreach materials in cooperation with MENR:
    - Create a web-presentation (in English, Ukrainian, and Russian) to explain the process of shale gas development.
    - Create a small handout (in English, Ukrainian, and Russian) to explain the process of shale gas development.
- Partner with a local NGO to begin the process of developing a public engagement campaign to both inform the public and solicit information and opinions from the public. IRG would work with the NGO to hold at least one public meeting in each basin to:
    - Present information about the true impacts of shale gas development.
    - Present information on the PSA process and ways to allow meaningful local input in the process (See Section 5.4.2).
    - Solicit information, concerns, and opinions from the public.

- IRG would also work with the NGO to outreach to local governments to work with the affected Oblasts to determine the level of interest in developing a local government task force in each shale gas basin that will meet periodically to hear presentations and make recommendations about funding needs to the MENR.

The short-term activities would consist of:

- Establishing a Ukraine team for the activity
- Conducting a series of conference calls with Ukraine partners
- One trip to Ukraine for two IRG Team members, including travel to each of the PSA-affected areas
- Meetings with affected local governments

Preparation of a report documenting the process and accomplishments of the activity, conveying the outreach materials and meeting plans, and making more detailed recommendations for longer-term follow-on activities, including the holding of public meetings.

Based on the experience and information gathered in this short-term activity, the IRG Team could, as a longer-term project, assist a local NGO in creating solutions to some of the issues raised in the community and local government meetings. These activities will not occur until development is actually occurring in each basin.

**Longer-term Activities:**

The goal of longer-term activities would be to assist local partners to implement and expand outreach activities and to develop national support for such outreach. Based on the experience and information gathered in this short-term activity, the IRG Team could assist a local NGO in holding the first public meetings, plan additional meetings, and begin to develop solutions to some of the issues raised in the community and local government meetings. Some of these activities would not occur until development is actually taking place in each basin. Longer-term activities might include:

- Schedule and hold at least one public meeting, planned during the short-term activities, in each of the two shale gas basins.[155]
- Continue to assist the NGO and the two local government task forces in completing their recommendations. The participation in the task force, and the questions of the task force members, will drive the process. Here are some preliminary ideas of the subjects that are likely to be covered at these meetings:
    - Oil and gas development's impacts to the environment: air, water, land
    - Roles of the local government in monitoring industry activity
    - Roles of local government in monitoring environmental quality related to oil and gas development
    - Costs of infrastructure improvements/repairs
    - Employment issues and worker training
    - Housing, schools, and other community concerns related to any population growth in the region related to shale gas development.
- Help facilitate an industry / community dialogue about the planned development at meetings in affected basins

[155] Ideally, both regional meetings would be held as short-term activities before October 1, 2012, but, realistically, such a timeframe would be overly ambitious. Planning and scheduling would depend on availability of Ukrainian University and NGO partners that have yet to be identified.

- There will likely need to be annual or biannual meetings to address issues that arise from development.
- At these meetings, the expectation will be that the industry will give the community a sense of the plan for development, answer questions, and take feedback.
- If there are community concerns, those may be addressed in subsequent meetings to try to find a resolution.

**Short-term Activity Resource Needs:**
The short-term activity would require funding for approximately 400 hours of effort for the University of Colorado team, and two seven-day trips to Ukraine for two team members (one member's trip has already been paid for in the current funding cycle), 10 hours of consulting to dub an existing video on drilling to Russian and Ukrainian, participation of the MENR to arrange logistics of the meetings, hosting website, and printing shale gas development handout (as an in-kind contribution), logistics of the meetings (including translation of prepared materials), and approximately 300 hours of effort by the Pre-Carpathian University and local NGO (each). The short-term activities would consist of:

- Establishing a Ukraine team for the activity
- Conducting a series of conference calls to plan the two meetings (locations, logistics, participants, development information to be presented, potential means for local input and funding solutions, etc.)
- Two trips to Ukraine including one meeting in each of the PSA-affected areas
- Meetings with affected local governments
- Preparation of a report on the activity that can be used to evaluate the need for and content of future, longer-term outreach activities.

## 5.4. IMPROVING PRIMARY AND SECONDARY LEGISLATION AND REGULATIONS

The laws of Ukraine in the oil and gas area represent a mix of modern legislation, natural resource laws from an earlier period, and some ad hoc modifications of legislation to circumvent perceived difficulties in existing legislation and regulation. The suggested activities in this subsection represent the assessment of the IRG Team, including its Ukrainian members, regarding the needed improvements in the framework for oil and gas development and environmental protection.

In the process of preparing this PEA, the IRG team prepared a Regulatory Analysis document (Volume II) that addresses the major laws implicated in shale gas development. This review was unable, in the time available, to investigate fully the rich framework of laws, regulations, and standards that could apply to shale gas development. Such an in-depth evaluation can begin with the existing Regulatory Analysis document (Volume II of this report), but can only be accomplished with the direct participation of Ukraine legal analysts and shale gas development stakeholders. Although no individual Ukraine entity has a complete understanding of the complex legal framework applicable to shale gas, considerable expertise on these materials rests in the MENR and other state and regional bodies of government as well as in bodies of local self-government, NGOs, public associations, universities, international development companies, and law firms. Indeed, the Government of Ukraine has recognized in its National Action Plan the need for external evaluation of its policies, recognizing, for example, the need for NGOs to conduct a public assessment of national environmental policy and produce a report, to be published and disseminated with support from the MENR (Action 1.11).

An expansion of the Regulatory Analysis document could (1) engage multiple stakeholders on visioning the content and format of the document expansion (what are the legal issues that need to be fully addressed and understood) and (2) utilize these stakeholders in preparing the revision (Section 5.4.1). The revised analysis can be used as a resource for both citizen and NGO participation in shale gas development planning and implementation (Section 5.4.2); and for a discussion of regulatory reform (Section 5.4.3)

In this regard, the following short- and long-term follow-on activities could help to develop the necessary additions and changes to law needed to support sound development of shale gas.

### 5.4.1. EXPAND THE REGULATORY ANALYSIS DOCUMENT – SHORT-TERM ACTIVITY

The first short-term follow-on task would organize a multi-party review of the existing Regulatory Analysis document (Volume II). The purpose is to expand the document to include additional laws, regulations, and standards as deemed appropriate by the multi-party group to create a document of value to a variety of shale gas development stakeholders. For example, the national oil and gas department, (Derzhhirpromnahliad) has a body of technical oil and gas regulations that were not translated, nor evaluated, in the current regulatory document. The expansion would be useful as a handbook for potential development and also recognize that laws of Ukraine are gradually being adapted to those of the European Union. In part, the work group would evaluate in greater detail EU law applicable to shale gas development and provide a detailed comparison of EU and Ukraine law and regulation to assist with future Ukraine regulatory reform meetings (see Section 5.4.3).

The expansion would also recognize that the regulatory framework needs to be able to adjust as lessons are learned, and as gaps and issues emerge. At the same time, private investors making a commitment to invest in the sector will require a stable and predictable regulatory environment to help lower levels of perceived risk. The working group could, in part, consider how to balance these needs and achieve commitment on the part of the investing parties, since many of the responsibilities for ensuring sustainable operations in the extraction of shale gas will likely end up resting on the shoulders of the private sector participants. Topics might include the roles of:

- Self-regulation and reporting
- Third-party international certification bodies (such as ISO) and sustainability reporting frameworks such as the Global Reporting Initiative, the International Petroleum Industry Environmental Conservation Association Guidance, and the Environmentally Friendly Drilling Program scorecard
- Adherence to international codes of conduct in the oil and gas sector
- Participation by the lending community in ensuring compliance with environmental standards in order to qualify for financing
- Government incentivized Corporate Social Responsibility programs that reward firms with good track records with new concessions and penalize firms with poor track records

**Short-term Activities:**
Short-term activity tasks would include:

- Organize a multi-party review team (estimated at four to six participants); organize into subgroups, as necessary, to evaluate specific sections of the existing document
- Obtain a translation of the existing Regulatory Analysis document for use by participants
- Use email correspondence and conference calls to set the agenda for the review and parameters for discussion
- Hold at least one preliminary discussion of the document by conference call

- Arrange logistics for review meetings in Kyiv (preferably two consecutive half-days)
- Hold follow-up conference calls, as necessary
- Prepare a report of activities including recommendations for longer-term expansion of the analysis

**Short-term Activity Resource Needs:**
The short-term review activity would require short-term technical assistance, translation of the current Regulatory Analysis document for review by participants prior to the meeting, one meeting in Kyiv, participation of the MENR and, perhaps, assistance to arrange logistics of two half-day review meetings (intended as an in-kind funding contribution of the parties), and logistical expenses for the meetings (including simultaneous translation of discussions and travel expenses and honoraria for participants, where necessary to assure a diverse participant group). In general, participant time in reviewing the Regulatory Analysis document would be expected as in-kind contributions to the review.

**Longer-term Activities:**
Depending on the outcome of the short-term activity, a longer-term activity would utilize these participants to prepare an expanded analysis, including a detailed comparison of EU and Ukraine law and regulation. This analysis might take the form of an expanded written report or, perhaps, a website resource, depending on the determination of the multi-party review committee and available personnel and funding for the longer-term effort. For this longer-term effort, financial support for NGO and other non-industry and non-governmental participants would be required for preparing the expanded analysis. The revised analysis, including a detailed listing of applicable EU Law could be used as a resource for both citizen and NGO participation in shale gas development planning and implementation (Section 5.4.4); and for a discussion of Ukraine regulatory reform (Section 5.4.3)

### 5.4.2. AIR AND WATER QUALITY REGULATION AND MONITORING – SHORT- AND LONG-TERM ACTIVITY

Impacts of shale gas development on air and water quality are principal issues of concern in shale gas development areas throughout the world. Regulation of air and water pollution are likely to be considered in expansion of the Regulatory Analysis document (see Section 5.4.1), but the importance of these issues suggest a need for a review of air and water issues that integrates both technical and legal analysis. The overall goal of this activity is to thoroughly review of air and water conditions within shale gas basins to create specific recommendations for new standards and air and water quality monitoring.

The short-term activity will:

- Create a list of air and water pollutants that are likely to be created by shale gas operations
- Determine specific standards, if any, that exist in Ukraine for those pollutants
- Consult with the MENR to determine what data are currently available on those pollutants within the shale gas basins

Following completion of this and other short- and long-term activities, consider the following:

- Make recommendations for what additional baseline data is necessary, as well as make recommendations for ongoing monitoring for those pollutants (see Section 5.2.1 (short-term study planning) and Section 5.2.2 (longer-term baseline study implementation).
- Make recommendations for improved standards for those pollutants, looking to norms found in U.S. and EU law (See Section 5.4.3)

### 5.4.3. WORKSHOP ON REGULATORY REFORM – SHORT-TERM ACTIVITY

Informing discussion of regulatory reform is a long-term goal of the follow-on activities described in Sections 5.4.1 and 5.4.2. Following revision of the Regulatory Review document and preparation of the Citizen's Guide, a workshop for all stakeholders to discuss creation of a new shale gas law and/or revision of the PSA Law and individual environmental laws applicable to shale gas development would be an important next step for revising Ukraine law to more effectively regulate shale gas development.

Such a workshop should be cosponsored by USAID, the American Chamber of Commerce in Ukraine, MENR, individual international companies, NGOs, and the Precarpathian Law Institute

- The cosponsors should support participation of NGOs and citizens
- Topics of discussion might include:
  - Access to Information
  - Public and local government participation
  - The Model Framework for Drilling and Completion (see Appendix 4 for Table of Contents of these proposed regulations)
  - Monitoring and enforcement
  - Bonding
  - Air and water quality regulation (See Section 5.4.2 above)

This multi-stakeholder workshop would best be held after expansion of the regulatory analysis described in Sections 5.4.1 and 5.4.2 so that the information compiled and reported with these activities can inform the regulatory reform workshop. The multi-party work group convened for the regulatory analysis could be utilized as a resource to focus this reform workshop on the highest priority issues.

### 5.4.4. PREPARE A GUIDE TO CITIZEN AND NGO PARTICIPATION IN ENVIRONMENTAL PROTECTION – SHORT-TERM ACTIVITY

The body of Ukraine law that provides for citizen and NGO participation in environmental protection is complex. A better understanding by the public of the role of citizens and NGOs in the shale gas development process could lead to enhancement of public understanding of shale gas development, public participation in decision making, environmental protection, and, perhaps, public acceptance of shale gas development. A better understanding of the role of citizens and NGOs by the development community could reduce conflict over development. Supporting preparation of this guide would also help the Government of Ukraine to address two action items in the National Action Plan (see Appendix 6):

- Item 1.10 Develop a program for public access to ecological information and for public participation in environmental decision-making, in accordance with the Aarhus Convention, by 2012, and implement it by 2015.
- Item 1.12 Develop mechanisms and procedures for public input into environmental decision-making and enforcement, including public participation in Environmental Impact Assessments and other environmental planning procedures.

**Short-term Activity Resource Needs:**
A Citizen's guide for participation in environmental protection in Ukraine would best be prepared by an environmental NGO (with technical assistance) that understands both the existing avenues for participation, the shortcoming of current avenues, and what guidance materials are already available.

### 5.4.5. PROVIDE AN EXPERT RESOURCE FOR THE INTERMINISTERIAL COMMISSION – SHORT-TERM ACTIVITY

Serve as a resource to the Interministerial Commission as they raise questions about the Regulatory Analysis report and how to implement some of its recommendations into the regulatory framework for PSAs they will be negotiating over the next few months.

# 6. ENVIRONMENTAL ASSESSMENT TEAM COMPOSITION

| Person | Title | Discipline | Qualifications |
|---|---|---|---|
| Jason Steele | IRG Project Manager | | |
| Donald Hertzmark | Technical Project Manager | Economics | PH.D, MS, MA in Economics, BSFS in International Affairs, natural gas markets specialist, experience in Europe, Russia and Ukraine on energy issues |
| Richard Haut | Technology Specialist | Drilling Technology | 30 years of experience in environmentally benign drilling technologies |
| Gerhard Thonhauser | Technology Specialist | Drilling Technology | Ph.D. in Petroleum Engineering |
| Kathryn Mutz | Attorney and Ecologist | Law | J.D. with over 30 years of experience with energy issues; currently at Natural Resources Law Center |
| Matthew Sura | Attorney | Law | J.D., Research Associate, of the Natural Resources Law Center |
| Oksana Kyshko Yerli | Local Attorney | Law | Experience in writing Ukraine's PSA legislation |

# APPENDIX 1:TERMS OF REFERENCE

## DRAFT TERMS OF REFERENCE: *ENVIRONMENTAL & REGULATORY ASSESSMENT FOR SHALE GAS DEVELOPMENT IN UKRAINE*

### Introduction

Within the framework of the US Government- Government of Ukraine Memorandum on Shale Gas Development, USAID is prepared to assist the Government of Ukraine in addressing the environmental and regulatory aspects of shale gas development and production. Ukraine is in the early stages of establishing the regulatory framework for shale gas development. This cooperation will serve to increase Ukraine capabilities to address environmental concerns in shale gas development and create a framework for monitoring and mitigating possible negative impacts and facilitating sound investments by international and Ukrainian companies.

The Ministry of Ecology and Natural Resources has been assigned lead responsibility for working with the USAID team. USAID, under its Regional Energy Security contract with the International Resources Group (IRG), has assembled a team of international experts with experience in key areas of environmental and legal/regulatory development related to gas shale operations.

This draft Terms of Reference has been prepared to support discussions between USAID and the Ministry with the goal of agreeing upon an approach to this environmental assessment that responds to the needs of Ukraine and complies with USAID environmental requirements for assistance in fields that have the potential for significant environmental impact.

### Terms of Reference

**Objective**: To begin the process of helping the government of Ukraine to develop an environmentally sound framework for pursuing shale gas development.

This assessment will compare a range of feasible energy alternatives to shale gas development and identify the relevant environmental, economic, legal and regulatory issues associated with shale gas development.

USAID and the IRG technical team will coordinate with the Ministry of Ecology and Natural Resources, the Shale Gas Working Group and technical experts designated by that group to ensure that other interested agencies and organizations in Ukraine will be involved in the process and to ensure an environmental assessment that is conducted in an open, transparent and collaborative manner.

This Terms of Reference consists of the following tasks and deliverables:

1. Preparation of an Environmental Scoping Statement
2. Preparation of an Programmatic Environmental Assessment
3. Recommendations for Follow-on Activities

### Task 1: Preparation of an Environmental Scoping Statement

The purpose of the environmental scoping process is to identify the significant issues relating to shale gas development and to determine the scope of the issues to be addressed in the Programmatic Environmental Assessment. The task will consist of the following activities:

a. Comparison of shale gas to other energy alternatives
b. Coordination with energy and environmental stakeholders
c. Identification of technical, economic, legal and regulatory issues
d. Scoping assessment of the environmental impacts of shale gas development

The deliverable for this task will be a written statement outlining costs and benefits of shale gas development relative to other energy development alternatives in Ukraine. It will also identify and prioritize the potential environmental impacts that will be considered in the Programmatic Environmental Assessment.

#### *Subtask 1a: Comparison of shale gas to other energy alternatives*

In order to assess the costs and benefits of developing shale gas relative to other energy alternatives in Ukraine, the IRG Team will utilize the national TIMES energy system planning model for Ukraine in cooperation with the Institute for Economic Forecasting under the National Academy of Sciences. The model[156] is currently being use to evaluate the options for meeting the regional security needs of Ukraine through various approaches, including use of renewable energy sources, implementation of energy efficiency measures, continued utilization of conventional and nuclear fuel sources, and improved conversion technology for conventional resources. The model is used to compare alternative scenarios to a reference (or business-as-usual) scenario, Shale gas can be added to the model, based on various projections for the resource potential and development cost, and these alternative scenarios compared to the various options described above. The model results will provide a comparison of the relative impacts of shale gas development in terms of changes in the energy system cost, environmental emissions (particularly CO2), energy imports, technology investment requirements, and other measures.

#### *Subtask 1b: Coordination with energy and environmental stakeholders*

The IRG Team will coordinate with the Shale Gas Working Group, led by the Ministry of Ecology and Natural Resources, to establish a technical expert coordination group that will provide local expertise and input to the assessment in all the areas described in the next subtask.

Public participation is a required component of the scoping process. Participants may include, but are not limited to, representatives of host government, local governments, public and private institutions, USAID Mission staff and contractors. The scoping process shall include field visits, public stakeholder meetings,

[156] The model describes the energy system of Ukraine starting with resource extraction, process that convert primary energy carriers into electricity, pipeline quality natural gas, liquid fuels, etc., end use devices that deliver energy services such as lighting, space heat, industrial motor drive, etc., to meet future energy demands that are driven by GDP growth, population growth, and other factors. The current model does not include the transport sector.

review of existing information on potential environmental impacts. The Contractor shall provide a written report summary with list of participants of all public meetings conducted during the scoping process.

*Subtask 1c: Identification of technical, economic, legal and regulatory issues*

The IRG Team will work with the Ministry of Ecology and Natural Resources to define the areas that may receive attention in the baseline data development and analyses of potential impact of shale gas activities in the future. A list of the potential issues to be considered throughout the Scoping process is provided below;

- Legislative
- Regulatory and Licensing/Leasing/Concessions
- Capacity for Administration, Monitoring and Enforcement
- Land Use and Potential Impacts in Prospective Basins
- Wildlife and Endangered species
- Local Government and Community impacts
- Water Use and Acquisition
- Chemicals Used in Drilling Process
- Waste-water Well Injection
- Flow-back and Water Produced from Wells
- Water Treatment and Waste Disposal
- Drilling infrastructure
- Hydraulic fracturing infrastructure
- Pipeline interconnections – gathering systems, pipelines and compressor stations
- Institutional Capacity at National and Local Levels
- Technical Support Organizations
- Technical Capacity
- Required Training and Human Resources Development
- Air Quality and Greenhouse Gas Emissions
- Effect on Neighboring Countries
- Worker Safety Standards

*Subtask 1d: Scoping assessment of the environmental impacts of shale gas development*

The Scoping process shall result in a written statement that includes the following:

1) A description of:
    - The timing of the preparation of environmental analyses, including phasing if appropriate;
    - Variations required in the format of the Environmental Assessments; and,
    - The tentative planning and decision-making schedule.

2) A description of how the analysis will be conducted, and the disciplines and qualifications of the professionals that will participate in the analysis.

The Scoping Statement shall discuss the scope and significance of issues to be analyzed in the Environmental Assessment, including direct and indirect effects of shale gas projects on the environment, and the identification of the issues that are not significant. The Scoping Statement should focus on what alternatives and probable significant environmental impacts should be considered as well as the proposed range of alternatives for consideration. The Scoping Statement shall include a discussion of public participation and stakeholder engagement that occurred during the process, and include as attachments copies of public announcements of public meetings and sign-in sheets of participants of these meetings. It shall also include a list of stakeholders that were consulted during the Scoping process.

### Task 2: Preparation of an Environmental Assessment

The purpose of the Environmental Assessment is to identify and review key issues related to the mitigation and monitoring of environmental issues related to gas shale developments in the Ukraine. The task will consist of the following activities:

a. Identification of key issues and monitoring/mitigation approaches
b. Review of Ukrainian laws and regulations that are related to gas shale development
c. Review capabilities for monitoring, reporting and verification (MRV) and their relevance to shale gas development
d. Preparation of the Programmatic Environmental Assessment

The deliverable for this task will be a written report that discusses best management practices based on experiences in the USA and recommendations concerning Ukraine laws. The report will contain information to comply with USAID's requirements in accordance with 22 CFR 216.6.

#### *Subtask 2a: Evaluation of key issues and monitoring/mitigation approaches*

The IRG Team will work with the Ministry of Ecology and Natural Resources and competent technical organizations in Ukraine to carry out a broad-based Environmental Assessment. The IRG Team includes technical experts that are working to promote environmentally sound standards for shale gas drilling and production. The Environmental Assessment will consider potential significant environmental effects of operations and include best practice information on alternatives to avoid or minimize adverse effects or enhance the quality of the environment. The Environmental Assessment shall succinctly describe the environment of the prospective areas for exploration and production, with possible input from the collaborative resource assessment work of the US Geological Survey. Key impacts will include potential for water and aquifer pollution, well technology, recommended practices and surface impacts of shale gas operations. It will also include a review of the infrastructure – gathering systems, pipelines and compressor stations; gas field services infrastructure necessary to conduct operations.

The analysis of alternatives performed in the Scoping Study will be updated as needed to incorporate any new information obtained during the assessment.

#### ***Subtask 2b: Review of Ukrainian laws and regulations that are related to gas shale development***

Detailed review and analysis of existing relevant laws and regulations will be carried out to determine gaps and areas that need to be strengthened to address the specific issues involved in shale gas exploration and production, from both an environmental and economic perspective. These may include

- The framework Law on Environmental Protection that was adopted in 1991 before the collapse of the Soviet Union.

- The Law on Air Protection (1992, new version dated of 2001)
- The Sub-soil Law
- The Production Sharing Law
- The Water Code (1995)
- The Law on Waste (1998)

Other relevant laws (as identified in the Scoping Study) that address air protection, mineral resources, ecological expertise, etc. will also be reviewed. The development of new laws, such as the proposed Alternative Energy Law will be considered as appropriate.

### *Subtask 2c: Review capabilities for MRV and their relevance to shale gas development*

The IRG Team will identify the MRV activities that would be required to support environmental regulation of shale gas development and review the current capabilities of various technical groups in Ukraine to support these activities.

### *Subtask 2d: Preparation of the Programmatic Environmental Assessment*

The IRG Team will collaborate with the technical experts under the Shale Gas Working Group, led by the Ministry of Ecology and Natural Resources, to prepare the Environmental Assessment in accordance with the scoping statement. In general, the Environmental Assessment will address the following elements, as appropriate:

(a) **General Purpose**. The purpose of the Environmental Assessment is to provide USAID and the Government of Ukraine with a full discussion of the potentially significant environmental impacts of shale gas drilling operations. It will identify strategies and practices that would avoid or minimize adverse effects or enhance the quality of the environment so that the expected benefits of shale gas development can be weighed against any adverse impacts upon the human environment. The Environmental Assessment will also include a full review of significant economic, legal and regulatory issues affecting the Government of Ukraine's decision to pursue the exploration and development of shale gas resources.

Ukraine is in the very early stages of this policy initiative and has an opportunity to put in place sound laws, regulations and MRV procedures that will have significant beneficial effect if they are properly designed and enforced. The Environmental Assessment is intended to support this process.

(b) **Collaboration with Ukraine on Preparation**. The Environmental Assessment will identify the collaboration between the IRG Team and the Ministry of Ecology and Natural Resources, the Ministry of Mines and Energy, and other interested government, local, and non-government organizations in carrying out the assessment. The Environmental Assessment will also include a discussion of public participation and stakeholder engagements that occurred during the process, and include as attachments copies of public announcements of public meetings and sign-in sheets of participants of these meetings.

(c) **Content and Form**. The Environmental Assessment shall be based upon the scoping statement and shall address the following elements, as appropriate:

(1) **Summary**. The summary shall stress the major conclusions, areas of controversy, if any, and the issues to be resolved. The major areas to be considered will be determined through the Scoping Study process.

(2) **Purpose**. Support the Government of Ukraine to evaluate the environmental implications of pursuing shale gas development and to consider the legal and regulatory requirements to both attract international investors and protect the environment.

(3) **Alternatives Including the Proposed Action**. Identify and examine a number of reasonable alternatives for meeting Ukraine's energy security needs and include consideration of energy efficiency measures, renewable energy sources, coal, coalbed methane, improved technologies for conventional energy generation, and shale gas. The analysis shall incorporate the technical and economic feasibility of each of these alternatives, their ability to meet Ukraine's energy security needs over the long term, and provide a comparison of their relative environmental impacts. The assessment should consider several potential scenarios for Ukraine's energy development and what the economic, energy, and emissions impacts might be under different assumptions.

(4) **Affected Environment**. The Environmental Assessment will succinctly describe the environment of the area(s) that may be affected by the shale gas drilling operations.

(5) **Environmental Consequences**. This section of the Environmental Assessment will discuss each of the impacts identified in the Scoping Study, provide a preliminary assessment of their significance; propose mitigation measures and include consideration of social, legal and economic issues that are relevant to decision-making.

Although a full list of environmental impacts to be considered in the course of this assessment will be determined during the environmental scoping process, an illustrative list is provided below:

- Water pollution from storing and transporting chemicals and fuels
- Contaminated drinking water from escaped gas/chemicals
- GHG emissions from extraction and production of gas
- Leakage of VOCs from gas wells and compressor stations
- Changes in sub-surface hydrology, including long-term damage to aquifers from fracturing chemicals
- Safety and air pollution impacts from well fires and blowouts
- Contamination of soils and water from drill cuttings and flowback fluids (heavy metals, naturally occurring radioactive materials, and other pollutants )
- Local impacts and economic disruption from influx of construction personnel and support services
- Source of pipe casing and cementing materials
- Air pollution due to truck traffic and mobile generators
- Impacts from new road building
- Impacts from new lands development
- Wetland/habitat degradation
- Impacts to any Endangered Species
- Impacts to Nearby Residents
- Damage to existing roads
- High noise levels

- Increased light pollution
- Traffic impacts
- Occupational impacts to workers
- Well decommissioning impacts

(6) **Legal and Regulatory Issues**. This section will identify the potential impact of possible legal and regulatory approaches to shale gas development. Such issues could include identifying contradictions between the civil code, the sub-soil laws, and the law on oil and gas. It could also include recommendations for new laws or regulations specifically for shale gas projects.

(7) **List of Preparers**. This section will list the names and qualifications (expertise, experience, professional discipline) of the persons primarily responsible for preparing the Environmental Assessment.

(8) **Appendices**. Appendices may be prepared and attached as necessary.

### Task 3: Recommendations for Follow-on Activities

The IRG Team will work with the Ministry of Ecology and Natural Resources and other energy sector stakeholders in Ukraine to identify and prioritize areas for follow-on technical assistance activities. These could include:

- Enhancing GOU Capacity to Develop an Environmentally Sound Strategic Approach to Shale Gas Development
- Developing Mitigation and Monitoring Plans
- Improving Primary and Secondary Legislation and Regulations
- Establishing baseline environmental information that can be used for environmental impact assessments associated with definitive gas shale development projects and activities.

### Roles and Responsibilities

For the Government of Ukraine and the Ministry of Ecology and Natural Resources will appoint a project manager who will coordinate their activities and act as a point of contact. The Shale Gas Working Group, led by the Ministry of Ecology and Natural Resources, will establish a project technical team with expertise in the technical, legal, regulatory, environmental, and economic areas necessary for the assessment that will interface with the US Team.

For the US Government, USAID will be the lead agency and Robert Ichord will be the project manager for the US Team. Under a USAID contract, IRG will be responsible for the technical implementation of the implementation of this Terms of Reference. The IRG Team, lead by Pat DeLaquil, will mobilize relevant technical experts from the US and Europe, including personnel from the Environmentally Friendly Drilling Program.

# APPENDIX 2: LIST OF PERSONS MET AND INSTITUTIONS CONTACTED IN UKRAINE

| Contact | Organization | Phone | Email |
|---|---|---|---|
| Tetyana V. Tymochko<br>Head | All-Ukrainian Ecological League | (380-44) 289-3142 | vel@ecoleague.net |
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| Vladimir Shatilenko | Chevron, Ukraine | | |
| Adam Mycyk, Oleksander Martinenko, Vitaliy Radchenko, Tetyana Rabczak | CMS-Cameron McKenna | +38 044 391 33 77 | First.last@cms-cmck.com |
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| Olena Kravchenko, Yelyzaveta Aleksyeyeva, Hanna Khomechko, Alina Samura | Environment, People, Law, L'viv | (38032) 243-38-88 | e.aleksyeyeva@epl.org.ua |
| Lemlem Said Issa | EU Twinning Project at NERC | | |

| Contact | Organization | Phone | Email |
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| Berkutova Alyona (Expertiza section) | Ministry of Ecology and Natural Resources | | |
| Ivan Ivanets | Ministry of Ecology and Natural Resources | | |
| Svitlana Syedova | Ministry of Ecology and Natural Resources | | |
| Volodymyr Ignashchenko | Ministry of Ecology and Natural Resources | | |
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| Mr. Petruk (sp?) | Ministry of Ecology: Director of Water | | |
| Andriy Bukvych, Advisor | Ministry of Energy and Coal | | |
| Volodymyr Makukha<br>Deputy Minister | Ministry of Energy and Coal Industry of Ukraine | (380-44) 206-3801 | Makukha@mev.energy.gov.ua |
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| Ivan Martinko (sp?) | Ukraine Geological Service, Environmental Expert | | |
| Olena Tarasova | Ukrainian Eco Club Greenwave | | |
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# APPENDIX 3: TENDERING DOCUMENT FOR OLESKA PSA[157]

Exhibit 2, Part 1

**CABINET OF MINISTERS OF UKRAINE RESOLUTION**

**dated 30 November 2011 N 1297**

**Kyiv**

**On holding the tender on concluding an agreement on sharing hydrocarbons that are extracted within Oleska area**

The Cabinet of Ministers **decrees**:

1. To agree with the proposal of the Ministry of ecology and natural resources on holding the tender on concluding an agreement on sharing hydrocarbons that are extracted within Oleska area (hereinafter – the tender) upon the terms specified in the annex.

2. The Inter-agency commission for arranging the conclusion and implementation of production sharing agreements shall ensure the arrangement of a tender in accordance with the Law of Ukraine "On Production Sharing Agreements", namely:

1) develop and approve tender documentation within two months and ensure the publication of the announcement on holding the tender in official printed matters of Ukraine and foreign mass media;

2) ensure receiving applications for the tender within two months since the date of the publication of the announcement on holding the tender;

3) prepare and submit the conclusions and suggestions for determining the winner to the Cabinet of Ministers of Ukraine not later than within one month after the deadline of submission of applications.

**Prime Minister of Ukraine** **M. AZAROV**

Ind. 70

Ukraine
dated 30 November 2011 N 1297

[157] This translation was accurate as of 5th February 2012. Additional modifications were proposed on 6th February 2012 and will be included in the final report.

# TENDER TERMS AND CONDITIONS
## on concluding an agreement on sharing hydrocarbons that are extracted within Oleska area

## The procedure of holding the tender

1. The tender on concluding an agreement on sharing hydrocarbons that are extracted within Oleska area (hereinafter – the agreement) shall be held according to the procedure envisaged by article 7 of the Law of Ukraine "On Production Sharing Agreements".

2. The citizens of Ukraine, foreigners, stateless persons, legal entities of Ukraine or other countries, associations of legal entities established in Ukraine or abroad having adequate technical and financial capabilities and qualified to use the subsoil, which is confirmed by documents issued in accordance with the laws (procedures) of the state of the participant can participate in the tender on concluding an agreement (hereinafter – the tender). Two or more legal entities (associations of legal entities) can jointly participate in the tender.

3. In order to participate in the tender, an investor (investors) (hereinafter – the investor) shall submit a respective application to the Inter-agency commission for arranging the conclusion and implementation of production sharing agreements (hereinafter – the Inter-agency commission) containing:

1) documented data on:

the investor (full name, citizenship, residence, profession – for natural persons; name, location, state, according to the laws of which the legal entity or association of legal entities is registered, the main type of activities envisaged by the statute and the size of the authorized (joint) capital – for the legal entity or association of legal entities);

experience in the sphere of subsoil use, as well as the data on technical and financial capabilities for performing works and on the technologies that will be applied in the subsoil use;

2) obligation to meet the requirements specified in paragraphs 16 – 18 of these tender terms and conditions.

4. The application for the participation in the tender shall be supplemented by:

1) duly certified copies of the document on state registration and statutory documents – constituent agreement, statute etc.;

2) a duly certified document on the amounts of paid contributions to the authorized (joint) capital;

3) the data on:

stock owners (for joint stock companies – owners of the largest holdings) and their share in the authorized (joint) capital;

the main activities, the number of employees, the experience in the sphere of subsoil use, including the experience of the exploration and/or extraction of shale rocks gas, gas of central-basin type, gas (methane) of coal deposits indicating the names of subsoil areas, types and results of operations, applied technology and production capacity;

the period during which an investor plans to undertake geological exploration (including research and industrial development) of a subsoil area and start commercial development of deposits;

technical equipment and technologies that are planned for use;

financial ability of the applicant;

sizes and types of investment;

4) the data of the last audit;

5) a copy of the legal entity's financial balance for the previous year certified by its manager;

6) original payment documents on the payment for the participation in the tender;

7) a program of suggested works, with the terms of beginning and end of works;

8) suggestions for production sharing;

9) commitment to staff training and use of goods and services of domestic origin;

10) an action plan for the protection of the subsoil and environment, standards of protection of the subsoil, environment and human health, which will be applied during the works taking into account the respective requirements specified in paragraph 20 of these terms and conditions of the tender;

11) programs of the development of local industrial and social infrastructure;

12) additional proposals concerning the terms and conditions of competition.

An investor can submit additional documents and materials.

5. The application and attached documents and materials (hereinafter – the documents) shall be written in Ukrainian. If a tender participant is a nonresident, the documents submitted in English shall be accompanied by the mandatory translation into Ukrainian.

The application and documents shall be sent by post or submitted directly to by an investor or their representative in paper and electronic media.

Submitted applications shall be registered by the Inter-agency commission on the day of their submission.

If the documents are submitted not in the full amount, the application and documents are not considered.

The consideration of applications and documents shall be performed by the Inter-agency commission within one month after the deadline for applications submission.

6. During the tender creating equal conditions for all participants and confidentiality shall be ensured.

7. The consideration of applications of participants shall be performed using the following criteria:

1) the efficiency of the conditions of the use of natural resources in accordance with the work program;

2) the effectiveness of technological solutions on work performance;

3) the effectiveness of environmental protection measures;

4) attractive investment conditions;

5) the level of financial support and previous experience of the investor for carrying out the work and investment program in accordance with the terms and conditions of the tender;

6) attractive proposals on production sharing in favor of the state;

7) the experience of the investor of the exploration and/or extraction of shale rocks gas, gas of central-basin type, gas (methane) of coal deposits;

8) ensuring the development of local industrial and social infrastructure;

9) ensuring the use of goods and services of domestic origin.

8. Following the consideration and evaluation of submitted materials, the Inter-agency commission shall prepare and submit its proposals regarding the determination of the winner (winners) of the tender (hereinafter - the winner) to the Cabinet of Ministers of Ukraine.

The results of the tender shall be published in official printed matters and communicated to each participant.

9. The tender is deemed to have failed in the case when none of the submitted application meets the terms and conditions of the tender.

## Tender object characteristics

10. Oleska area, on which the tender is announced (hereinafter – the area), is located within Lviv and Ivano-Frankivsk oblasts and limited by such geographical coordinates:

| land corner number | northern latitude | eastern longitude |
|---|---|---|
| 1 | 50°16'30" | 24°22'39" |
| 2 | 50°10'25" | 24°26'16" |
| 3 | 50°04'25" | 24°29'50" |
| 4 | 49°58'22" | 24°33'24" |
| 5 | 49°51'32" | 24°37'25" |
| 6 | 49°45'55" | 24°40'41" |
| 7 | 49°44'03" | 24°27'05" |
| 8 | 49°43'17" | 24°27'20" |
| 9 | 49°36'47" | 24°29'36" |
| 10 | 49°33'51" | 24°30'42" |
| 11 | 49°31'02" | 24°36'06" |
| 12 | 49°31'54" | 24°43'07" |
| 13 | 49°29'48" | 24°43'12" |
| 14 | 49°29'06" | 24°43'25" |
| 15 | 49°28'56" | 24°43'28" |
| 16 | 49°25'33" | 24°45'57" |
| 17 | 49°22'10" | 24°46'30" |
| 18 | 49°23'05" | 24°48'55" |
| 19 | 49°22'00" | 24°49'51" |
| 20 | 49°20'39" | 24°51'01" |
| 21 | 49°19'16" | 24°49'40" |
| 22 | 49°16'01" | 24°49'56" |
| 23 | 49°14'43' | 24°53'35" |
| 24 | 49°14'06" | 24°55'19" |
| 25 | 49°10'12" | 24°50'51" |
| 26 | 49°07'42" | 24°54'02" |
| 27 | 49°07'09" | 24°58'03" |
| 28 | 49°07'03" | 24°58'44" |
| 29 | 49°04'39" | 24°58'14" |
| 30 | 49°05'09" | 24°54'49" |

| land corner number | northern latitude | eastern longitude |
|---|---|---|
| 31 | 49°02'46" | 24°53'45" |
| 32 | 49°00'36" | 24°58'03" |
| 33 | 48°59'29" | 24°57'52" |
| 34 | 49°00'26" | 25°01'07" |
| 35 | 48°59'21" | 25°03'44" |
| 36 | 48°58'36" | 25°05'32" |
| 37 | 48°59'09" | 25°06'25" |
| 38 | 48°57'44" | 25°06'40" |
| 39 | 48°56'53" | 25°08'31" |
| 40 | 48°55'29" | 25°07'03" |
| 41 | 48°52'30" | 25°08'03" |
| 42 | 48°52'19" | 25°08'29" |
| 43 | 48°51'44" | 25°09'56" |
| 44 | 48°52'21" | 25°10'33" |
| 45 | 48°53'11" | 25°10'34" |
| 46 | 48°32'03" | 25°23'36" |
| 47 | 48°37'39" | 25°16'40" |
| 48 | 48°42'13" | 25°10'35" |
| 49 | 48°46'47" | 25°03'44" |
| 50 | 48°43'03" | 24°57'42" |
| 51 | 48°48'46" | 24°47'59" |
| 52 | 48°54'22" | 24°38'22" |
| 53 | 48°54'20" | 24°34'55" |
| 54 | 48°54'21" | 24°34'55" |
| 55 | 49°02'11" | 24°29'51" |
| 56 | 49°09'45" | 24°24'57" |
| 57 | 49°16'51" | 24°20'20" |
| 58 | 49°24'10" | 24°15'32" |
| 59 | 49°24'45" | 24°06'32" |
| 60 | 49°29'00" | 24°02'42" |
| 61 | 49°33'04" | 24°01'36" |
| 62 | 49°39'02" | 24°03'20" |
| 63 | 49°44'18" | 24°03'35" |
| 64 | 49°45'39" | 24°04'22" |

| land corner number | northern latitude | eastern longitude |
|---|---|---|
| 65 | 49°52'37" | 24°08'26" |
| 66 | 49°53'11" | 24°03'08" |
| 67 | 49°53'42" | 23°58'14" |
| 68 | 49°58'22" | 23°55'35" |
| 69 | 49°59'42" | 23°54'50" |
| 70 | 50°04'30" | 23°52'51" |
| 71 | 50°10'54" | 23°50'12" |
| excluding Lishchinska area | | |
| 1 | 49°31'22" | 24°19'56" |
| 2 | 49°31'44" | 24°27'36" |
| 3 | 49°24'44" | 24°28'20" |
| 4 | 49°24'28" | 24°21'50" |

The total area is 6324 sq. km.

The area includes all sedimentary deposits that lie within its perimeter and limited by the depth of subsoil use with the mark 10 thousand meters from the surface or geological foundation (depending on what will be achieved first).

Mineral resources are named fossil fuels (natural gas, gas of shale rocks, gas of the central-basin type, gas (methane) of coal deposits, oil, condensate) (hereinafter – hydrocarbons).

After signing and state registration of the agreement the investor shall be granted a special permit for subsoil use for the purpose of geological exploration, including research and industrial development, with subsequent extraction of hydrocarbons (industrial development) within the area for the term of fifty years. The validity term of a special permit for subsoil use may be extended in the manner prescribed by law.

## The list and term of carrying out works in the area

11. The winner of the tender - investor should ensure carrying out the following works:

1) geological exploration in the area, including two-dimensional seismic survey, well drilling at the stage of geological exploration;

2) completion of the stage of geological exploration, including research and industrial work, not later than in five years with the possibility of further additional exploration;

3) in case of the investor's decision to move to the stage of industrial development – equipping a deposit (deposits) and drilling of operation wells;

4) preparing a report on the results of geological exploration of the area and its submission to the State Geological Information Fund according to the established procedure;

5) in case of opening a deposit of hydrocarbons – submission of the materials on the assessment of hydrocarbon reserves in due course to the State Commission on Mineral Resources for approval of such reserves.

12. If there is need for a winner to carry out works within the subsoil area, a special permit for the use of which is provided to another subsoil user, works in this area shall be held by the winner with the consent of this subsoil user.

## Minimum investment amount

13. The minimum amount of investment to be made by the investor during the period of geological exploration should not be less than UAH 1.3 billion.

14. In case of the investor's decision to move to the stage of industrial development, the total amount of investment, including the investment required for industrial development, shall be determined by the tender, but should not be less than UAH 25 billion.

## The main criteria for production sharing

15. All products shall belong to the state by the time of production sharing between the state and investor. The maximum part of compensation production, at the expense of which the investor will get reimbursement of their costs, shall be 70 percent of total production up to full reimbursement of the investor.

The share of the state in profitable production shall be not less than 15 percent of the total amount of such production.

## The peculiarities of the terms of the agreement from the state's side

16. The winner of the tender shall settle an agreement concerning the area together with the economic entity, 100 percent of the authorized capital of which is owned by the state, or the economic entity established with its participation (hereinafter – the economic entity), which will be determined by the Inter-agency commission on a competitive basis. This business partnership receives 50 percent of the rights and obligations of investors (except those that are the exclusive operator rights and responsibilities under the agreement) and, in particular, 50 percent of the total shares of all investors in the profitable production.

17. The winner of the tender shall be appointed an operator of the agreement who shall ensure the proper implementation and financing of the activities under the agreement.

The application for the tender must contain clearly defined obligation of the investor that in case of determining them the winner of the tender, the agreement will be concluded with the participation of the business partnership as one of the investors on the terms set out in paragraph 16 of these terms and conditions of the tender. Applications for participation in the tender, which do not contain the specified obligation of the investor, will not be accepted.

18. The winner and business partnership shall settle a joint operating agreement within 120 calendar days after the announcement of the tender results in accordance with accepted international practice or another agreement (hereinafter – the agreement), which sets out their mutual rights and obligations under the agreement.

19. After the conclusion of the contract, the state represented by the Cabinet of Ministers of Ukraine, the winner of the tender and business partnership shall settle an agreement for fifty years.

The agreement shall envisage the following main conditions:

- annual declaration of mining characteristics;
- compliance with the procedure of using geological, geophysical and other information;
- the procedure and special features of cost accounting for industrial and technological needs;
- defining the procedure and term of assessment of the level of environmental pollution in the area at the time of settling an agreement;
- determining the amount and period of implementation of measures to protect subsoil and environment, their financing;
- determining the procedure of negotiation and approval of annual work programs;
- the terms of use of the parts of the area within which the activities on geological exploration and/or extraction of other minerals are performed or will be performed according to special permits received by another subsoil user for the use of subsoil plots located within the area on which the agreement is settled;
- ensuring the safe custody of the state share of extracted hydrocarbons before transferring them to the state;
- insurance of property risks, including the loss of extracted hydrocarbons due to natural disasters;
- the terms of exceptional risk during mining.

## Optimal economic, technological, environmental and other measures for the efficient use of subsoil

20. The investor shall add information about optimal economic, technological, environmental and other measures for the efficient use of subsoil to the application for the tender, in particular:

1) the measures for the early commencement of commercial production of hydrocarbons and maximization of gas production;

2) the use of new, environmentally sound technologies, equipment, advanced technical developments for efficient exploration and extraction of hydrocarbons;

3) the measures for efficient use and protection of lands, which the investor intends to implement;

4) the composition of chemicals, which the investor plans to use during hydraulic fracturing of the layer;

5) technologies and technological solutions, which the investor will apply to protect groundwaters and surface waters from chemicals used for hydraulic fracturing of the layer, as well as the maximum use of groundwaters unsuitable for drinking and reservoir waters of the repeated use for these purposes;

6) the measures for the efficient use of water resources required, particularly, for hydrocarbons production using the technology of hydraulic fracturing of the layer;

7) technological solutions and measures, which the investor plans to implement to protect the air and prevent greenhouse gas emissions.

## The essential requirements of the state for the conditions and performance of works envisaged by the agreement

21. The investor shall be obliged to:

1) perform search, evaluation and production of hydrocarbons, as well as perform any other works envisaged by the agreement, according to the work programs agreed by the parties, plans and estimates developed and approved in the manner specified in the contract;

2) make investments in the amount not less than the amount determined by the tender and according to the agreement;

3) after the completion of the certain stages of works return the areas determined by the investor unpromising for further geological exploration (including research and industrial) works and/or industrial development;

4) submit geological, geophysical, technical, economic and other information, as well as rock samples obtained during the respective works to the State Geological Information Fund;

5) comply with the requirements of the legislation, namely, of labor, subsoil and environmental protection legislation, perform obligations under the agreement;

6) give preference to goods, works and services of domestic origin under equal conditions with regard to prices, term of performance, quality and compliance with international standards;

7) hire employees for the needs specified in the agreement primarily from the citizens of Ukraine;

8) register their permanent representative office on the territory of Ukraine if the investor is the operator under the agreement and nonresident within three months since the date of the settlement of the agreement.

## The term for submitting applications for the tender

22. The deadline for submission of applications for the tender is two months since the date of announcement of the tender. Applications submitted after 6 P.M. on the last day of the deadline for submission of applications for the tender shall be returned to participants in the unopened envelopes.

## The fee for participating in the tender

23. The fee for participating in the tender is UAH 500 thousand. The fee shall be paid to a register account of the State Committee for Geology and Mineral Resources of Ukraine.

24. The fee for participating in the tender that took place will not be refunded to the participants. If the tender is determined as one that did not take place, the fee for the tender will not be refunded to the participants in full.

## Tender documentation

25. The tender documentation developed by the Inter-agency commission must include, inter alia:

cartographic materials regarding the area;

general characteristics and geological description of the area;

the list of available geological information that can be purchased at the State Committee for Geology and Mineral Resources of Ukraine.

The cost of tender documentation package is UAH 100 thousand.

# APPENDIX 4: EXAMPLE OF MODEL HYDRAULIC FRACTURING REGULATIONS (U.S.)

The following table of contents is from a model regulatory code for hydraulic fracturing in the U.S. The entire document will be made available to MENR officials in a follow up activity.

**DRAFT MODEL REGULATORY FRAMEWORK**
**FOR HYDRAULICALLY FRACTURED**
**ONSHORE HYDROCARBON EXPLORATION AND PRODUCTION WELLS**

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# APPENDIX 5: BIODIVERSITY IMPACTS

## Primary and Secondary Impacts on Biodiversity

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Seismic lines & grids:**<br>• Vibroseis machinery may cause damage to vegetation and surface hydrology<br>• Short-term disturbance to wildlife and human populations from vibrations and shot-hole drilling activities (explosions)<br>• Erosion and changes in surface hydrology from unplugged or improperly plugged shot holes and seismic lines (cleared vegetation) | Exploration | • Schedule operations during least sensitive periods, avoiding migration, nesting and mating seasons.<br>• Shot-hole methods should be considered in the place of vibroseis machinery where vegetation cover is required and where access is a concern. Ensure that the charge is small enough and deep enough to avoid cratering. Consider aquifer protection and suitable plugging. Use offsets to avoid specific sensitivities. Ensure that misfired charges are disabled and removed. Mobilize cleanup crews after operations.<br>• If using vibroseis machinery on soft ground, avoid excessive compaction from vehicles and baseplate.<br>• Ensure appropriate handling and storage of fuels and hazardous materials (e.g., explosives).<br>• Cut seismic lines by hand to minimize disturbance.<br>• Minimize the width of corridors to ensure compatibility with operational, health and safety requirements.<br>• Do not cut trees that are larger in diameter than local regulations permit, or in the absence of regulations, greater than 20 centimeters (8 inches) in diameter.<br>• Minimize clearing of vegetation. Leave in place smaller vegetation, topsoil, root stock, seeds and endangered or protected species and species used by local communities for commercial or subsistence use (identified in the environmental assessment).<br>• Treat all onshore operations as if "offshore" to maintain isolation from access routes and communities. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Base camp construction:**<br>• Wastes, fires and discharges (sewage) impact local habitats<br>• Destruction of habitats through creation of access routes to base camps and creation of base camp sites (potentially long term)<br>• Short-term disturbance of local habitats from base camp light, noise and other activities | Exploration, Drilling/Completion | • Minimize the size of camps and facilities consistent with operational, health and safety requirements.<br>• Reduce waste and control waste disposal (solids, sewage).<br>• Prepare contingency plans for spillages, fire risks, etc.<br>• Keep the workforce within defined boundary and to the agreed access routes.<br>• Light sources should be properly shaded and directed onto site areas.<br>• Educate workforce on environmental concerns and design and implement policies to protect biodiversity. |
| **Helipads/airfields:**<br>• Short-term disturbance of habitats from helipad clearings; disturbance of wildlife populations from noise (impacts usually local and short-term) | Exploration, Drilling/Completion, Production/Process, Transmission | • Use helicopters within safety limits where minimization of ground transport is required (e.g., access, clearing).<br>• Construct helipads to reduce disturbance consistent with operational, health and safety requirements.<br>• Assess lowest impact location for helipads and flight paths.<br>• Schedule operations during least sensitive periods, avoiding migration, nesting and mating seasons. |
| **Other infrastructure:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing local habitats | Exploration, Drilling/Completion, Transmission | • "Minimize the footprint." Use existing infrastructure to the extent possible to avoid or reduce road construction and clearing.<br>• In clearing vegetation, use hand-cutting techniques to the extent possible, thereby avoiding the use of heavy machinery. |
| **Drainage:**<br>• Erosion and changes in surface hydrology, causing short- and possible long-term changes in local habitats | Exploration | • Take topography, natural drainage and site runoff patterns into account. Ensure adequate drainage away from streams, rivers and other waterways. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Erosion (topsoil loss):**<br>• Impedes ability of habitats to revegetate, causing possible long-term damage to affected area<br>• Siltation of waterways, with negative impacts on aquatic and marine environments | Exploration | • Take topography, natural drainage and site runoff patterns into account. Ensure adequate drainage.<br>• Stabilize all slopes, revegetating with native species to reduce/avoid erosion.<br>• Break-up compacted surfaces and replace topsoil, brash, seed source, leaf litter, etc. |
| **Site clearance:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing and fragmenting local habitats | Exploration | • Select site to reduce effects on environmental and local communities and to minimize the need for clearing, using existing infrastructure.<br>• Choose site to encourage natural revegetation by indigenous flora and fauna and to avoid the removal of vegetation, topsoil and seed source for decommissioning. |
| **Traffic:**<br>• Short-term disturbance of habitats from traffic; short-term disturbance of wildlife populations from noise<br>• Compaction of soils and changes in surface hydrology<br>• Killing or maiming of local wildlife | Exploration, Drilling/Completion, Production/Process, Transmission, Reclamation | • Use existing infrastructure to the extent possible to avoid or reduce road construction and clearing.<br>• Keep traffic to the absolute minimum requirements for operations.<br>• Impose and enforce speed limits and provide driving guidelines for vehicle operators.<br>• Treat (water) road surfaces to manage dust.<br>• Allow only authorized employees access to site(s) transportation. |
| **NOx emissions:**<br>• Short-term disturbance to wildlife from ground-level NOx gas | Exploration, Transmission | • Ensure requirements from the planning phase are met to minimize effects from exhausts and to address any NOx problems. |
| **SO2 emissions:**<br>• Short-term disturbance to wildlife from emissions<br>• Local damage to flora and fauna<br>• Contribution to impacts arising from acid rain | Exploration, Transmission | • Ensure requirements from the planning phase are met to minimize effects from exhausts and to address any SO2 problems. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **VOC emissions:**<br>• Short-term disturbance to wildlife from emissions<br>• Local damage to flora and fauna | Exploration, Transmission | • Ensure requirements from the planning phase are met to minimize effects from exhaust and to address any VOC problems. |
| **Noise:**<br>• Short-term disturbance to wildlife from emissions | Exploration, Drilling/Completion, Production/Process, Transmission | • Minimize extraneous noise sources and use adequate noise attenuation on engines. |
| **Other infrastructure:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing local habitats | Exploration, Drilling/Completion, Transmission | • Use existing infrastructure to the greatest extent possible to avoid or reduce road construction and clearing.<br>• In clearing vegetation, use hand-cutting techniques to the extent possible, thereby avoiding the use of heavy machinery. |
| **Drainage:**<br>• Changes in surface hydrology, causing short- and possibly long-term changes in local habitats and possible contamination from run-off | Exploration, Drilling/Completion, Production/Process, Transmission | • Take topography, natural drainage and site run-off into account. Avoid areas prone to flooding.<br>• Incorporate drainage and minimize disturbance to natural drainage patterns. Engineer slopes and drainage to reduce erosion. Design for storm conditions, ensure off-site natural runoff does not wash over site, and use perimeter drainage ditches.<br>• Seal bund and ensure suitable drainage of machinery areas, fuel and chemical storage and mud-mixing areas.<br>• Provide base material compatible with local ground conditions. Hard core should be laid on geotextile membrane. Avoid concrete at sites.<br>• Limit leveling activity.<br>• Protect groundwater from drill stem penetration and shallow aquifers from possible site contamination.<br>• Where watercourses and aquifers are deemed sensitive, consider a fully sealed site; avoid use of mud pits, use lined steel tanks.<br>• Mud and burn pits, if used, must have adequate contingency capacity, especially in areas of high rainfall, and must be fully lined and bunded.<br>• Treat surface drainage water in an interceptor with hay filter or similar material. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| Erosion (topsoil loss):<br>• Impedes ability of habitats to revegetate, causing possible long-term damage to affected areas<br>• Aquatic and marine environments adversely impacted by siltation from erosion | Exploration, Drilling/Completion, Production/Process, Transmission | • Protect watercourses from contamination and siltation.<br>• Avoid clearing steep slopes and creating well-defined paths, and when unavoidable, use biodegradable material (jute, straw, etc.) and native species to stabilize slopes. |
| **Site clearance:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing and fragmenting local habitats | Exploration, Drilling/Completion, Transmission | • Site to minimize impacts on water resources, conservation interests, settlement, agriculture, sites of historical and archaeological interest and landscapes. Consider using sites that are already cleared or disturbed, are of low ecological value or that may be easily restored (e.g., agricultural land).<br>• Schedule operations during least sensitive periods, avoiding migration, nesting and mating seasons.<br>• Select the least sensitive locations within the confines of the bottom target/drilling envelope. Consider directional drilling to access targets beneath sensitive areas.<br>• Plan subsequent restoration requirements prior to and during operations.<br>• Use cluster drilling to minimize the "footprint."<br>• Minimize cleared area and size of site; maximize the perimeter to area ratio to aid natural revegetation.<br>• Use hand cutting to clear vegetation. If machinery is necessary, be selective in using it.<br>• Do not burn brush and uprooted materials.<br>• Where vegetation and soil are removed, ensure proper separation and storage. Collect seed, rootstocks and brash for subsequent revegetation. |
| **NOx emissions:**<br>• Short-term disturbance to wildlife from emissions | Exploration, Drilling/Completion, Production/Process, Transmission | • Ensure that requirements from planning phase are met to minimize the effects of exhausts.<br>• Ensure that well test procedures are followed.<br>• Minimize flaring of gas.<br>• Knockout drums should be used on flares to prevent condensate emissions.<br>• Use flaring instead of venting.<br>• Never use continuous venting, and minimize emergency venting.<br>• Use low-NOx burners in process heaters. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **SO2 emissions:**<br>• Short-term disturbance to wildlife from emissions<br>• Local damage to flora and fauna<br>• Contribution to impacts arising from the generation of acid rain | Exploration, Drilling/Completion, Production/Process, Transmission | • Ensure that requirements from planning phase are met to minimize the effects of exhausts.<br>• Ensure that well test procedures are followed.<br>• Minimize flaring of gas.<br>• Knockout drums should be used on flares to prevent condensate emissions.<br>• Use flaring instead of venting.<br>• Never use continuous venting, and minimize emergency venting.<br>• Remove hydrogen sulfide and mercaptans from sour gases before flaring. |
| **VOC emissions:**<br>• Short-term disturbance to wildlife from emissions<br>• Local damage to flora and fauna | Exploration, Drilling/Completion, Production/Process, Transmission | • Ensure that requirements from planning phase are met to minimize the effects of exhausts.<br>• Ensure that well test procedures are followed.<br>• Minimize flaring of gas.<br>• Knockout drums should be used on flares to prevent condensate emissions.<br>• Use flaring instead of venting.<br>• Never use continuous venting, and minimize emergency venting. |
| **Produced water:**<br>• Contamination of local waterways, water table and ground surface with subsequent impacts on flora and fauna | Exploration, Drilling/Completion | • Any produced water from well test operations must be properly disposed of. Disposal options must be addressed in planning phase, and subsequent requirements must be met. Reinject untreated produced water. |
| **Effluent/sewage water:**<br>• Contamination of local waterways, water table and ground surface with subsequent impacts on flora and fauna | Exploration, Drilling/Completion | • Carefully consider water receptors and supply sources (groundwater, surface or marine). In areas of water shortage, use water separation/recycling mud system. If marine sources are used, care must be taken with regard to disposal.<br>• Treat contaminated water and affluent as liquid waste.<br>• Use local sewage disposal facilities where available. For small, isolated sites, soak away/septic field systems can be used, biodegradable solids may be buried, and liquid discharges should be controlled to ensure that local water resources, both surface and groundwater, are not contaminated.<br>• Use package treatment plants for the rig camp. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Drill cuttings/mud:**<br>• Contamination of site collection pits, local waterways, water table and ground surface with subsequent impacts on flora and fauna | Exploration, Drilling/Completion | • Use non-toxic water-based muds. Minimize use of oil-based mud (OBM) and synthetics to that required by operational reasons and use down-hole disposal of OBM wastes; otherwise, treat as hazardous waste.<br>• Reuse invert (diesel-based) muds and drilling-mud pond decant water. |
| **Oil spills:**<br>• Contamination of local habitats, especially waterways, water table and ground surface with subsequent impacts on flora and fauna | Exploration, Drilling/Completion, Transmission | • Requirements of oil spill and emergency plans must be met before operations commence. |
| **Waste deposition:**<br>• Adverse impacts on site ecosystems from waste discharges | Exploration, Drilling/Completion | • Containerize spent oils and lubes for appropriate disposal or recycling.<br>• Where approved disposal sites are available and suitable, use them for all off-site waste disposal. On-site disposal may be considered for inert materials. Ensure detailed documentation and manifesting. Ensure adequate consultation with local authorities regarding nature, type and volumes of wastes arising and capability and capacity of local resources.<br>• Do not discard litter or debris around sites. All wastes to be containerized on-site.<br>• In isolated and remote areas, with no local disposal facilities, non-toxic dry and liquid wastes may be burned, giving due consideration to atmospheric effects. If necessary, portable incinerators can be used to provide a cleaner burn.<br>• Containerize contaminated soils that cannot be treated in situ and remove off-site for treatment.<br>• Consider bulk supply of materials to minimize packaging wastes. Return unused materials to suppliers when possible.<br>• Hazardous materials usage, storage and disposal requirements must meet planning requirements. |
| **Drainage:**<br>• Erosion and changes in surface hydrology, causing short- and possibly long-term changes in local habitats | Exploration, Drilling/Completion | • All practices identified for exploration drilling should be applied to drainage during field development.<br>• Use consolidated, impermeable base at all facilities with permanent in-built drainage systems.<br>• Segregate drainage systems for offsite and non-contaminated clean site areas and oily drainage system for process areas. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Site clearance:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing local habitats | Exploration, Drilling/Completion | • All practices identified for site clearance in exploration should be applied to field development.<br>• Consult with local authorities and communities before sites are selected and cleared.<br>• Consider construction and drilling activities and impacts separately from operational activities. Construction and drilling will use intensive methods and will be longer term compared to exploration construction and drilling requirements.<br>• Sites should only be cleared where long-term disturbances and impacts on the local environment and infrastructure can be avoided.<br>• Locate all facilities at single site to minimize the "footprint."<br>• Maximize use of satellite/cluster drilling sites, horizontal wells and extended-reach drilling in sensitive areas.<br>• Planning for site selection and preparation should include consideration of eventual decommissioning and restoration. |
| **Traffic:**<br>• Short-term disturbance of habitats and wildlife populations from traffic and noise<br>• Compaction of soils and changes in surface hydrology; blockage of streams and other waterways<br>• Killing and maiming of local wildlife by vehicles | Exploration, Drilling/Completion, Transmission, Reclamation | • All practices identified for exploration should be applied to traffic during field development.<br>• Requirements for permanent long-term access routes include appropriate design and engineering, especially regarding the impacts of long-term disturbances from vehicle traffic volume and density in relation to environmental infrastructure and local communities. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Pipeline corridors (ROW):**<br>• Destruction and fragmentation of habitat from the clearing of vegetation<br>• Introduction of invasive species during revegetation activities<br>• Interference with wildlife movements | Exploration, Drilling/Completion, Production/Process, Transmission | • Flowlines and pipeline routing will require consideration in relation to disturbances and effects (bury, surface). Avoid sensitive habitats and build along existing access routes, using spatial planning exercises with relevant stakeholders to design route.<br>• Minimize width of corridors during construction and operation, and plan for closure of ROW to the greatest extent possible after completion.<br>• Allow trees and shrubs to re-establish through minimized cutting and clearing.<br>• Time clearing activities to avoid nesting/migration periods.<br>• Use selective removal of trees and shrubs through cutting.<br>• Limit amount of pipeline trench open at any one time, especially in sensitive habitats, with escape ramps at a maximum every 1 km (0.62 miles). |
| **Soil deposition:**<br>• Burial/blanketing of sensitive habitats<br>• Increased erosion, leading to water turbidity, and impacts on benthic organisms and habitats | Exploration, Drilling/Completion, Transmission | • Avoid sensitive habitats for deposition areas.<br>• Do not deposit material on slopes – use flat areas.<br>• Maximize distance between disposal areas and surface waters.<br>• Minimize dump heights/slopes to prevent excessive erosion.<br>• If deposition is temporary, consider bunding or other measures to control erosion of solids.<br>• If deposition is permanent, revegetate as quickly as possible with appropriate local species to stabilize area. |
| **Revegetation:**<br>• Revegetation with non-native or invasive species can disrupt ecosystems and crowd out native species. | Exploration, Drilling/Completion, Production/Process, Transmission | • Revegetate only with native species appropriate to the areas cleared. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Other infrastructure:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing local habitats | Production/Process | • All practices identified for exploration should be applied to other infrastructure during production.<br>• Evaluate construction and drilling activities and impacts separately from operational activities.<br>• Assess full implications of well treatment and processing, storage, power generation and other support and accommodation facilities in relation to long-term disturbances and impacts.<br>• Evaluate the implications for biodiversity of development of local infrastructure, especially infrastructure related to onshore service functions (port and harbor operations, resource use conflicts, waste treatment and disposal, socio-economic impacts, employment, local services and supply, support infrastructure for employee and family accommodations, etc.). |
| **Produced water:**<br>• Contamination of local waterways, water table and ground surface with subsequent impacts on flora and fauna | Production/Process | • All practices identified for exploration should be applied to produced water during production.<br>• Install produced water treatment facilities, particularly if local infrastructure cannot support requirements.<br>• Re-inject any untreated produced water down hole.<br>• Evaluate beneficial reuse of treated produced water, especially in areas of water stress. |
| **Effluent/sewage water:**<br>• Contamination of local waterways, water table and ground surface with subsequent impacts on flora and fauna | Production/Process | • Install waste treatment facilities, particularly if local infrastructure cannot support requirements. Do not discharge untreated water into local waterways. |
| **Drill cuttings/mud:**<br>• Contamination of site collection pits, local waterways, water table and ground surface with subsequent impacts on flora and fauna | Production/Process | • All practices identified for exploration should be applied to drill cuttings/mud during production.<br>• Provide contained storage areas for drill cuttings and muds.<br>• Fully assess terms of treatment and disposal options for drill cuttings and muds. Reinject cuttings and muds. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Oil spills:**<br>• Contamination of local habitats, especially waterways, water table and ground surface with subsequent impacts on flora and fauna | Production/Process | • Prepare detailed contingency plans and conduct personnel training and regular spill response exercises.<br>• Establish consultation and liaison activities with local authorities and communities to make them aware of the possibility of spills and potential mitigation measures. |
| **Waste deposition:**<br>• Damage to site ecosystems from waste discharges | Production/Process | • Install waste treatment facilities, particularly if local infrastructure cannot support requirements.<br>• Solid wastes, particularly toxic and hazardous substances, will require full assessment in relation to treatment and disposal options. If local facilities are unavailable, incineration facilities may be required, and a full assessment of implications will be necessary.<br>• Prepare and implement a detailed waste management plan.<br>• Provide contained storage areas for produced oil, chemicals and hazardous materials, including treatment of tank sludges.<br>• Monitor waste streams and fulfill compliance requirements. |
| **Helipads/airfields:**<br>• Disturbance to habitats from clearing for helipads and disturbance to wildlife populations from noise (usually local, but could be more widespread if same flight patterns are used over the long term) | Reclamation | • Early in the project lifecycle, develop full decommissioning, restoration and aftercare plan in consultation with local authorities.<br>• Break up compacted surfaces and replace topsoil, brash, seed source, leaf litter, etc.<br>• Remove all non-native materials.<br>• Stabilize all slopes.<br>• If necessary, revegetate with native species to avoid erosion.<br>• Review success of restoration at later date and take remediation measures if site has not been returned to intended condition. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Other infrastructure:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing and fragmenting local habitats | Reclamation | • Develop full decommissioning, restoration and aftercare plan in consultation with local authorities.<br>• Consult with local authorities and other stakeholders concerning which infrastructure should remain, taking into account the short- and long-term impacts on biodiversity.<br>• Break up compacted surfaces and replace topsoil, brash, seed source, leaf litter, etc.<br>• Remove all non-native materials.<br>• Stabilize all slopes.<br>• If necessary, revegetate with native species to avoid erosion.<br>• Review success of restoration at later date and take remediation measures if site has not been returned to intended condition. |
| **Land filling:**<br>• Loss of land-use options<br>• Long-term dispersion of contaminants from unrestored areas<br>• Long-term impacts on drainage patterns<br>• Invasion by non-native species in unrestored areas<br>• Health and safety issues for subsequent users of the area | Reclamation | • Successful reinstatement will require planning and implementation and should not be viewed as an afterthought or a short-term commitment.<br>• Develop full decommissioning, restoration and aftercare plans in consultation with local authorities and communities.<br>• Remove all debris and contaminated soils.<br>• Reform contours to match natural surroundings.<br>• Restore natural drainage patterns.<br>• Mud pits, where used, should be closed out according to local regulatory requirements.<br>• Infill burn and waste pits to meet local regulatory requirements.<br>• Re-spread original topsoil and brash, vegetation, leaf litter and organic material.<br>• Revegetate if necessary, using only native species compatible with the surrounding habitat.<br>• Document and monitor site recovery, taking remediation measures where necessary. |

| Issue/Problem | Stage of Operation | Mitigation Measures |
|---|---|---|
| **Base camp removal:**<br>• Wastes, fires and discharges (sewage); damage to local habitats from wastes, fires and discharges (sewage)<br>• Destruction of habitats through creation of base camps and access routes to base camps (possibly long-term)<br>• Disturbance to local habitats from light, noise and other human activities at base camps<br>• Erosion and changes in surface hydrology | Reclamation | • Develop full decommissioning, restoration and aftercare plans in consultation with local authorities and communities.<br>• Remove all debris and contaminated soils.<br>• Reform contours to match the natural surroundings.<br>• Restore natural drainage patterns.<br>• Mud pits, where used, should be closed out according to local regulatory requirements.<br>• Infill burn and waste pits to meet local regulatory requirements.<br>• Respread original topsoil and brash, vegetation, leaf litter and organic material.<br>• Revegetate if necessary, using only native species compatible with the surrounding habitat.<br>• Review success of restoration at later date and take remediation measures if site has not been returned to intended condition. |
| **Pipeline corridors (ROW):**<br>• Destruction and fragmentation of habitat | Reclamation | • Remove, if appropriate, all permanent structures, foundations, bases, roads, etc.<br>• Remove all debris and contaminated soils.<br>• Render access routes around pipeline corridors inaccessible or to conform with local requirements.<br>• Break up compacted surfaces and replace topsoil, brash, seed source, leaf litter, etc.<br>• Reform contours to match the natural surroundings.<br>• Restore natural drainage patterns.<br>• Respread original topsoil and brash, vegetation, leaf litter and organic material.<br>• Revegetate if necessary, using only native species compatible with the surrounding habitat.<br>• Review success of restoration at later date and take remediation measures if site has not been returned to intended condition. |

| START OF SECONDARY IMPACTS TABLE | | |
|---|---|---|
| **Access roads**<br>**Potential secondary impacts:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing local habitats | Exploration, Drilling/Completion, Production/Process, Transmission | • Treat all onshore operations as if "offshore" to maintain isolation from access routes and communities.<br>• Consult local authorities and other stakeholders regarding preferred locations, using spatial analysis and regional planning to ensure activities do not lead to secondary impacts.<br>• Block and control all access to the project site and concession areas.<br>• Choose the site to encourage natural rehabilitation by indigenous flora and fauna; avoid removing vegetation and topsoil; preserve topsoil and seed source for decommissioning.<br>• Select site to minimize effects on environmental and local communities; minimize clearing.<br>• Use existing access, if available.<br>• Avoid loops in roads, which can isolate and fragment habitat.<br>• Use "dog-legs" to discourage access.<br>• Prohibit transport of unauthorized/third party passengers. |
| **Non-native species introduction**<br>**Potential secondary impacts:**<br>• Displacement or elimination of native flora and fauna | Exploration, Drilling/Completion, Production/Process, Transmission | • Prohibit the workforce from introducing pets, livestock and other animals.<br>• Because vehicles and machinery may carry exotic seeds and animals, clean vehicles and machinery that have been used in areas outside of project sites prior to commencement of work.<br>• Develop a quarantine system that inspects and cleans all incoming supplies prior to their use. |
| **Opening new areas**<br>**Potential secondary impacts:**<br>• Immediate destruction of local habitats, with wider destruction possible unless access is prohibited (possibly long term)<br>• Increased pressure on flora and fauna populations | Exploration, Drilling/Completion, Production/Process, Transmission | • Through spatial analysis or regional planning with local stakeholders, select the site to minimize effects on environment and local communities and to reduce the need for clearing.<br>• Use existing infrastructure to the extent possible to avoid or reduce road construction and clearing.<br>• Create offsets for any habitat that cannot be restored. |

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| **Immigration**<br>**Potential secondary impacts:**<br>• Immediate destruction and fragmentation of local habitats, with wider destruction possible unless the number of immigrants decreases over time (possibly long-term and widespread)<br>• Increased pressure on flora and fauna populations<br>• Erosion and changes in surface hydrology/water quality from increased human activities | Exploration, Drilling/Completion, Production/Process, Transmission | • Strictly control all access to project site and concession areas.<br>• Through spatial analysis or regional planning with local stakeholders, select the site to minimize effects on environment and local communities and to reduce the need for clearing.<br>• Create offsets such as new protected areas or additions to community land to mitigate any destroyed or damaged habitat. |
| **New settlements**<br>**Potential secondary impacts:**<br>• Destruction and fragmentation of local habitats, with wider destruction possible unless the number of immigrants decreases over time (possibly long term and widespread)<br>• Increased pressure on flora and fauna populations<br>• Erosion and changes in surface hydrology/water quality from increased human activities | Exploration, Drilling/Completion, Production/Process, Transmission | • Through spatial analysis or regional planning with local stakeholders, select the site to minimize potential for the formation of new settlements.<br>• Work with local communities and authorities to prevent new settlements and relocate immigrant communities away from sensitive habitats.<br>• In protected areas or sensitive habitats that have experienced new settlements, conduct voluntary resettlement activities, modeling process on existing cultural resettlement practices common among groups in project area.<br>• Create offsets such as new protected areas or additions to community land to mitigate any destroyed or damaged habitat.<br>• Follow World Bank resettlement procedures to relocate settlements. |

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| **Cultivation**<br>**Potential secondary impacts:**<br>• Destruction and fragmentation of local habitats, with wider destruction possible unless the number of immigrants decreases over time (possibly long-term and widespread)<br>• Introduction of invasive/non-native species into local ecosystems<br>• Erosion and changes in surface hydrology/water quality | Exploration, Drilling/Completion, Production/Process, Transmission, Reclamation | • Prohibit workers, local communities and migrant populations from cultivating areas cleared for company operations.<br>• Reclaim cultivated areas through reforestation and planting of native species. |
| **Hunting/poaching**<br>**Potential secondary impacts:**<br>• Elimination or decreased populations of local species, possibly leading to extinction of the species<br>• Ecological alterations through removal of keystone species such as predators | Exploration, Drilling/Completion, Production/Process, Transmission | • Control workforce activities (e.g., hunting, poaching and interaction with local populations).<br>• Prohibit the workforce from uncontrolled purchasing and trading of bushmeat and local wildlife (pets, souvenirs) in conjunction with local communities.<br>• Work with local authorities and communities to monitor and control hunting and poaching arising from new access in operations areas. |
| **Gathering non-timber forest products (NTFPs)**<br>**Potential secondary impacts:**<br>• Increased pressure on flora and fauna populations<br>• Ecological alterations through removal of keystone species | Exploration, Drilling/Completion, Production/Process, Transmission | • Prohibit workforce from gathering NTFPs.<br>• Work with local authorities and local populations to monitor and control collection of NTFPs that stems from new access to operation areas. |

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| **Local commerce with communities**<br>**Potential secondary impacts:**<br>• Increased pressure on flora and fauna populations<br>• Elimination or decreased populations of local species, possibly leading to extinction of the species | Exploration, Drilling/Completion, Production/Process, Transmission | • Prohibit unregulated commerce with local communities.<br>• All commerce should be defined prior to commencement of operations, ensuring that endangered or rare flora and fauna or flora and fauna used by local communities for subsistence are not traded or sold to workforce at unsustainable levels. |
| **Access roads**<br>**Potential secondary impacts:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing local habitats | Exploration, Drilling/Completion, Production/Process, Transmission | • All practices identified for seismic should be applied to access roads during exploration and appraisal.<br>• Limit erosion potential by avoiding steep slopes and drainage courses and cut and fill techniques. Incorporate appropriate drainage, culverting and bridging techniques.<br>• Road construction should use local material, but minimize the cutting of timber. |
| **Hunting/poaching**<br>**Potential secondary impacts:**<br>• Decrease or elimination of specific local species (possibly leading to extinction)<br>• Alterations in ecology through removal of keystone species such as predators | Exploration, Drilling/Completion, Production/Process, Transmission | • All practices identified for seismic should be applied to hunting/poaching during exploration and appraisal.<br>• Provide resources (e.g., scientific data, funding) for local and regional protection efforts of threatened species. |
| **Gathering non-timber forest products (NTFPs)**<br>**Potential secondary impacts:**<br>• Increased pressure on flora and fauna populations<br>• Alterations in ecology through removal of keystone species | Exploration, Drilling/Completion, Production/Process, Transmission | • All practices identified for seismic should be applied to gathering NTFPs during exploration and appraisal.<br>• Provide resources (e.g., scientific data, funding) for local and regional protection efforts. |

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| **Access roads**<br>**Potential secondary impacts:**<br>• Erosion and changes in surface hydrology<br>• Vegetation cleared, disturbing and fragmenting local habitats | Reclamation | • Successful reinstatement will require planning and implementation and should not be viewed as an afterthought or a short-term commitment.<br>• Consult with local authorities and other stakeholders concerning which access roads should remain. Retention of access routes in or around protected areas and sensitive habitats should be discouraged and alternatives created.<br>• Render access routes inaccessible.<br>• Break up compacted surfaces and replace topsoil, brash, seed source, leaf litter, etc.<br>• Remove all non-native materials.<br>• Stabilize all slopes.<br>• If necessary, revegetate with native species to avoid erosion.<br>• Review success of restoration at later date and take remediation measures such as offsets if access has not been completely sealed off. |
| **Non-native species introduction**<br>**Potential secondary impacts:**<br>• Displacement or elimination of native flora and fauna | Reclamation | • Identify and remove introduced species. Long-term eradication programs may be necessary and should be done in consultation and cooperation with local authorities, non-governmental organizations and communities.<br>• Document and monitor site recovery. |
| **Opening new areas**<br>**Potential secondary impacts:**<br>• Destruction and fragmentation of local habitats with wider destruction possible unless access is prohibited (possibly long-term)<br>• Increased pressure on flora and fauna populations | Reclamation | • Develop full restoration and aftercare plans in consultation with local authorities and communities.<br>• Restoration plan must be followed and the site restored to original condition.<br>• Break up compacted surfaces and replace topsoil, brash, seed source, leaf litter, etc.<br>• Remove all debris and contaminated soils.<br>• Reform contours to match the natural surroundings.<br>• Restore natural drainage patterns.<br>• Respread original topsoil and brash, vegetation, leaf litter and organic material.<br>• Revegetate if necessary, using only native species compatible with the surrounding habitat.<br>• Document and monitor site recovery and take measures such as offsets if affected habitats cannot be fully restored. |

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| **Immigration**<br>**Potential secondary impacts:**<br>• Destruction and fragmentation of local habitats with wider destruction possible unless the number of immigrants decreases over time (possibly long-term)<br>• Increased pressure on flora and fauna populations<br>• Erosion and changes in surface hydrology and water quality from increased human activities | Reclamation | • Work with local authorities and communities to redirect migratory flows away from important habitats.<br>• Render access routes inaccessible and establish control mechanisms to prevent re-entry.<br>• If affected habitats cannot be fully restored, take measures such as offsets. |
| **New settlements**<br>**Potential secondary impacts:**<br>• Destruction and fragmentation of local habitats, with wider destruction possible unless the number of immigrants decreases over time (possibly long-term)<br>• Increased pressure on flora and fauna populations<br>• Erosion and changes in surface hydrology and water quality from increased human activities | Reclamation | • Work with local authorities and communities to voluntarily relocate migrant communities away from settled areas, sensitive ecosystems and protected areas. Follow World Bank resettlement procedures at a minimum.<br>• Develop full restoration and aftercare plans in consultation with local authorities and communities.<br>• Restoration plan must be followed and the site restored to original condition.<br>• Document and monitor site recovery and take measures such as offsets if affected habitats cannot be restored. |

# APPENDIX 6: UKRAINE NATIONAL ACTION PLAN

The Ukraine National Action Plan represents an effort to create a comprehensive set of goals and timetables for both the state of the country's environment and for the involvement of the public in environmental matters.

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| **1** | **Public Information and Awareness** |
| 1.1 | Develop a national environmental information system according to EU standards by 2020. (to include a national database of natural resources, and a database on amounts and sources of pollution). |
| 1.2 | Increase environmental information and environmental social marketing through the media by 15% by 2015 and by 30% by 2020. |
| 1.3 | Promote the development of information centers, regional offices of the specially authorized body of executive power on environmental protection and the Aarhus Information Centre established at the specially authorized body of executive power on environmental protection. |
| 1.4 | Support projects of environmental NGOs with government funds, increasing their funding to 3% of the budget of the State Fund for Nature Protection by 2020. |
| 1.5 | Develop a strategy for environmental education for sustainable social and economic development by 2015. |
| 1.6 | Implement a program of environmental education for government employees that work on environmental issues by 2015. |
| 1.7 | Establish a network of regional (oblast level) ecological education centers based in established educational institutions and/or NGOs by 2015. |
| 1.8 | Implement a program of environmental education for the general public at national, regional, and local levels. |
| 1.9 | Make information from government agencies responsible for environmental protection publicly available through official websites and the media. |
| 1.10 | Develop a program for public access to ecological information and for public participation in environmental decision-making, in accordance with the Aarhus Convention, by 2012, and implement it by 2015. |
| 1.11 | NGOs conduct a public assessment of national environmental policy and produce a report, to be published and disseminated with support from the MENR. |
| 1.12 | Develop mechanisms and procedures for public input into environmental decision-making and enforcement, including public participation in Environmental Impact Assessments and other environmental planning procedures. |
| 1.13 | Develop agricultural experiment stations and extension services in every oblast to develop and teach practices for sustainable, environmentally-friendly agriculture to local farmers, and transfer appropriate technologies. |
| 1.14 | Provide state support for the creation and development of the places that use energy and resource saving technologies of residential construction, as well as the comprehensive implementation of such technologies by 2015. |
| 1.15 | Introduce ecological and environmental education at the national, regional (oblast), and local level. Public Participation in Environmental Management. |
| **2** | **Environmental Conservation** |

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| 2.1 | Increase the level of environmental safety by means of the implementation of a comprehensive approach to risk assessment, prevent and minimize the effects of natural disasters in accordance with the Johannesburg Plan of Implementation by 2015. |
| 2.2 | Reduce emissions of common pollutants from:<br>a) stationary sources by 10 percent by 2015 and by 25 percent by 2020 compared to the baseline level;<br>b) mobile sources by means of setting standards for the amount of pollutants in exhaust gases by 2015 according to Euro-4 standards, by 2020 — according to Euro-5 standards. |
| 2.3 | Determine target indicators for the amount of hazardous substances in the atmosphere, in particular for heavy metals, non-methane volatile organic compounds, airborne dust particles (with a diameter of less than 10 microns) and persistent organic pollutants for the purpose of their inclusion when setting technological standards of pollutants emission from stationary sources. |
| 2.4 | Optimize the structure of the energy sector of the national economy due to the increase in the use of energy sources with low carbon dioxide emissions by 10 percent by 2015 and by 20 percent by 2020, as well as ensure the reduction of emissions of greenhouse gases according to the international commitments declared by Ukraine within the framework of the Kyoto Protocol to the United Nations Framework Convention on Climate Change. |
| 2.5 | Define the basic principles of the state policy on adaptation to climate change by 2015, develop and gradually implement the national action plan on mitigating the effects of climate change and preventing the anthropogenic influence on climate change for the period up to 2030, particularly within the framework of the implementation of the mechanism of the Kyoto Protocol to the United Nations Framework Convention on Climate Change, joint implementation projects and targeted environmental (green) investments projects. |
| 2.6 | Reform the system of state governance in the sphere of the protection and efficient use of waters through the introduction of integrated management of water resources based on the basin principle. |
| 2.7 | Reconstruct existing municipal wastewater treatment facilities and construct new ones in order to reduce the level of contamination of waters with pollutants by 15 percent by 2020 (primarily with organic substances, nitrogen and phosphorus compounds), as well as to reduce the discharge of insufficiently treated wastewater by 20 percent (compared to the baseline year) by 2020. |
| 2.8 | Decrease the area of plowed land in Ukraine by 5-10% by 2020 through a program to remove from lands from crop production that are on slopes greater than 3%, in watershed zones, or that are eroded or polluted, and restoration of natural, native vegetation on these areas. |
| 2.9 | Develop procedures to incorporate environmental protection requirements in any decisions that involve the transfer or change of land use designation (for construction, industry, energy, transportation, etc.) by 2015. |
| 2.10 | Develop and introduce by 2020 a system of management of agrarian landscapes to restore the environment and create an ecological network that will conserve biotic and landscape diversity. |
| 2.11 | Increase the area of forest cover in Ukraine to 17% by 2020 (compared to 13-14% now) by reforestation and afforestation of Forest Fund lands and new forest shelterbelts, except on areas of remaining steppe vegetation. |
| 2.12 | Introduce green mining technologies, as well as mandatory reclamation and environmental rehabilitation of territories affected as a result of the production activities of the enterprises of chemical, mining, oil refining industries by 2020; namely, ensure the reclamation of at least 4.3 thousand hectares of lands by 2020. |
| 2.13 | Ensure the fullest use of the extraction of mineral resources, minimizing waste during their extraction and processing. |
| 2.14 | Exercise the state registration of artesian wells and equipping them with measurement devices for measuring the volume of extracted water by 2015. |
| 2.15 | Enhance the effective functioning of the state system of coordination of activities of the bodies of executive power and local self-government bodies on preventing the onset of natural and man-made emergencies and increasing responsiveness to them when they occur by 2020. |
| 2.16 | Improve the national system of informing people of natural and man-made emergencies by 2020. |
| 2.17 | No 2.17 in Ukrainian table. |
| 2.18 | Enforce the implementation of the measures to reduce the amount of radionuclides outside the exclusion zone and the zone of unconditional (mandatory) resettlement by 2015 by means of the functioning of a scientifically |

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| | based system that combines natural renewable processes with land reclamation, forest protection and technical measures enhancing the barrier functions of the natural and man-made complex of the exclusion zone. |
| 2.19 | Ensure the disposal of 70 percent of household waste of the cities with the population of at least 250 thousand people at specialized and environmentally friendly landfills by 2015, as well as the disposal of such waste in full amount by 2020, as well as reduce the portion of waste subject to biological degradation by 15 percent compared to the baseline level in special places of household waste storage by 2020. |
| 2.20 | Increase the amount of preparation, utilization and use of waste as secondary raw materials by 1.5 times by 2020; introduce new technologies of utilization of solid household waste. |
| 2.21 | Ensure the final detoxification of pesticides unsuitable for use by 2020 by means of the introduction of environmentally friendly technologies for their detoxification; development of the action plan for replacing the most dangerous chemicals produced and used in key sectors of economy by 2015 and its implementation by 2020, as well as ensure their safe transportation and storage. |
| 2.22 | Exercise control over the import of genetically modified organisms to the territory of Ukraine, prevent their proliferation; improve the permit system in the sphere of treatment of genetically modified organisms by 2015, including their transboundary movement, ensure the coordination of genetic engineering activities. |
| **3** | **Achievement of the Environmental Condition Safe for Human Health** |
| 3.1 | Prevent violations of sanitary and hygiene requirements for air quality in urban places (with the population of at least 250 thousand people) by means of the creation and improvement of the systems of automatic monitoring and enhancing environmental control over air quality by 2015. |
| 3.2 | Ensure prevailing compliance (90 percent) with sanitary and hygiene requirements for the quality of surface waters in the places of intensive water use by people (for places with a population of at least 250 thousand people) by 2020; ensure full compliance with regulatory requirements for the sources of district drinking water supply by 2015. |
| 3.3 | Ensure prevailing compliance (70 percent) with sanitary and hygiene requirements for the quality of water used for the needs of drinking and cooking by rural population by 2020. |
| 3.4 | Prepare the State targeted program of assessment and prevention of risks for human health in Ukraine caused by environmental factors by 2015, which envisages the application of the methodology of risk assessment; introduction of environmental risk management by 2020 (including the cases of emergencies of man-made and natural character). |
| 3.5 | Introduce the system of environmental labeling for commodity products and food. |
| 3.6 | Detect environmental risk areas and prepare the State targeted program of reducing industrial pressure on human health in environmental risk areas for the period up to 2020. |
| 3.7 | Enhance state ecological control over the compliance with the legislation in the process of placement, construction, operation of new industrial enterprises and other facilities and reconstruction of existing ones on the basis of human health risk assessment by 2015. |
| 3.8 | Develop the institutional framework for informing people of environmental risks by 2015. |
| 3.9 | Expand the range of issues of sanitary-epidemiological and environmental protection character in the program of management staff training by 2015 and improve the system of continuous professional training for the persons working in the sphere of environmental protection by 2020. |
| 3.10 | Develop the regulatory legal framework for environmental insurance based on identifying the issues of causing harm to human health by 2015. |
| 3.11 | Develop the State environmental monitoring system by means of its modernization; enhance the coordination of activities of the subjects of monitoring and improvement of data management systems as a basis for making managerial decisions by 2015. |
| **4** | **National Environmental Policy** |
| 4.1 | Develop and implement the regulatory legal support of mandatory integration of the environmental policy with other documents that contain political and/or program principles of state, industry (sector), regional and local |

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| | development by 2012. |
| 4.2 | Institutional development and enhancing the capacity of state governance in environmental protection sector. |
| 4.3 | Involve all economic and social sectors and stakeholders in developing and implementing a framework national environmental policy, "Environment for Ukraine." National Development Policy |
| 4.4 | Establish environmental management systems and prepare state targeted programs of greening of individual sectors of the national economy, which envisage technical re-equipment and introduction of energy efficiency and resource saving technologies, low waste, waste-free and environmentally friendly technological processes. |
| 4.5 | Develop and introduce a system of incentives for economic entities that implement the environmental management system, principles of corporate social responsibility, apply the ecological audit, certification of production, products quality according to international environmental protection standards by 2015. |
| 4.6 | Develop a clean production strategy and action plan for Ukraine by 2015. Energy Sector |
| 4.7 | Develop a methodology for determining a degree of environmental risk driven by production activities at environmentally hazardous facilities by 2015. |
| 4.8 | Install anti-noise structures/screens (where urban places are located near highways) in urban places with the population of at least 500 thousand people by 2015 and in urban places with the population of at least 250 thousand people – by 2020. |
| 4.9 | Create economic conditions for the development of infrastructure of green types of vehicles by 2015, in particular public transport; increase the share of public transport in the total infrastructure by 25 percent by 2020. |
| 4.10 | Increase the requirements for ensuring environmental safety and reliability of pipeline transport |
| 4.11 | Review the regulatory legal framework in order to ensure environmental protection requirements, in particular regarding energy and resource saving, in the process of industrial and residential design, construction, reconstruction and dismantling of constructions. |
| 4.12 | Increase energy and resource saving in multi-family houses |
| 4.13 | Create the enabling conditions for widespread adoption of organic and ecologically-friendly agricultural practices by 2020. |
| 4.14 | Develop the incentives to promote the implementation of environmental management systems in military formations by 2015, ensure environmentally friendly environmental management in the process of operational and combat training during military trainings and exercises by 2020. |
| 4.15 | Eliminate the effects of environmental damage caused by military activities; namely, compensate damages to the state caused by temporary presence of foreign troops on the territory of Ukraine. |
| 4.16 | Implement environmental management systems and enhance state environmental control over the objects of tourism and recreation, as well as hotel and restaurant facilities; develop ecological tourism and eco-friendly recreation. |
| **5** | **Biodiversity Conservation** |
| 5.1 | Develop a national program to track and control the introduction of non-native invasive species (terrestrial, aquatic, and marine). |
| 5.2 | Pass legislation to control domestic and international trade of endangered species by 2015. 5.3 Implement a national campaign to educate the public and decision-makers about the importance of ecosystem services, and conduct assessments of their economic value throughout Ukraine, by 2015 |
| 5.3 | Run a public information campaign regarding the value of ecosystem services based on the example of ecosystems of Ukraine by 2015; form and further apply the valuation of ecosystem services by 2015. |
| 5.4 | a. Designate habitats to be managed as buffer zones around protected areas, and corridors linking them, so as to form an "Ecological Network" that, together with the protected areas themselves, would cover 41% of Ukraine by 2015. b. Increase the area of protected areas governed by the Nature Protection Fund to 10% of Ukraine by 2015, and 15% by 2020. |

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| 5.5 | Incorporate an "ecosystem approach" to environmental management into Ukrainian legislation and management policies and practices in accordance with the European Union by 2020. |
| 5.6 | Incorporate an "ecosystem approach" to environmental management into Ukrainian legislation and management policies and practices in accordance with the European Union by 2020. |
| 5.7 | Develop financial mechanisms and incentives for biodiversity conservation based on an economic assessment of the economic value of biodiversity, and including economic analysis of the financial sustainability of protected areas and development of mechanism to make them financially sustainable. |
| 5.8 | Take administrative measures to terminate the catastrophic decrease in reserves of aquatic living resources as a result of their excessive exploitation and deterioration of the environment by 2015. |
| **6** | **Ensuring Ecologically Balanced Environmental Management** |
| 6.1 | Prepare and approve a draft Concept of 10-year policy framework for sustainable consumption and production (SCP) pursuant to Johannesburg Plan of implementation on sustainable development (2002), develop and implement a draft Strategy and national plan of action up to 2015. |
| 6.2 | Further develop the national system of cadastres of natural resources, state statistical reporting on the use of natural resources and environmental pollution. |
| 6.3 | Re-equip production facilities based on the implementation of innovative projects, energy efficiency and resource saving technologies, low waste, waste-free and environmentally friendly technological processes by 2020. |
| 6.4 | Implement a system of economic and administrative mechanisms by 2015 for the purpose of encouraging the manufacturer to perform sustainable and renewable environmental management and environmental protection, as well as introduction of new cleaner technologies and innovations in the sphere of environmental management. |
| 6.5 | Increase the energy efficiency of production by 25 percent by 2015 and by 50 percent by 2020 compared to the baseline year by implementing resource saving in energy sector and industries that consume energy and energy resources. |
| 6.6 | Increase the use of renewable and alternative energy sources by 25 percent by 2015 and by 55 percent by 2020 compared to the baseline level. |
| 6.7 | Increase the share of land used in organic agriculture by 7 percent by 2020. |
| 6.8 | Create an environmentally and commercially reasonable system of payments for special use of natural resources and fee for environmental pollution by 2015 in order to encourage economic entities to efficient environmental management. |
| 6.9 | Reform the existing system of environmental protection funds by 2015 for the purpose of increasing centralization of funds at the level of oblasts, the Autonomous Republic of Crimea, cities of Kyiv and Sevastopol. |
| **7** | **Improvement of Regional Environmental Policy** |
| 7.1 | Develop and implement mid-term regional environmental protection action plans as the main instrument for the implementation of the national environmental policy at the regional level. |
| 7.2 | Develop the methodology and prepare local environmental protection action plans by 2015. |
| 7.3 | Integrate the environmental component with the strategic documents on the development of cities and regions, take into account the requirements of Aalborg Charter during the evaluation of the regional programs of social and economic development, review master plans of development of large cities in order to implement the provisions of the above mentioned international documents. |
| 7.4 | Legislative support of the transition from socio-economic planning to ecological and socio-economic planning of regional and local development by 2015. |
| 7.5 | Develop the regulatory legal framework for ecological and economic macro regions by 2020. |
| 7.6 | Perform the classification of regions by the levels of the man-made environmental risks; create appropriate geographic information data and maps banks by 2015. |

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| 7.7 | Implement a pilot project on the combination of territorial planning system with the procedures of long-term forecasting, ecological and socio-economic planning, as well as conduct a strategic environmental assessment on the example of the Carpathian macro region by 2015. |
| 7.8 | Develop the "public — government — business" partnership at the regional level in order to guarantee social and ecological standards of environmentally friendly living of people by 2020. |
| 7.9 | Reduce the negative impact of urbanization processes on the environment, stop the destruction of the natural environment within cities, improve the indicators of landscaping and greenery areas of general use, reduce the level of pollution of atmospheric air, water bodies, as well as noise and electromagnetic pollution by 2020. |

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