OPINION OF THE MARIO MOLINA CENTER CONCERNING THE SUSTAINABLE PRODUCTION OF SHALE GAS AND OIL IN MEXICO

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Technological development involving the combined use of hydraulic fracturing and directional drilling, has allowed extracting natural gas and oil from very low permeability geological structures (shale); thus, it has allowed us to have access to vast hydrocarbon resources in the subsoil that were previously unavailable. As a result, in the United States where this technology was developed and applied, the production of natural gas has been greatly increased and its price has significantly been reduced. In Mexico huge reserves of shale gas and oil have also been identified and the intention to exploit them exists.

The cleanest fossil fuel is natural gas. If it is produced in such a way that it doesn't leak nor negatively impacts people and ecosystems, it may be a transition energy that allows taking the country towards a low carbon economy based on renewable and clean energy sources.

Hydraulic fracturing has developed very rapidly in the U.S. and it is a technology that compared to the conventional oil industry, is very flamboyant, it uses lots of water and entails many and important environmental risks. This is the reason why it's a technology that has met opposition from affected communities and environmental groups in the United States and all countries where plans have been announced to use it. In some places moratoriums and even prohibitions for its use have been established.

Due to the real and perceived impacts of hydraulic fracturing and the opposition it has caused, companies and authorities have been dedicated to developing best practices, technologies, procedures, standards, systems and standards to minimize the risks and impacts that this activity entails. Countries such as Mexico that are contemplating the exploitation of these resources have the opportunity to learn from the successes and mistakes present in the rapid development which occurred in the United States. We are in the privileged position to understand the lessons learned by others and adopt best practices for the production of unconventional hydrocarbons.

Based on a detailed assessment of the state of the art technology and regulation concerning the production of shale gas and oil, the Mario Molina Center has reached the conclusion that: in light of international experiences and in virtue of recent technological advances, nowadays it is possible to develop shale gas and oil in Mexico in a way that is safe and respectful towards the environment. This requires the use of best practices and available technologies and to have proper regulation and a rigorous and effective supervision. International experience indicates that the sustainable production of shale gas and oil if properly planned does not entail significant additional costs**.**

To help achieve this objective the Mario Molina Center makes the following recommendations:

GIVE CERTAINTY TO SOCIETY, BUSINESSES AND OTHER PRODUCER AGENTS LOCATED IN PROSPECTIVE AREAS ON WATER AVAILABILITY AND MANAGEMENT

1. The authority in charge of water management should develop and publish a regional plan of water use and availability in the prospective areas of unconventional hydrocarbon exploitation. This document should contain as key elements:

    - Origin and water use by activity.
    - Availability of surface water and groundwater.
    - Location and physical characteristics of aquifers and extraction wells.
    - Capacity of wastewater treatment.
    - Volume and possible locations of wastewater discharges.
    - Geological storage capacity for wastewater disposal (if it exists).
    - Quality of water resources from groundwater and surface water.
    - Projected water use and availability for 10 years.
    - Strategies for water use in the region.

2. The producer company of shale gas or oil must prepare and submit for assessment to the authority, in parallel with the operating permits a water management plan that must contain at least the following elements:

    - Identification of proposed sources and the required volume of water during the development's lifetime for hydrocarbon extraction.
    - Physical and chemical characteristics of the water sources to be used.
    - Methods to be used for the treatment and disposal of return fluids.
    - Water resources rate of use.
    - Methods to protect aquifers and surface waters located in the development zone.
    - Strategies for reuse of produced water.
    - Program for the use of brackish water or wastewater.
    - Strategies for minimizing the use of water resources.

    Areas with high water stress should seek the minimal use of fresh water.

3. The operator must deliver the resulting data from monitoring the quality of water from aquifers and surface water in the development area of their production activities. Monitoring should be carried out and certified by an independent third party and should include assessment of the following: aspects: acidity, hydrocarbons and dissolved solids, heavy metal concentration, conductivity, presence of naturally occurring radioactive materials. There should be ongoing monitoring, measurements must be made before drilling, during operation and after abandonment of wells.

ENSURE THE ABILITY TO DETECT WATER AND AIR POLLUTION

4. Before initiating oil activity, an environmental baseline should be established that contains the physical and chemical characteristics of aquifers and surface waters in

the prospective areas of shale gas and oil exploitation. In regards to water, the baseline must include measuring the following parameters: acidity, hydrocarbons and dissolved solids, heavy metal concentration, conductivity, and presence of naturally occurring radioactive materials.

5. Regulators must know the chemical composition of fracturing fluids to be used for well stimulation. The information provided by operators in this regard should contain: total volume of the base fluid and proppant; name and formula of the intentionally added chemical substances to the base fluid; description of the function of the substances in the stimulation treatment; concentration of each intentionally added substances.

6. Chemical tracers must be used in fracturing fluids to the possible allocation of responsibilities in the event of aquifers' contamination.

7. In addition to creating an environmental baseline data involving use, demand and water quality, air emissions and air quality, a comprehensive characterization of the region should be carried out that includes:

    - Infrastructure for product, raw materials and waste transportation
    - Geological faults and history of earthquakes in the area
    - Biodiversity and natural protected areas
    - Productive activities in the prospective areas
    - Areas with vulnerability to floods
    - Public health in the region's existing communities

    All variables involved in the baseline and the characterization of the development area must be monitored on an ongoing basis during the full life cycle of the productive activity.

MINIMIZE THE RISK OF WATER POLLUTION BY BEST PRACTICES IN DRILLING AND WELL STIMULATION

8. In order for groundwater systems not to be contaminated, authority and companies must ensure the mechanical integrity of wells producing shale gas and oil during its lifetime. This can be achieved by requiring strict standards compliance for cementing and well cladding, as well as the execution of integrity tests supervised by a third party, beforehand the stimulation process to ensure the drilling isolation.

9. The hydrocarbons regulator must pre-establish a minimum vertical distance between the well stimulation activities and the nearest source of water for human consumption. This restriction will serve to minimize the risk of contamination by migration of hydrocarbons or other contaminants to aquifers or surface water through created fractures by stimulation operations.

ENSURE COMPREHENSIVE WASTE MANAGEMENT STEMMING FROM OPERATIONS BY MEANS OF SPECIFICATIONS AND RESTRICTIONS ON MONITORING AND INTEGRAL MANAGEMENT

10. The authority in charge of water management in Mexico should establish special conditions for discharge of treated wastewater from the extraction of shale gas and oil.

11. The operator must submit for the authorities' consideration a waste management plan, in which special attention should be put to the handling, storage, transportation and disposal of return fluids sets. The management plan must include the expected return fluid volumes, capacity and physical Characteristics of the temporary storage units on site, transportation for delivery to final disposal or treatment, type of treatment or final disposal, and temporality of each of the stages of the management plan.

12. The return fluid storage and water produced at the drilling site must be done in closed tanks above ground until their transportation for the appropriate treatment. Storage tanks must be air-tight seal, corrosion resistant and have the capacity according to the amount of expected wastewater.

13. For return fluids disposal and produced water by injection into impermeable geological formations, the operator must identify in advance the well or wells where the action will be carried out. Certainty should be given to the authority of the suitability of such wells by delivering the latest assessment of mechanical integrity.

REDUCE EMISSIONS OF GREENHOUSE GAS AND CONTAMINANTS THROUGH THE RESTRICTION OF BURNING OIL, THE PROHIBITION OF VENTING AND THE USE OF TECHNOLOGIES TO MINIMIZE FUGITIVE EMISSIONS

14. The operators must submit to regulators in the oil and gas sector a program to minimize hydrocarbon fugitive emissions. The program should include strategies focused on the use of the best technologies and preventative maintenance of process equipment which results in increased operational efficiency and minimizing leakage of methane and other volatile organic compounds.

15. The deliberate venting of gaseous hydrocarbons to the atmosphere should be prohibited. Companies will need to perform hydrocarbon vapors recovery practices by storaging in closed tanks the recovered well fluids and drive the captured gaseous hydrocarbons to the online sale, collection system or electricity on-site generation.

16. The burning of gaseous hydrocarbons should be restricted to those cases where for security reasons excess gas production in the system should be burned. The burners used shall have a continuous ignition equipment over the lifespan of the well and a high combustion efficiency.

17. Special attention should be paid to methane emissions and other volatile organic compounds during the well's completion stage for the release of dissolved

hydrocarbons in the return fluid. To solve this issue, operators must use the so-called Renewable Energy Certificates (RECs).

18. The hydrocarbon regulator on environmental matters will have to develop a baseline of greenhouse gas emissions and criteria pollutants in the region. They should also prepare a report of air quality in the communities most likely to be affected by atmospheric transportation of compounds and the formation of secondary pollutants.

ANTICIPATE POSSIBLE ENVIRONMENTAL AND INFRASTRUCTURE DAMAGES IN LOCATIONS NEARBY THE SUPPLY CHAIN ROUTES

19. Operators shall submit to the authorities' assessment a logistic supply plan, which contains information on the expected transport movements of supplies (pipelines, water, sand, chemicals, etc.). Transportation of waste for disposal or treatment, transportation of products as well as the volumes and number of freight units used for the field development process. Water transportation by trucks should be minimized.

20. In the proximity of populations low noise technologies and equipment must be used and working hours should be arranged with residents.

21. A seismic stoplight should be installed to control the process of fracking and contaminated water disposal to the subsoil and to allow us to stop injection activities as soon as the pre-established seismicity limit is exceeded.

DESIGN AND IMPLEMENT AN EFFECTIVE STRATEGY FOR MONITORING THE EXTRACTION ACTIVITIES OF SHALE GAS AND OIL, IN A WAY THAT THE MONITORING CAPACITY OF THE AUTHORITIES IS NOT SURPASSED

22. The regulator must ensure compliance with the regulations in his area of expertise by designing a system of rigorous and effective inspection. The system must be laid out in a way that it ensures the technical adequacy of inspectors and assessors, and the required number of staff to carry out supervision and monitoring. We should consider the participation of independent third parties and certifications for drawing samples and laboratory tests, as well as conducting environmental and security audits.

23. A working group should be created for the ongoing review of the development effects of shale oil and shale extraction activities, outline strategies to solve problems and update the regulatory framework. The group should be composed of representatives from the affected communities, local governments, regulators at a state and federal level, environmental groups, operating companies in the region as well as academic and research institutions. The policy and technology overview in regards to the production of shale oil and gas is changing continuously and rapidly, it is important to keep up to date of these developments to ensure that the systems, procedures and practices that will be adopted in Mexico incorporate state of the art in the matter.

ESTABLISH A COMMUNICATION MECHANISM WITH SOCIETY TO DISCLOSE INFORMATION ON THE PROGRESS OF SHALE GAS AND OIL EXTRACTION ACTIVITIES

24. The regulatory authorities and operating companies must establish a communication mechanism with society to disclose information on the progress of plans, programs and oil and shale gas extraction activities. The information must have data such as: development plans, issued permits, operators, used water resources, date of commencement of operations, chemical substances used in the process and location of developments.

25. The participation of society and specifically the communities directly affected should be promoted from the beginning. Information should be given in a clear, objective and complete manner about the benefits and risks involved in the production of shale gas and oil. Obtain and maintain a social license for these kind of activities is crucial to achieve the objective for the development of shale gas and oil to be profitable, safe and environmentally friendly.