Shale Development: Understanding and Mitigating Risks Associated with Well Construction and Hydraulic Fracturing

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The rapid increase in development of unconventional resources is unlocking vast new domestic volumes of natural gas and oil and has the potential to provide a basis for enabling United States energy security. At the same time, development has also led to increasing public concern over a range of potential safety, health, environmental risks and social impacts. For example, concerns over the potential for the well construction process or hydraulic fracturing fluids to contaminate the groundwater, chemical spillage and water disposal issues, and induced seismicity are a few selected examples of specific public concerns, which are subject to numerous research efforts and increasing regulatory attention.

Sound engineering design principles and operational practices concerning well construction, water management, integrity monitoring should be followed to prevent accidental releases and mitigate other concerns. Experience and data show that an appropriate regulatory framework considering the local context, coupled with an operator's implementation of an effective risk management framework supported by the consistent use of sound engineering practices and standards are key enablers to the safe and responsible development of these resources.

The inherent risks associated with shale development are managed by assessing the risk level, understanding risk in the context of probabilities and consequences, and implementing mitigation methods based on the local context to reduce the risk to an acceptable level. An effective and widely-adopted approach is use of a "risk matrix" methodology to assess and understand risk levels and subsequently identify suitable risk mitigation approaches. Using this type of methodology a recent comprehensive study[1] evaluates a range of potential risks associated with shale development, considering potential safety, health, and environmental exposures from both a subsurface and surface perspective and impact to land, water, and air resources. This presentation will specifically focus on key risk and mitigation of: (a) unplanned subsurface fluid migration resulting from the well construction process, (b) accidental surface release of fracturing fluids and chemicals, and (c) induced seismicity from wastewater disposal and hydraulic fracturing injection operations.

The risk of potential shallow water aquifer contamination from the hydraulic fracturing process will be described based on data from thousands of micro-seismic fracture diagnostic measurements[2] and extensive state and federal investigations that have found no evidence of fracturing chemicals contaminating aquifer sources; with understanding that poor well construction can lead to isolated instances of gas migration. The methods used to mitigate risks and exposures will be described and include discussion of engineered well designs and multiple barriers considering local geology and aquifer location; integrity testing of well prior to operations; monitoring of operations; and remediation of well construction issues if they are encountered.

The risk of potential surface release and/or spill of chemicals and unplanned subsurface fluid migration will also be described based on data from a comprehensive Groundwater Protection Council report[3] from ~389,000 wells; with data indicating incident frequency ~0.1% and very localized site impact consequence. The methods used to mitigate risks and exposures will be described and include discussion of prudent regulation and inspection; use of redundant barriers and containment; implementation of improved standards for reserve pit construction; improved standards for demonstrating well integrity; addressing "orphan" well and "legacy" site issues; and proactive remediation when issues may be encountered.

Finally, the risk of potential induced seismicity will be discussed, considering both waste-water injection operations and hydraulic fracturing operations. The risk of induced seismicity will be characterized from data collected as part of a comprehensive USA National Academy of Sciences report[4], extensive micro-seismic measurements obtained in fracturing operations conducted in many N. America shales[5], as well as studies associated with hydraulic fracturing in the U.K.'s Bowland Shale[6] and the Horn River Basin[7] in Canada. A science-based risk assessment methodology[8] shows hydraulic fracturing is a very low risk activity relative to potentially inducing negative consequence seismicity; under very rare and unique geologic circumstances, waste-water injection (disposal) operations may be identified as an elevated risk. Induced seismicity risk mitigation approaches will be described and include avoiding high-pressure large volume injection directly into significant and active faults and use of a “stoplight approach” based on monitoring methods considering local conditions when significant risk may exist.

Reliable and safe development of shale resources, enabling substantial economic and environmental benefit while meeting the forecast energy demand, can be achieved with a collaborative engagement between the public, regulators, and operating companies. It is important that reasonable regulations considering local conditions be in place, coupled with a responsible operations philosophy and effective risk management framework implemented by all operators, supported by the consistent and appropriate use of sound engineering practices and standards.

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