SHale gas Exploration and Exploitation induced Risks

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Guidelines for monitoring the environmental impacts of shale gas operations

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General Overview

- Defining standards for monitoring the effects of hydraulic fracturing techniques on environment to establish monitoring procedures and protocols, considering methods to analyze the effects of induced seismicity, groundwater contamination and air pollution (ground deformation, pore pressure, ecc. ??)
- Pre-operational time: the monitoring allows to quantify the background values
- Operating time: the monitoring allows to distinguish and measure the possible effects of operational activity on soil, water and air and the variations of all the monitored parameters, compared to the background values previously estimated.
- Post-operational time: the monitoring allow the evaluation of long term effects

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General overview

- An accurate monitoring requires :

(i) an efficient well-designed monitoring setup

(ii) the adoption of the most proper analysis algorithm, relying on recent methodological and computational advances.

- It is important to gather basic geological, structural and seismotectonic information on the monitored area in order to be able to understand the dynamic and the characteristics of the faults existing in the area as well as to create the velocity model of the subsurface (Close cooperation with the site operator).

General Overview

- A crucial concern is the collaboration with operators both at the initial stage concerning recognition of the geological conditions of the site as well as later stages when the monitoring is carried out before, during and after of technological operations.

- A geological and structural model of the subsurface is needed to a good understanding of the vertical distance which should be preserved between hydraulic stimulation and overlying aquifers (potable water).

General Overview

- All the monitoring activities should be adopted/adjusted to the technological plans of the operator.
- Promotional actions have to be undertaken well before bringing in site the monitoring equipment, in order to explain the local community the aims of the monitoring and the activities which will be implemented.
- A similar situation applies to local administration, where a close cooperation based on mutual understanding is needed.

General Overview

- The optimally planned location may be affected by some problems with:
  - ground owners (agreement for land rental, the amount of pay, types of agreement etc.),
  - safety (location of shelters for equipment, types of security/protection etc.),
  - power supply (access to direct current, solar panels, fuel cells etc.).
  - the recommended on-line data transmission (access to internet, weak GSM signal coverage etc.).

General Overview

- Borehole monitoring will need specific regulatory permits, which may be difficult and certainly is time consuming to obtain and is expensive. Ideally, seismic monitoring should be carried out in deep boreholes.
- Regardless the fact, that the majority of the equipment is unmanned, site visits are inevitable.
- Public perception: It is important to make people aware about risks and benefits of the shale gas development.

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Seismic monitoring

The pre-operational installation is to monitor background seismicity, to observe and notice any natural quakes in research area.

- *Verification of correct operation*: the recording of short (i.e. one day) seismic data can be used to verify the correct functionality of the seismic instrumentation
- *Network optimization and site selection*: noise characterization can be used to improve the network geometry, avoiding locations close to sources of natural and anthropogenic noise
- *Noise assessment*: the frequency dependent seismic noise, and its temporal variation can be used to build realistic synthetic data, and assess the network performance in terms of microseismicity detection and location
- *Characterization of background seismicity*: the operation of the network before the activities start is important to identify, locate and characterize seismic sources and seismicity rates in the target volume, which are classified as background seismicity. Later deviations from locations, rates and characteristics of seismic signals from those of the background seismicity, may be use to early detect induced seismicity.

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Seismic monitoring

The co-operational installation provides:

- *Quick identification of anomalous seismicity*: implying deviations from the location of seismicity, waveform amplitude, waveforms and spectra characterization a seismicity rates.
- *Estimation of seismic source parameters*, such as epicentral location, depth, focal mechanism, moment tensors and/or spectral source parameters.
- *Fracture tracking*: understanding and tracking the growth of the fracture itself.
- *Consequent support to operational protocols and traffic light systems*.

Seismic monitoring

The post-operational installation aims to:

- *Early characterization of delayed induced seismicity*: the main tasks of the co-operational installation remain valid in this phase, as it has been proposed and observed in several cases that seismicity may continue for some time after the end of the injection operations.
- *Return to preseismic seismicity rates*: the post-operational installation and end of the monitoring period should take place once assessed the return to the pre-injection seismicity conditions.

Water contamination

- A site characterisation prior to drilling based mainly on fracture location that could provide migration pathways;
- A dynamic conceptual model, updated as new information become available. An initial conceptual model would serve as the basis for the design of the monitoring network;
- Special consideration at an early stage for water management issues in terms of water supply and waste water;
- A baseline monitoring programme at two levels: at an extended scale using existing monitoring points and at site level using a dedicated network of monitoring wells;
- A minimum of 12-month baseline monitoring (with monthly sampling) to quantify uncertainties, understand the aquifer dynamics and define a statistically-robust baseline for future reference;
- Subsequent variable-frequency monitoring depending on the stage and progress of shale gas activities, including post-decommissioning;
- The selection of key indicator parameters to monitor once shale gas activities have begun, in order to reduce monitoring costs;
- Soil gas monitoring for fugitive methane emissions in the immediate vicinity of the shale gas pad;
- The definition of trigger levels based on statistical one-sided tolerance intervals using the robust non-parametric approach;
- Technological surveillance of innovation in monitoring technology to fill identified gaps.

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Air monitoring

- Preparatory phase

  Analysis of air quality using available historical data for each of the analyzed air pollutants characterized by its own natural background levels depending on location and variability at different time scales.

- Choice of location and duration of monitoring

  The monitoring station should be located at a suitable distance from the well, after analyzing the distribution of wind. The experience gathered during the SHEER project indicates that at a distance of over 1 km from a single well, the impact on air quality is very small. If the impact on the population is being investigated, the station should be located in the nearest inhabited place from the borehole. Continuous monitoring for not less than one year is required.

- Selection of monitoring equipment

  The choice of measuring equipment is obviously dependent on the measurement program, however, the basic version should include pollutants relevant for two possible aspects: a) traffic pollutants, primary and secondary such as nitrogen oxides, carbon monoxide, particulate matter, sulfur dioxide, volatile organic compounds, ozone and b) pollutants specific to gas exploitation processes: methane, non-methane hydrocarbons, carbon dioxide, radon. A weather station at the measuring location is required.

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Air monitoring

- Monitoring

  The technical aspects should be implemented in accordance with the general guidelines for air pollution monitoring networks, in order to ensure adequate quality and comparability of results. This includes equipment maintenance, periodic calibrations etc. The results of continuous measurements should be reduced to hourly averages, except for special cases when shorter averaging periods, even 1 minute averages, can be useful.

- Data analysis

  Comparison of the observed time series of concentrations (1-hour means) to the appropriate concentration limits. In case of exceedances the source region have to be determined (analysis of air pollution situation in the region, air trajectory analysis, or modeling of pollutants transport).

  Episodes of concentrations of pollutants significantly (e.g. more than two standard deviations) exceeding the background values should be identified.

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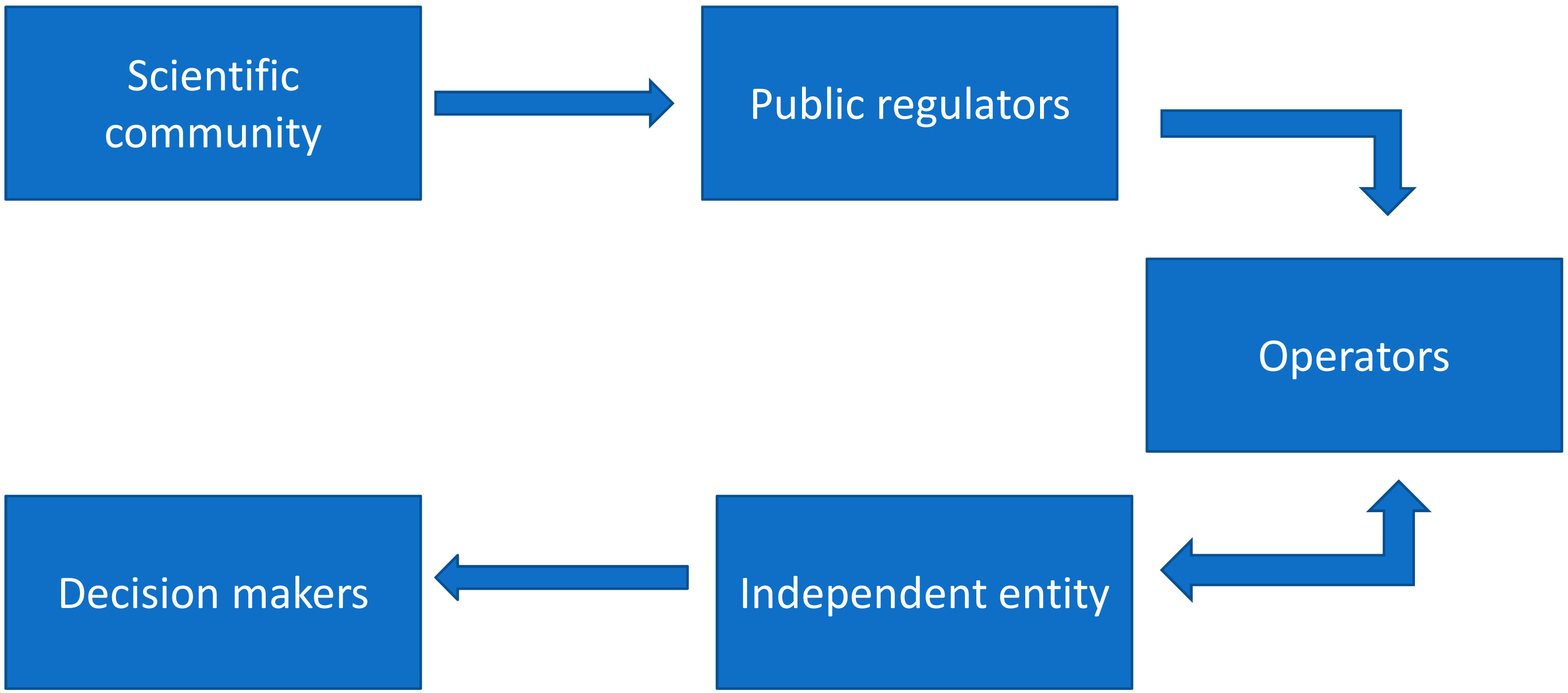
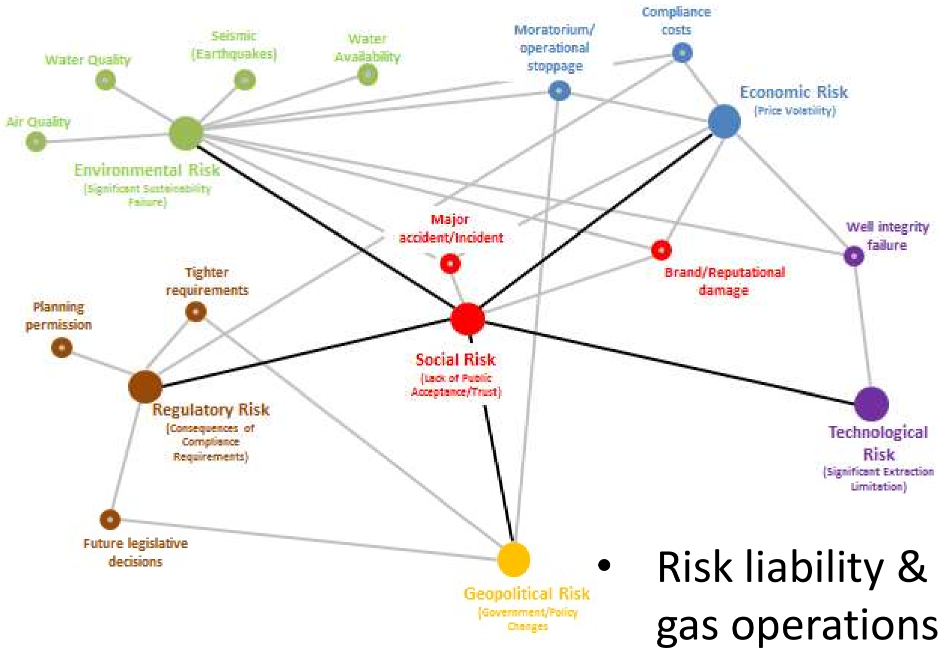
From guidelines to decision makers



Thank you

Do we need environmental monitoring?



Yes

- Reduce liability
- Ensure compliance with regulators
- Secure short and long term sustainability of the natural environment
- Improve social licence
- Early recognition to reduce mitigation costs in the event of environmental issue

No

- Risk liability & legal action even if shale gas operations are not primary cause.
- Should an issue occur the environmental problem may remain unchecked, grow larger & more difficult to mitigate
- Regulatory risk
- Future risk of unchecked environmental problems

Kelly, 2017