Baseline concentration and raw gas composition. Relevance for Shale Gas operations.

TransAtlantic Knowledge Sharing on Unconventional Hydrocarbons: Resources, Risks, Impact and Research Needs

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Outline

➢ Key points
➢ Types of emissions
➢ Different sources
➢ Knowledge gaps
➢ Baselines
➢ Raw Shale Gas composition
➢ Conclusions
Key points

- Emissions to atmosphere have a significant potential environmental impact of shale gas exploration and exploitation.
- How to minimize emissions of atmosphere pollutants and greenhouse gases.
- Develop the methods and framework to minimize environmental risks of atmosphere emissions.
- Identification of suitable tracers in (shale) gas
- Construction of a (raw) gas composition database
- Baseline concentrations of selected tracer(s) over Europe
- The location of a potential European shale gas industry and associated estimated potential loss rates.
- Modelling the release and dispersion of the tracer(s) under various leakage scenarios
- Compiling detection limits of suitable monitoring instruments and location of instruments in such a way that exceedance of acceptable loss rates would be picked up by the system.
Types of emissions

GREENHOUSE GASES
- Methane (CH$_4$)
- Carbon dioxide (CO$_2$)

AIR POLLUTANTS
- Nitrogen oxides (NO$_x$)
- Volatile organic compounds (VOCs)
- Hazardous air pollutants (HAPs)
- Particulate matter (PM)
- Carbon monoxide (CO)
- Sulphur oxides (SO$_x$)
Different sources

- CH$_4$
  - Vented (for example release of gases during flow back)
  - Fugitive emissions from gas processing equipment (such as pneumatic controls, valves, well heads and others)
  - leakage of (raw) shalegas

- CO$_2$, SO$_x$, and NO$_x$
  - fossil fuel combustion

- CO, VOCs
  - Incomplete combustion.

- Ozone (O$_3$)
  - exploration and production operations

- PM
  - Combustion
  - Dust or soil during pad construction, due to earth movement, and traffic on access roads.
Different sources

- VOCs
  - Formed during the incomplete combustion
  - Emitted during the dehydration step of natural gas
  - Associated with fugitive emissions
  - Flaring from shale gas extraction, but in small concentrations

- Hazardous air pollutants (HAPs)
  - Benzene, toluene, ethylbenzene and xylenes.
    - fugitive emissions (is considered to be small).
    - dehydratation of the gas before entering the distribution line.
  - H$_2$S
    - flow back of fracturing fluids and produced water during well completion.
Knowledge gaps

 ➢ Absence of important baseline information about environmental conditions in shale gas regions

 ➢ Well integrity
  - Gas compositions at various European players.
Baseline

- A baseline can be considered as the level or quantity of emissions in a specific scenario where there is a projection of possible activities to be implemented in future.

- A low-cost sampling strategy, suitable for establishing pre-fracturing baseline data as well as providing an integrated assessment of emissions from shale gas operation sites, needs to be developed.
The objectives of a Baseline study are:

- Measure target pollutant concentrations at least for one-year.
- Collect enough data for the annual average concentrations estimation.
- Implement monitoring program in line with existing monitoring systems to enable data comparability.
- Apply standard monitoring protocols ensuring consistent high quality data.
- Use conventional data reduction, data summary and analysis techniques to characterize the data.
Different sources may influence air quality such as, cars, trucks, aircraft, biomass boilers and incinerators. Total emissions from the different sources and the distance to the receptor influences air pollution concentrations and air quality impacts.

The monitoring should not only provide a snapshot of the emissions and concentrations but should consider the changes over time.

Methane is one of the main concerns regarding GHG emissions.

The understanding of background levels and the setting of baselines with the aim of minimizing the potential methane emissions requires the adoption of good practices for environmental management supported by strong regulation and high quality data.

An integrated monitoring study of methane emissions may be a suitable mean of distinguishing the contribution of different sources of methane to ambient levels. This subject is linked with the potential presence of other methane sources (e.g. landfill, agricultural activity or gas pipeline/compressor station).

All data analysis needs to be carefully interpreted taking, also, into account the meteorological conditions of the site. This may require the implementation of a more intensive monitoring programme.
Raw Shale Gas composition

- Shale gas composition is much affected by the shale geological formation and by the type of well that the gas comes from.
- Raw shale gas composition depends on the region from which the gas originates.
- Natural shale gas found at a well has a composition different from that received by consumers due to pre-processing of the gas.
- Variations on the Shale gas compositions in the same site depending on the well.
Raw Shale Gas composition

There is no precise formula of natural shale gas, the main component is usually:

- methane.
- Hydrogen \((H_2)\),
- carbon monoxide \((CO)\),
- carbon dioxide \((CO_2)\),
- nitrogen \((N_2)\),
- and other different hydrocarbons, mainly ethane \((C_2H_6)\), but also propane \((C_3H_8)\), and butane \((C_4H_{10})\).
- other impurities: hydrogen sulphide \((H_2S)\), sulphur dioxide \((SO_2)\), heavy hydrocarbons, helium \((He)\), condensates, water, etc.
- Heavy liquid hydrocarbons: heptane, hexane, pentane, etc.
- Mercury may also be found in small concentrations.
## Raw Shale Gas composition

<table>
<thead>
<tr>
<th>Site/Well</th>
<th>CH$_4$ (%)</th>
<th>C$_2$ (%)</th>
<th>C$_3$ (%)</th>
<th>CO$_2$ (%)</th>
<th>N$_2$ (%)</th>
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</thead>
<tbody>
<tr>
<td>Barnett, USA/Well 1</td>
<td>80.3</td>
<td>8.1</td>
<td>2.3</td>
<td>1.4</td>
<td>7.9</td>
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<tr>
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<td>2.7</td>
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<td>Marcellus, USA/Well 1</td>
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<td>16.1</td>
<td>4.0</td>
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<td>3.0</td>
<td>1.0</td>
<td>0.3</td>
<td>0.2</td>
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<tr>
<td>Antrim, USA/Well 1</td>
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<td>3.5</td>
<td>1.0</td>
<td>3.0</td>
<td>65.0</td>
</tr>
<tr>
<td>Antrim, USA/Well 3</td>
<td>77.5</td>
<td>4.0</td>
<td>0.9</td>
<td>3.3</td>
<td>14.3</td>
</tr>
</tbody>
</table>

Shale gas composition at different sites and wells at Barnett in Dallas-Fort Worth area of Texas (Bullin and Krouskop 2009)
Conclusions

- The lack of baseline concentrations was identified as an important knowledge gap to assess the impact of emissions to the air due to shale gas operations.

- Baseline observations can provide the pre-shale gas development state of the environment. At a later stage, this it is very important to properly identify, quantify and characterize environmental impacts that may be associated with shale gas operations.

- At present, there is the need to develop methods and data for estimating emissions from unconventional shale gas operations.

- Methane is identified as a compound of major concern, so, there should be a detailed scientific research programme of methane measurement, aimed at better understanding and characterising sources and quantities of methane emissions associated with shale gas operations.
Conclusions

- The management of methane at unconventional gas installations will benefit from the development of new measurement and monitoring techniques and improvement of existing systems.

- An assessment of potential leakage rates can be used to predict possible changes in methane and ethane concentrations in the atmosphere.

- Modelling these concentrations, determining the variations and comparing those with detection limits of commercially available equipment, allows an assessment on the threshold for leakage detection and how this detection can be optimized.
Disclaimer

• This presentation is part of a project that has received funding by the European Union’s Horizon 2020 research and innovation programme under grant agreement number 640715

• The content of this presentation reflects only the authors’ view. The Innovation and Networks Executive Agency (INEA) is not responsible for any use that may be made of the information it contains
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