

Shale Gas

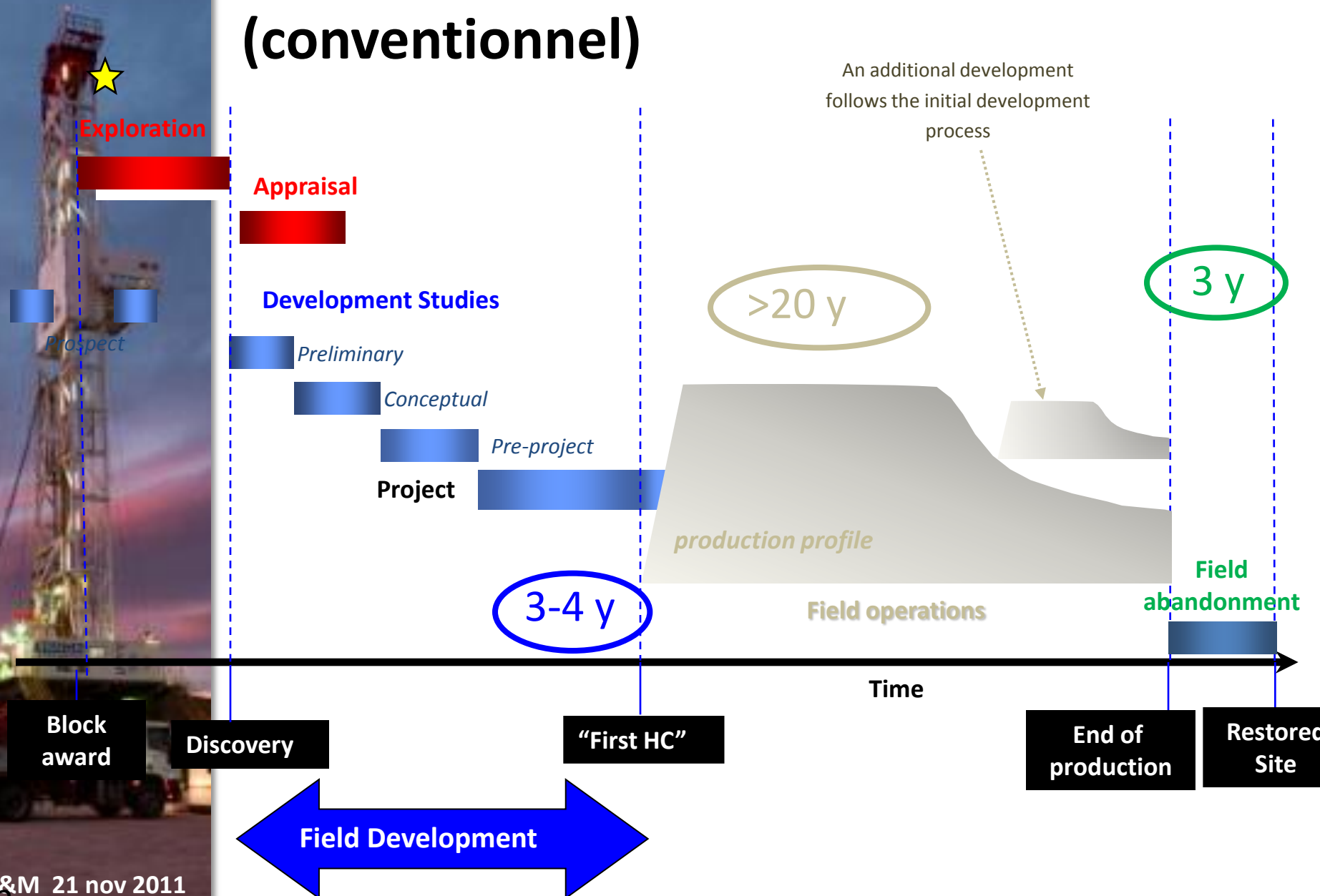


Sylvie Duflot- Total Gas Shale Europe



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Les différentes phases d'un projet (conventionnel)



Du gaz naturel dans une roche peu perméable

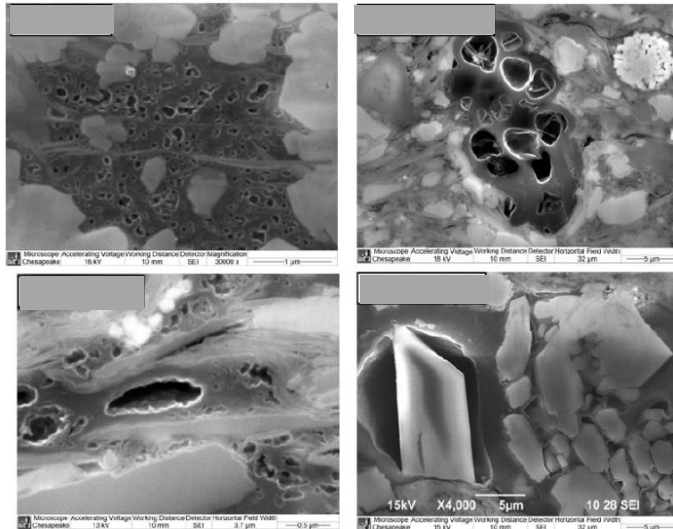
- ▶ Shale gas is generated through burial of argillaceous sediments, rich in organic matter, where it remained trapped.
- ▶ It is mostly made of methane.

Le gaz de schiste et le gaz naturel ont la même origine et la même composition



- ▶ Permeability of these rocks is extremely low.

Les caractéristiques de la roche nécessitent l'usage de techniques spécifiques pour assurer un niveau de productivité économique



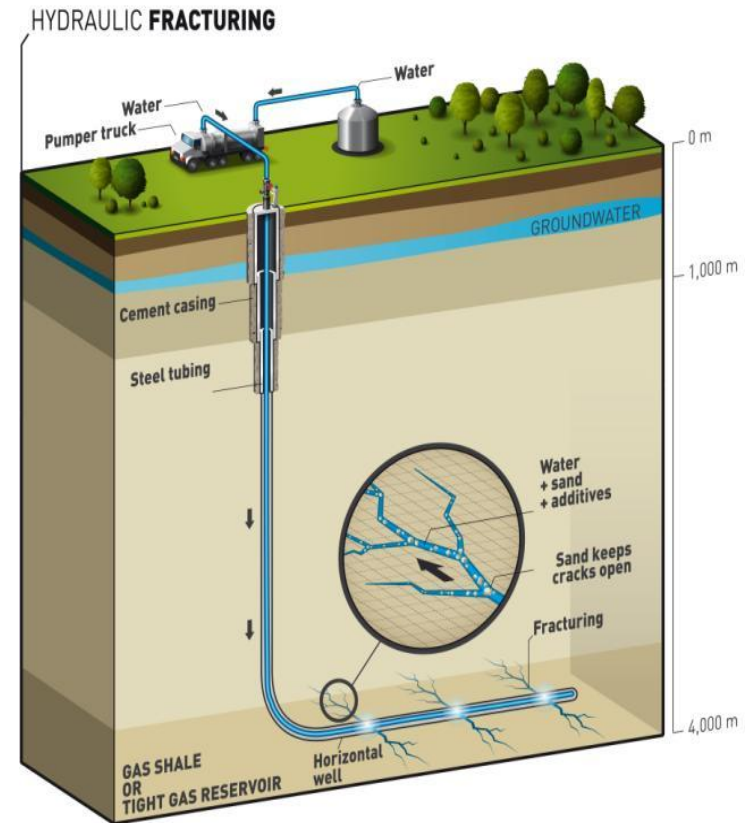
Specific production techniques

- Two types of technology required to enable sustainable production :

- Horizontal drilling, which increases the productive section of each well
- Controlled hydraulic fracturing, which artificially improves rock permeability.

- The amount of gas retrieved from each well remains low

- This implies a large number of wells to reach a significant level of production



These techniques are known to the industry and also used for conventional hydrocarbon production and deep geothermal energy.



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Well architecture – a reminder

Shale gas wells are governed by the same principles as other types of wells. (conventional O&G, water, geothermal energy)



Well drilling operations are completed through a succession of phases.

- A drilling fluid is always present within the borehole.
- A drilling phase is followed by running-in with a casing and its cementation.
- Quality control for casing and cement integrity is compulsory.

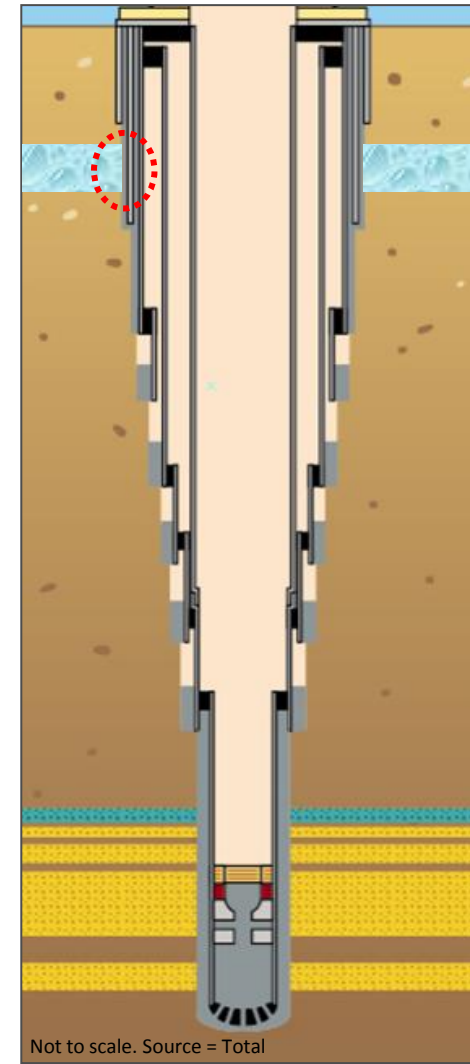
Well design is aimed at isolation from the surrounding geological formations

- Pressure barrier (drilling fluid, mudcake)
- Mechanical barrier (casing, cement)

Surface phases are designed to protect ground waters.

- Water based drilling fluids
- One to two fully cemented casing strings

O&G vertical well architecture



Not to scale. Source = Total

Drilling a well is a state-regulated process, following industry best practices and company internal procedures, using fit-for-purpose materials



Hydraulic fracturing

- ▶ **Objective = re-open or artificially create a network of small fractures / cracks**

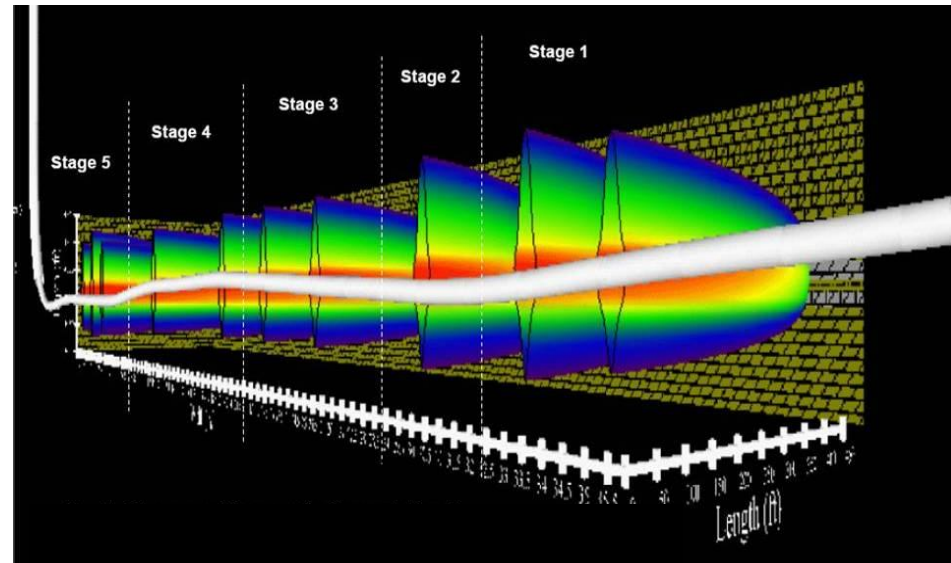
- In the targeted interval
- Around the wellbore

- ▶ **Operational procedure :**

- Performed by successive stages
- Perforate production tubing and cement
- Pump fluid, propping agent (sand) and additives
- Let network develop
- Stop pumping, retrieve flow back fluids

- ▶ **Network characteristics**

- Develops perpendicular to minimum constraint direction
- Extend about 100m laterally, a few tens of meters vertically



- ▶ **Average figures**

- Horizontal drain length = 1500 to 2000m
- 5 to 10 fracturation stages
- 1500 - 2000 tons of sand for a 5-stage well
- 10 to 20,000 m³ water
- 90% water, 9.5% sand, 0.5% additives (volumes)

Frac design is variable : adapted to reservoir and well characteristics



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Frac fluids

Several stimulation fluid systems are available

- Gel, Visco Elastic Fluids or Slick Water
- Depends on the permeability of the formation
- Shale gas is mainly stimulated using slick water

Additives role

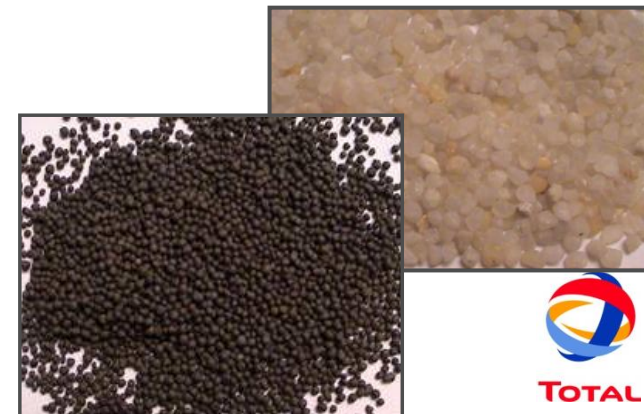
- Reduce frictions
- Improve proppant carrying capacity (gel)
- Allow water removal while leaving proppant downhole after frac (gel breaker)
- Remove bacteria
- Prevent corrosion and scale deposits
- Inhibit shale if needed

Way forward

- Shift toward the use of low or non-toxic products (food industry)
- Transparency: <http://fracfocus.org/>



Concentration	Unit	Component in System	Purpose	MSDS
917	Liter	Water		
81	Liter	22% Liquid KCl		KCl
0.6 to 0.84	Kg	CleanWG1	Friction reducer	FDP-S951-09
0.12 to 0.36	Kg	CleanBreakE	Breaker	FDP-S981-10
1	Liter	CleanSurf	Non-emulsifying Surfactant	FDP-S962-09



The exact fluid composition depends on reservoir properties and well conditions

Make acceptability first priority

Aquifers



Protection of aquifers during drilling, fracking and production



Security and reliability of wells and installations

Reduction in quantity and impact of additives

Use of seismic data for localization and control of intervals to be fraced

Water



Minimize water usage



Reduce water usage in fracking operations

Search for solutions avoiding uses of public domain water domain and fresh water

Maximize water re-usage after adequate treatment

Ground



Minimize impact of industrial activities



Reduce number of industrial sites by drilling more production horizontal wells in each clusters

Install clusters close to existing infrastructures.

Transport fluids by pipelines.

Site restoration

Local communities



Impact of operations



Consult and exchange with local communities

Take due care of local biodiversity, land view, heritage, dwelling and traffic issues in installations planning

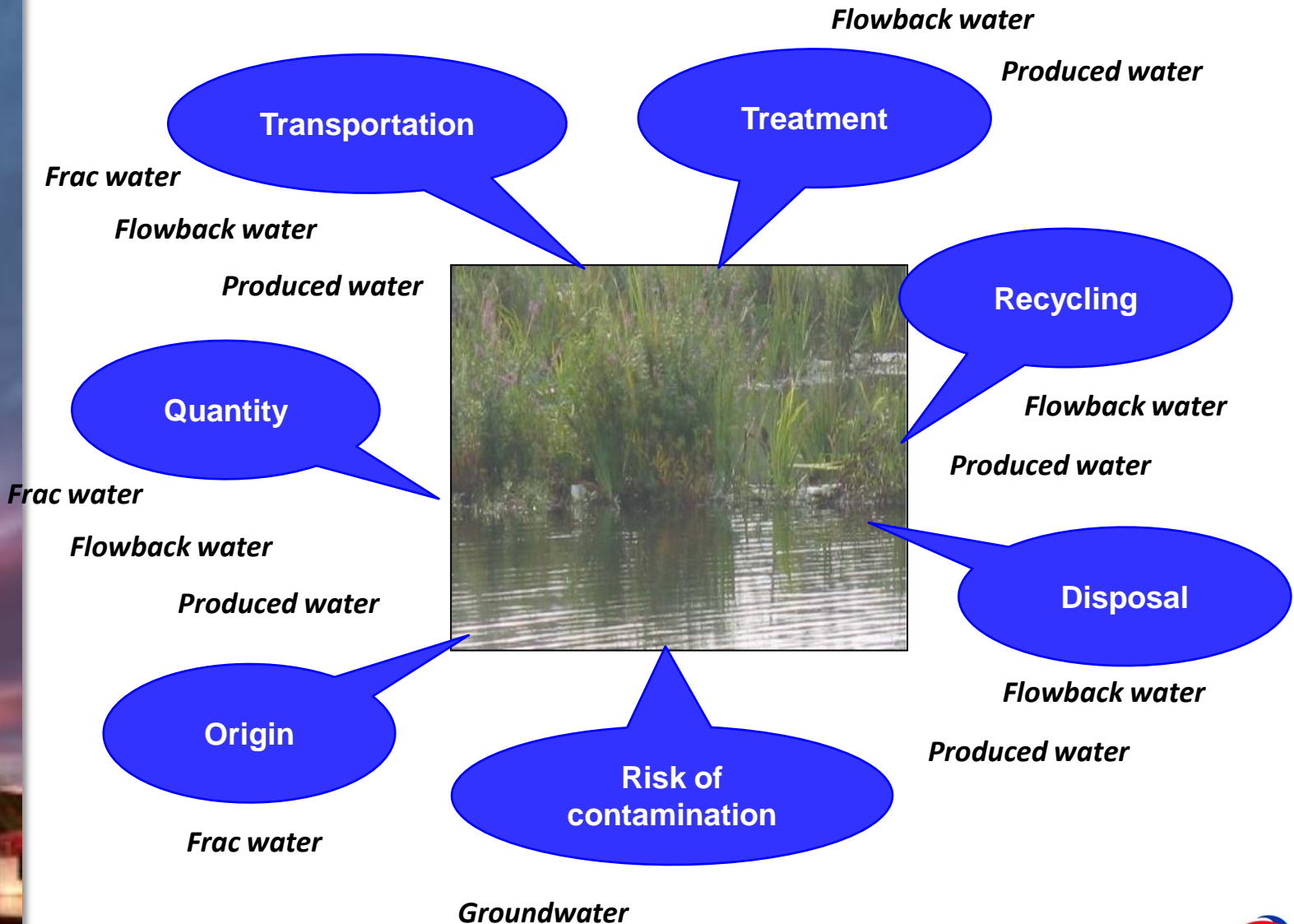
Monitoring and respect of commitments

Legitimate questions requiring adequate answers and actions



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Water management



Water management is well know to the O&G industry

Surface footprint

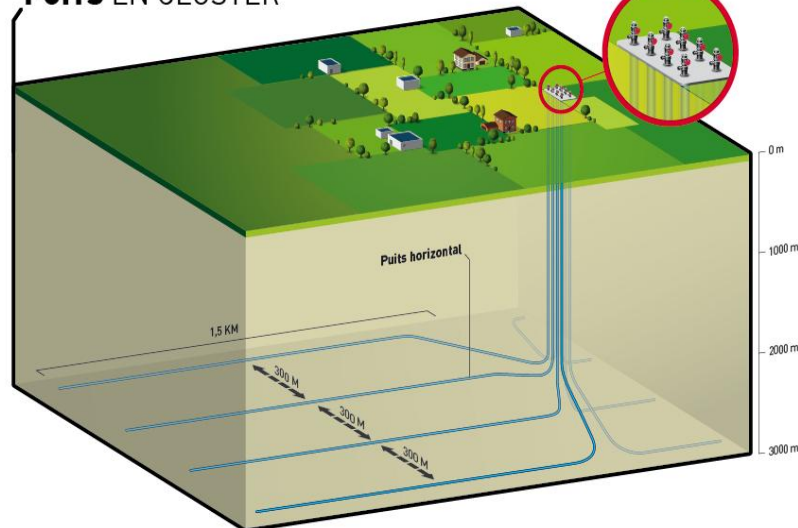
► A “cluster” based development

- Reduction of the number of surface locations
- Optimized surface footprint (input and output of material, fluids etc...)
- Optimized location of well horizontal section in the objective

A solution adapted to the European context

► Site rehabilitation

PUITS EN CLUSTER



Drilling phase

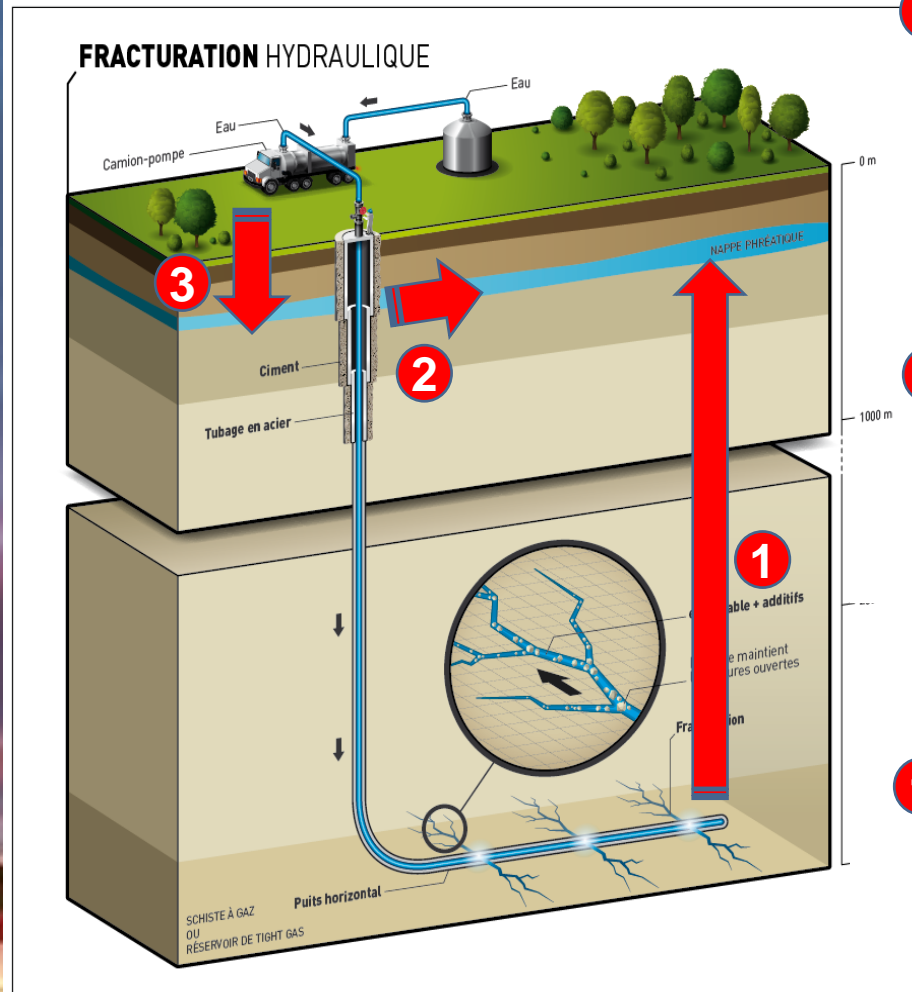


Fracturation phase



Production phase

Groundwater : risk perception



3 Contamination related to spill or containment failure.

Risk known to the O&G industry and more widely to a large number of industries

2 Contamination due to well integrity issues.

Risk known to the O&G industry (and others), requires respect of regulation and good industry practices

1 Contamination due to hydraulic fracturing.

Risk considered as extremely unlikely given safe distances from aquifers are respected

In a nutshell

- ❖ Shale gas exploration still in its infancy in Europe;
- ❖ There are associated challenges;
 - ... which are well-identified
 - ... which can be addressed in a safe way
- ❖ Shale gas will only be developed if industry, governments and the civil society are convinced it is worthwhile.



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