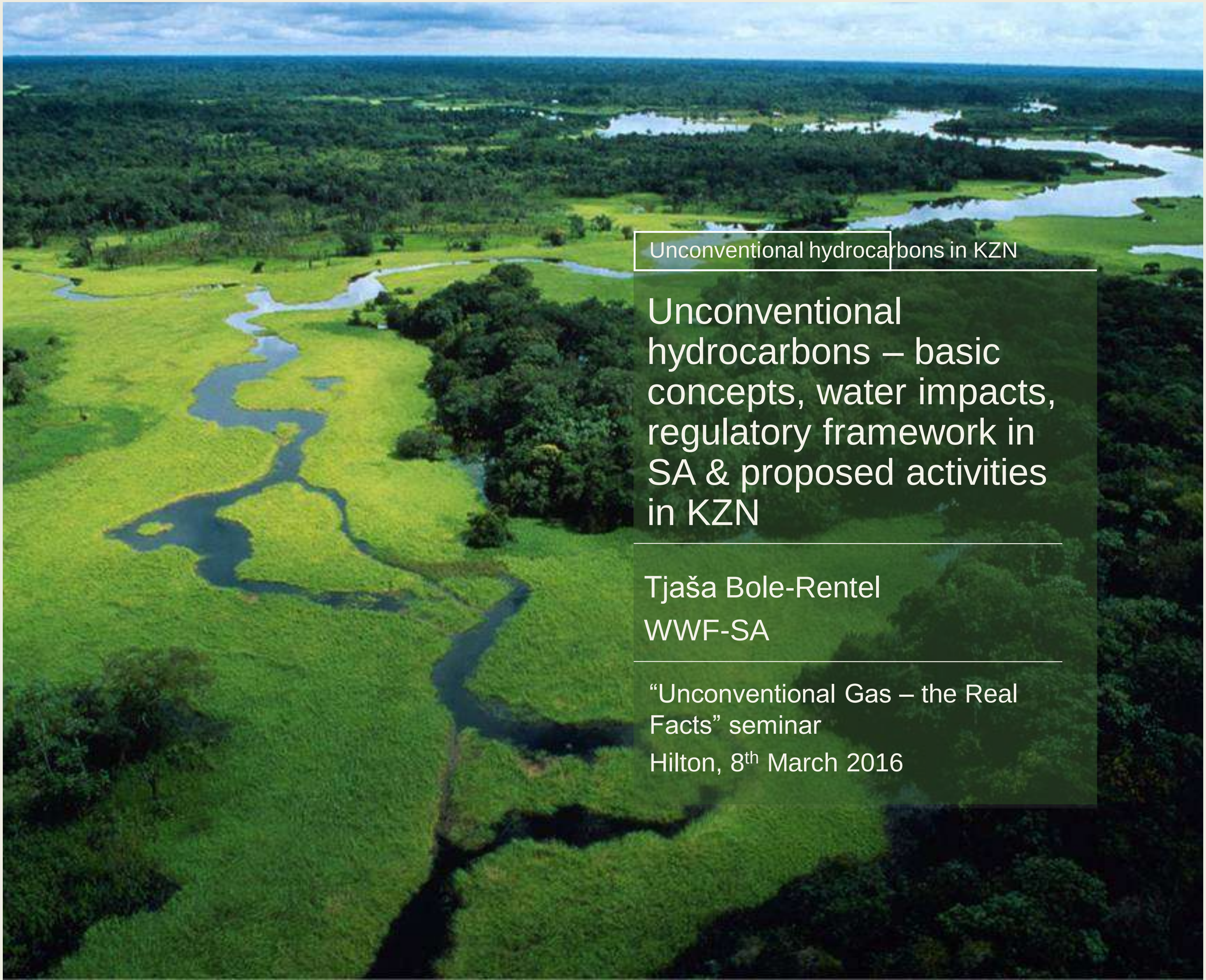


Unconventional hydrocarbons – basic concepts, water impacts, regulatory framework in SA & proposed activities in KZN

Tjaša Bole-Rentel
WWF-SA

"Unconventional Gas – the Real Facts" seminar

Hilton, 8th March 2016

Presentation outline

- Basic concepts
- Water-related risks of unconventionals
- Current regulations under the MPRDA
- Hydrocarbon prospecting activities / ambitions in KZN

Unconventionals – the basics

- What is “Unconventional gas”?
- What does production of “Unconventional gas” entail?
- Why are unconventional gas resources attractive?
- What are the main environmental risks associated to them?

Natural gas – what is it?

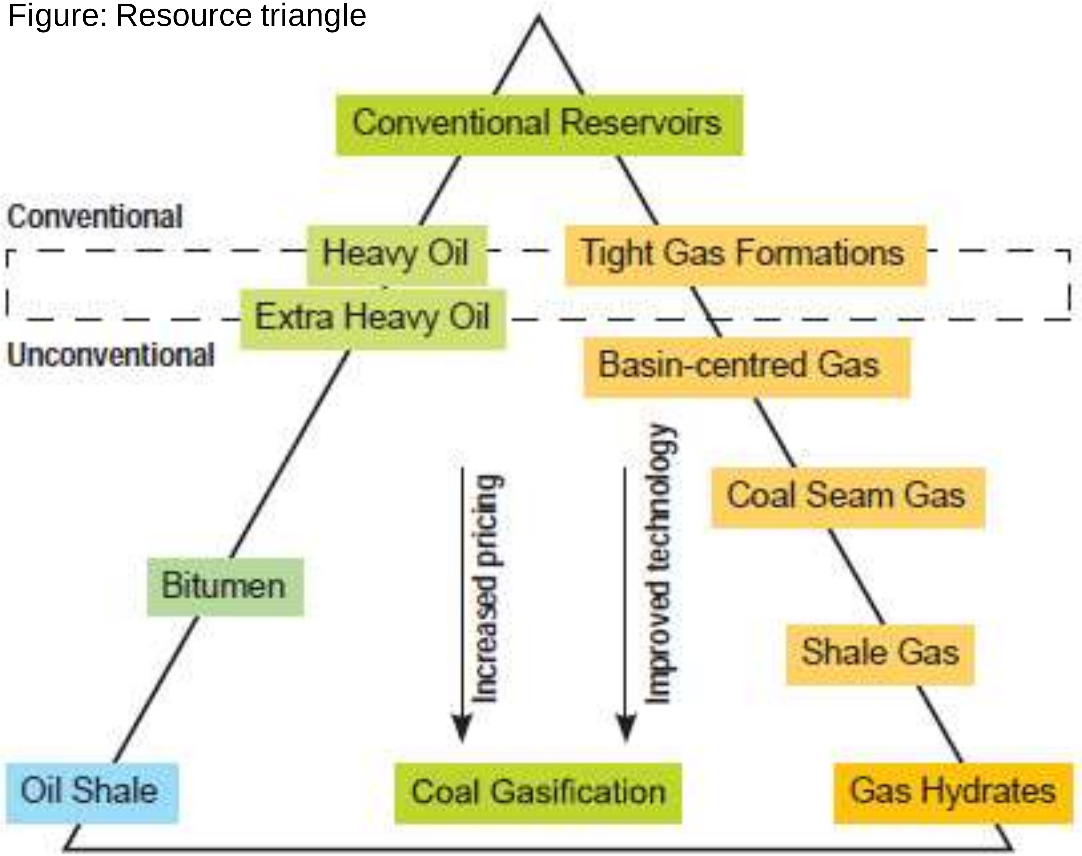
“Natural gas is a flammable gas, consisting largely of methane and other hydrocarbons, occurring naturally underground (often in association with petroleum) and used as fuel.”

Both conventional and unconventional gas are natural gas – the difference is in how they are extracted:

- **Conventional gas (CG)** is located in geological pockets or permeable rocks and can escape freely after drilling.
- **Unconventional gas (UG)** is trapped impermeable rock formations, such as shale, tight sands and coal beds (also called coal seam gas in Australia), that need to be fractured in order to release gas in commercial quantities.

Conventional vs Unconventional hydrocarbons

Figure: Resource triangle



Source: modified from Chan (2011) and Holditch (2009)

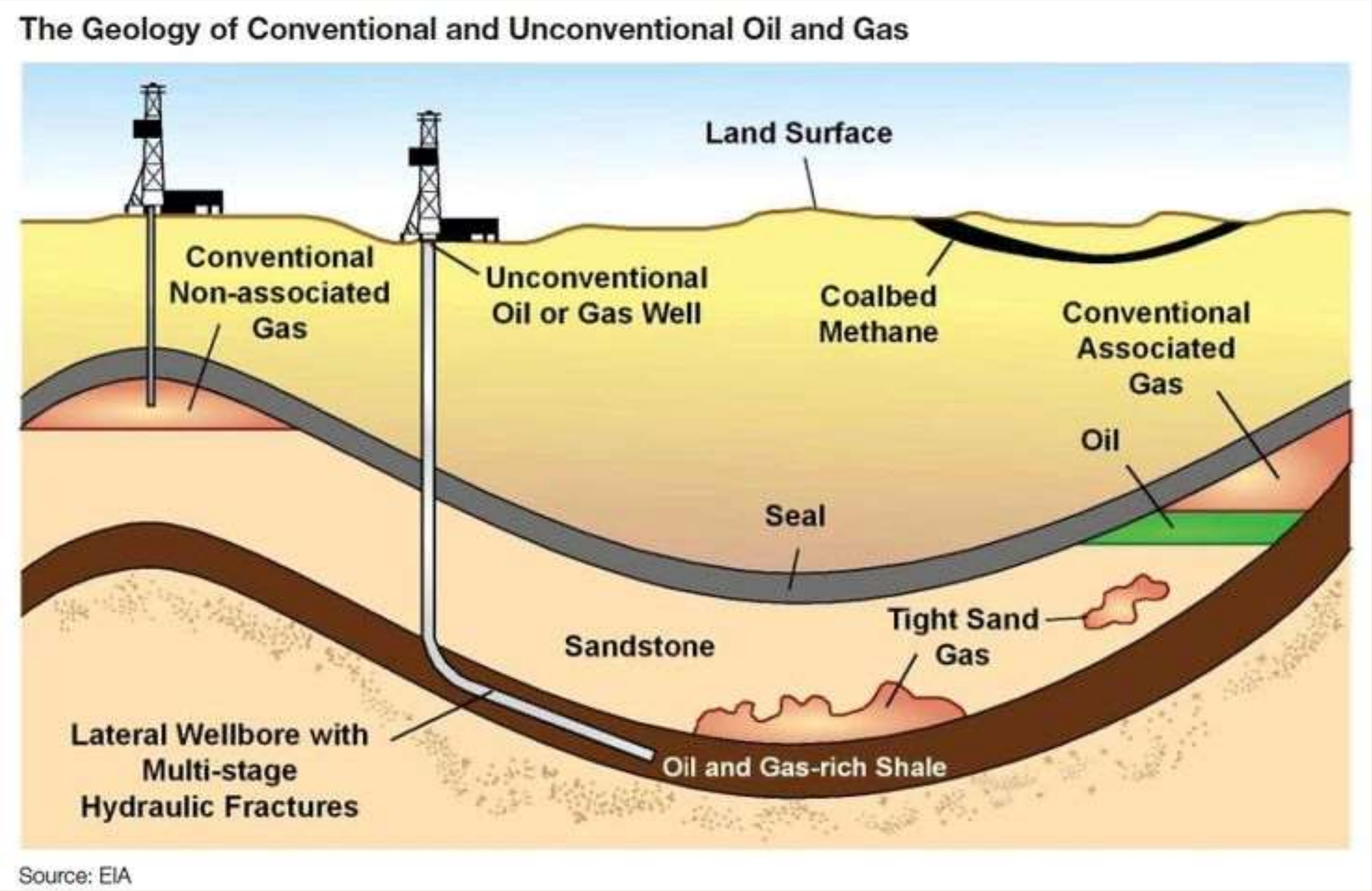
Shale gas and Coal bed methane definitions

“Shale gas” is natural gas derived from organic-rich shale formations, which act as both the source and reservoir for the gas.

“Coal bed methane (CBM) or Coal seam methane” is a source of natural gas that is generated and stored in coal beds. CBM exists in the coal in three basic states: as free gas; as gas dissolved in the water in coal; and as gas "adsorbed" on the solid surface of the coal.

In South Africa, the presence of methane gas in coal is well known from its occurrence in underground coal mining, where it presents a serious safety risk. Historically, the methane was vented to the atmosphere, but is now becoming an increasingly important source of natural gas globally.

The Geology of Conventional vs Unconventional gas



Production of UG

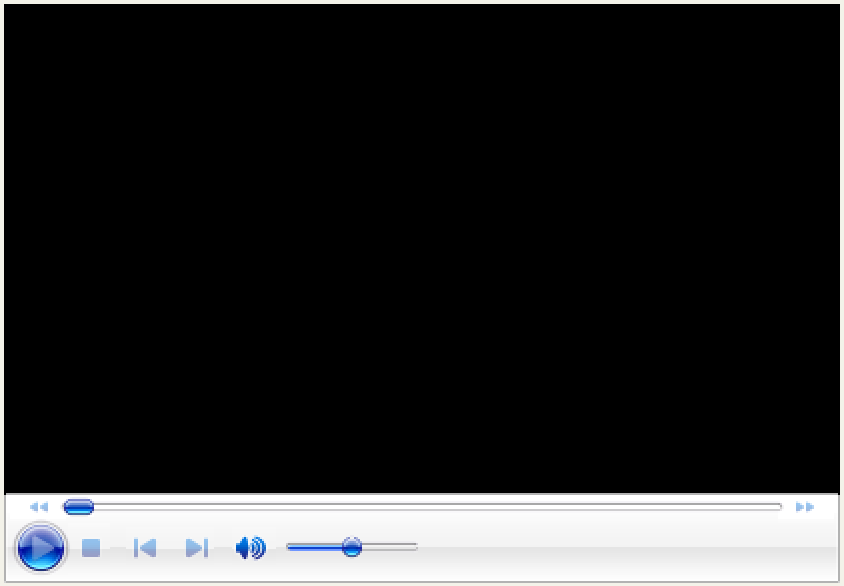
SHALE GAS

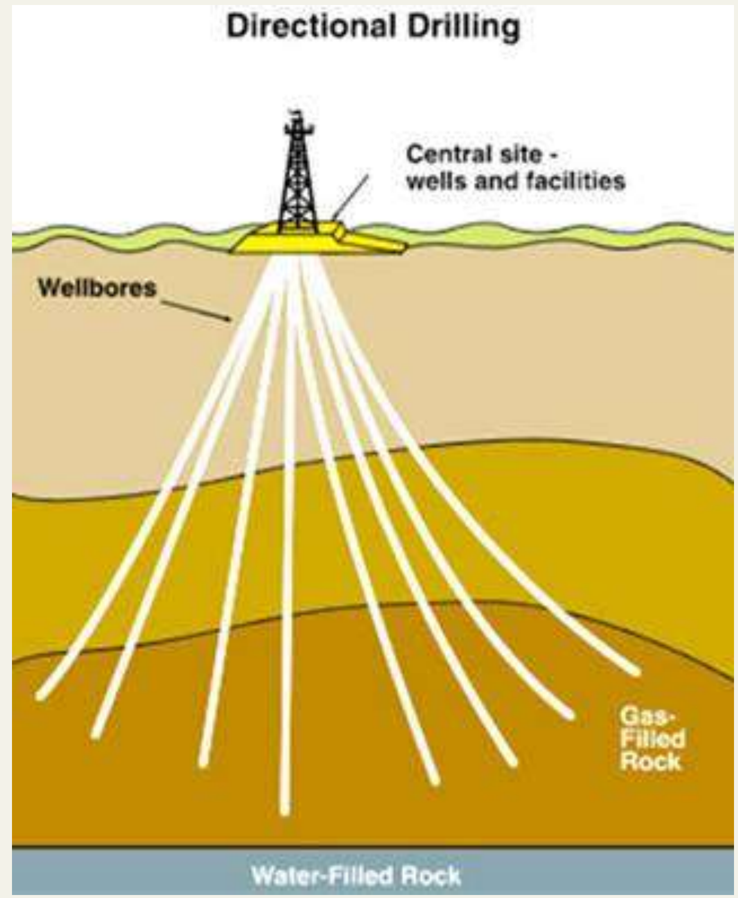
- Typically found at depths between 1500 - 3000 m.
- Horizontal well 1500 - 3000 m.
- The rock is hydraulically fractured multiple times (usually in stages).
- Fractures extend between 150 - 250 m perpendicularly from the horizontal well.
- Several horizontal lateral bores can extend from a vertical well.
- Uses more water than CBM production.
- Resource size estimated at 30 TCF (DMR, 2012).

COAL BED METHANE (CBM)

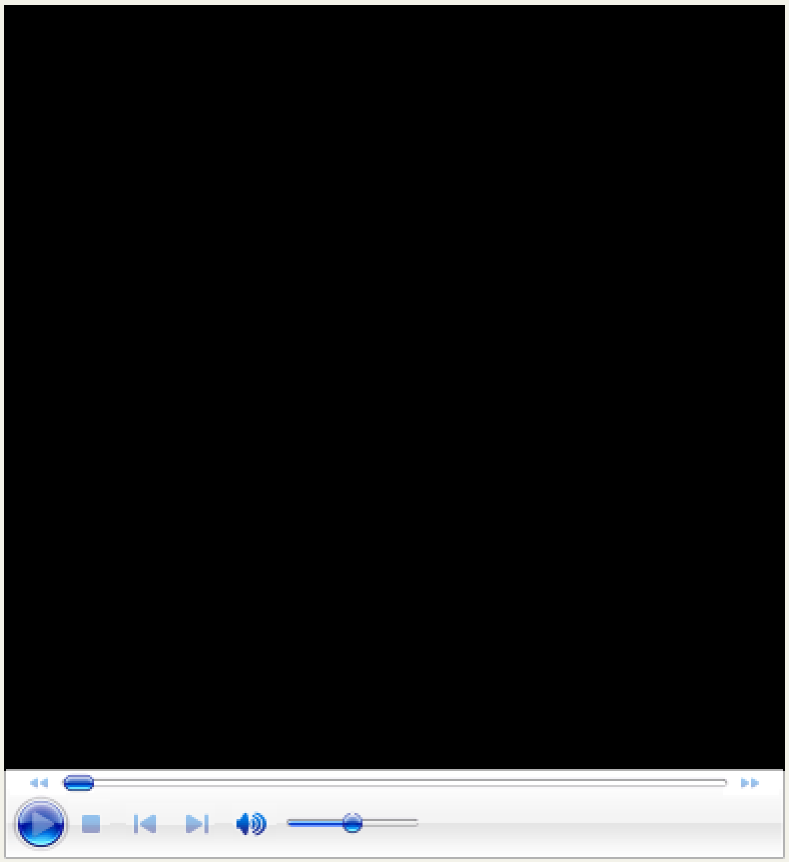
- Typically found at depths of 800 - 1200 m (but can also be found as little as 100 metres below the surface).
- May lead to higher venting (gas freely released into the atmosphere) of methane as compared with shale gas.
- Drilling and fracking at shallower depth means higher risk of water contamination.
- Requires less water as input, but produces more high salinity water than shale gas production.
- Resource size estimated at 10 TCF (Reuters, 2012).

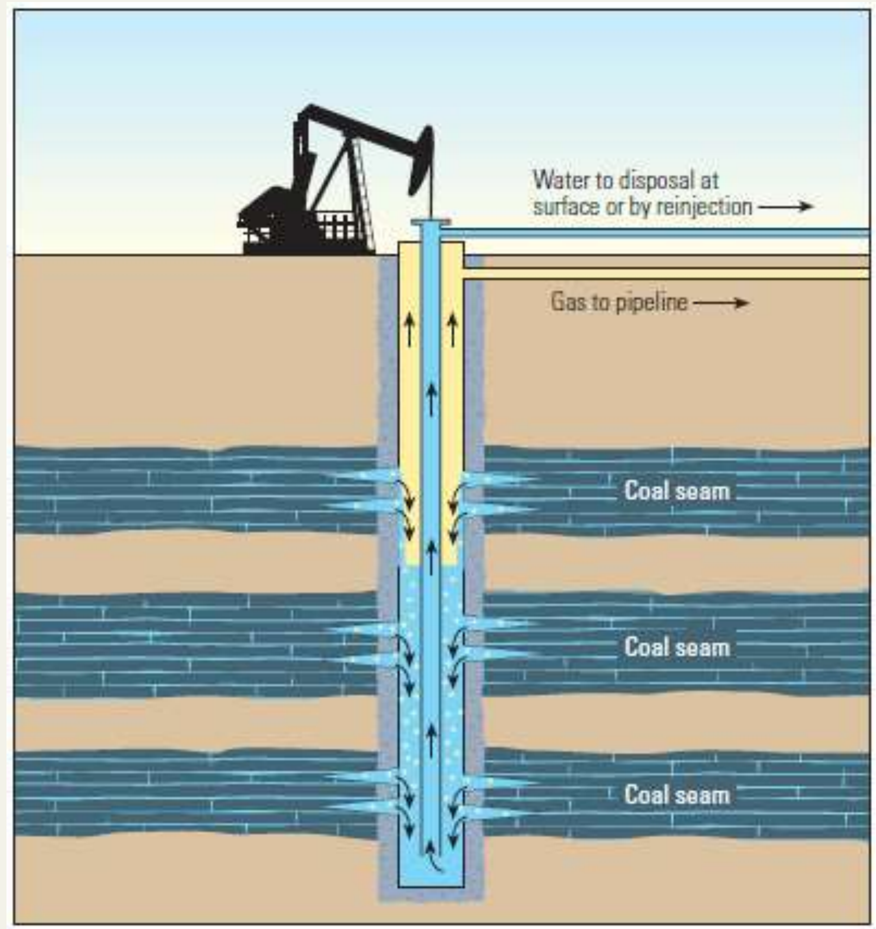
Production of UG – shale gas





Production of UG – coal bed (seam) methane

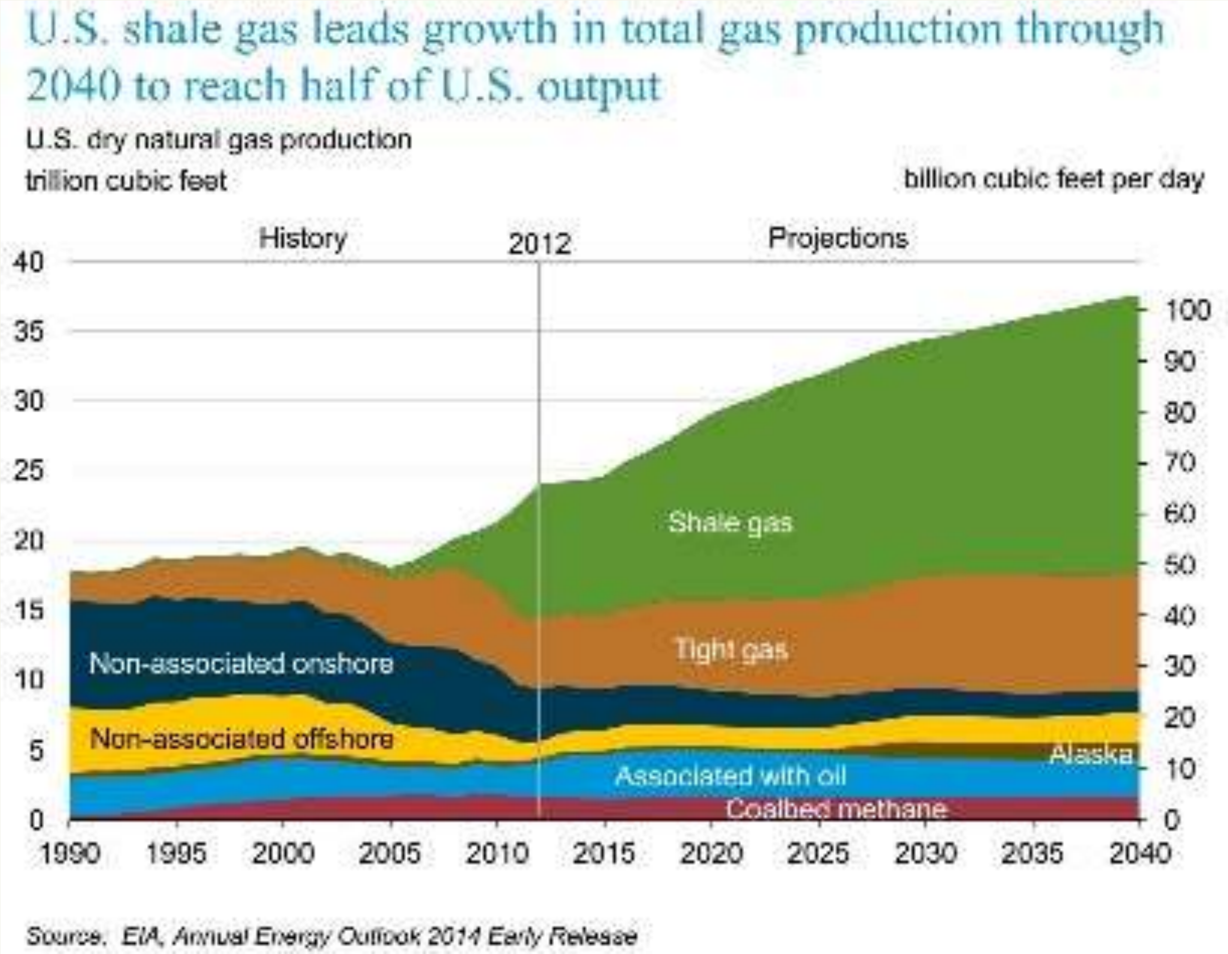




Why the hype about unconventional gas (UG)?

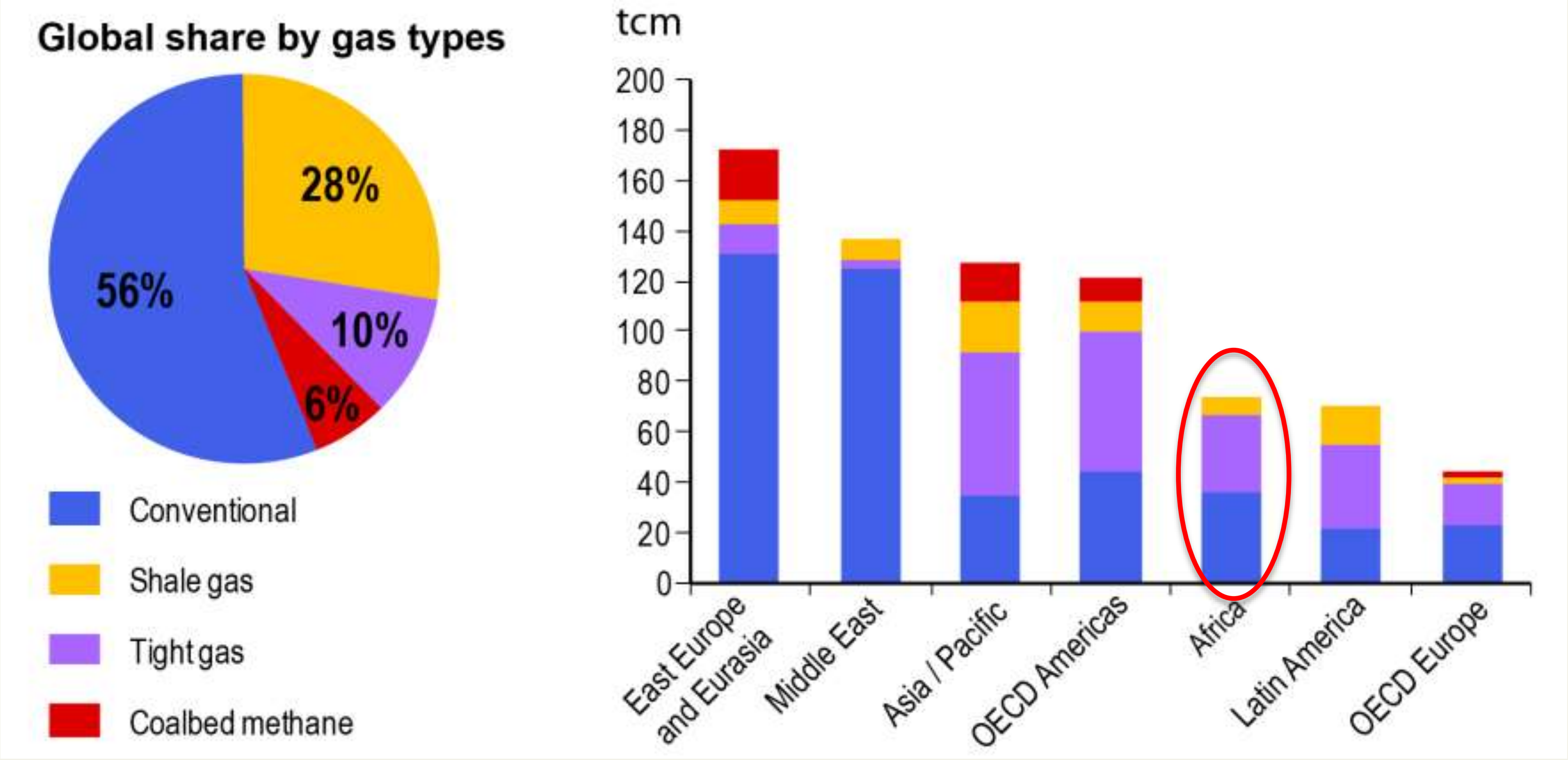
- There is enough UG world-wide to increase gas from 13% of global energy resource base in 2009 to 25 % in 2035 (IEA 2011), ranking gas as the second most important source of exploitable energy after oil (IEA, 2012).
- As the geographic distribution of UG differs from that of conventional fossil energy resources, it changes the dynamics of the international geopolitics of energy.
- Countries which are largely dependent on foreign imports to meet their energy supply might look at local UG as one way to improve their energy security.
- It is often advertised as a a “cleaner” fossil fuel, thus having a role in the fight against climate change.

The US shale revolution



What about the rest of the world?

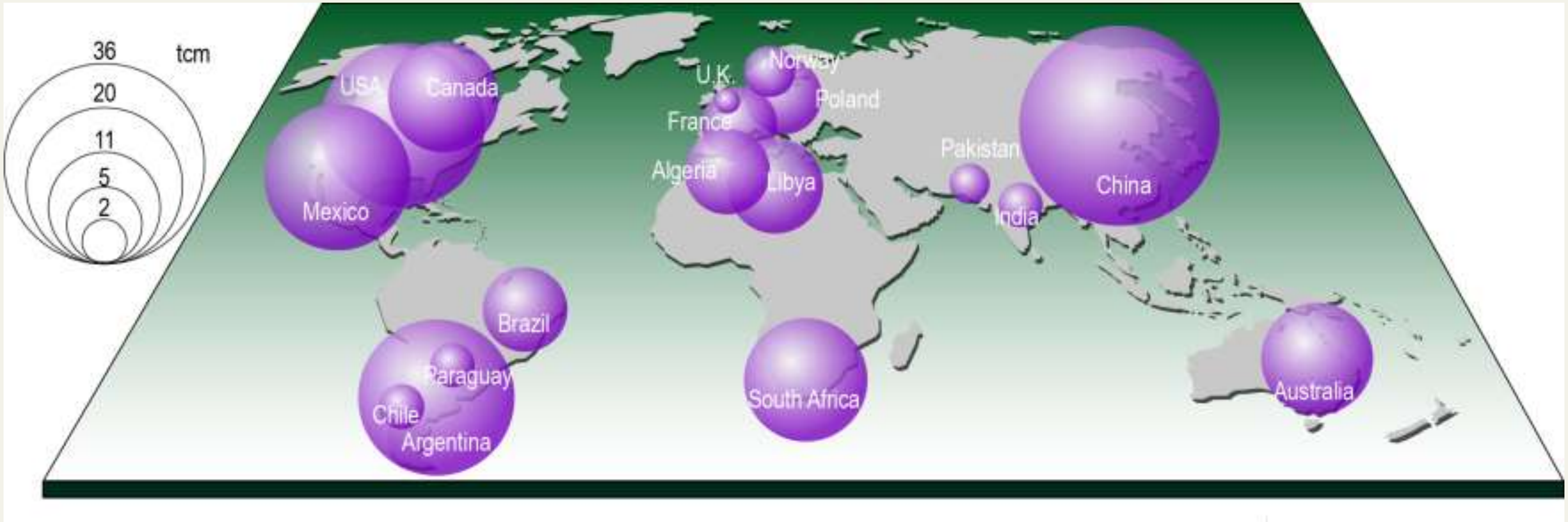
Global remaining technically recoverable gas by types



Data source: IEA, 2012

What about the rest of the world?

Technically recoverable shale gas reserves in trillion cubic metres (tcm) in the top 18 countries



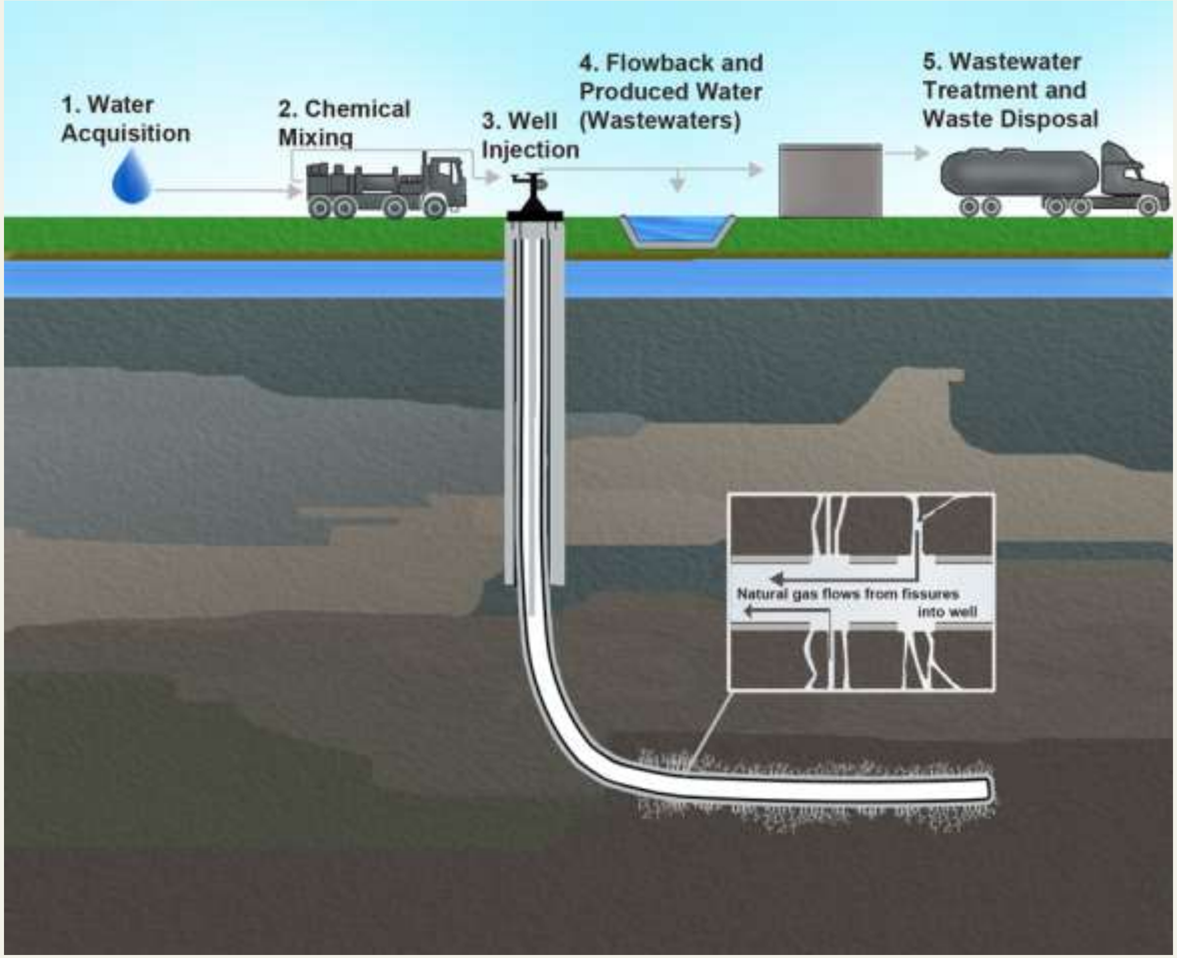
Data source: Royal Society, 2012

Technical potentials estimated as big in several regions, however no meaningful commercial production anywhere else outside North America.

Water impacts of Unconventional Gas

- What are the water demands of UG wells and where will the water come from?
- What are the contamination risks?
- What are the issues with wastewater management and disposal?

Water cycle of UG wells



1. Water acquisition

Fracking is an extremely water-intensive activity!

- Shale gas wells on average use 10 – 20 mio l of water – for a single fracking event!

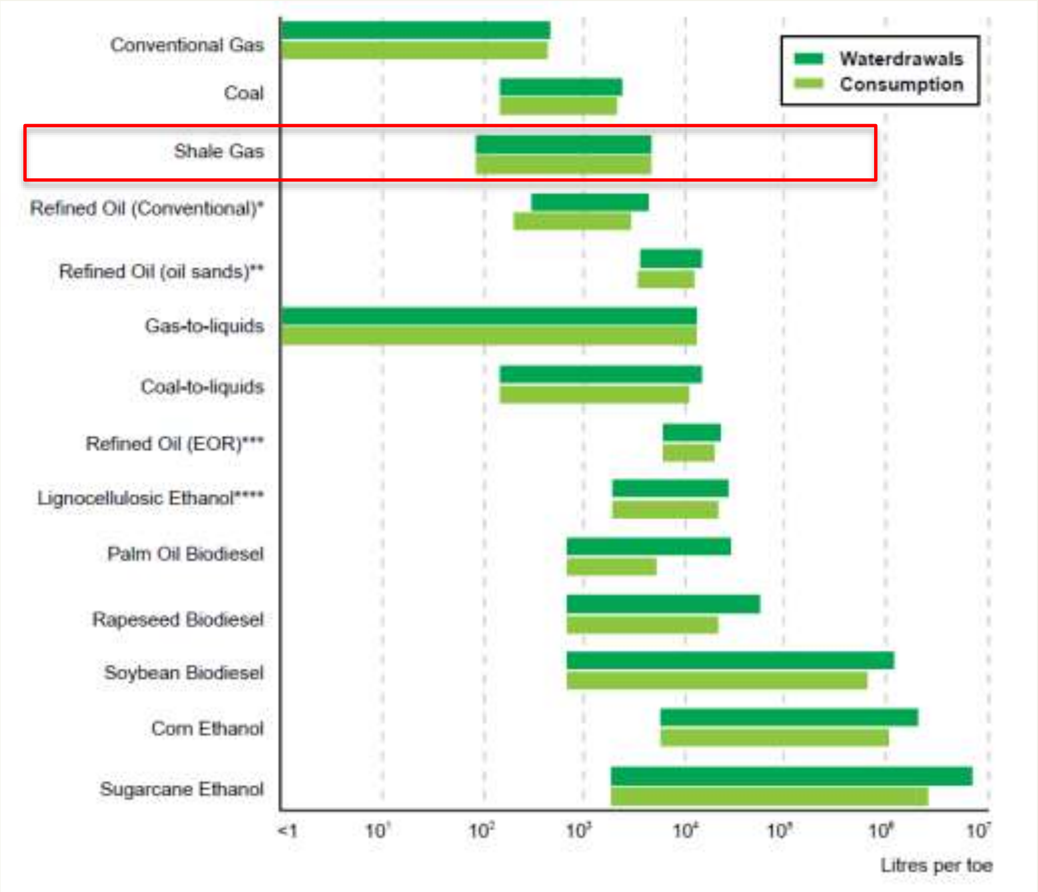
DMR (2012) used a figure of 24 mio l for the Karoo, which is equal to:

- the water requirement of Fraserberg, a town within the Shell license area with a population of around 2,400 people, for more than 50 days or
- the irrigation requirement for approximately 3ha of lucerne for one year or an average sheep farmer's water requirement for almost two years.

CBM wells use much less, depending on whether fracking is required or not.

Contextualising water demands of UG with other fuels

Figure: Water withdrawals and consumption for the production of various fuels



Sources: Schornagel (2012); US DOE (2006); Gleick (1994), cited in (IEA, 2012)

Water demands variables

- The water requirements for UG wells depend on:
  - the well depth,
  - gas recovery rates,
  - the number of fracturing stages,
  - the amount of flowback water and produced water, and
  - the flowback recycling rate.

- An increasing number of wells are being re-fractured every three to five years to maintain their production flow over their production life of 20–40 years.

- Vast majority of figures available for shale wells are based on North American experience –> not necessarily transferable to local context.

Possible water sources for gas wells

❖ **Freshwater**

- **Surface water:** rivers, dams, lakes
    - Usually least cost-option
    - Large-volume sourcing from small surface waters may reduce in-stream flow rates and degrade local environmental quality
- **Groundwater**
    - Withdrawals exceeding natural re-charge rates can potentially compromise water quantity as well as quality
    - Can potentially mobilise contaminants or can allow infiltration of lower-quality water from the surface or adjacent formations
    - Sustained pumping could decrease groundwater discharge to streams, affecting surface water quality, especially in drought-prone regions

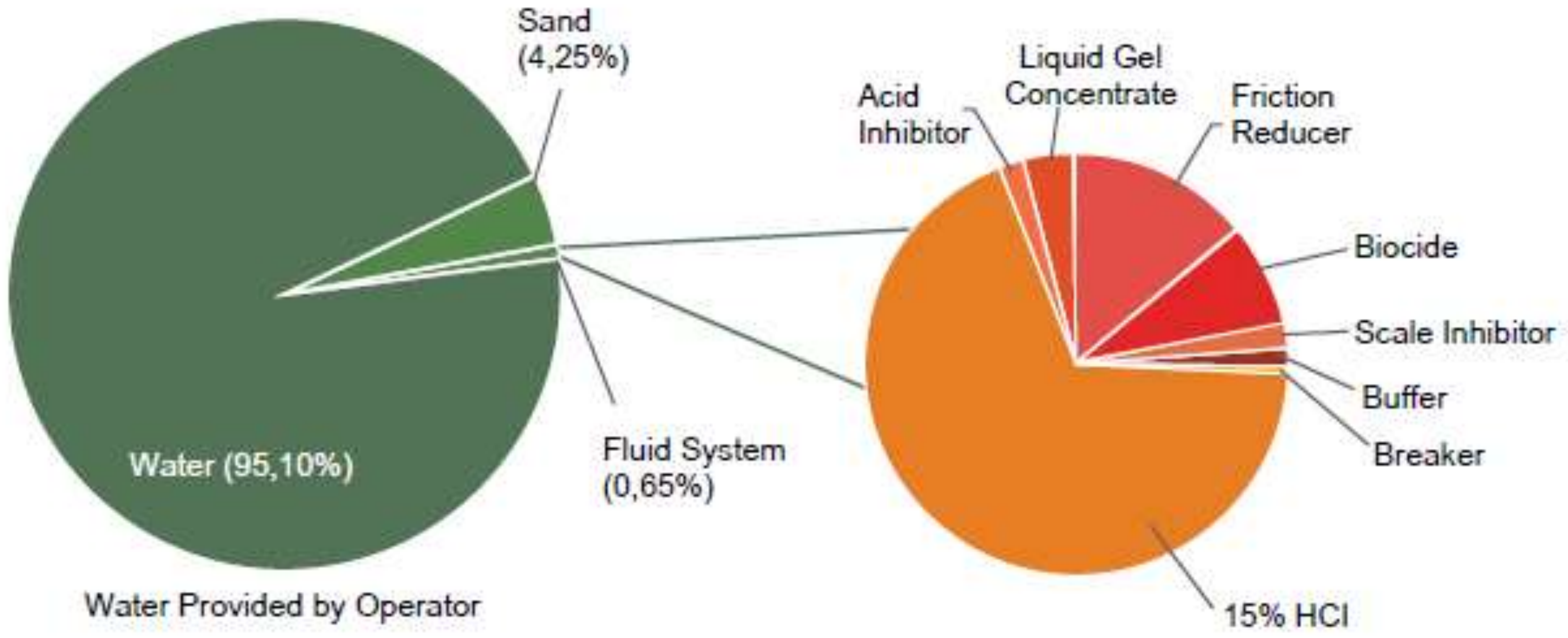
Possible water sources for gas wells (cont.)

❖ **Brackish & brine water**

- Improved salinity tolerance of drilling and fracking equipment broadens the spectrum of water sources that well operators can use:
  - Various wastewater streams, including municipal waste water or industrial water, including flowback water and produced water from fracked wells
  - Brine water from deep aquifers
- Use of high-salinity water can reduce demand for fresh water from shale gas operations, but not likely to eliminate entirely
  - Freshwater still required during drilling stage
  - Flowback rates usually < 50%

2. Chemical mixing

Figure: Typical composition of fracking fluid



Source: Halliburton, cited in (DMR, 2012)

Possible impact on public health

- We are far from a full understanding of all the possible health implications of increased presence of fracking chemicals in our environment (even in a highly diluted form!)
- Colborn and others (2011) carried out literature review on 353 chemicals and found that "more than 75% of the chemicals could affect the skin, eyes, and other sensory organs, and the respiratory and gastrointestinal systems. Approximately 40–50% could affect the brain/nervous system, immune and cardiovascular systems, and the kidneys; 37% could affect the endocrine system; and 25% could cause cancer and mutations."
- In Texas, urine samples taken from h… wells revealed that toluene was prese… xylene present in 53% (Rahm 2011).

Xylene and toluene won't be allowed in SA!

3. Well injection

- For all the media hype, well injection and the actual fracturing, is probably the least problematic part of UG development!
- Biggest concern here is induced seismicity, but strong earthquakes triggered by fracking are not very likely. Small earthquakes have been recorded.
- Induced seismicity is a bigger threat in underground disposal of fracking wastewater, however this will likely not be allowed in SA.

4. Flowback and produced water

- The generation of wastewater is an inevitable consequence of UG operations. The actual amounts vary widely across UG type, wells and plays.
- Generally, CBM wells produce more wastewater than shale wells.
- While no good estimate of the amount of wastewater likely to be produced UG wells can be offered at this stage, it is likely to be in the order of millions of litres per well.
- Shale gas wells generally produce much less wastewater per unit of gas produced than conventional gas wells. On the other hand, the generally higher concentration of shale wells in a region can lead to high amounts of wastewater generation, overwhelming existing local wastewater management capabilities.

What are flowback and produced water?

Flowback water

- Is the fracturing fluid that returns to the surface following an injection event
- It is made up of clays, chemical additives, and dissolved ions and solids; its exact chemical composition depends on the composition of the injected fracking fluid, the rock it fractures and the gas it releases
- Most of the flowback occurs within three to four weeks after hydraulic fracturing takes place

Produced water

- Is the water that is brought to the surface during the production of oil and gas
- It is a mixture of the remaining flowback and water that occurs naturally in the shale (formation water), now released from the formation as a result of fracturing
- It has high concentrations of total dissolved solids (TDS) and leaches out minerals from the shale rock including barium, calcium, iron and magnesium. It also contains dissolved hydrocarbons such as methane, ethane and propane, and sometimes NORMs such as radium isotopes.

5. Wastewater treatment and disposal

- The shale gas industry employs three main wastewater management strategies:
    - Disposal by injection into a deep underground well
    - Treatment at a centralised wastewater treatment facility (public, or privately owned) and eventual release into the environment
    - Partial treatment and re-use in future fracking operations.
- South Africa lack of any sort of experience in the management of wastewater produced by natural gas extraction
- Recycling of fracking fluid is becoming increasingly relevant owing to both cost and environmental considerations.
- Factors that can limit the recycling rate of flowback and produced water are: salinity levels, the use of certain chemicals, production schedule.
- Re-using fracking wastewater for fracturing new wells is a temporary wastewater management solution.

Water contamination risks

- During drilling and well completion:
    - Release of hydraulic fracturing fluids to groundwater owing to inadequate well construction or operation
    - Movement of hydraulic fracturing fluids from the target formation to drinking-water aquifers through local man-made or natural features (e.g. abandoned wells and existing faults)
    - Movement into drinking-water aquifers of natural substances found underground, such as metals or radioactive materials that are mobilised during hydraulic fracturing activities
- During and after production:
    - Potential contamination of aquifers with fugitive hydrocarbon gases
    - Potential release of flowback water and/or produced water to surface and/or groundwater through spills and/or leaks
- During wastewater treatment and disposal:
    - Contaminants reaching drinking-water owing to surface water discharge of inadequately treated wastewater
    - By-products formed at drinking-water treatment facilities by the reaction of hydraulic fracturing contaminants with disinfectants

Water contamination risks (cont.)

- The discussion on water contamination risks from UG has mainly focused on hydraulic fracturing, while overlooking more significant threats to water resources.
- Surface spills of fracking chemicals, inappropriate wastewater disposal and drinking-water contamination through poor well construction are the most often documented threats to water resources posed by shale gas operations to date.
- Hydrogeology can cause fluid migration through connection of natural and induced fractures.
- Research to date suggests that stray gas contamination is the main threat from shale gas operations' sub-surface activities. There is insufficient evidence to confirm a systemic contamination of groundwater by fracking fluid or produced brine.
- Each UG extraction area is unique and presents its own set of challenges.

Water contamination risks (cont.)

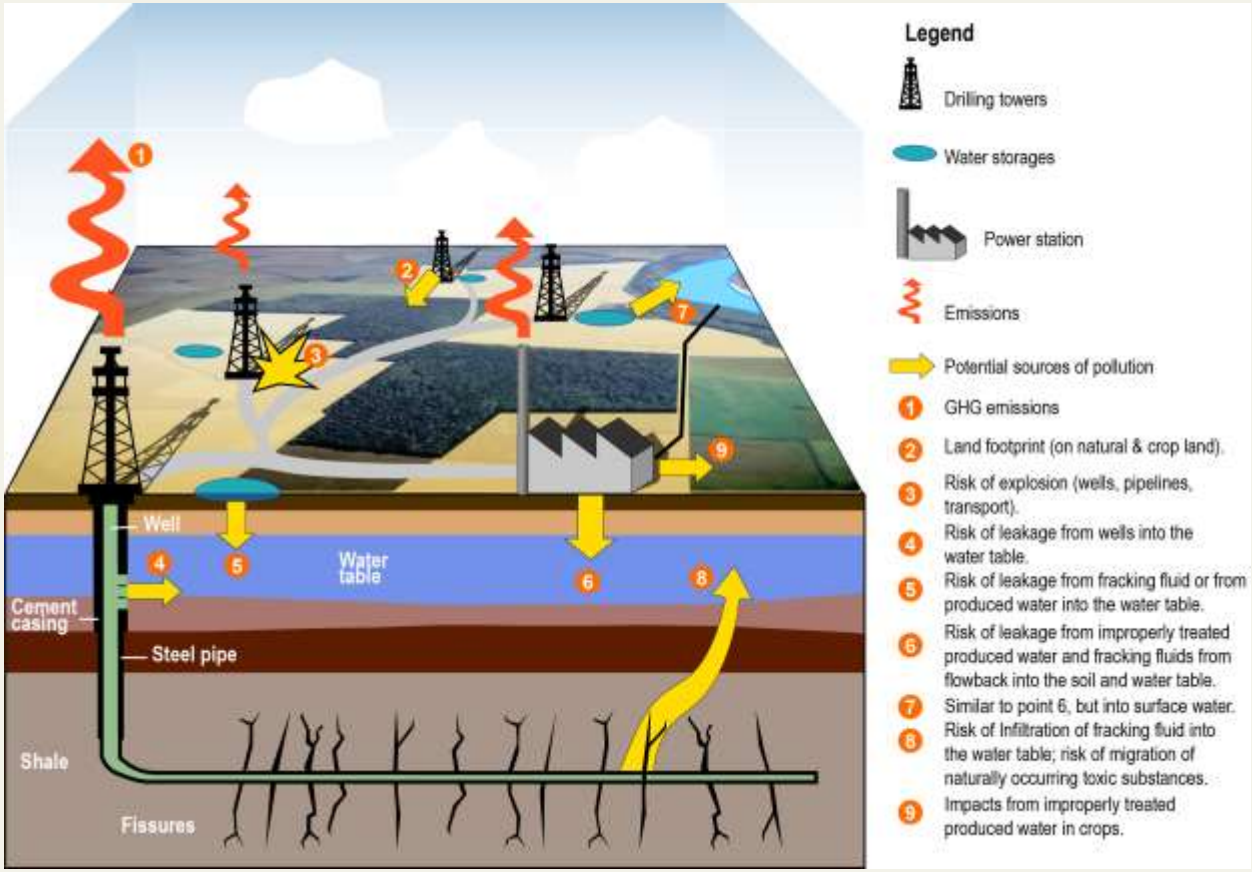
Unequivocally proving a water contamination event (below surface) caused by UG operations (especially shale!) represents a great challenge, due to:

- Effects or events in the environment adjacent to fracking operations are often evident only sometime after the operations have taken place
- Lack of baseline information on water quality prior to the commencement of UG operations
- Complexity of natural variations in water quality and the related difficulty in differentiating natural from anthropogenic sources of contamination
- A lack of methods to simultaneously determine the source, timing and mechanism(s) of pollutant migration into shallow aquifers
- Numerous other variables involved in groundwater contamination studies

Re-cap: Main water issues associated to UG

1. **Water sourcing:** Drilling and completion of UG wells requires water inputs in the order of several million litres per well, which can impact on local ecosystems and can compete with existing local and regional water uses.
2. **Water contamination:** There are several possible pathways for water contamination by UG developments, both below and above the ground level, caused by faulty well construction, migration of fracturing fluid in natural pathways, or the mishandling of the chemicals used for hydraulic fracturing or its wastewater.
3. **Wastewater management and disposal:** Some portion of the injected fracturing fluid returns to the surface through the well, following the well's completion. This water can run into millions of litres and is high in dissolved minerals, including trace amounts of naturally occurring radioactive metals (NORMs), residual fracturing chemicals and dissolved hydrocarbons. If managed improperly, it represents a significant threat to human health and the environment.

Environmental risks of unconventional gas



Source: UNEP/GRID-Geneva, 2012

Environmental risks of unconventional gas

Jonah Field in Wyoming

Flowback and fracking fluid storage in open air settings.

Drilling requires the clearing of land which alters the landscape. Here, trees have been cleared to build a road to reach the drilling site.

Recommendations (UNEP)

- Fracking should be avoided in areas of water scarcity, in close proximity to densely populated areas, and/or in areas where it can impact on agricultural production.
- Sites deep below the water table are safer (IEA, 2012).
- Rigorous training and strict oversight can prevent (or contain) surface spills and leaks from wells and ensure that any waste fluids and solids are disposed off properly (IEA, 2012).
- To minimize climate impacts, developers should be encouraged to implement a zero-venting and minimal flaring policy. This is technically feasible by separating gas during the drilling process (IEA, 2012).
- CO_2 can react with materials used to construct a well. For example, it is known to reduce cement's strength and increase its permeability. CO_2 can also corrode steel, and thus injection wells should be designed to minimize this risk (Nygaard, 2010).

UG developments in South Africa

- Where are we in terms of UG development in SA?
- What is the regulatory environment like?

A brief timeline of shale gas in South Africa

2010/2011

Shale gas hits the SA energy agenda, with a slew of applications to government, to prospect for this natural resource. Areas targeted for prospecting are scattered and cover about 20% of the country.

2012

Civil society lobbies government to err on the side of caution. Government places a moratorium on the issuing of exploration licences.

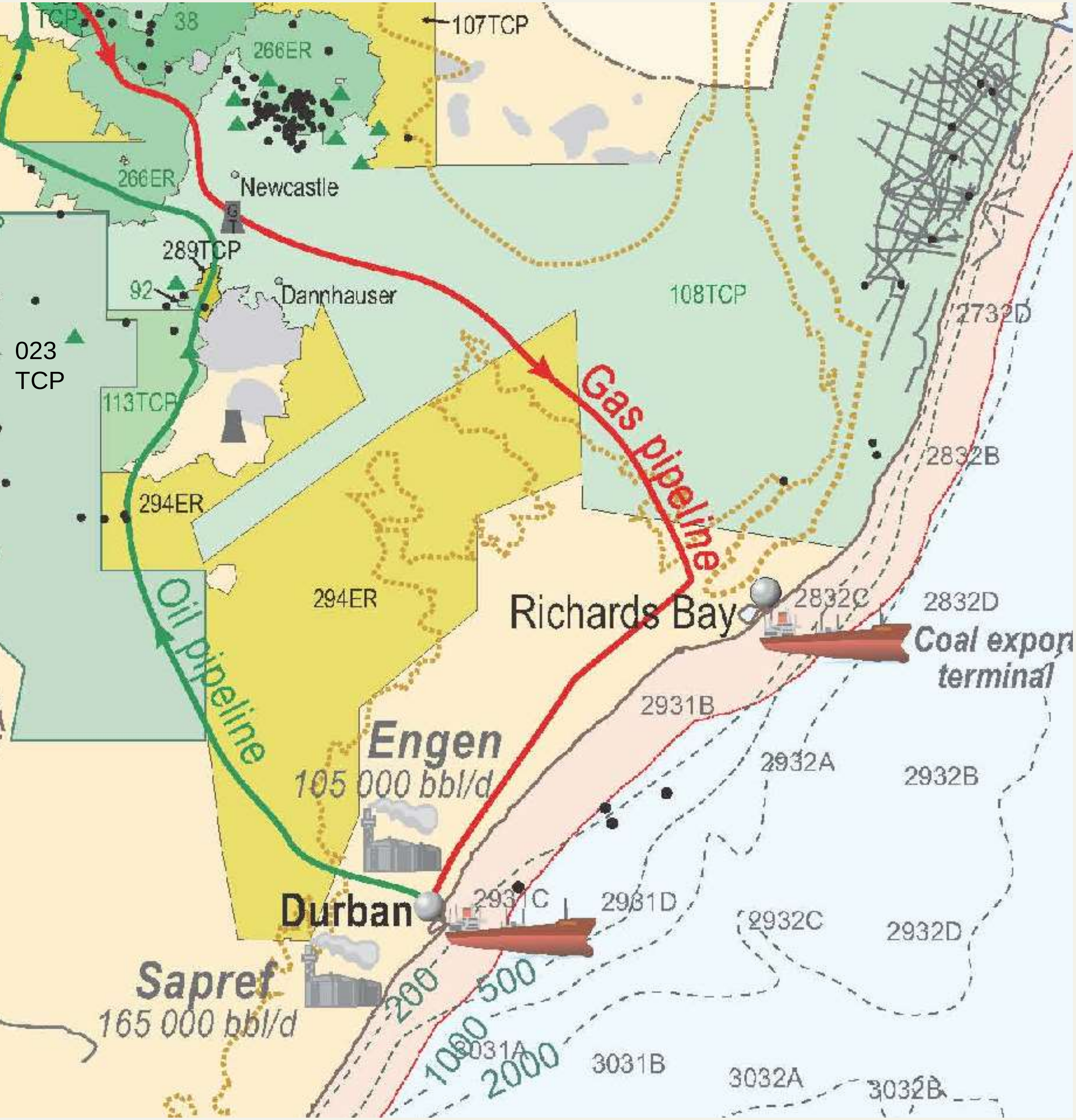
2013

The moratorium is lifted, but fracking is listed as a 'controlled activity', meaning companies need a water licence to do it. The DMR publishes additional draft regulations on exploration for petroleum resource that include fracking – but it is roundly criticised as being inadequate by civil society.

2015

The Minister of Mineral Resources gazettes the new Regulations for Petroleum Exploration and Production despite much criticism. TKAG takes the DMR to court over the Regulations

Source: Adapted from the Environmental Monitoring Group (2015)



Technical Cooperation Permits:
108 TCP – Rhino Oil & Gas (granted)
023 TCP – Sungu Sungu (granted)
113 TCP – Motuoane Energy (granted)

Exploration Rights:
266 ER & 267 ER – Kinetiko Energy (under consideration)
294/1 (?) ER – Rhino Oil & gas (under consideration)

“Fracking” Regulations

- In June 2015 the Minister of Mineral Resources gazetted the **Regulations on Petroleum Exploration and Production** under the Mineral and Petroleum Resources Development Act of 2002.
- They include additional provisions for shale gas EIAs, specific provisions for shale gas wells design and construction, operations and management (including waste management) and well suspension and decommissioning.
- The gazzetted Regulations do not represent a material improvement on the much criticised draft Regulations.
- SAFCEI, CER, TKAG in particular provided good feedback on the Regulations.

"Fracking" Regulations (cont.)

Some of the main criticisms includes:

- Setbacks (distance wells and sources of freshwater) have been aggravated by even further reducing these setbacks to ridiculously low distances; i.e. well site is allowed at only 500 metres from existing water boreholes.
- A lot of the safety requirements are very vague (i.e. for groundwater monitoring).
- The standard definition of "well integrity" is being deviated from.
- It does not say anything on minimum depth limitations for fracking (which jave been legislated or at least discussed in a number of countries in view of international best practices).
- Industry best practices with regards to suppression of methane emissions, have not been introduced.
- Recycling and re-use of fracking fluid need only be "considered".
- It lacks anything on public access to information.

"Fracking" Regulations (cont.)

In 2015, TKAG submitted a law suit to the Gauteng High Court is to review and set aside the Regulations for Petroleum Exploration and Production, that came into effect on 3 June 2015. The review is based on the following grounds:

- the Minister of Mineral Resources is not empowered to make regulations concerning environmental issues that are covered by the 2015 Regulations
- the 2015 Regulations are vague
- the 2015 Regulations are not based on relevant material concerning South African conditions (i.e. relevant considerations were not taken into account when the 2015 Regulations were framed, and irrelevant material concerning conditions in foreign countries was taken into account)
- the 2015 Regulations are not based on relevant international scientific learning (i.e. relevant material to be considered in the framing of appropriate regulations was not taken into account)
- there was no proper public participation process that preceded the publication and adoption of the 2015 Regulations

Rhino’s ER application

- Where are we in terms of UG development in SA?
- What is the regulatory environment like?

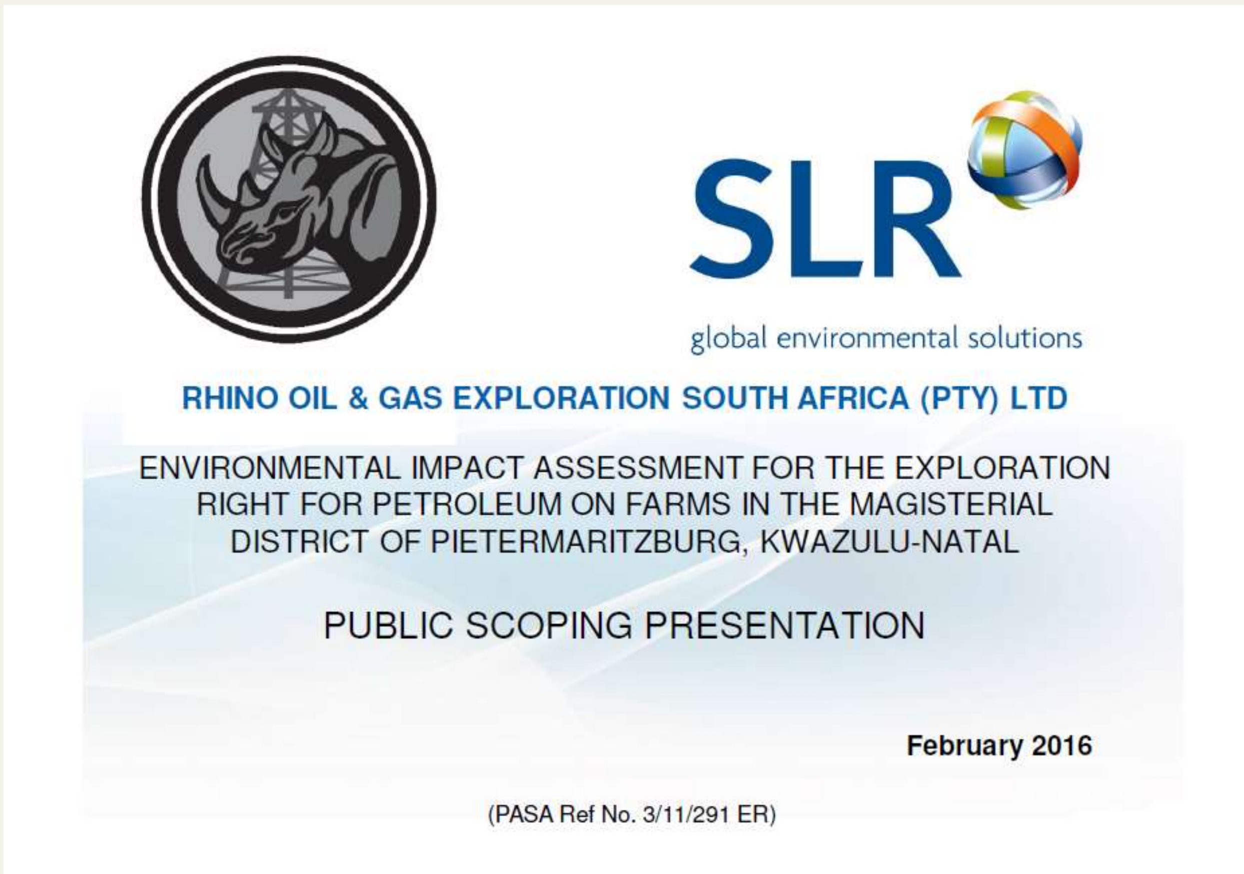
Background information

- Rhino Oil & Gas Exploration South Africa (Pty) Ltd has lodged an exploration rights application with the Petroleum Agency South Africa (PASA).
- Minerals included in the application are: oil & gas, condensate, CBM, helium and biogenic gas.
- The exploration area (designated as ER 294 in the PASA hub map and ER 291 in the BID provided by SLR) encompasses 1.5 mio ha (10,000 farms including some protected areas) in central KZN.
- Early phase exploration (3 years) to determine presence of targeted minerals using "non-invasive" exploration techniques (seismic surveying, core drilling etc; no hydraulic fracturing).
- The exploration rights application must include an environmental assessment.
- The BID lists a number of possible environmental impacts, but the crux of the problem is summarised in the sentence "…approval of this work could open the way for future, larger-scale projects in the area. These may have much greater impact and be difficult to stop if investment has been made."

Initial comments to BID

- The referenced exploration area (291ER) in the BID does not correspond with the PASA map on Petroleum exploration and production activities in SA.
- Large tracts of the area under application overlap with KZN's strategic water source areas (that's areas that get more than 135 mm MAR) and contribute a disproportionate amount of water to downstream uses (compared to the land areas that receive the precipitation). This means that compromising water quality in these areas can have disproportionately negative effects on downstream users.
- The EIA will be carried out by SLR – they also did Falcon's EIA which was criticised at least for being a superficial desk-top study that did not take into account local sensitivities and offering no real mitigation strategies for the environmental risks identified.
- Protected Environments and Nature Reserves should be explicitly excluded from the prospecting area.
- The process of managing the impacts and rehabilitation of exploration sites is to be done following the terms of the EMP approved by PASA, which does not have the man-power to effectively monitor its implementation.

Few more comments on the Rhino/SLR public scoping presentation



Few more comments on the Rhino/SLR public scoping presentation

NOVEMBER 2015 MEETINGS

– Why is Rhino applying for rights over areas (and doing an EIA) where various legislation and regulation will prevent any production from happening?

Application area is over properties where it is lawful to hold a right. But no exploration work will be undertaken in any area where a restriction prevents such work. Such approach is necessary to get the Regional picture required to inform decision making.

COMMENT:
Not so straightforward. Needs legal input to determine seniority where several different “rights” are held over one piece of land.

Few more comments on the Rhino/SLR public scoping presentation

Impact for South Africa

- South Africa consumes approximately 655 000 bbl/day (USEIA 2014) while we import 425 000bbl/day of oil from mainly from Saudi Arabia (38%) followed by Nigeria (31%)
- Our domestic production comes from the offshore fields that are mature and nearing the end of their life spans; the rest comes from CTL (Coal-to-Liquid) plants in Secunda.
- South Africa imports an additional 120 000bbl/day in the form of petroleum products, mainly from Asia.
- By developing the hydrocarbons industry it will give a much needed boost to the economy by way of revenues, jobs and to one day become a net exporter of Hydrocarbons.

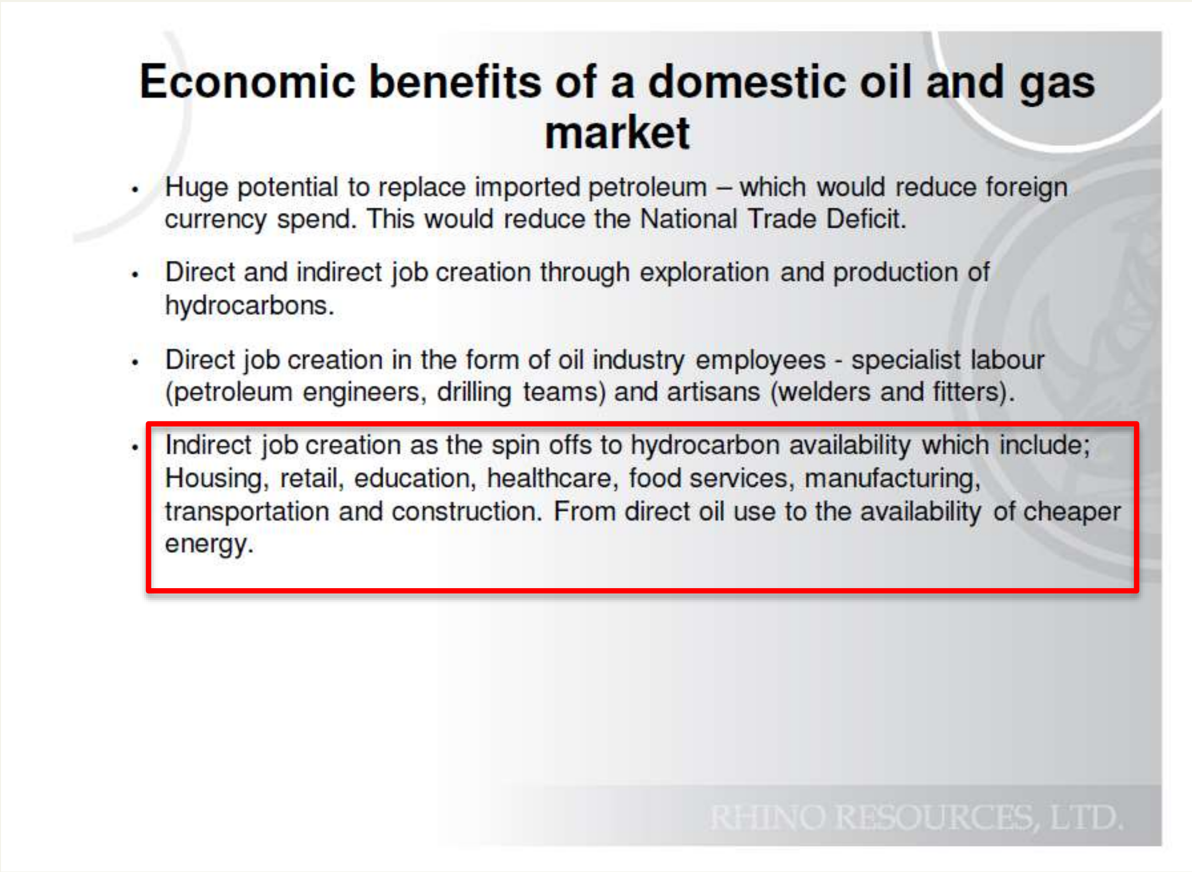
As the White House Council of Economic advisors announced in August, 2013:

"Every barrel of oil or cubic foot of gas that we produce at home instead of importing abroad means more jobs, faster growth and a lower trade deficit"

COMMENT:

- The potential for revenue and job creation of hydrocarbon industries is routinely over-stated.
- SA is highly unlikely to ever become a net exporter of hydrocarbons, if production based on unconventionals (which are generally more expensive than conventionals).
- The solution to reducing our dependency on imported fossil fuels is not in further developing a domestic fossil fuel industry, but switching away from fossil fuels towards cleaner energy.

Few more comments on the Rhino/SLR public scoping presentation

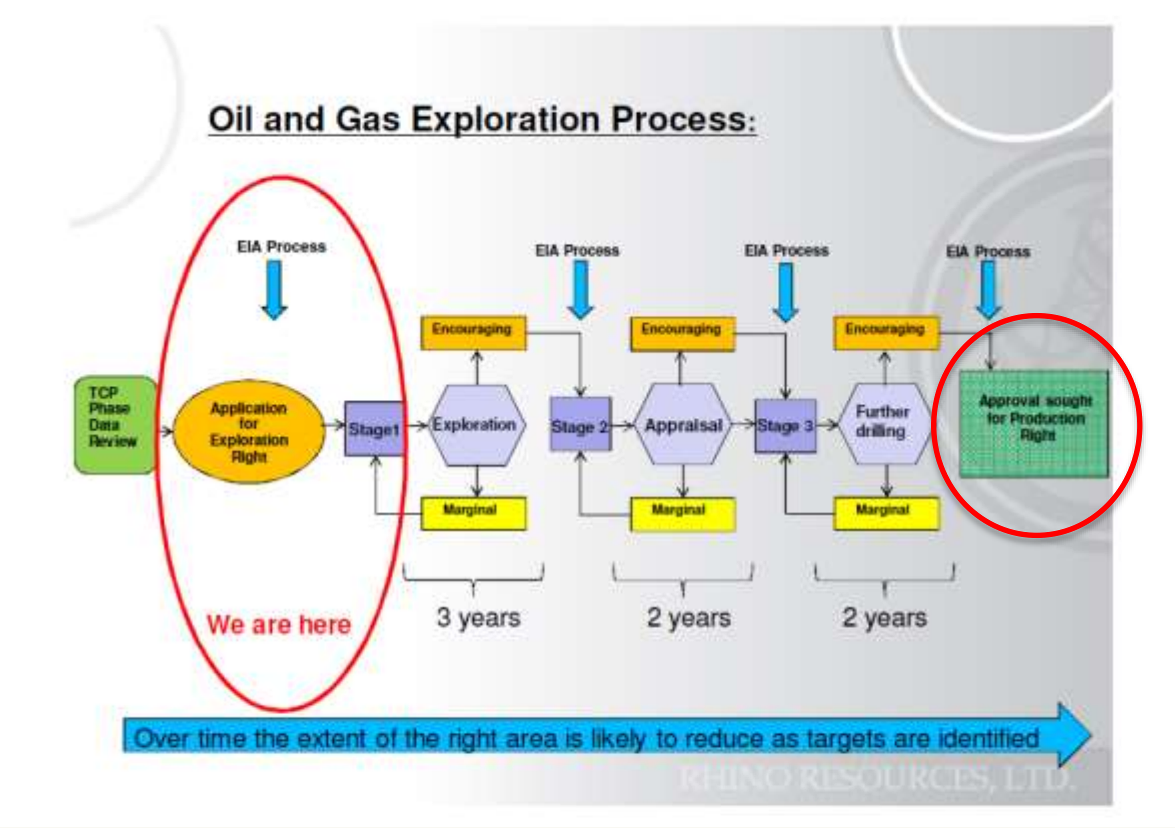


COMMENT:

Job creation during exploration phase negligible (Falcon mentioned only about 5 local jobs would be created, Rhino mentions 20 – and they are temporary). Creation of jobs in case full sector development goes ahead is contingent on developing the necessary skills domestically.

DOMESTIC ENERGY ≠ CHEAPER ENERGY

Few more comments on the Rhino/SLR public scoping presentation



COMMENT:

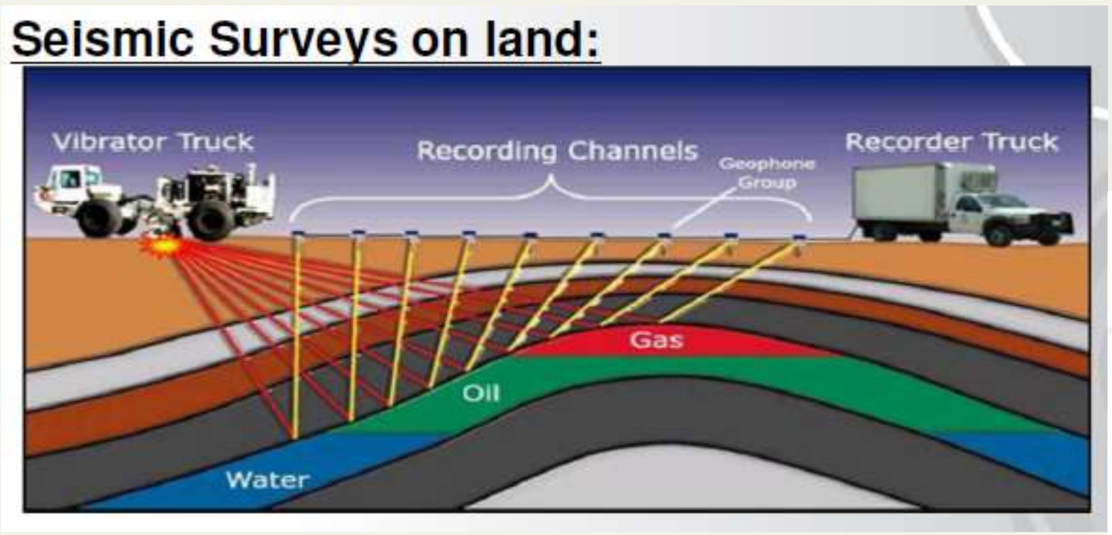
Under current law, if exploration successful, production right approval is only a formality.

Few more comments on the Rhino/SLR public scoping presentation

“ The exploration work program will be restricted to non-invasive techniques.”

COMMENT:

Seismic surveying can hardly be considered “non-invasive”



Concluding remarks

- Production of UG may result in unavoidable environmental impacts even if extracted properly, and more so if done inadequately. Even if risk can be reduced theoretically, in practise many accidents from leaky or malfunctioning equipment as well as from bad practises are regularly occurring.
- Project-level environmental impact assessment is an inappropriate mode of environmental management – in this case regional strategic environmental assessment may be more appropriate.
- There is a serious lack of capacity to monitor and enforce compliance with any conditions of approval.
- Ultimately, the solution is to reduce dependence on fossil fuels.

Thank you

tbole@wwf.org.za
Hilton, 08/03/2016

www.panda.org

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