An introduction to shale oil & gas

Philippe Charlez, IOGP
IOGP members produce half of the world’s oil and a third of the natural gas.

Our main objective: **promote safe, responsible and sustainable operations**
1. The US shale revolution

In the 1990s and 2000s, the US is increasingly dependent on oil & gas imports. Prices are on an upward trend.

It’s the trigger of an energy revolution:

Entrepreneurial experimentation in the Barnett Shale proves economic viability and triggers an energy revolution and manufacturing renaissance.
The shale revolution turns the US into one of the top global oil & gas producers

- Oil production peaks: from now on, US production falls
- First oil crisis
- Second oil crisis
- Oil counter shock
- Peak oil import: the US has never imported as much oil
- The US becomes the largest gas producer in the world and the second largest oil producer

![Graph showing energy dependency, oil dependency, and gas dependency from 1970 to 2014.](BP_outlook_2014)
Shale drives down natural gas prices, giving the US economy a competitive edge.

Energy-intensive industries benefit most:
- Cement
- Glass
- Steel
- Petrochemicals

Gas prices ($/MBTU)

BP outlook 2014

Production (Bn Pounds)

Operating costs (US$/pound)

Source: IFRI

Jobs are created (direct, indirect, induced)

Source: IHS CERA

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<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2020</th>
<th>2035</th>
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<tbody>
<tr>
<td>Million jobs</td>
<td>1.75</td>
<td>3</td>
<td>4</td>
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<tr>
<th>Job breakdown</th>
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<tr>
<td>Direct</td>
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<tr>
<td>Indirect</td>
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<tr>
<td>Induced</td>
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Production (Bn Pounds)

Source: IFRI
US power generation moves to gas from coal, lowering GHG emissions

Renewables have continued to grow, not crowded out by gas

Meanwhile, the EU moves in the opposite direction:

Source: Pétrole et gaz informations N° 1831

2. Some science about shale oil and gas

Shale oil and gas are exactly the same products as oil and natural gas from conventional extraction.
Oil and gas are chemicals made just of two elements: carbon and hydrogen.

The microscopic plants and animals that lived in the ocean millions of years ago sank to the bottom of the sea.

Buried deeper and deeper under the surface of the earth, heat transformed them into hydrocarbons.
Shale gas is natural gas!

Shale oil and gas are exactly the same product as oil and natural gas from conventional extraction. The difference is the source: conventional exploits reservoir, shale exploits source rock.

Conventional hydrocarbons are found in reservoirs:
1. Coarse grains
2. High permeability
3. Limited extension (at most as large as Greater London)

Hydrocarbons migrate from source rock and are sometimes trapped in a reservoir.

Shale is found in the source rock:
1. Very fine grains
2. Very low permeability
3. Very large extension (it could be as large as half of France)
The first hydraulic fracturing happened in Oklahoma in 1947. More than two million have been carried out by now in the US.

Geologists have known about gas from shale for decades, but for many years development was not economically viable.

In the late 1990s, a combination of two proven technologies – horizontal drilling and hydraulic fracturing – and advanced IT made gas from shale commercially viable.
Shale is normally at least 1,000 metres deeper than fresh water aquifers.

Multiple layers of steel and concrete isolate the well from the freshwater aquifers.

Hydraulic fracturing happens thousands of metres underground. A fracture’s maximum diameter is about 600 metres.

Fracture profiles
- Aquifer of potable water
- Fracture tops
- Fracture bottoms
- Depth of fracturing stages
Life-cycle water usage and radioactivity

Compared with conventional gas, shale gas requires only 1.7% additional water. Industry can use fresh water, but also brackish and sea water.

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<th>Energy</th>
<th>M³/MWh</th>
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<tr>
<td>Nuclear</td>
<td>2.1</td>
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<tr>
<td>Coal</td>
<td>1.9</td>
</tr>
<tr>
<td>Gas</td>
<td>1</td>
</tr>
<tr>
<td>Shale gas</td>
<td>1.017</td>
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Living in a shale gas basin like the Barnett in the US exposes a person to as much radiation as flying a round trip from Paris to New York City. One medical scanner is equivalent to living for 100 years in the Barnett basin.
Fracturing fluids are 90% water, 9% sand, 1% chemicals

The industry voluntarily discloses the chemicals it uses for hydraulic fracturing in the EU: [www.ngsfacts.org](http://www.ngsfacts.org)

Additional information on chemical disclosure for Polish wells can be found at [www.opppw.pl](http://www.opppw.pl)

- **Water 90%** - 10,000 to 20,000 m³/well (5 to 10 pools) - no need of high quality water: sea water or water from salted aquifers also works

- **Sand 9%** - 1,500 to 2,000 tons - keeps the fissures in the rocks open and allows the gas to flow to the well

- **Chemicals 0.5-1%** - used to viscosify the fluid, remove bacteria and prevent corrosion
Produced water is handled carefully and can be reused.

1. The water flowing back from the well to the surface is treated and it can be fully reused.
2. Treatment captures the methane mixed in the water, avoiding GHG emissions.
3. The reduction of methane flaring and venting further reduces GHG emissions.

Tyndall Centre University of Manchester
Low footprint: a shale gas pad has the extension of two football fields.

To produce an equivalent amount of energy with wind mills or solar panels, we would need 10 to 30 times the surface.

Source: Chesapeake

Source: Lane Energy, Poland
Earthquakes: less than the vibrations from a truck

Industrial activities induce low-intensity seismic events:
- Mining, dams
- Geothermal energy
- Oil & gas extraction

In shale gas, vibrations are generally lower than a truck passing by.

Source: International Gas Union

* In 2011 there were small tremors at Preese Hall near Blackpool, UK, where hydraulic fracturing operations were taking place.

The Paris metro vibrations are equivalent to $7$ times Blackpool.
Shale is a global phenomenon!

### Notional additional resources

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<tr>
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<th>Gas Gboe</th>
<th>Oil Gbbl</th>
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<tr>
<td>Conventional</td>
<td>1100</td>
<td>1650</td>
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<tr>
<td>Shale oil &amp; gas</td>
<td>1200</td>
<td>350</td>
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<tr>
<td>Additional (%)</td>
<td>110</td>
<td>20</td>
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### World map showing shale gas and oil resources by country

- **Shale gas** (Gboe): Poland 25, France 23, Romania 9, Denmark 5, UK 4, Netherlands 4, Others 9, **Total 80**
- **Shale oil** (Gboe): Poland 3.3, France 4.7, Romania 0.3, Denmark 0, UK 0.7, Netherlands 2.9, Others 1, **Total 12.9**

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Source: EIA 2013
The EU has potentially significant shale resources

Europe’s shale gas resources are within the Top 10 worldwide

Main shale gas resource areas in Europe

Technically Recoverable Resources (in trillion cubic feet)

Sources EIA 2014
In 2035, the EU is expected to import 89% of its gas. Shale gas can cut that to as little as 62%.

Lower energy prices compared with a no-shale gas scenario: higher available income for households and a more competitive industry.

It could also mean up to 3.8 trillion euros added to the economy between 2020 and 2050.

It could mean up to 1.1 million new jobs created by 2050.

A 30-year development would require:
- 23,000 to 50,000 wells
- 450 mln m³ to 1 bln m³ water*
- 230 km² to 500 km²

* in 2012, France used 33 Gm³

Source: Poyry/IOGP 2013
IOGP activities on shale gas

• NGS Facts (chemicals disclosure website): http://www.ngsfacts.org


• IOGP Fact Sheets: Chemicals, Seismicity, Emissions, Water: http://www.iogp.org/PapersPDF/v2_Shale_FAQs_1.2_high.pdf

• Studies:
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