KN4

Conditions to Export the Shale oil and Tight Gas Revolution out of North America

PHILIPPE Charlez* (Total)

SUMMARY

According to the International Energy Agency, the world is entering a golden age of gas. Gas is at the same time an abundant but also a green resource when compared to oil and coal. This golden age will not only rely on conventional resources. Unconventional resources (shale gas, tight gas and coal bed methane) will play a major role in the future energy mix. According to the Energy Information Administration, shale gas could double the world gas resources.
How to export the Unconventional Revolution in the MENA Countries

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TOTAL Exploration-Production
Paris - France

*Hydrocarbons from source rock

US unconventional oil and gas boom

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Geopolitical consequences on oil and gas fluxes

Source: BP outlook 2013, IEA outlook 2012

- LNG US export
  - 20 Mtons in 2020 (8%)
  - 40 Mtons in 2025 (15%)
  - 90 Mtons in 2035 (20%)

Consequences
- Inversion of flow from Middle East to Far East

The four pillars of the US success

Knowledge of subsurface
Oil & gas operators & services
Full political support
Favourable mining rules

Impressive operational performances
Drilling: Days 11, Lateral length: Feet 4529, Well cost: M$ 2.8, Technical cost: $/MBTU 0.86

US method not exportable
World shale oil and gas stakes (in Gboe)

<table>
<thead>
<tr>
<th>Country</th>
<th>Resources (Tcf)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Saudi Arabia</td>
<td>280 to 650</td>
</tr>
<tr>
<td>UAE</td>
<td>215</td>
</tr>
<tr>
<td>Algeria</td>
<td>700</td>
</tr>
<tr>
<td>Libya</td>
<td>290</td>
</tr>
</tbody>
</table>

Mature stage

Pilot stage

Immature stage

Notional additional resources

<table>
<thead>
<tr>
<th></th>
<th>Gas Gboe</th>
<th>Oil Gbbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>1100</td>
<td>1650</td>
</tr>
<tr>
<td>Unconventional</td>
<td>1200</td>
<td>350</td>
</tr>
<tr>
<td>Additional (%)</td>
<td>110</td>
<td>20</td>
</tr>
</tbody>
</table>

Differences between source and reservoir rocks

**Reservoir rock**

1. Rather homogeneous rocks
2. Medium to coarse grains,
3. High permeabilities (mD to D)
4. Limited extension (1000 km²)
5. Trapping mechanism
6. No organic matter preserved

**Source rock**

1. Heterogeneous rock
2. Very fine grains
3. Very low permeabilities (nD)
4. Very large extensions
5. Rock self trapping/sourcing
6. Porous organic matter
**How to export: two main leverages**

**Geoscience drivers**
1. Ultra low permeabilities
2. Ultra quick decline curves
3. Very large extension

**Development drivers**
1. Several 10's of explo/appr wells
2. Several 1000's of dev wells
3. Horizontals multi-fracked

O&G in place not “naturally” translated into reserves

Coupling HF with horizontal transform the play into a reservoir

DRILLEX = up to 90% CAPEX

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**Play & SRV quality: a « 4G » process**

**Play quality**
- Total Organic Content
- Source rock maturity
- Mineralogy
- Petrophysics: k, F
- Pore pressure

**SRV quality**
- Stresses
- Natural fractures
- Brittleness
- Rock fluid interaction
- Completion strategy

**Hydrocarbon in place**

**Reserves**

**Sweet spot = play quality + SRV quality**

**Completion becomes a geosciences issue**
3 key issues

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1st key issue: play & SRV mapping (after SLB/Terratek)

- Logs data
- Core data
- Seismic data
- Upscaling
- Multivariate & ranking
- SRV quality

Trial & error method

1. Low play & SRV
2. High play & low SRV
3. High play & SRV

Locate sweet spots = minimizing wells
Economical & environmental challenge

2nd key issue: SRV modeling to optimise completion strategy

A R&D TOPIC

- Microseismic Events
- DFN Realization
- Compare to MSM
- Calibrate UFM & DFN
- Predict Fracture Geometry
3rd key issue: LPG alternative fluids to water

Flow back = 20% to 40% of injected volume

Per frac stage
1 olympic pool = 2000 m³ of water

Physical properties

<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>Propane</th>
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</thead>
<tbody>
<tr>
<td>Viscosity (cps)</td>
<td>0.66</td>
<td>0.08</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>1.02</td>
<td>0.51</td>
</tr>
<tr>
<td>Surface Tens (d/cm)</td>
<td>72</td>
<td>7.6</td>
</tr>
<tr>
<td>Clay sensitivity</td>
<td>Reactiv</td>
<td>Inert</td>
</tr>
<tr>
<td>Corrosion</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Bacteria</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Scale</td>
<td>Yes</td>
<td>No</td>
</tr>
</tbody>
</table>

SAFETY issue

Conclusion: the deal is not technical...it is cultural

Exploration | Delineation | Development | Production

Remote operation & decision center

First oil

- Extremely quick decision required
- 24h management and expertise
- Decision to be taken remotely
- 360° business view

Deep cultural changes

Change technicity is easy, culture is a nightmare
Questions?

The deep water model

The unconventional model

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