Oil: What risks for Europe's supplies?

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Oil: What risks for Europe's supplies?

- Generalities - oil types
  - reserves : 1P vs 2P
  - production : relationship to reserves, production profiles

- Middle East, US, Russia
  - Evolution of discoveries, field size, remaining reserves, distribution of production in function of discovery year, breakeven price, ...
  - Exemple of Saudi Arabia

  - Future productions
    - Methodology
    - Saudi Arabia, Iran, Iraq, Kuwait
    - US shale oil
    - Russia

- World Panorama
  - Looking at the production cycle
  - Peaking of conventional oil and consequences
  - Conclusion
I) Generalities
Oil shale

Shale gas

Conventional natural gas liquids

Extra-heavy oil
Bitumen
Tar sands

Unconventional natural gas liquids

Conventional natural gas liquids

Extra-heavy oil
Bitumen
Tar sands
## Classification of oil

<table>
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<tr>
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<th>Tar sands Extra heavy</th>
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<td>Quality of reservoir</td>
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![Conventional oil](image1.jpg)

![Tar sands Extra heavy](image2.jpg)

![Shale oil](image3.jpg)

![Oil shale](image4.jpg)
## Classification of oil

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<td>Green</td>
<td>Red</td>
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<tr>
<td>Quality of oil</td>
<td>Green</td>
<td>Red</td>
<td>Green</td>
<td>Red</td>
</tr>
</tbody>
</table>

Past  Future

Energy available for the economy

Energy spent to extract oil

Growing energy cost

Oil no longer an energy source

Oil production will not stop because oil is exhausted, but due to energy costs (and thus economical costs).
### Classification of oil and gas types

<table>
<thead>
<tr>
<th></th>
<th>Conventional oil and gas</th>
<th>Tar sands Extra heavy</th>
<th>Shale oil and gas</th>
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**Oils with best return on energy/money invested are exploited first**

[Diagram showing production Mb/d over 2019]
Proven reserves vs proven + probable reserves

1P (90%) vs 2P (50%)

Remaining reserves (Gb)

Norway

Publicly available
- EIA
- BP statistical review

Production (Mb/d)

Proven reserves are everywhere: in geography books, newspapers, magazines, economic documents, reports for governments to base their energy policies, …
Proven reserves vs proven + probable reserves

1P (90%)  2P (50%)

Confidential, in private paid databases
- Rystad
- IHS
- Wood Mackenzie

Publicly available
- EIA
- BP statistical review

Proven + probable reserves are more appropriate to estimate what oil companies expect to extract, and their evolution with time is more informative. In this example, their decline warns of production difficulties ahead, while proven reserves continue growing, providing no warning. This drawback of proven reserves is a consequence of their definition. Unfortunately, most people do not have access to proven + probable reserves.
Proven reserves are useless to monitor depletion and forecast production.

In this example, proven reserves follow the production decline and do not anticipate it.
Much worse, as proven reserves are the only numbers that countries publish, they have become political tools; they seldom correspond to definitions of proven reserves. In the rest of the presentation, we will show data of proven + probable reserves only.
History of **discoveries** and **production** for norwegian crude.

Knowing the discovery cycles helps forecasting the production cycles.

- **Discovery peak** ~ 20 years
- **Production peak** ~ 15 years
- **Secondary discovery peak**
- **Secondary production peak**

Data from Norwegian Petroleum Directorate, graphic from P. Brocorens.
History of **discoveries** and **production** for norwegian crude.

Field by field data illustrates the growing efforts deployed to extract oil.

Data from Norwegian Petroleum Directorate, graphic from P. Brocorens
II)

State of reserves and production forecasts for

**Middle-East**


**US shale oil**

**Russia**

Based on Rystad Energy. (2022, May 2). Lifting the curtain on Russia’s oil and gas sectors that will bring in an estimated $260 billion in 2022.
Jean-Marc Jancovici*
Chairman

Matthieu Auzanneau*
Executive director

Olivier Rech*, consultant;
co-author of the IEA World Energy
Outlook 2007, 2008 and 2009

Alain Lehner, Engineer,
Director of the Reservoir Development division and Chairman of the Reservoir Committee at Total from 2004 to 2011

Marc Blaizot*, Engineer geologist, Director of Exploration at Total from 2009 to 2015

* Member of ASPO France
Jean-Marc Jancovici*
Chairman

Matthieu Auzanneau*
Executive director

Jacques Percebois, Economist, Honorary Professor at the University of Montpellier, director of the Center for Research in Energy Economics and Law (CREDEN)

Francis Perrin, Senior Research Fellow at IRIS, specialised in energy issues

Philippe Sébille-Lopez*, Director of Géopolia, specialised in energy geopolitics


* Member of ASPO France
Contribution to the analysis of the short to long-term supply risk
- Discoveries and Production outlook for the 16 main supplying countries (95% net imports EU-27 and 70% global oil production)
- Time horizon: 2030 to 2050

Sources
- Ucube database from Rystad Energy
- Independent expertise from the authors and associated experts

Production forecast by comprehensive analysis of the exploration-production cycle
- Producing fields
- Undeveloped resources (Discovered Resources Opportunities)
- Prospective resources (Yet To Find)
- Synthetic diagnosis on Light Tight Oil
Origin of net crude oil imports in EU27 (Mt) before the war in Ukraine
Oil discoveries are in long-term decline

Ghawar, biggest field in the world
Oil discoveries are getting smaller

Saudi Arabia

average field size (Mb - log scale)

/100
The delay between discovery and “first oil” increases in all countries, without exception.

This field brought into production in 2018 has been discovered 60 years before.
Most oil is produced from old discoveries (even decades ago)

Saudi Arabia - Production by decade of discovery

Recent development of fields discovered in 1950s
Production is shifting towards resources of higher breakeven price

Saudi Arabia – distribution of production and remaining resources in function of the breakeven price in 2019

Will this oil be ever exploited?
Same trends in other countries

Evolution of cumulated discoveries and remaining reserves of crude oil (Gb, 2P)

**Exemple**

- **Saudi Arabia**
  - 45% produced
- **Iraq**
  - 35% produced

- **Iran**
  - 60% produced
- **Kuwait**
  - 55% produced
Depletion rate of the cumulative discoveries to date across the 16 countries is close to 70%.

14 out of 16 countries are experiencing a decline or a production level lower than the maximum observed in the past.
Methodology

Contribution to the analysis of the short to long-term supply risk
- Discoveries and Production outlook for the 16 main supplying countries (95% net imports EU-27 and 70% global oil production)
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Rystad Data Base Highlights

Pros:
- Field by Field oil production history and forecast data
- Oil types (crude, condensates, etc.)
- Field type: onshore/offshore; conv/non conv...
- CAPEX and OPEX based on wells drilled: past and future

and cons:
- No water and gas production and injection history
- No geological reservoir data (carbonates/sandstones; porosity/permeability
- No reservoir depth

Able to derive initial and remaining reserves with associated costs
Methodology

Contribution to the analysis of the short to long-term supply risk
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Production forecast by comprehensive analysis of the exploration-production cycle
- Producing fields
- Undeveloped resources (Discovered Resources Opportunities)
- Prospective resources (Yet To Find)
- Synthetic diagnosis on Light Tight Oil
- Use of a proprietary decline model calibrated to some known fields
- Use of reserves and well capex data from the Rystad database
- In addition to Rystad data, integration of water and gas production, and calculation of the number of water and gas injectors required for field management

**Importance of water management (need to drill wells to reinject water)**

- Use of the proprietary model to analyze 18 fields of the 16 relevant countries and comparison with Rystad's forecasts.

*Example of carbonate reservoirs in the Middle East*

Authors: P. Carpentier et al.
Several important points to highlight:

- Importance of oil price changes on reserves (higher prices significantly increase reserves, and vice versa). We observed a variation of + to -20% on reserve estimates.

- The database assumes that fields will be well-managed (good monitoring, allowing for optimal oil recovery).

- This will be very challenging for deep offshore fields > 500m

- Higher number and costs of the measures (difficulties in allocating oil, water, and gas production to wells and thus optimizing).

- Therefore, there may be either an overestimation of reserves or an underestimation of future costs.
In conclusion

Based on the study of the 18 fields, the profiles in the Rystad database have been adjusted to account for these technical considerations:

- Costs are likely underestimated (number of necessary wells, surface facilities, etc.). For instance, in the Middle East, many fields are still producing with relatively little associated water or gas, but this will change and complicate their management.

- Profiles are probably too optimistic in general (insufficient integration of complexity in some fields, H₂S issues, challenging EOR techniques to implement), especially for deep offshore fields.

- **We can assume a 10 (onshore) to 20 % (deep offshore) less remaining reserves**
<table>
<thead>
<tr>
<th>Producing fields</th>
<th>Found but undeveloped fields</th>
<th>Yet To Find fields</th>
<th>Light Tight Oil</th>
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</table>

**Discovered Resources Opportunities in billion barrels**

- Arabie Saoudite - 37,1 Gb
- Kazakhstan - 8,2 Gb
- Mexique - 4,6 Gb
- Nigeria - 2,3 Gb
- Libye - 1 Gb
- Egypte - 0,2 Gb
- Iraq - 24 Gb
- Etats-Unis (hors LTO) - 6,2 Gb
- Koweit - 3,5 Gb
- Norvège - 2,2 Gb
- Azerbaijan - 0,5 Gb
- Iran - 14,9 Gb
- Russie - 4,8 Gb
- Royaume Uni - 3,2 Gb
- Angola - 2 Gb
- Algérie - 0,3 Gb

**Countries:**
- Iran
- Iraq
- Saudi Arabia
Limited overall revisions (+2 Gb) from Rystad estimates (88 Gbo) in the 16 studied counties, but significant for some.

<table>
<thead>
<tr>
<th>Pays</th>
<th>Bassins</th>
<th>Source Rystad Energy *</th>
<th>Source auteurs rapport</th>
<th>Révision auteurs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabie Saoudite</td>
<td>Central Arabian Offshore</td>
<td>13,8</td>
<td>1,7</td>
<td>-14,3</td>
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<tr>
<td></td>
<td>Central Arabian Onshore</td>
<td>8,5</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Rub al Khali Onshore</td>
<td>0,7</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Koweït</td>
<td>Central Arabian Onshore</td>
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<td>1,7</td>
<td>-5,4</td>
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<tr>
<td>Iran</td>
<td>Central Arabian Offshore</td>
<td>4,3</td>
<td>1,7</td>
<td>+6,8</td>
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<tr>
<td></td>
<td>Rub al Khali Offshore</td>
<td>0,3</td>
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<tr>
<td></td>
<td>South Caspian Basin Offshore</td>
<td>0,5</td>
<td>1,1</td>
<td></td>
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<tr>
<td></td>
<td>Zagros Foldbelt Onshore</td>
<td>1,2</td>
<td>9,7</td>
<td></td>
</tr>
<tr>
<td>Irak</td>
<td>Widyan Onshore</td>
<td>1,1</td>
<td>5</td>
<td>+4,5</td>
</tr>
<tr>
<td></td>
<td>Zagros Foldbelt Onshore</td>
<td>0,8</td>
<td>4,8</td>
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<td>Western Arabian Onshore</td>
<td>1,2</td>
<td>0,2</td>
<td></td>
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* Source Rystad Energy: 88 Gbo
* Source auteurs rapport: 88 Gbo

+4,5
-14,3
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Saudi Arabia – liquid hydrocarbons (projections post-2020)

- Future developments of future discoveries (post-2020)
- Future developments of identified fields
- Fields in development
- Producing fields
- Abandoned fields
- Crude oil

*Future disc.*

*77 undeveloped fields*

*2030*
liquid hydrocarbons (projections post-2020)

- Future developments of future discoveries (post-2020)
- Future developments of identified fields
- Fields in development
- Producing fields
- Abandoned fields
- Crude oil

Kuwait

Iran

Iraq

Production (Mb/y)
### Light Tight Oil

- **Producing fields**
- **Found but undeveloped fields**
- **Yet To Find fields**

#### Uncertainties:
- geological (sweet spots)
- economic (funding flows and costs)
- political (between US federal and local)

#### High estimate
from Rystad Energy (April 2020)

#### Low estimate
from authors and associated experts

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### US – Light Tight Oil – hydrocarbon liquids
(projections post-2020)

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2010</th>
<th>2020</th>
<th>2030</th>
<th>2040</th>
<th>2050</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gb/y</td>
<td>0</td>
<td>0</td>
<td>7</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: données Rystad Energy - analyse et projections post-2020 The Shift Project
U.S. tight oil production – selected plays
million barrels of oil per day

- Eagle Ford (TX)
- Spraberry (TX Permian)
- Bakken (ND & MT)
- Wolfcamp (TX & NM Permian)
- Bone Spring (TX & NM Permian)
- Niobrara-Codell (CO & WY)
- Mississippian (OK)
- Austin Chalk (LA & TX)
- Woodford (OK)
- Rest of US ‘tight oil’

Data source: EIA derived from state administrative data collected by Enverus. Data are through July 2023 and represent EIA’s official tight oil estimates, but are not survey data. State abbreviations indicate primary state(s).
Note: Improvements to play identification methods have altered production volumes of various plays.

Last Results from EIA –July 2023- Closer to High estimate trend
Russia
Expected decline, but uncertain long-term effects of sanctions and exit of occidental oilfield services companies

Russia crude production outlook before and after invasion of Ukraine
Million bpd

Source: Rystad Energy research and analysis; Rystad Energy UCube. May 2022
Production cycles are similar at all levels: from single fields to the world.

Lately, the Middle East and US were the drivers of production growth. If they stop growing, the world likely stops growing.

Could the consequences be similar to what happened when conventional oil peaked?
History of discoveries and production for world conventional crude oil

Most energy experts did not anticipate the peaking of conventional oil production despite obvious warnings:

1) Declining discoveries since 1960s
2) Growing gap between production and discoveries since mid-1980s

- Declining discoveries since 1960s
- Growing gap between production and discoveries since mid-1980s

+ shale oil
History of **discoveries** and **production** for world conventional crude oil, and IEA forecasts (World energy outlook)

An exception. In 1998, the IEA team used a methodology that took into account the shape and physics of production cycles. Despite uncertainties in reserve estimates (50% between low and high values), the forecasted peak dates only differ by 10 years.
History of *discoveries* and *production* for world conventional crude oil, and IEA forecasts

weo2018, p134: “The level of conventional crude oil resources approved for development in recent years is in line with the needs of the Sustainable Development Scenario but is far below the level needed to meet demand growth in the New Policies Scenario”.

Later, the IEA team and methodology changed, with no peak in sight. Since then, forecasts are revised downwards, and the IEA itself warns of future revisions.
History of **discoveries** and **production** for world conventional crude oil, and IEA forecasts

weo2021, p20: “...the amount being spent on oil and natural gas, dragged down by two price collapses in 2014-15 and in 2020, is geared towards a world of stagnant or even falling demand for these fuels.”

This IEA message is ambiguous. If upstream investment are insufficient, supply will decline, not demand. Demand thus needs to decline for the markets to be balanced.

data: eia, iea, Laherrère; P. Brocorens graphic
weo2021, p20: “Oil and gas spending today is one of the very few areas that it is reasonably well aligned with the levels seen in the NZE to 2030”.

The IEA warns of future downwards revisions, again, and of insufficient alternatives to fill the gap.
weo2021, p20: “...a surge in spending to boost deployment of clean energy technologies and infrastructure provides the way out of this impasse, but this needs to happen quickly or global energy markets will face a turbulent and volatile period ahead. Clear signals and direction from policy makers are essential. If the road ahead is paved only with good intentions, then it will be a bumpy ride indeed.”
An example of bumpy ride: the peaking of conventional oil and its effect on oil prices and the world economy.

Peak of conventional oil expected in 2010-2020; unconventional oil must develop. Being more costly, a price jump of 50% is forecasted.
Conventional oil is peaking

by lack of anticipation, prices started to rise

The IEA team has changed
No peak of conventional oil in sight

prices are revised downwards, and the warnings of the IEA report of 1998 are forgotten;

Source du prix du pétrole: eia
For several years, the peaking of conventional oil maintained flat the global oil supply. Excess demand, stimulated by economic growth, had to be curbed by rising oil prices. The weakest link of the world economy finally broke. It was the financial crisis.

Financial crisis

Compare the price spike due to a peaking of conventional oil production...

...to the spike due to Iraq invading Kuwait while Soviet Union was collapsing.
Oil price evolution and IEA forecasts

The IEA finally said peak oil might have been passed.

Conventional peak oil reached in 2006

Financial crisis

rearview mirror effect

Source du prix du pétrole: eia
Oil price evolution and IEA forecasts

- Conventional oil has peaked
- US shale oil boom
- Financial crisis
- WTI spot price $2020/b
- WE01998
- WE02000
- WE02002
- WE02004
- WE02006
- WE02008
- WE02010 new policies
- WE02012 new policies
- WE02014 new policies
- WE02016 new policies

Back to normality? The IEA is more cautious.

Source du prix du pétrole: eia
The US shale oil boom lasted long enough to undermine all efforts to raise awareness among the public and politicians about the need to take peak oil seriously.
In 2014, the US replaced Saudi Arabia as « swing producer » thanks to the reactivity of the shale oil companies to oil prices. This ability to stabilize markets will progressively disappear.

In 15 years, the US reduced their net oil imports by 12 million barrels. Oil from exporting countries was redirected to other countries, allowing China and India to grow their consumption with limited competition. Without reduction of domestic consumption, the US will start importing again, and competition will increase.
<table>
<thead>
<tr>
<th>European Region</th>
<th>2025-2030</th>
<th>2030-2040</th>
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<tbody>
<tr>
<td><strong>Europe</strong></td>
<td>for the block of the 16 main oil exporters to EU, production peaks...</td>
<td>... then declines</td>
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<td>Search of new exporters (deep offshore from Brasil, Guyana, Surinam, Austral Africa; Andean foothills from Colombia-Ecuador-Peru-Bolivia-Argentina)</td>
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</table>

The peak and decline of US oil production, along with similar trends in other countries, collectively drive the overall production for the group of 16 major exporters to the EU towards a peak and decline. Competition between importers for declining exports from those countries will be somewhat mitigated by rising exports from countries that have recently initiated production cycles.

<table>
<thead>
<tr>
<th>Middle East</th>
<th>Conventional production peaks...</th>
<th>... and stays on a plateau</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Growing importance to supply markets</td>
<td>Effect on exports of growing local consumption</td>
</tr>
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</table>

With production peaking and declining in other parts of the world, the Middle East’s market share is likely to increase. However, with production remaining stagnant and local consumption expected to rise due to economic growth and demography, there may be less oil for export than expected. This is especially true for countries experiencing declining production. For them, declining exports could become a significant destabilizing factor, as observed in Syria and Yemen prior to the Arab Spring. Algeria is a country facing a similar risk.
### 2025-2030

<table>
<thead>
<tr>
<th>World</th>
<th>Production peaks….</th>
<th>… then declines</th>
</tr>
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</table>

- Volatile markets, price spikes….
- unless unconventional or synthetic oil generalizes (Canada-Mexico-Colombia-Argentina-Russia-Kazakhstan-Libya-Venezuela…. Middle East ?)
- or the transition starts seriously

The scenario of a peak and decline in world production may be postponed if unconventional or synthetic oils, particularly shale oil, become widespread. Wherever conventional oil is found, shale oil is also present nearby, and developments in other countries than in the US are likely to occur. However, below-ground characteristics (geology,…) are not always suitable and above-ground conditions (economy, politics,…) are not as favorable as in the US. US shale oil companies operated for years with negative free cash-flow. This model differs from the oil rent model followed in the Middle East. Significant development in such countries could necessitate an increase of the oil price to a new level, which could be painful for importing countries.

Also, the scenario of a peak and decline in world production could be mitigated in its negative consequences if the transition finally starts seriously.
In the past, there was much controversy to know whether a peak and decline of world oil production would occur and when.

Today, many energy experts say peak oil is imminent and show similar oil production trajectories (see figure above), but the controversy is now on the nature of the peak. Peak supply is driven by physical and geological factors, and is accompanied by price spikes. In this presentation, we presented arguments that support that view. Peak demand is driven by consumers leaving oil faster than oil leaves them, and is accompanied by soft prices. The IEA scenarios are presented as peak demand, but at the same time the IEA warns of production constraints that are characteristic of peak supply.

In a peak supply, excess capacity generally disappears for long periods, and any event that disturbs production (geopolitics, accident, storm,…) then has an amplified effect on prices. People’s attention often becomes fixated on these events, causing them to overlook the underlying causes: depletion and reduced energy return for the remaining resources.