YTF – statistical analysis of 1700 prospects and leads

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Norwegian Petroleum Directorate
Norway’s Petroleum Resources

• The Norwegian Petroleum Directorate (NPD) is responsible for maintaining a complete inventory of petroleum resources in Norway.

• This is done in accordance with established resource classification routines, regular reporting from the oil companies and NPD’s geological mapping.

• NPD compile and publish annually figures on field reserves, contingent resources and YTF resources.
More than half of the resources still remain

- Undiscovered resources: 20%
- Resources in discoveries: 5%
- Resources in fields: 6%
- Reserves: 21%

48% sold and delivered
Estimating Undiscovered, Yet To Find (YTF) Volumes

\[ \text{YTF} = \text{Number of prospects} \times \text{Size} \times \text{Probability} \]

Probability of oil/gas (HC phase)
1: Number of Accumulations
Number of features / feature density

Assessment of feature density is based on one or more calibration areas where all relevant elements can be counted.

These elements are the number of:
- discoveries
- dry wells
- mapped prospects
- leads

+ number of postulated prospects (which could be mapped in the future).
NPD’s Database

• Maintain Extensive Prospect database updated by
  • NPD in-house mapping
  • License Applications
  • Prospect mapping in the Licenses (Exploration committees / L2S)
    - Many Prospects are recorded with several historic estimates
• Pre-drill estimates compared to Well results – reported by the Operators
• All Discoveries and Fields – annual reporting from the Operators
• Complete well data base with all interpretations and reports
Norway – some numbers  June 2017

903 Production Licenses signed

1764 Exploration Wells

4553 Production / Injection Well

81 Fields in Production (116 fields totally)

1100 Prospects

600 Leads

74 Plays identified and analysed by NPD
2: Size of future discoveries

We think they are bigger than they are
Size of prospects and discoveries

1. Sizes of mapped prospects in the play.

2. Information from discoveries is important for confirmed plays. Knowledge of discovered volumes are essential for assessment in mature plays, while information from analogues is also important for less explored cases.

3. Calculating the size of future discoveries builds on estimates of volume and fluid (liquid and gas) parameters.
Discoveries last 10 years pr. region sorted by size

*Johan Sverdrup is not included.
Smaller discoveries

Average discovery size – last 5 years

<table>
<thead>
<tr>
<th>Year</th>
<th>Average Discovery Size (Mill. Scm.o.e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2012</td>
<td>10</td>
</tr>
<tr>
<td>2013</td>
<td>6</td>
</tr>
<tr>
<td>2014</td>
<td>5</td>
</tr>
<tr>
<td>2015</td>
<td>2</td>
</tr>
<tr>
<td>2016</td>
<td>3</td>
</tr>
</tbody>
</table>
Discovery size vs estimates in applications
NCS Pre vs Post-drill volume estimates 1998

K. Ofstad et al. (1998) Evaluation of Norwegian Wildcat Wells
Discoveries ranked by prognosed resource estimates, sorted on prognosed HC - phases
Exploration targets 2007-2016 - oil
Exploration targets 2007-2016 - gas
Hydrocarbon columns, Norwegian Sea 1990-2015. Prognosis vs. reported results (base case)

- **Prognosed hc columns**
  - (262 prospects, incl. 45 with multiple cases)
  - 54% ≥ 200 m
  - 46% < 200 m

- **Reported hc columns in discoveries**
  - (116) 6 months after drilling
  - 21% ≥ 200 m
  - 79% < 200 m
3: Probability of Success
Prospect Probability and Discovery Success

The probability of making future discoveries comprises the probabilities of a play being confirmed (play probability) and of a prospect becoming a discovery if the play is confirmed.

The historical finding rate for this and comparable plays is an important parameter.
North Sea – all plays. Success rate and resource growth 1966-2016

Running average success rate of last 50 wells – total and for discoveries > 1 mill. Sm$^3$ o.e.

The last 50 wells - average success rate of 50%.
Norwegian Sea – all plays. Success rate and resource growth 1980-2016

Running average success rate of last 20 wells – total and for discoveries > 1 mill. Sm$^3$ o.e.
Barents Sea – all plays. Success rate and resource growth 1980-2016

Running average success rate of last 20 wells – total and for discoveries > 1 mill. Sm$^3$ o.e.
NPD play **nru,jm-1**: U. Triassic - M. Jurassic, Northern North Sea. Success rate and resource growth

Running average success rate of last 20 wells – total and for discoveries > 1 mill. Sm³ o.e.
NPD play **njl,jm-1**: Late Triassic – Middle Jurassic, North Sea. Success rate and resource growth.

Running average success rate of last 20 wells – total and for discoveries > 1 mill. Sm³ o.e.
NPD play **nhjl,jm-2**: Late Triassic – Middle Jurassic, Norwegian Sea. Success rate and resource growth

Running average success rate of last 20 wells – total and for discoveries > 1 mill. Sm³ o.e.
4: Probability of phase petroleum

Evaluations of source rock and migration are used initially to assess the probability of proving
• oil
• gas
• combination of both (multiphase discovery).

Information from the history of discoveries is very important for assessment in mature areas.
## Plays on the Norwegian Continental Shelf

<table>
<thead>
<tr>
<th>Sea</th>
<th>Total</th>
<th>Confirmed</th>
<th>Unconfirmed</th>
</tr>
</thead>
<tbody>
<tr>
<td>North Sea</td>
<td>24</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Norwegian Sea</td>
<td>21</td>
<td>12</td>
<td>9</td>
</tr>
<tr>
<td>Barents Sea</td>
<td>29</td>
<td>12</td>
<td>17</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>74</strong></td>
<td><strong>41</strong></td>
<td><strong>33</strong></td>
</tr>
</tbody>
</table>

Examples of some plays in the Norwegian Sea:
Play assessment procedure in NPD

No. of prospects:
- «official estimate»
- Mapped (leads)
- postulated

Size distribution

Discovery rate

Petroleum properties
The play analysis is assessment of both the chance that the play exist - and the YTF potential of the play.

Results:

- Number and size of future potential accumulation
- HC type in potential accumulations
- Total potential petroleum volume of the play with uncertainty range
- The potential economic value of the play
- Aggregated numbers for specific regions and the entire Norwegian shelf
Undiscovered resources split by regions

- **Barents Sea**
  - Gas: 59%
  - Liquids: 41%

- **Norwegian Sea**
  - Gas: 53%
  - Liquids: 47%

- **North Sea**
  - Gas: 34%
  - Liquids: 66%

**Total**: 2920 million Sm3 oe
Total recoverable undiscovered resources over time for each part of the NCS
Remaining resources
Creaming curve for the NCS 2013-15
Creaming curve including undiscovered resources, Barents Sea

Cumulative resources in millions Sm3 o.e.

- 1985
- 1990
- 2000
- 2011
- 2014

- 7121/4-1 Snøhvit
- Goliath
- 7220/8-1 (Skrugard)
- 7220/1-3 (Gohta)
- 7220/11-1 (Alta)

Accumulated resources estimated in billions Sm3

Creaming curve updated February 2015, undiscovered resources updated December 2013
Exploration failures on the Norwegian continental shelf

- Wildcats (2007 - 2016)
- Focus: dry targets and reason for failure

- North Sea: ~ 200 targets
- Norwegian Sea: ~ 100 targets
- Barents Sea: ~ 70 targets
All targets – trap types

Barents Sea
- Stratigraphic: 44%
- Structural: 56%

Norwegian Sea
- Stratigraphic: 18%
- Structural: 82%

North Sea
- Stratigraphic: 35%
- Structural: 65%
NCS All targets – stratigraphic level

Barents Sea

Norwegian Sea

North Sea
Discovered volumes in most tested targets

- Barents Sea: \(~180\text{ mill. Sm3 oe}\)
- Norwegian Sea: \(~140\text{ mill. Sm3 oe}\)
- North Sea: \(~220\text{ mill. Sm3 oe}\)
Main reasons for failure

North Sea

- Reservoir Presence: 28%
- Presence of Closure: 16%
- Presence of Reservoir: 10%
- Source/Charge: 46%

Norwegian Sea

- Reservoir Presence: 38%
- Presence of Closure: 12%
- Presence of Reservoir: 15%
- Source/Charge: 35%

Barents Sea

- Reservoir Presence: 41%
- Presence of Closure: 27%
- Presence of Reservoir: 12%
- Source/Charge: 20%

Legend:
- Orange: Reservoir Presence
- Yellow: Reservoir Quality
- Green: Source/Charge
- Brown: Trap

- Presence of source
- Maturity of source
- Migration of HC
- Presence of closure
- Presence of top seal
- Presence of lateral seal
- Presence of reservoir
- Quality of reservoir
In Summary:
- Still many opportunities for exploration on the NCS

- The Authorities work hard to give the industry access to these opportunities
- Maintaining a long-term perspective
- Important to learn from earlier mistakes and successes
Thank you for your attention!