Leads, Prospects, Plays and Resource estimation

Why should the government know?
Key questions: from the President, politicians, media, oil companies, NGOs........

• How much oil and gas?
• Where are the resources?
• When will they be found?
• When can they be produced?

Can YOU answer?
I need to know the Petroleum Resource volume in order to:

• make national financial strategies and budgeting
• make legislation and tax regulations
• facilitate promotion,
• initiate licensing
• negotiate contract terms
• formulate investment strategies
### Project Maturity sub-classes

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>On Production</td>
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<tr>
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</tbody>
</table>

### Project status category

<table>
<thead>
<tr>
<th>Code</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>S</td>
<td>Sold and delivered</td>
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<td>Lead and Play</td>
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### Resource classes

- **RESERVES**
  - Production
  - RECOVERABLE
    - On Production
    - Approved for Development
    - Justified for Development
  - CONTINGENT RESOURCES
    - Development Pending
    - Development unclarified or on Hold
    - Development not Viable
  - Unrecoverable

- **PROSPECTIVE RESOURCES**
  - Prospect
    - Lead
  - Play

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**What resource class do you need to know?**
<table>
<thead>
<tr>
<th>Resource class</th>
<th>Category</th>
<th>Project status</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRODUCTION</td>
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<td>PROVED</td>
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<tr>
<td>RESERVES</td>
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<tr>
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</table>

I want to know the Proven oil reserves!
In 2 minutes!!!!!
Proven oil reserves (million barrels)

<table>
<thead>
<tr>
<th>Country</th>
<th>OIL (MMbbl)</th>
<th>(GAS BCM)</th>
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</thead>
<tbody>
<tr>
<td>CAMBODIA</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>CHINA</td>
<td>????</td>
<td></td>
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<tr>
<td>INDONESIA</td>
<td>3500</td>
<td>17 bcf</td>
</tr>
<tr>
<td>KOREA</td>
<td></td>
<td>0.4 tcf</td>
</tr>
<tr>
<td>MALAYSIA</td>
<td>3000</td>
<td>400 tcf</td>
</tr>
<tr>
<td>PHILLIPINES</td>
<td>28</td>
<td>3 tcf</td>
</tr>
<tr>
<td>THAILAND</td>
<td>435</td>
<td>11 tcf</td>
</tr>
<tr>
<td>TIMOR LESTE</td>
<td>700</td>
<td>14 tcf</td>
</tr>
<tr>
<td>VIETNAM</td>
<td>150</td>
<td></td>
</tr>
</tbody>
</table>
Proven Reserves:

BP: -

CIA: 0 million barrels oil, 0 billion m$^3$ gas
Proven Reserves:
BP: 14 800 million barrels
CIA: 20 350 million barrels oil, 3030 billion m³ gas
Proven Reserves:
BP: 4 200 million barrels
CIA: 3 990 million barrels oil, 3000 billion m³ gas

13.10.2011
Proven Reserves:

BP: -

CIA: 0 million barrels oil, 50 billion m$^3$ gas
Proven Reserves:
BP: 5 800 million barrels
CIA: 4 000 million barrels oil, 2 350 billion m$^3$ gas
Proven Reserves:

BP: -

CIA: 138 million barrels oil, 98 billion m³ gas
Proven Reserves:

BP: 400 million barrels oil

CIA: 435 million barrels oil, 312 billion m³ gas
Proven Reserves:

BP: -

CIA: 553 million barrels oil, 200 billion m³ gas
Proven Reserves:

BP: 4,400 million barrels

CIA: 600 million barrels oil, 192 billion m$^3$ gas
Proven Reserves:
BP: 6 700 million barrels
CIA: 5 670 million barrels oil, 2 039 billion m³ gas
Total recoverable resources:

- ~ 13 billion Sm$^3$ o.e.
  - 5.5 billion Sm$^3$ o.e. Produced
  - 3.1 billion Sm$^3$ o.e. Reserves
  - 1.7 million Sm$^3$ o.e. Contingent resources in fields and discoveries
  - 2.6 billion Sm$^3$ o.e. Undiscovered resources
Resource account for Norwegian shelf

Systematic analysis based on all data acquired

Published on paper and internet
We are going to talk about Prospective Resources

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<th>NPD 2001</th>
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We are going to talk about Prospective Resources.
Definitions

• Petroleum system.
  – A group of plays within a given geographical area having a common source rock.

• Play.
  – A geographically and stratigraphically delimited area where common geological factors exist in order that petroleum accumulation can occur.

• Prospect.
  – A potential petroleum trap.
  – With a mappable reservoir rock volume.
Prospect Volume

Producible oil volume = Gross Rock volume $\times$ N/G ratio $\times$ porosity $\times$ Hydrocarbon saturation $\times$ Formation volume factor $\times$ Recovery factor
Methods for resource assessment

- Analogue
- Petroleum Systems
- Areal yield
- Volumetric yield
- Geochemical material-balance
- Historical methods
- Prospect and play analysis
- Direct or combinations of methods
<table>
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<tr>
<th>LOK</th>
<th>Basin Description</th>
<th>Methodology</th>
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</table>
| Very High      | The basin is very well explored and has a multitude of discoveries in all plays. Most plays are regarded as mature but some will be regarded as emerging. A large proportion of the basin is covered by 3D seismic. The success rate is on a decreasing trend | Mature fields  
Material balance  
Decline analysis  
New fields and discoveries  
Quantitative Reservoir Simulations.  
Probabilistic volumetric calculations  
Play and Prospects  
Probabilistic prospect analysis  
Play analysis level A |
| High           | The basin is well explored and has several discoveries. Most of the plays are confirmed, but some are still unconfirmed. Some 3D seismic surveys exist outside of the discoveries and the 2D grid is dense. The success rate is on an increasing trend | New fields and discoveries  
Probabilistic volumetric calculations  
Plays and Prospects  
Probabilistic prospect analysis  
Play analysis level B |
| Moderate       | The basin is moderately explored. At least one play is confirmed, but most plays are unconfirmed. Only 2D seismic data exists outside of the discoveries | Plays and Prospects  
Probabilistic prospect analysis  
Play analysis level C |
| Low            | Little exploration has taken place. No plays are confirmed. Only a few regional seismic lines or a very coarse grid of 2D seismic exists | Plays  
Play analysis level C |
| Very Low       | None or very little exploration has taken place in the basin. No or little seismic exists. | Delphi and Analogue methods |
Analogue – when you know little about the basin

- Sedimentary basins with no or little exploration and with very little data/information about geological evolution and prospectivity.
- Compare the basin with other known explored basins anticipated to be of similar geological evolution where information is available.
- Require good analogue database.
Petroleum system (PS)

• The petroleum system is the essential elements and processes as well as all genetically related hydrocarbons that occur in petroleum shows, seeps, and accumulations whose provenance is a single pod of active source rock.

• Source rock is basis for PS
Petroleum system

- Limit of mature and active Source
- Play 1 (unconfirmed)
- Play 2 (confirmed)
- Prospect
- Field/Discovery
- Reservoir/Seal distribution
- Geographical extent of Petroleum System
- Source Rock Distribution

Dr. Alfred Kjemperud

Modified from R. Birtles, 2000
**Play fairway analysis**

**Petroleum systems**

- **Reservoir**
  - Isopach
  - GDE
  - Reservoir present CRS
    - Reservoir effectiveness CRS

- **Source/charge**
  - Source present
    - Charge effectiveness CRS

- **Trap/Seal**
  - Trap/seal present
    - Trap/seal effectiveness CRS

**Play fairway composite common risk segment (ccrs)**
Total Petroleum System TPS (USGS)

The TPS is a naturally occurring hydrocarbon-fluid system in the lithosphere that can be mapped, and includes the essential elements and processes needed for oil and gas accumulations to exist. Assessment based on probability for

1. **Charge** (source rock and thermal maturity)
2. **Rocks** (Reservoir, trap and seal)
3. **Timing** (relative ages of migration, traps and preservation)
In the Circum-Arctic Resource Appraisal (CARA), 35 provinces were examined, of which 25 were judged to have a 10-percent or greater probability of at least one significant undiscovered petroleum accumulation in any constituent assessment unit (AAU), and were therefore quantitatively assessed. Shown in these three maps are the relative probabilities for all assessment units assessed and the estimated relative potentials for undiscovered oil and gas in the assessed provinces.
Assessment Unit (AU) within the Total Petroleum System (TPS)

• The assessment unit (AU) *is a volume of rock* within the TPS that encompasses fields, discovered and undiscovered, sufficiently homogeneous in terms of geology, exploration strategy and risk characteristics to constitute a single population of field characteristics with respect to criteria used for resource assessment.

• TPS may consist of several AU.
Arial yield

Potentially productive area * Yield

A simple, “quick and easy” method

Problem:
Does not take into account variations in depth!

Volumetric yield

Potentially productive area * 
Average net pay thickness * Yield
BASIN ASSESSMENT BY VOLUMETRIC YIELD

NC VOLUME FACTORS

BASIN AREA, $\text{m}^2$ (A)

$\times$

AVERAGE TOTAL-SEDIMENT THICKNESS, $\text{m}$ (T)

$\times$

POTENTIAL BBL/MI$^3$

POTENTIAL FIELDS IN BASIN


OD 0404007
Geochemical material balance

Calculate the amount of hydrocarbons generated from the source rock, migrated and entrapped.

Important factors:
- drainage area
- thickness of source rock above and below reservoir bed
- generated amount of hydrocarbons
- migrated amount of hydrocarbons
- entrapped amount of hydrocarbons

Problem:
The level of understanding of the basic processes and the ability to reconstruct the geological history.
PROSPECT ASSESSMENT BY GEOCHEMICAL MATERIAL BALANCE

NC VOLUME FACTORS

DRAINAGE AREA (A) x
SOURCE THICNESS (T₁ + T₂) x
% ORGANIC CONTENT x
% GENERATED INTO HYDROCARBON x
% MIGRATED x
% TRAPPED x
% POTENTIALLY RECOVERABLE

POTENTIAL FIELD IN PROSPECT
Historical method

- Field number and size

Extrapolate known prospect sizes and discovery rates from drilled prospects to undrilled prospects.

Problem:

Based on areas where all relevant prospects are mapped.

Prospect types which are not easily recognised, as stratigraphic traps are a problem.
EXTRAPOLATION OF DISCOVERY RATE EXPRESSED AS BARRELS DISCOVERED PER FOOT DRILLED

![Graph showing the extrapolation of discovery rate expressed as barrels discovered per foot drilled. The graph plots U.S. cumulative billion barrels of crude oil against BBL/FT drilled, with data points for 1940, 1945, 1950, and 1955. The graph includes lines indicating best, average, and worst performance.]
Discovery Process Modelling

![Graph showing discovery size vs. order of discovery.](Image)

- Discovery size (mill. Sm³ o.e.)
- Order of discovery

Legend:
- Blue dots: Actual data points
- Green line: Trend line
- Red dashed line: Extrapolation
- Grey dotted line: Additional trend line

Questions:
- ?
- ?
- ?
Estimating undiscovered resource volumes by statistical methods – play modelling

A Petroleum play is:

• Geographically and stratigraphically delimited area.
• Specific set of geological factors; reservoir, trap, source.
• Confirmed play: discovery.
• Unconfirmed play: no discovery.
  • The play is risked.
Common Risk Segment Overlay Process (to get the Composite Risk)

1. Reservoir Presence
2. Reservoir Effectiveness
3. Seal Presence + Effectiveness
4. Petroleum Charge

Result

Composite Common Risk Segment Map (shows overall play risk)
Statistical modeling

Input data:
- Number of prospects
- Discovery rate
- Petroleum properties

Assessment software: Data processing

Results: Number and size distribution of future discoveries, volume of oil, gas and condensate.
Reliably assessing the resource base takes:

1. Hard work
2. Skilled civil servants
3. Functional government institutions
   • May require assistance from cooperating countries
   • May require use of independent consultants