Reservoir Management

Goals for Reservoir Management

- **Primary Goal**
  - Maximizing the value of the asset (reservoir)
    - Net Present Value
    - For the owner
    - For the society

- **Secondary Goals**
  - Get sufficient information about the reservoir
    - Size and properties
  - Optimal recovery
    - Rate
    - Total recovery
  - Reduce/control costs
How to make use of info from the reservoir

- Collect info from seismic, well logs, cores, fluid samples, well tests etc..
- Put info together in geological model
  - Evaluate uncertainty
- Build reservoir simulation model
  - Evaluate uncertainty
  - Run simulations based on what if? questions
- Update models based on new info when required
Reservoir management is a lot like riding a bicycle,

- it is much easier to do than to tell how you do it

(if you know your goal)

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**Technology challenges (in Norway)**

- Improved predictions of exploration potentials
- Efficient and low cost drilling and intervention
- Cost efficient sub-sea developments planning for high recovery
Production technology Development

Example: Tyrihans field

PDO (1997) withdrawn - poor economics
- Drainage from a FPSO

PDO (2005), Sub-sea
Perhaps the most extensive use of advanced solutions so far proposed for the NCS.

Advanced wells, operators on land
Water and gas injection
Seawater pump on the seabed
40-kilometre pipeline electrically heated
Connected to nearby fields
No additional offshore staffing.

New technology has helped to increase the reserve with additional 6 billion cubic metres of gas and 38 million barrels of oil.
Reservoir Management: Technology Shifts

Shift 1: Reservoir data and modelling (80-90)
- Better reservoir description
- Most important element for improved oil recovery in the NCS up to about mid nineties
- 3-D seismic, geophysical and geological modelling

Shift 2: Advanced drilling (90-00)
- Drainage of unswept areas
- Most important element for improved oil recovery in the NCS from about mid nineties

Shift 3: The “Process” approach to reservoir management (00-10)
- “Integrated operations”
  - The IT revolution - transition to process control
  - Field optimisation is provided through real-time monitoring and control action

Where is the next shift?: The “Organic well systems”?

Advanced well systems – the key to the future

- Tailor made well systems for a given reservoir
- Continuously optimize production and injection along the well
- New ways of monitoring reservoir response
- New ways of transforming data to decisions
NPD involvement

Assessment and analyses

- Petroleum Resource Assessment
  - Fields in production
  - Fields to be developed
  - New discoveries
  - Prospects
- Cost evaluation
- Development analyses
- Area optimisation
- Transportation analyses
- Production Forecasting
- Risk Assessment
- Safety analyses
License monitoring

- NPD is monitoring to secure:
  - Prudent exploration, development and depletion of Norwegian petroleum resources
  - Safe construction and operation of production and transportation facilities
- NPD is monitoring that terms and conditions agreed in following documents are in compliance:
  - License Agreement
  - Approved “Plan for Development and Operation (PDO)”
  - Annual Production Permit
- Auditing normally performed only to verify compliance in connection with safety and metering requirements

License monitoring (cont.)

- Prerequisite for monitoring:
  - Transparency and openness; easy access to information
  - Authority
- Information provided by:
  - Data and reports from licensee (In accordance with regulations and agreements)
  - Attendance as observer in licensee meetings:
    - Management Committees
    - Technical Committees
Important factors related to recovery

Balance between previous experience and opportunities with new technologies

Characterisation of reservoir properties
- each reservoir is unique. Optimal data acquisition and use.

Reservoir models for reliable predictions
- basis for all economic evaluations. Reservoir uncertainty.

Residual/remaining oil and its distribution
- target for actual measures to mobilise additional oil

Expertise and knowledge is essential

Cost reductions may be risky ...
Petroleum Resource Classification

**Undiscovered resources**
- 8 Prospects

**Contingent resources**
- 7F Not yet evaluated
- 6 Development not very likely
- 5F Development likely but not planned
- 4F Resources in planning phase
- 3F Controlled for development
- 2F Approved development by authority
- 1 On production
- 0 Sold and delivered

**Reserves**
- 7A Possible future measures to increase the recovery factor

**Volume (Mill Sm3 oil)**

NCS - Around 54% (average) of the oil left in the ground with present plans and technology!

Need IOR techniques to make more oil producible
Elements behind
IOR decisions and implementation

- Active involvement by authorities:
  * legislation, fact base, frame conditions,
  * identify and challenge barriers,
  * comprehensive solutions
- License policy on NCS:
  * group of active partners, NPD in observer role
  * experience transfer
- R&D and new technology
  * creation of an environment of cooperation

Examples of active involvement by the authorities to launch projects:

- Ekofisk water injection: Secondary recovery (tax incentives and license extension)
- Statfjord gas injection: Alternative to gas flaring
- Oseberg gas injection: Importing gas from Troll (special terms for injection gas)
- Troll development: Thin oil zone production (license extension)
- Sleipner gas recirculation: Condensate production
- Valhall water injection: Secondary recovery (license extension)
- Snøhvit (Barents Sea): LNG development with special tax incentives
- Optimal use of infrastructure
- Promoting R&D
Reservoir Engineering Basic concepts

- Permeability \( k \)
- PVT (Pressure Volume Temperature)
  - Viscosity \( \mu \)
  - Density \( \rho \)
  - Bubble point pressure
  - GOR
  - \( B_o \) \( B_g \) \( B_w \)
  - Rock compressibility
- Saturations
  - \( S_o + S_w + S_g = 1 \)