Ormen Lange is localized near the edge of one of the world's biggest submarine slides.
The Storegga Slide

The Ormen Lange field is located close to the steep back wall left by the Storegga submarine slide.
### Facts

<table>
<thead>
<tr>
<th>Fact</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>100 km northwest offshore Mid-Norway</td>
</tr>
<tr>
<td>Production start</td>
<td>2007</td>
</tr>
<tr>
<td>Gas production</td>
<td>20 GSm³/yr</td>
</tr>
<tr>
<td>Recoverable gas reserves</td>
<td>375 GSm³</td>
</tr>
<tr>
<td>Recoverable Condensate</td>
<td>22 MSm³</td>
</tr>
<tr>
<td>Water depth</td>
<td>800 – 1 100 metres</td>
</tr>
<tr>
<td>Operator for development and construction</td>
<td>Norsk Hydro ASA</td>
</tr>
<tr>
<td>Operator for production</td>
<td>A/S Norske Shell</td>
</tr>
</tbody>
</table>
Development area

Vertical Exaggeration = 2.5X
Structure/manifold/Xmas tree/choke module
Replaceable Choke Module

- Sensitive equipment
- Wear components
Subsea Control Module
Subsea Concept Development

- The supplier industry have played an active and important role in the concept development
- Concept Study with FKS, 2002
- FEED study with FKS, January - April 2003
- FEED/ Familiarisation studies, April - August 2003
  - FKS
  - ABB
  - Aker Kværner
- These studies have all served as input to Norsk Hydro specifications
Scope of familiarization studies

- Review Design Basis
- Review Ormen Lange functional requirements
- Review technical specifications
- Develop subsea system design
- Identify available technology and qualification needs
- Outline testing philosophy
- Outline installation philosophy
- Schedule and cost estimates
- Risk management
- Interfaces
- HSE issues
Control system specifications and standards

- Subsea System Functional Requirements
  - Spec for Subsea Production Control System
  - Spec for Subsea Mateable Electrical/Optical Connectors
  - Spec for Cleaning and Flushing of Hydraulic Systems
  - ISO 13628-6 (as is) including IWIS addendum
  - IEC-61508, (waiting for new OLF-70)
Production Control System

- The main communication system is based on fiber optics.
- High voltage electrical transmission with transformer in UTH.
- Fully redundant hydraulic-, electric- and optical system.
- The hydraulic control system is a closed loop system, with synthetic control fluid.
- The system will be designed as far as possible on proven subsea control system components.
- The overall design will aim at minimizing common cause failures.
- The system will be flexible and allow for future expansion.
- The system will be fail safe on loss of electrical power and hydraulic supply pressure.
- A retrievable control module (SCM) will be located on each Xmas tree and on the manifold (MCM).
Production Control System - Functions

- Provide control of subsea valves and chokes
- Provide controlled and safe PSD/ESD
  - All automatic shutdowns are initiated from shore
- Provide pressure and temperature readings from Downhole, X-mas Tree and Manifold
- Measure water content in gas and inject MEG/CI correspondingly
- Provide sand/erosion indications
- Give alarm upon hydrocarbon leak
- Provide interface to future instruments with high data rates
Umbilicals

- The Ormen Lange field will be controlled via two 120 km long optical-/electro hydraulic umbilicals from Nyhamna.
- One main umbilical will be connected to template A and the other connected to template B.
- A crossover control umbilical will interconnect the two production templates, providing redundant control of all the subsea wells.
- Each main umbilical will contain power cables, fiber optic lines, hydraulic supply and return lines, corrosion/inhibitor and annulus bleed lines.
- Capacity shall be included to supply future template C and D.
- The subsea main umbilical termination head shall contain step down transformers to avoid high voltage connectors.
- The main umbilicals are assumed fabricated in one continuous length.
On shore located control equipment

- Subsea Power and Communication Unit
  - High level interface to land facility SAS
  - Fiber modems
  - COPS modems
  - Power Units
  - Insulation level monitoring
  - Hardwired signal will turn off power to subsea for one minute
Communication

- Primary communication is point-to-point fiberoptic TCP/IP, one fibre to each SEM
- Dual redundancy by A- and B- system
- Two umbilicals and crossover-umbilical with 64 fibres each
- The SCM’s are ‘communication nodes’
- ‘LAN’ interconnecting SEMs, enabling communication path for all SEMs in one single fibre
- Backup communication on COPS
Communication performance

- Subsea valves to start <1s after operator command
- Measurements every second (or on change)
- All protocols shall be widely used standards
- SPCU provide transparent link to SEM connected equipment
- 10 files of 100kbyte each in less than 10s from SEM to SPCU on each modem channel
- 10dB margin on S/N ratio giving BER<10E-8
- SEM transmit without SPCU polling
- SPCU send identical commands to A and B-SEM. Arbitration done by land facility SAS
- Transmit and receive on same fibre
Electrical Power

- High voltage, approx. 3kV in umbilical
- Transformer in UTH
- 400-800V to SCM’s
- 4 quads in each umbilical, ie. up to 9 SEM’s powered from each quad when all four templates are fully populated
Hydraulics

- Closed loop to maintain zero-discharge
- Synthetic fluid
  - Castrol Brayco Micronic SV/A as base case
  - Reliability aspects
- Change-over valves in SCM
- Electrically held isolation valves to bleed down each Xmas Tree
- Configurable Logic Cap on Manifold
- System performance
  - Open 4wells in one hour, then one well every hour for both umbilicals simultaneously
  - Hydraulic analysis
Umbilical cross section (typical)

- 4 power quads
- 64 fibres
- 3 off 19mm HP/LP/return
- 1 off 19mm scale inhibitor
- 1 off 19mm annulus test
- 1 off 19mm spare
Shutdown PSD/ESD

- All automatic shutdowns are initiated from shore
  - Subsea choke shutdown
  - Single barrier shutdown (PSD 5.01xS) (SIL1?)
  - Double barrier shutdown (PSD 5.01xD) (SIL1)
  - Electrical/hydraulic power-cut (SIL2)
Subsea Instruments

- Wet Gas Meter
  - 5% mass gas flow rate
  - 0.01% vol water sensitivity
- Water Fraction Meter
  - 0.01% vol water sensitivity
- PT/TT’s
- Acoustic Sand Detector
- Erosion Probe
- MEG flowmeter
- Choke LVDT
- Hydrocarbon leak detector
- Downhole PT/TT –IWIS
- Downhole optical ‘Geophone’
Redundancy considerations

- Roxar WGM
  - Mass flow rate
  - Condensate flow rate
  - Water flow rate
    - Backup mass flow: DP measurement over choke
    - Backup condensate: PVT calculations
    - Backup water flow rate: Sentech SeaCap

- Sentech SeaCap
  - Water fraction in liquid phase
    - Backup: Roxar WGM
Water Fraction Meter - Sentech SeaCap

- 8” Prototype built
- Full scale test planned
Wet Gas Meter - Roxar WGM

- Improving resolution on unit designed for Snøhvit
The main areas that may require qualification:

- Hydraulic fluid
  - The hydraulic fluid
  - Hydraulic components
- Umbilical Termination Head /Transformer Unit
- Electrical backup communication modem
- IWIS interface
- MEG dosage valves
- Optical feed through for the Xmas tree/tubing hanger
- Water in gas monitoring
  - Water Fraction Meter
  - Wet Gas Flow Meter
Challenges Distance/Monitoring

- Hydraulic capacity
- Hydraulic oil
- UTH / Transformer / Power transfer
- Reliability / Availability
  - Costly interventions
  - Fault tolerant system
- Adequate communication interfaces
- Water measurements
  - Hydrate
  - Corrosion
Subsea Production System Flow Diagram

- X-mas tree
- Choke module
- To shore

- Wellhead connector
- Wellhead from shore
- From shore
- Well slot
- MEG 6"
- ATV
- 20"
- Well slot
- 8 slots template
- MEG Flow Meter (MFM)

- WM = Water Fraction Meter
- WFM = Wet Gas Flow Meter
- E&M = Erosion & Momentum
- ASD = Acoustic Sand Detector
- MC = MEG Control

- Gas
- MEG
- Annulus

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