PETRONAS - PETRAD - INTSOK – CCOP DEEPWATER SUBSEA TIE-BACK

POWERING SUBSEA LOADS OVER LONG DISTANCES
Presentation Overview

- History
- Typical Subsea Consumers
- Electrical Configurations and Characteristics
- Subsea Electrical Market Status
- Reference Projects
- Summary
ABB Electrical Subsea History
Developing with the industry

1980-present
ESP
More than 200 electrical systems delivered

2000
SEPDIS
Subsea Frequency Converter

2000-2003
TOPACIO & CEIBA
First systems with subsea transformer

2000-2009
TYRIHANS
31km tie-back subsea electrical system

2006-2009
ORMEN LANGE
20MVA Subsea Transformer

2007-2010
ÅSGARD
Long Step-out Power qualification, 15MVA, 47km, 200Hz

2008-2011

Competence

System knowledge
Project execution
Industry/Vendor collaboration
Technology qualification

Developing with the industry
Typical Subsea Consumers

Supply subsea base equipment with electric power

- Subsea Power Consumers
  - Subsea Water Injection Pumps
  - Subsea Multiphase Pumps
  - Subsea Gas Compressors
  - Subsea Downhole Pumps
  - Subsea Booster Pumps
  - Subsea Separation
  - Pipe Heating

- New Field Developments: Marginal, Satellite and Deep Water
- Developments Without Platforms
- Long Distance Between Field and Platform/FPSO
- Extended use of Existing Infrastructure
Typical Configuration – Short Distance - Single Consumer

REFERENCE PROJECTS:
- Lufeng by STATOIL
- Troll-Pilot by Norsk Hydro
- ESPs (more than 200 units delivered worldwide)

STEP-OUT DISTANCE:
- Step-out distance up to 10-25 km, depending on load and pump characteristics

CAPABILITY:
- 1-4 MVA
- Operating transmission voltage typically 6 kV

TECHNOLOGY STATUS:
- All components qualified
Typical Configuration – Long Step-Out

REFERENCE PROJECTS:
• Tyrihans by Statoil
• Topacio by Mobil
• Ceiba by Amerada Hess
• Åsgard MF Project VSD & Long Step-out Power qualification

STEP-OUT DISTANCE:
• Step-out distance up to 60km, depending on load, frequency and pump characteristics

CAPABILITY:
• Up to 15 MVA
• Operating transmission voltage up to 50kV

OFFERING:
• Increased step-out
• Substantially reduced cable cost due to high transmission voltage
Hybrid Solution

- Supplying multiple consumers
- Competitive solution for Subsea drives
- Reduce cable cost (one cable from shore)
- Risk mitigation
- Maintenance access via helicopter
- Increased availability compared to using subsea converters
- Utilize standard products
- Capability > 100MW @ 100km
Considerations for Selecting Subsea Electrical Topology

- Distance
- Power
- Number of consumers
- Voltage

- Topside electrical system
- Complete subsea system
- Topside electrical system with subsea transformer
- Hybrid system

Cost & Risk
Capability Envelope – Topside Electrical Systems
Current Technology

Power/ MVA

Distance/Km

0  5  10  15  20  25  30  35  40  45  50  55  60

Topside electrical system  Topside with subsea transformer
Presentation Overview

- Typical Subsea Consumers
- History
- Typical Configurations and Characteristics
- **Subsea Electrical Market Status**
- Reference Projects
- Summary
Subsea Market – Technology Steps

Process Technology Forum 2007 – ÅSG MFP-project

Subsea boosting- technology steps

Total power [MW]

Step-out distance [km]

Water depth: • 200-500 m  • 500-1000 m
Subsea gas compression system pilot
Source Norsk Hydro

Subsea gas compression candidates
Symbol size indicates total installed power
year indicates start benefit / possible start up

Step out for power (km)

Water depth (m)

- 2008 Mikkel 10 MW
- 2008 Oseberg DSG-s 9 MW
- 2009 Corrib 8 MW
- 2013 Snøhvit compression 1 - 10 MW
- 2021 Snøhvit compression 1& 2 - 34 MW
- 2014 Tyrihans 15 MW
- 2016 Ormen Lange 50 MW

Jack & St Malo

Source: Norsk Hydro
Topside step-out stretch road map

- **Asgard**: 10 - 15 MVA, 200Hz
- **Existing**: 2006 - 2008
  - Tyrphans: 4 MVA, 70 Hz
- **Under development**:
  - 2008 - 2011

??
Why have subsea distribution and frequency converters not penetrated the market?

- Subsea distribution system has been on the drawing board for at least 15 years. Potential to save platform costs by placing all equipment subsea.

- So why has this not happened?

- Risk is the main reason.

- Risk mitigation is extremely important – by placing frequency converters topside, a major risk element is removed from subsea, supply via long cables.

- Since 2005 ABB has focused on step-out systems with:
  - Longer distances
  - Higher power
  - Deeper water
Presentation Overview

• Typical Subsea Consumers
• History
• Typical Configurations and Characteristics
• Subsea Electrical Market Status

**Reference Projects**

• Summary
Reference Project: Tyrihans

Field Operator: Statoil
Application: Subsea Raw Sea Water Injection
Capacity: 14 000 m³ untreated seawater/day
Pump Qty: 2
Tie-in distance: 31 km
Host platform: Kristin
Pump vendor: Aker Kvaerner Subsea
Project completion: 2009/2011

The project will add production worth > 1000 MUSD
Reference Project: Tyrihans

ABB Scope of Supply

• 2 x Topside VSD System
  • ACS1000 Water cooled converters
  • Oil filled step-down/up transformers
  • 2 x Subsea Transformer
  • 4000 kVA
  • Insulation monitoring system on pump side
  • Insulation monitoring system on umbilical

• System Design Report
  • Time domain simulations
  • Breakaway torque calculations
  • Loadflow calculation
  • Fault analysis
  • THD calculations
Frequency Converter

- Water Cooled
- ACS: 600, 800, 1000, 2000, 5000
- Sine filter
Subsea Transformer

Mechanical solution – Subsea Transformer

- Pressure compensator for volume variation
- Low voltage penetrators
- Tank of special corrosion resistant steel
- High voltage ”dry mateable” connection
Åsgard Minimum Flow Project
Åsgard MF Project VSD & Long Step-out Power qualification

Overall view of electrical test system

Phase 1
2007-2008

Key Design features:

- Power system rated for 15 MVA
- Designed for 8MW compressor shaft power
- Operating frequency up to 200 Hz
- Designed for direct and long step-out operation
- Designed to test different compressors (189/159/100Hz)
- Designed with advanced measuring system

Phase 2
2008-2010
Åsgard MF Project VSD & Long Step-out Power qualification

ABB scope of supply for Åsgard long step-out qualification program

- Equipment deliveries
- Qualification tests
- Simulations
- Installation
- Commissioning
- System Testing
Åsgard MF Project VSD & Long Step-out Power qualification

Technical challenges

- World longest cable connected to frequency converter output (47km)
- Biggest power rating for step-out system (Rated 15MVA Transmission)
- Highest supply frequency for long step-out system (up to 200Hz)
- Qualifying, building and testing
  - Detail simulation model of complete system
  - Converter (15MVA/200Hz, for Long Step-out Application)
  - Step-up Transformer (15MVA/200Hz)
  - Subsea Transformer (15MVA/200Hz)
  - Complete System testing
Subsea Step-down Transformer

Key Design features:
- Power rating 15 MVA
- Insulation level 52 or 72.5 kV
- Operating frequency up to 200 Hz
- Qualified with current and voltage measurement

Critical design parameters
- Reliability

Achieved by:
- Well established material
- Normal operating temperatures
- Natural cooling
- Pressure compensation
3-Phase Cable Simulator

**Design**
- 10 PI-sections with lumped components
- Fuse-less capacitors
- Air-core inductors
- Stainless steel resistors
- Protection and monitoring
- Outdoor installation
- Operating voltage up to 52 kV
- Loading up to 300 A
- Operating frequency up to 200 Hz

**Simulating features:**
- Cable length from 20 to 47 km
- Conductor size 150 or 240 mm²
Conclusion K-Lab / Åsgard Activities

**Advantages:**

- Minimizing big investments in new off-shore production
- Use of known technology and products optimized and adapted for this special application is important for availability and documented functionality
- VSD located on floating production units (easy maintenance)
- Motor-friendly VSD due to 9-level output voltages and Selected Harmonic Elimination control method – no output VSD filter needed despite long cables

**Status:**

- Successful completion of system test program
Presentation Overview

- Typical Subsea Consumers
- History
- Typical Configurations and Characteristics
- Subsea Electrical Market Status
- Reference Projects

**Summary**
Summary

Subsea Electrical Configurations

- Topside electrical system
- Topside electrical system with subsea transformer
- Hybrid system

Market and Technology Status:

- Topside electrical systems with subsea transformers qualified up to 15MVA up to 60km, up to 200Hz, Year 2006-2010
  - Successfully qualified by Åsgard MF Project
- High activity in qualifying systems for subsea compression
  - Long distances
  - Large powers
- Subsea Drives – Tested and offered up to 3,5MVA, Year 2000
  - Market penetration slow

Developments In Works:

- Qualify subsea transformers to 3000 meter