EUR23_34 - Replacing of Electrical Submersible Pump (ESP) Systems under offshore condition

Stephan Schröder, Wintershall Dea Deutschland GmbH

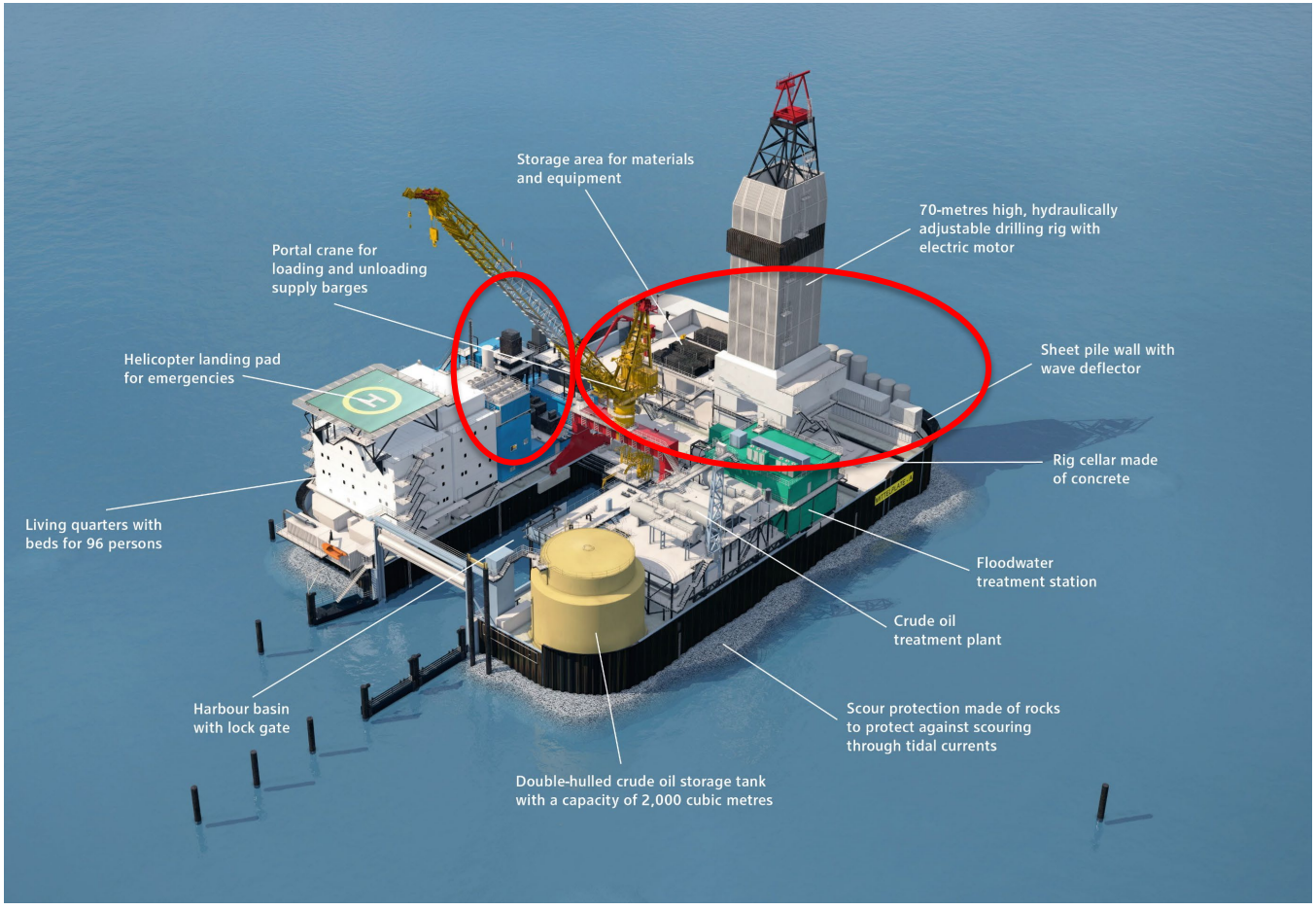
Summary

- Introduction
- Wintershall Dea at a Glance
- Facts & Figures
- Scope of Work
- Technical facts
- Work packages
- Achievements
- Lessons learned

Germany – Our Home Turf

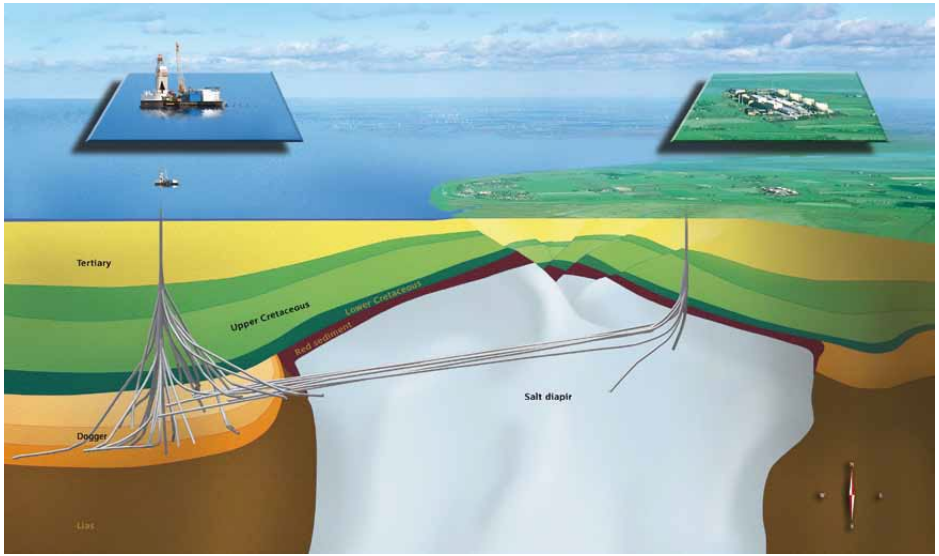
- Start of production
  - 1901 (first own oil wells at Dea)
  - In 1987 Germany´s most significant oil reservoir
- Activities
  - Producing from 3 oil fields and 14 gas fields
- Most important fields:
  - Mittelplate
  - Völkersen
  - Emlichheim
- Mittelplate is a drilling and production island located in the "Nationalpark German Waddensea"

Virtual Site Visit Mittelplate



Technical Outline Mittelplate Field

- First stage of processing at the island
- Oil transportation trough pipeline below the Waddensea tideland flats and return transportation of segregated water via pipeline to be fed back into the reservoir
- In total 30 wells on- and offshore are under operation
- Extended reach and multilateral wells



Scope of Work / Key Facts

- Replacement of the existing sixteen variable speed drives feeding the ESPs without unexpected downtime
- Restrictions to install new offshore modules due to limited space
- Use of existing infrastructure
  - Electrical Power Supply
  - DCS (Distributed Control System) / HMI (Human Machine Interface)
  - No replacement of downhole equipment
- Minimization of offshore work-packages (e. g. testing, inspection, etc.)
- Site Acceptance Test (SAT) incl. 3rd party inspection on shore

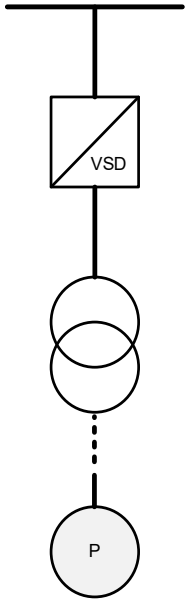
Scope of Work / Benefits

- Key facts:
  - Safe execution of the work
  - Avoidance of production losses
  - Continued operation of all ESPs during reconnection of each single ESP system
  - Complete systems test and performing Site Acceptance Test (SAT) on shore
- Benefits:
  - Cancellation of spare part supply contract
  - Increase of reliability
  - Upgrade for further field development

Typical Standard ESP system

Standard Stand – Alone ESP System

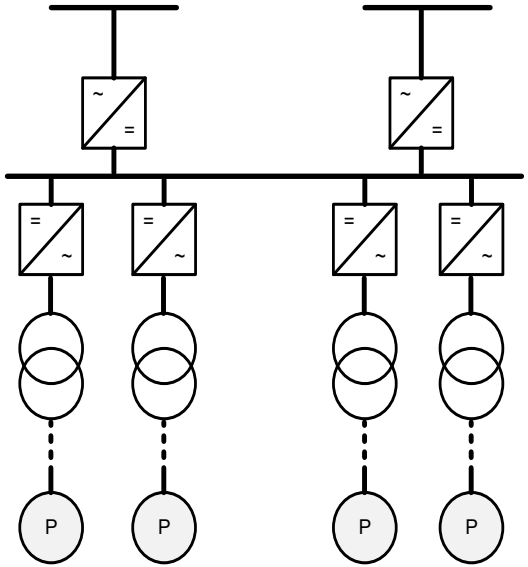
- Connection to Electrical Power National Grid / Power Supply
- Variable Speed Drive / VSD
- Step-Up Transformer
- Junction Box
- Christmas Tree
- ESP – Motor / - Pump
- Downhole Gauge / Data
- HMI / Remote Operation
- Chiller Unit (optional)



Mittelplate ESP system / Complexity

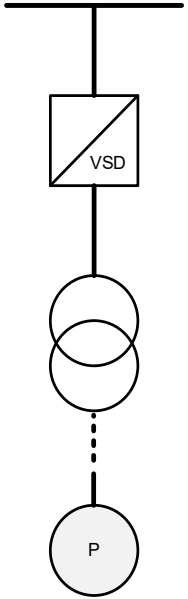
ESP-System at Mittelplate

- Connection to existing
  LV Distribution / Bypass
- Variable Speed Drives / VSD
  - 4 Rectifier
  - 2 DC busbar
  - 16 Inverter
- Step-Up Transformer
- Junction Box / Christmas Tree
- ESP – Motor / - Pump / -Downholedata
- Connecting to existing HMI
- Auxilliary Supply such as Chiller Unit



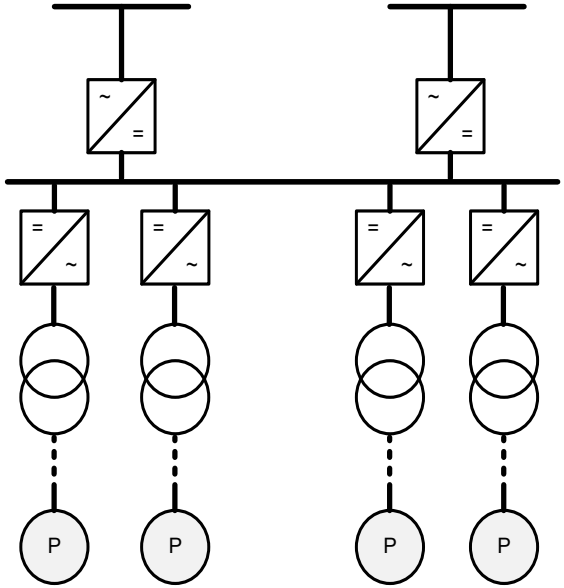
ESP System / Complexity

Standard ESP System



Comparison

ESP-System at Mittelplate



Low Voltage Distribution

1….4 Rectifier

DC busbar

1….16 Inverter

Step Up Transformer

1…..16 ESPs

Mittelplate ESP system / Components

System Configuration (2x):

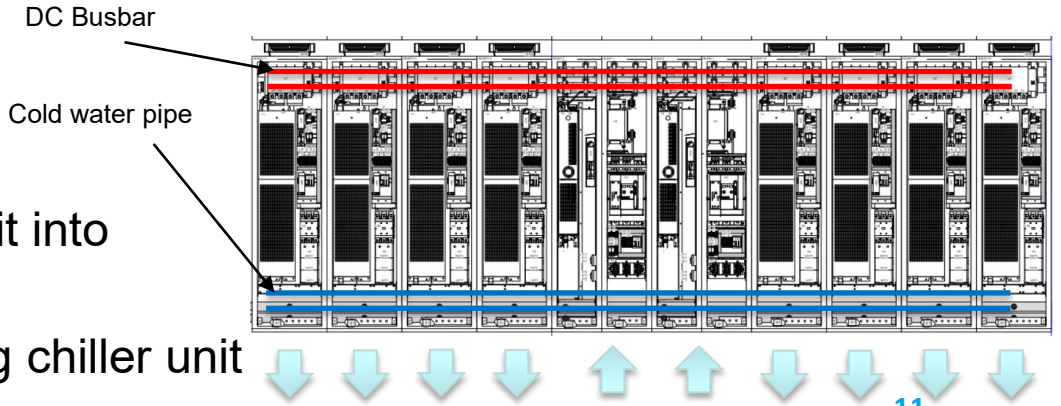
Voltage controlled frequency inverter (U/f)

2 x Incoming Throttle

2 x Feeder Modules

8 x Motor Modules

1 x DC busbar



Variable Speed Drives Unit:

- Tailormade application
- VSD chassis power units shall fit into new Offshore-Module
- Water cooled VSD unit including chiller unit

Mittelplate ESP system / Components

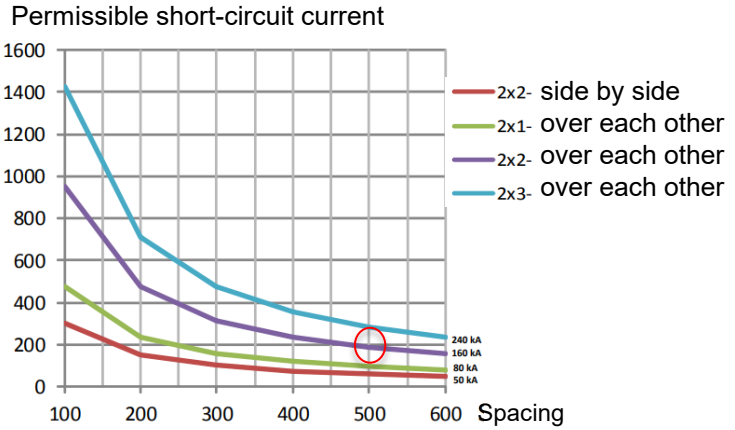
Short Circuit calculation of DC busbar:

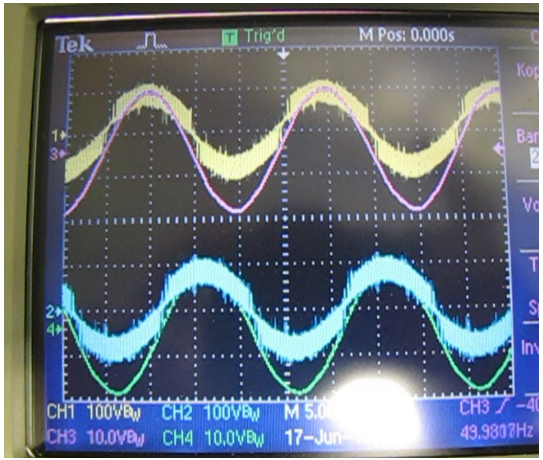
DC-Busbar:

- 2 x 2 over each other
- Calculated short circuit current = 185 kA
- 500 mm support spacing selected

Software applications:

- Implementation of Bypass synchronization (VSD => Grid)
- Adaption to existing DCS system
- Apparent current minimization





Mittelplate ESP system / Components

Throttle:

- In total 9 throttles were installed in parallel to the existing Set-Up
- Former ESP Step-Up Transformer Box was modified to collect 9 throttle

Technical Parameter:

Nominal Voltage: 690 V

Nominal Current: 950 A

Frequency: 35 – 60 Hz

Weight: 355 kg

Standard: IEC 60076

Mittelplate ESP system / Components

Step-Up Transformer:

- Designed to cope different voltage level
- Designed for VSD and Bypass operation
- Design optimised to fit into Step-Up Transformer Box

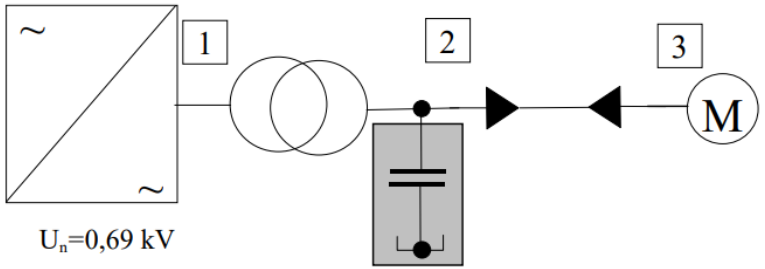
Technical parameter:

Primary Voltage:	485 V – 690 V
Secondary Voltage:	500 – 3000 V
Secondary Current:	max. 100 A
Apparent power:	519 kVA
Frequency:	25 – 60 HZ
Power factor:	0,8

Mittelplate ESP system / Component selection

System component calculation and simulation

- All single selected items were simulated as a resonant circuit
- Technical Boundaries:
  - ESP-Motor
  - VSD Outlet
  - ESP Cable type and length
- Three different measuring points were considered
  - VSD Outlet
  - X-Mas Tree
  - ESP Motor

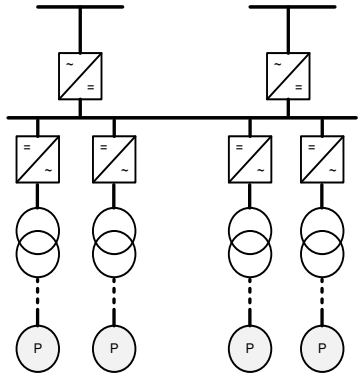


Mittelplate ESP system / Energy Savings

All new components were checked for energy optimisation

Following Efficiency improvements were achieved:

- Rectifier / Inverter => 98,11% to 98,51% => appr. 26 kW
- Throttle => 3,1 kW to 2,5kW => appr. 610 W
- Chiller Unit => 32,4 kW power input compressor
  energy savings 1:13 due to
  Free Cooling Unit



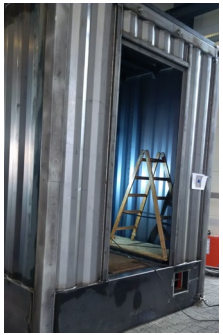
⇒ Fringe benefit: we achieved a saving of: appr. 329.000 kWh/a

Work packages / Challenges

- Installation of a new offshore module
- Integration into existing electrical grid
- Installation of cables under offshore conditions
- Power supply of new VSD system in parallel to existing VSD system under operation
- Connection to existing DCS and Human Machine Interface (HMI)
- Transportation to offshore location
- Reduction of offshore activities as a result of onshore testing
- Switching on the fly

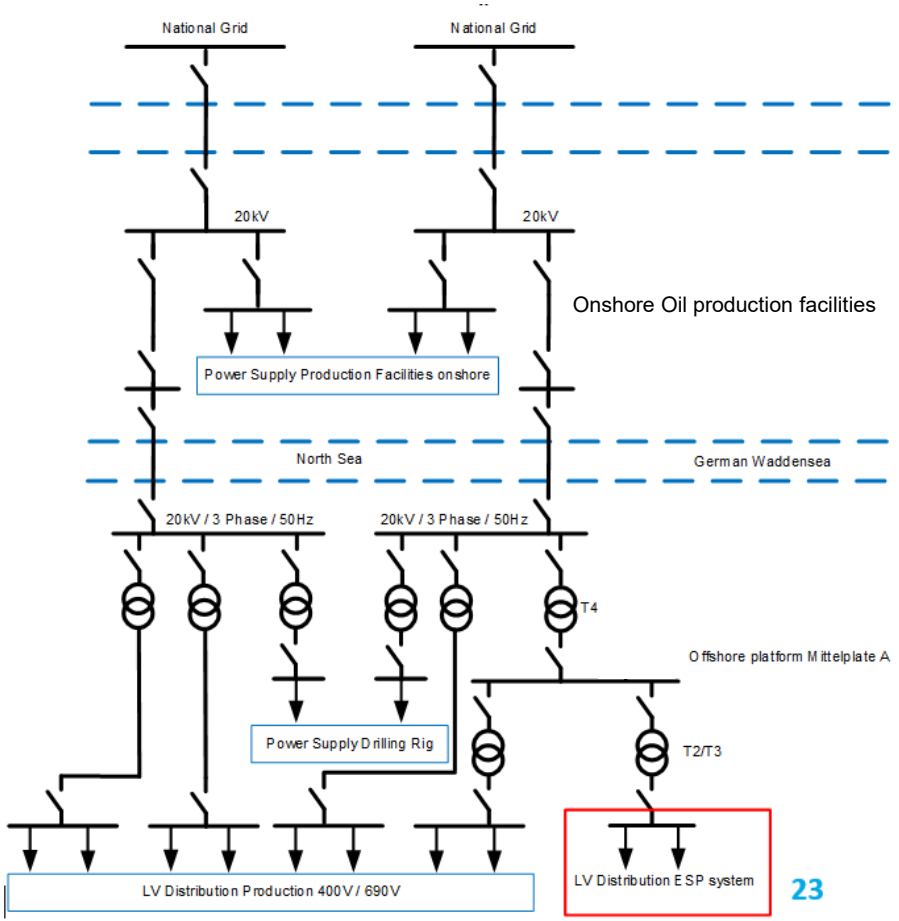
Work package / Installation of new offshore modules

- Existing VSD systems were installed in two offshore modules
- Installation of one new offshore module
- Splitting of existing 16 ESP-systems into two VSD-units
- Offshore Module tested according to DNVGL rules



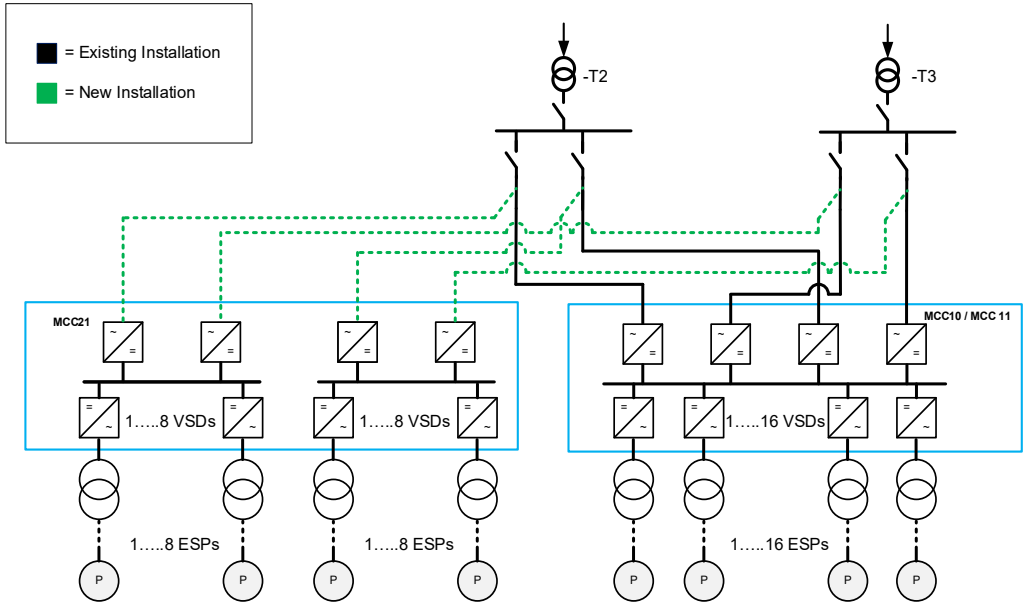
Work package / Simplified Electrical Single Line

- Power supply from renewable energy
- Power supply via two 20kV cables
- Emergency generator installed on- / offshore
- Medium Voltage Power distribution via 20 kV and 6 kV
- Low Voltage Power distribution via 690 V and 400 V



Work package / Connecting new VSD system

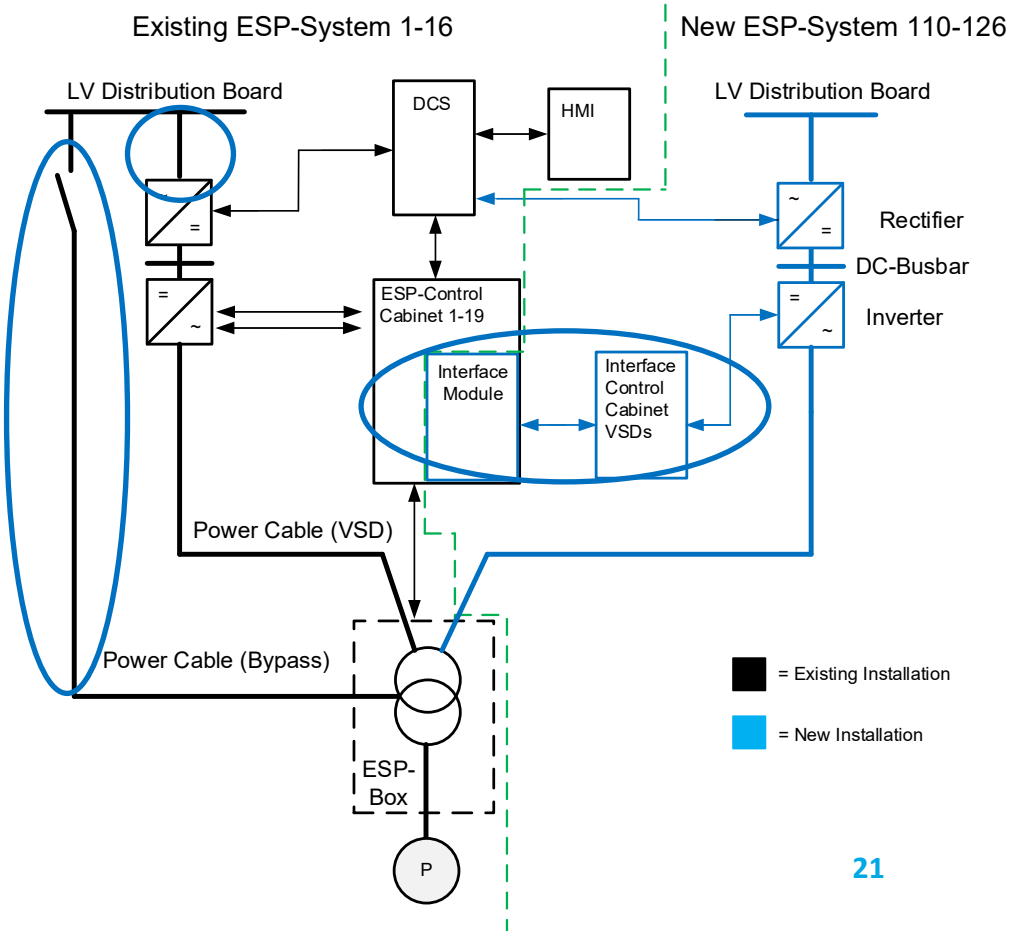
- New installation of cable trays
- New cable routing in parallel to the existing cables
- One low voltage distribution board feeding two VSD systems
- Reconnection of rectifier “step by step“



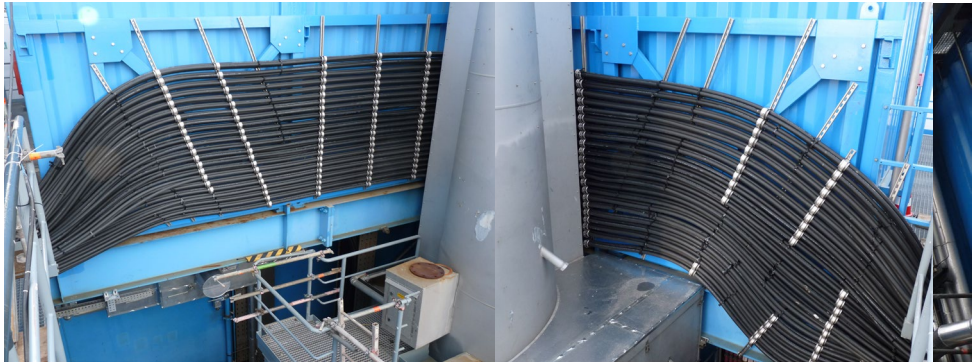
Work Package / Mittelplate ESP system / Complexity

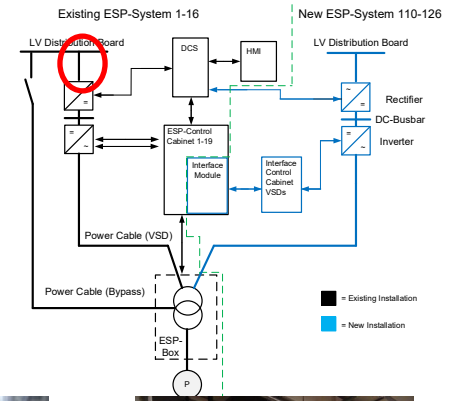
Standard Mittelplate ESP System including following connections:

- Low Voltage connection
- Medium Voltage connection
- DCS Connection and Interfaces



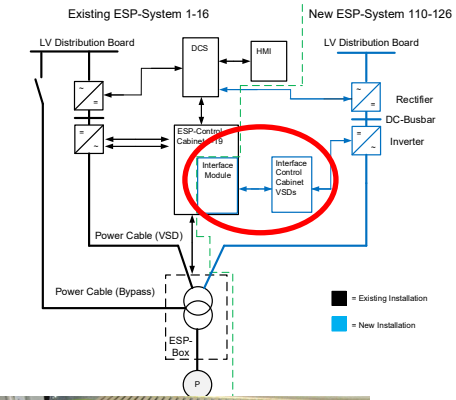
Work Package / Installation of Low Voltage Cables





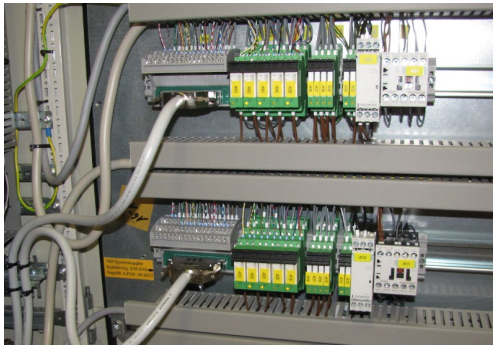
Work Package / Installation of Instrument Cables

- Installation of Instrument Cables necessary for adaption into existing system and commissioning
- New adapters were developed to link DCS with VSDs



Work package / Implementation into existing SCADA

- Concept study of stand alone DCS was carried out during FEED
  => Conclusion „Connecting to existing DCS mandatory“
- Adapters were fully tested during SAT onshore
- Complete test of the system logic between DCS and VSD onshore
- New tag numbers for the HMI system
  - Avoidance of operating errors by ensuring a clear assignment
  - TAG numbers 111 – 126 in parallel to the existing TAG numbers 1 - 16
  - Clear assignment for each ESP system



Work package / Implementation into existing DCS

Signalling ESP-System⇔ DCS:

- Start / Stop
- Frequenzy +/-
- Current / Voltage of all 3 phases
- Ramp-Up procedure
- Hand / Auto
- Synchronisation

Safety Signal from different loactions:

- Drill Cellar
- ESP Box
- VSD Module

Work package / Offshore Installation

All offshore installations were fully planned in advance

- Detailed monitoring of offshore activities
- Implementation of 2-Shift system
- Segregation into
  - Electrical
  - Mechanical
  - Nautical
  - Corrossion / Painting
  - Piping / Insulation
  - Scaffolding
  - Internal ressources

Work package / Reduction of offshore activities

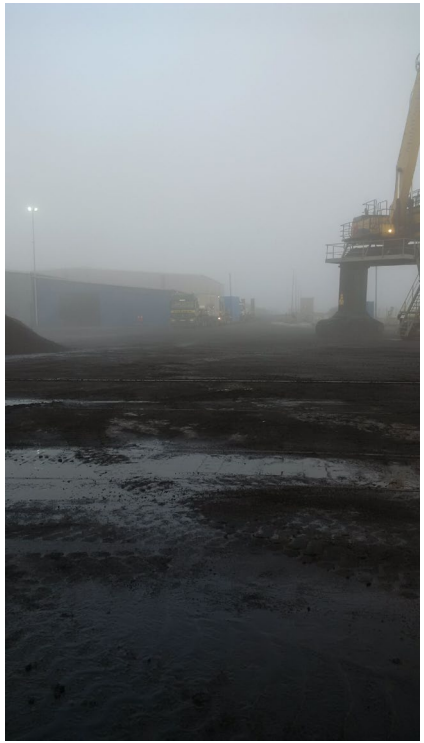
- Full Site Acceptane Test (SAT) was performed on land loaction
- Optimisation of work packages has reduced offshore time
- Whole eqiupment was tested under operating conditions
  - Chiller Unit
  - Low voltage distribution switchgear
  - VSDs / Step-up Transfomer
  - ESP- Motor
  - ESP control cabinet incl. DCS and HMI
  - Synchronisation of ESP Bypass

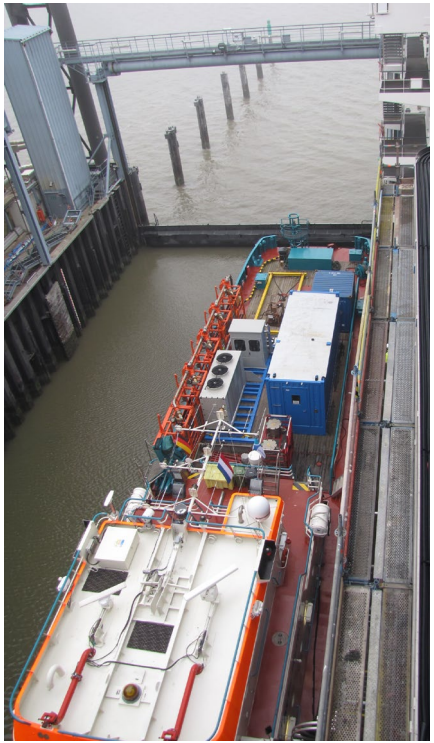
Work package / Transport under offshore conditions

Challenges:

- Permits for oversized load required
- Transportation to MPA via Vessel
- Separate Vessel for transportation
- Oversized Transportation via Ferry crossing Elbe river not allowed
- Height limitation at „Elbe Tunnel“

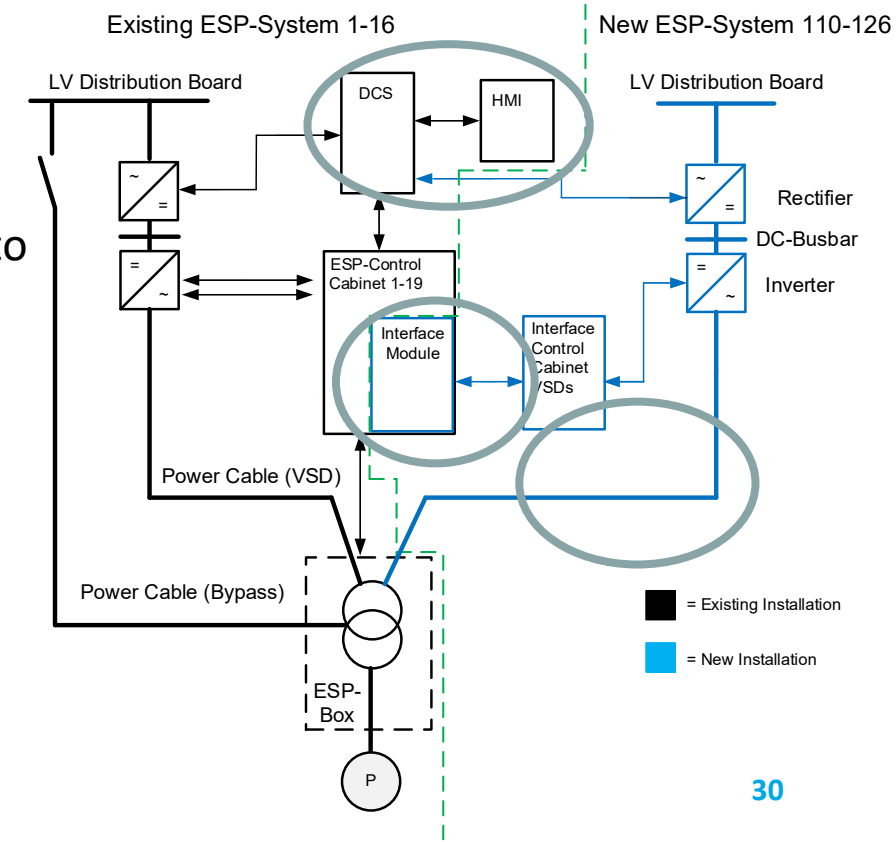
Work package / Transport under offshore conditions






Work package / Switching on the fly

- Three teams work in parallel
  - Electrical power cabling
  - Installation of the interface module into the existing control cabinet
  - Implementation of the new face plates at DCS and HMI
- Commissioning and handover after approval by three teams
- All changes has to be made without downtime



Results achieved / Commercial

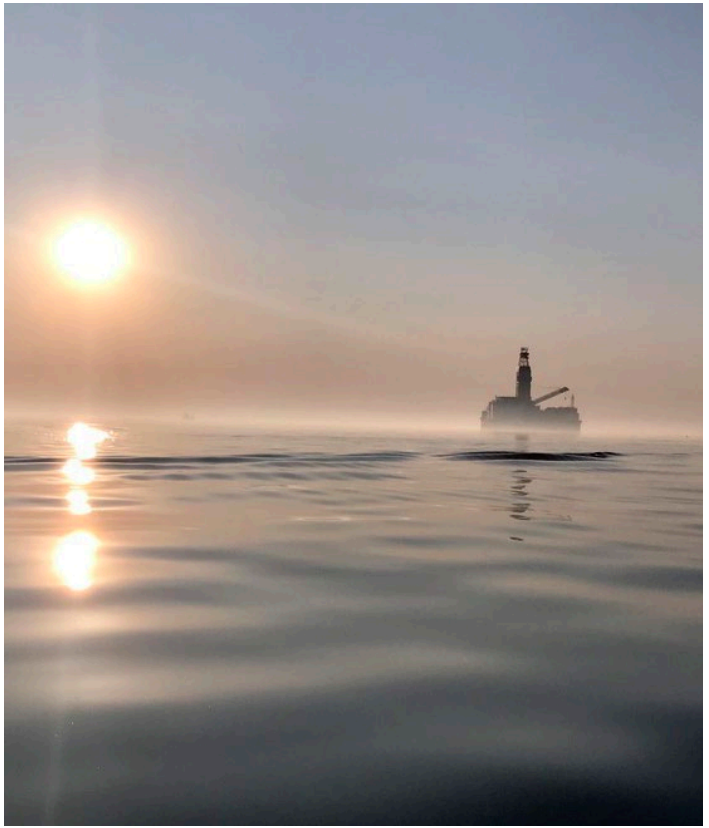
- Three weeks of production downtime have been successfully avoided
- Project duration has been reduced from 18 month to 15 month and therefore ahead of schedule
- Total downtime of only four hours per ESP
- Cost reduction for SAT and offshore installation to 1/3 due to modulized equipment and onshore testing
- Avoidance of additional DCS installation due to usage of existing DCS

Results achieved / Technical

- New compact containerized solution allows an installation at limited space
- SAT which was performed onshore reduces the offshore installation time and the risk of downtime
- Replacement time has been cut off by working with three teams in parallel

Lessons Learned

- Involvement of all Stakeholder
- Looking for simple solutions
- Close monitoring of offshore activities
- Clear and transparent communication
- Develop back-up options in advance
- Transportation is part of engineering
- Plan precautionary measures for Waiting on Weather (WoW)
- Clear safety philosophy and awareness



Conclusions

- Thank you for your attention
- Please feel free to ask questions