EUR23_21 – Recommended Practice for electrification of oil and gas facilities

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Summary

- Introduction to IOGP
- Introduction to Electrification
- IOGP Electrification Recommended Practice
- Example – Brownfield Mechanical-driven Compressor replacement
- Example – long step-out power from Shore

https://www.iogp.org/workstreams/energy-transition/

https://www.iogp.org/bookstore/product/recommended-practices-for-electrification-of-oil-and-gas-facilities/

IOGP - Introduction

International Association of Oil & Gas Producers

IOGP is the global voice of the industry and the only industry association that advocates for NOC's, IEC's, smaller operators and key service companies globally.

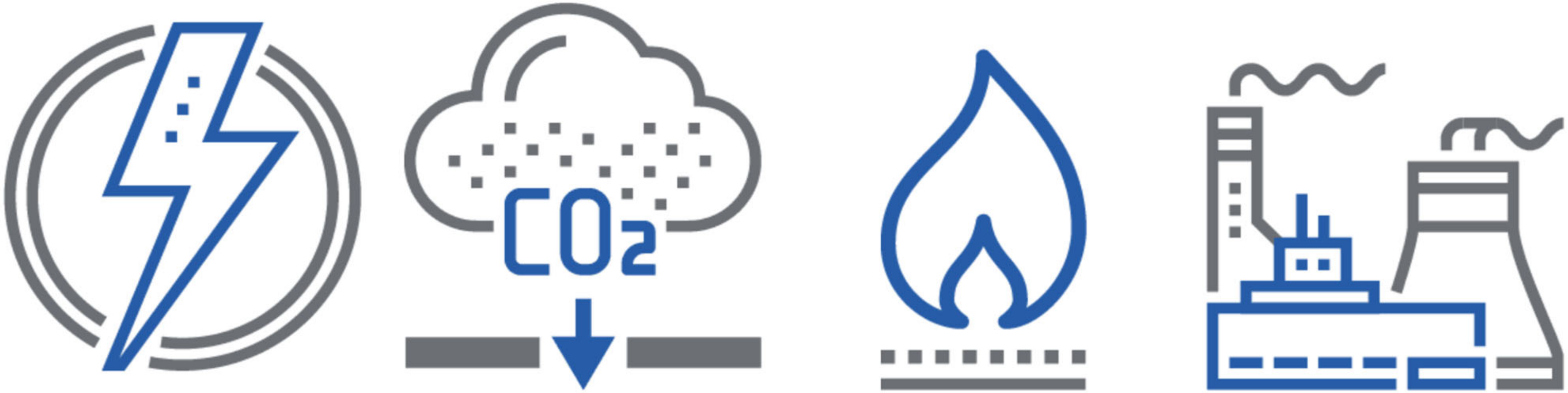
Its Members produce over 40% of the world's hydrocarbons and, with an almost 50-year history, is uniquely positioned to support and advocate for them.

IOGP drives:

- constructive discussion with Governments and regulatory bodies
- performance and efficiency in HSSE management
- reduced cost and schedule in capital projects
- science-based recommendations that inform decision making, using its historic data and expertise
- collaboration on the energy transition while providing the technical work that underpins it

Looking ahead, IOGP is also futureproofing the industry by defining future workforce needs in terms of skills and diversity.

Decarbonisation via Electrification



Electrification | CCTS | Flares & vents | Energy efficiency

The four Energy Transition topics are:

1. Electrification
2. Carbon Capture Transportation and Storage
3. Minimization of all flaring and venting activities
4. Best available technology in energy efficiency

Progressing Lower Carbon Agenda via Standardisation and Collaboration

Theme	Electrification	Energy Efficiency	Flares and vents	CCUS
Intent	Use lower carbon energy	Reduce Life of Field energy demand	Design, specify, procure and operate for near-zero methane emissions	Eliminate CO_2 to atmosphere

Main Themes

IOGP task force 1 focused on Electrification

Progressing Lower Carbon Agenda via Standardisation and Collaboration

Theme	Electrification	Energy Efficiency	Flares and vents	CCUS
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Why Electrification?

- The use of electricity for shaft power (compression, pumping) and heat (fired heaters, boilers) allows the facility to use lower carbon intensity electricity AND to get to higher efficiency
  - Use so-called “green” electrons rather than burn hydrocarbons
- An electrified solution means projects do not “lock in” Greenhouse Gas (GHG) emissions for the lifetime of the asset
  - Electrify now, use fully green electrons later

Electrification Scope

•Power from shore or nearby facilities, including national grid as well as shared infrastructure

•Integration of renewables power supply, including backup power supply

•Decarbonisation of self-generation

Electrification - Stakeholders

1 Standards Development Organisations
2 CLC/TC 14, CLC/JTC 6, TC 234
3 TC 67, TC 207, TC 265, TC 301

IOGP Lower Carbon Scoping Work Group	12 Operators	12 SDOs[1] / Industry Groups	

Our Members

We have 82 Members.

Upstream members

- Abu Dhabi National Oil Company (ADNOC)
- Aker BP
- Aker Energy
- Assala Energy
- Beach Energy
- BHP
- bp plc
- BW Energy
- Cairn Energy
- CC Energy Development
- CEPSA EP
- Chevron Corporation
- Chrysaor Holdings
- CNOOC International
- ConocoPhillips
- Dolphin Energy Ltd
- Dragon Oil
- Egypt General Petroleum Corporation (EGPC)
- Eni SpA
- Equinor
- ExxonMobil
- Genel Energy
- GeoPark
- Gulf Keystone Petroleum
- Hess Corporation
- Husky Oil Operations Ltd
- INPEX Corporation
- KazMunayGas
- Kosmos Energy
- Kuwait Oil Company
- MOL Group
- Neptune Energy
- North Caspian Operating Company (NCOC)
- North Oil Company
- Oil Search Ltd
- OMV
- Pan American Energy
- Pertamina
- Petróleo Brasileiro SA (Petrobras)
- PETRONAS
- PGNiG
- PLUSPETROL SA
- Premier Oil
- PTT Exploration and Production Public Company Ltd (PTT EP)
- Qatargas
- Qatar Petroleum
- Repsol
- Saudi Aramco
- Shell International Exploration & Production BV
- SOCAR
- Sonangol EP
- Spirit Energy
- Suncor
- Total
- Tullow Oil
- Vår Energi
- Wintershall Dea
- Woodside Energy Ltd
- YPF SA
- Zakum Development Company (ZADCO)

National and other associations

- American Petroleum Institute (API)
- Australian Petroleum Production & Exploration Association (APPEA)
- Bundesverband Erdgas, Erdoel und Geoenergie e.V. (BVEG)
- Canadian Association of Petroleum Producers (CAPP)
- Consejo Colombiano de Seguridad (CCS)
- Energy Institute (EI)
- HeliOffshore
- Insituto Brasileiro de Pétroleo, Gás e Bioconbustíveis (IBP)
- International Association of Drilling Contractors (IADC)
- International Association of Geophysical Contractors (IAGC)
- IPIECA
- Netherlands Oil and Gas Exploration and Production Association (NOGEPA)
- Norwegian Oil & Gas Association
- Oil Gas Denmark
- OGUK
- Regional Association of Oil, Gas and Biofuels Sector Companies in Latin America and the Caribbean (ARPEL)

IOGP Associate Members

- Aker Solutions
- Baker Hughes
- OPITO
- SBM Offshore
- Schlumberger
- TechnipFMC plc

12 Operators

BP
Chevron
ConocoPhillips
Eni
Equinor
ExxonMobil
Petrobras
PETRONAS
Saudi Aramco
Shell
Total
Woodside

12 SDOs[1] / Industry Groups

API
CEN[2]/Marcogaz
DNV GL
Energy Institute
IPA
IPIECA
ISO[3] / NEN
OGCI
Standards Norway
World Economic Forum

CCAC – OGMP
CCSA
GCCSI
GGFR
IDRIC
IEA GHG
IEC
MGP
National Decommissioning Centre, UK
Neptune Energy
Norwegian Env't Agency
North Sea Energy
OGTC
ZEP

Deliverables

- Lessons Learned Report (internal)
  - To be repeated / avoided for future electrification projects

- Recommended Practice (external - published 2022)
  - “How to” guide based on the lessons learned
  - Includes references to other valuable sources

- Equipment Compendium Updates (in progress)
  - Equipment/technology specific
  - Gives more details on technologies for deployment

Recommended Practice

- The use of electricity for shaft power (compression, pumping) and heat (fired heaters, boilers) allows the facility to use so-called “green” electrons rather than burn hydrocarbons

- Even in cases where connection to a low carbon intensity grid is not *immediately* possible, an electrified solution can replace mechanical drivers and fired equipment which would otherwise “lock in” emissions for the lifetime of the asset

- The recommended practice provides
  - A summary of technologies most likely to be used in an electrification concept
  - Methodologies for evaluation of the benefits and challenges of electrification
  - Guidance on key activities and studies to be done during a project development

Recommended Practice - Content

- Scope for electrification
  - Greenfield vs brownfield
- Power transmission solutions
  - HVAC
  - HVDC
- Power system components
  - Subsea power cables
  - HVAC substations
  - HVDC substations
  - Electric drives, heaters, other loads
  - BESS, renewable power generation
- Project technical feasibility assessment
- Project techno-economic feasibility assessment
  - Project benefits
  - Project trade-offs
- Project development activities
  - Grid connection
  - Studies
  - Project management & NTR
- Project delivery / execution activities
  - Design & engineering verification

PCIC energy

Examples

Brownfield Mechanical-driven Compressor replacement

Brownfield Mechanical-driven Compressor replacement

Project

AWG platform electrification

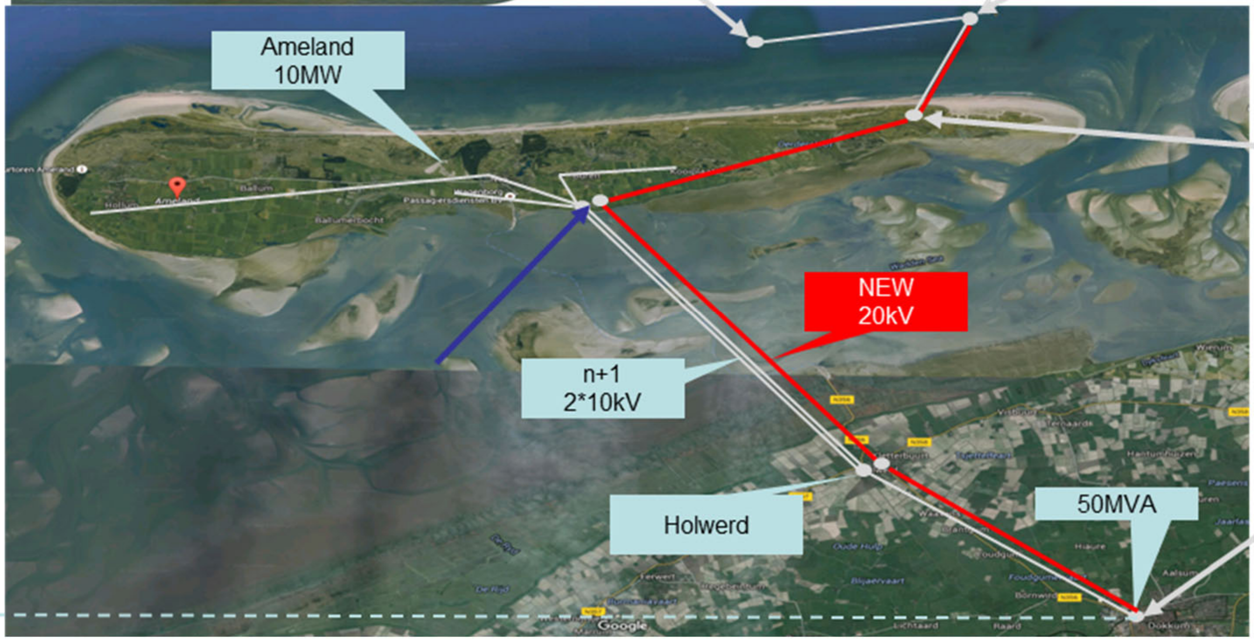
- NAM (Shell/XOM/EBN)

Project Overview

AME-2: offshore location

New 20kV cable to Ameland for AWG-1 and AME-1

AWG compressor driven by electric motor



AWG-1: production platform

AME-1: land location

Dokkum MV transformer station

Project Overview

- Part of “Duurzaam Ameland” development

Ameland Gas West

- Start production 1986
- Production ~1M m3/d
- Gas Turbine (GT) mechanical drive gas compressors
- GT generators
- Attended Installatoin
- Close to shore
- End of life >2035

Electrification Project Scope

- Convert the AWG production platform near Ameland (NL North sea)
  - from gas-powered
  - to an electrically-driven facility
- Subsea cable from AME-1 to the AWG platform, a new compressor and the overall integration into the production system
  - 5 km; 8MW; 20kV; seabed / land single cable from Ameland; water depth 0m(!) – 5m

  [Includes cable to Ameland island and AME-1 by local power company]
- Gas turbine driven exchange for 7MW fully electric driven compression
- Major brownfield modifications / integrations on AWG-1
- New E-house including transformer and Variable speed drive system (VSDS)
- De-complexing and electrification of the AME-1 location

Electrification Project Schedule

Project Milestones

- 2014 Notification of NOx emission limits changes (including offshore)
- 2016 Identify/Assess
- 2017/2018 Define; Contracting & Procurement (CP) strategy for Long lead items
- 2018 Final Investment decision
- 2021 Subsea Cable laying
- 2022 Commissioning and Start-up

Many partners

Contractors / equipment suppliers

- Boskalis / Technip / TNO / JDR cables / ABB

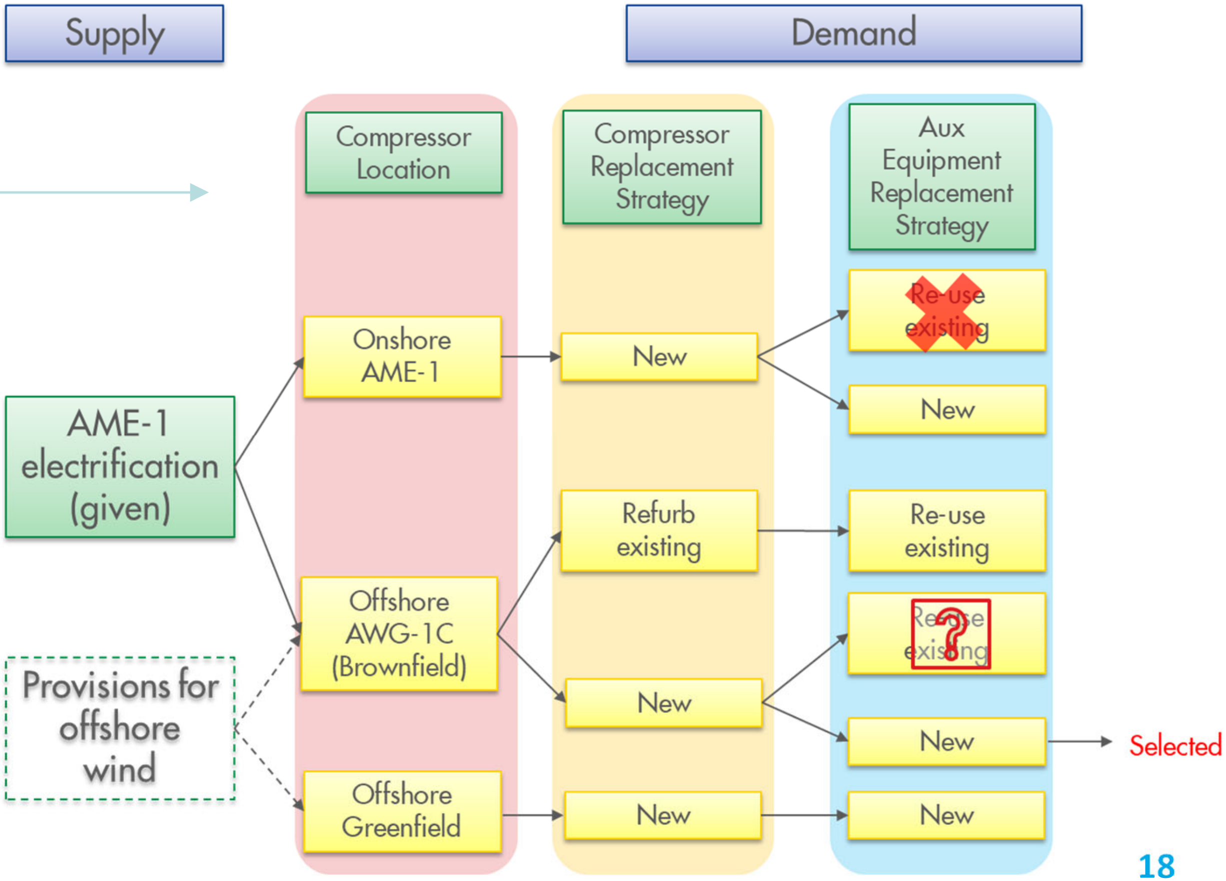
Project Challenges, key decisions

- Compressor options
  - Re-use

  Or
  - New

  Process/Control/Project interactions

- Power supply (grid capacity) insufficient for existing compressor power
  - New (smaller) compressor
  - Standard motor
  - Better control



Power Transmission Challenges and Solutions

- New cable @ 20kV from Dokkum to AME-1 (Liander) and from AME-1 to AWG-1 (NAM)
- Cable capacity limits
- Onshore grid capacity limits
  - Offshore VSDS input transformer inrush
  - Choice of drive for harmonics
- Medium Voltage (MV) stations, Dokkum, Holwerd, Kooiplaats to be extended/modified
- New MV station next to AME-1 (permit issues)

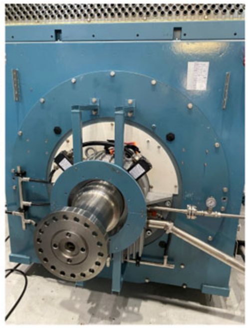
Project Development / Execution Challenges

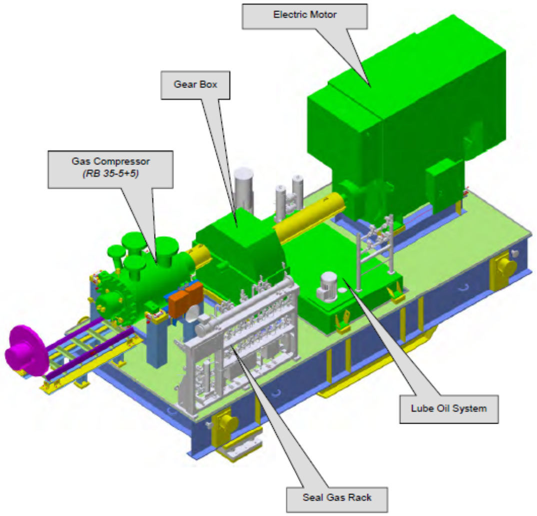
- Non-technical risk given proximity to shore
- Large number of partners and views
- Cable through nature reserve (Natura 2000)
- Cable crossing Waddenzee (depth)
- Different companies / permits
  - Permitting by grid company until AME-1
  - To AWG-1 = NAM
- Connection lead time min. 2 years
- Permits vs. project schedule risk

Electrification Components

Compressor drive and motor

- New Compressor & motor module installed by single lift
- Active Front-end (AFE) Voltage Source Converter (VSC) VDS chosen due to issues with cable capacity, voltage drop/regulation etc.
- Pre-magnetisation dry-type transformer to avoid large transformer inrush



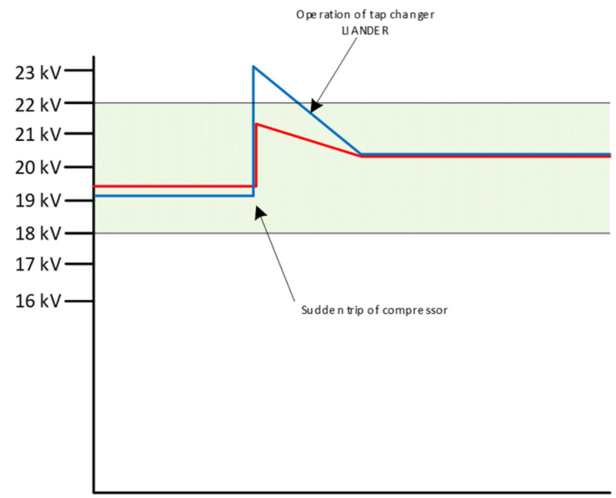


Electrification Components (other)

- Limited interface to existing plant control system
- Simplified Shutdown System including Fire & Gas (no GT interactions)
- Additional Uninterruptible Power Supply equipment
- Additional Fibre Optic cable connections provided

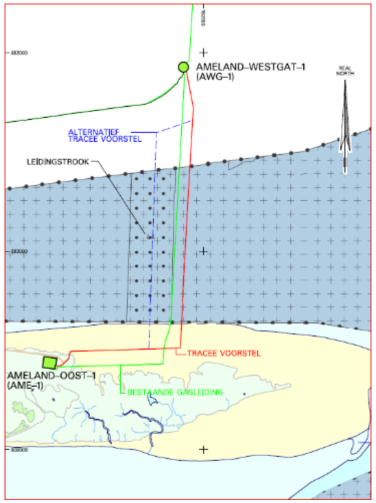
Project Technical Feasibility (Grid connection)

- Limited cable ampacity/capacity
- Limited grid Short Circuit capacity
  - (initially 60 MVA; will rise to > 100 MVA)
  - Direct on-line motor start voltage drops not acceptable
  - AFE VSC selection allows grid-side active filtering

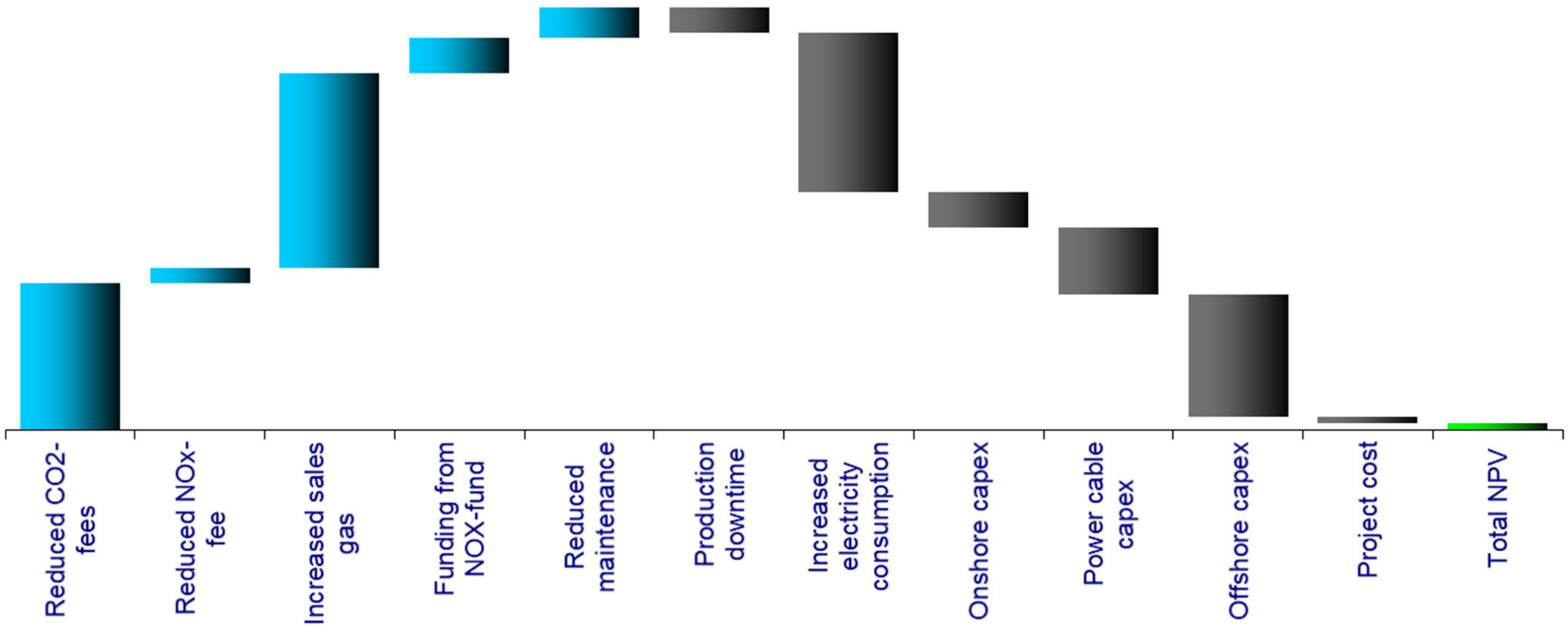


@ 135 MVA AME-1
@ 55 MVA AME-1

- Cable routing problematic
  - Existing pipelines
  - Unexploded munitions (UXO) risk (survey just-in-time)
  - Avoid Horizontal direct drilling (if possible) to reduce cost



Project Techno-Economic Feasibility – typical only



Project development

- Key studies
  - Compressor options study (power vs. recovery)
  - Power system studies including harmonics, dynamic studies (with grid company)
  - Typical Geotech studies for shallow/tidal/sandy cable lay

- Key activities
  - Ongoing management of non-technical risk - engagement with Duurzaam Ameland partnership

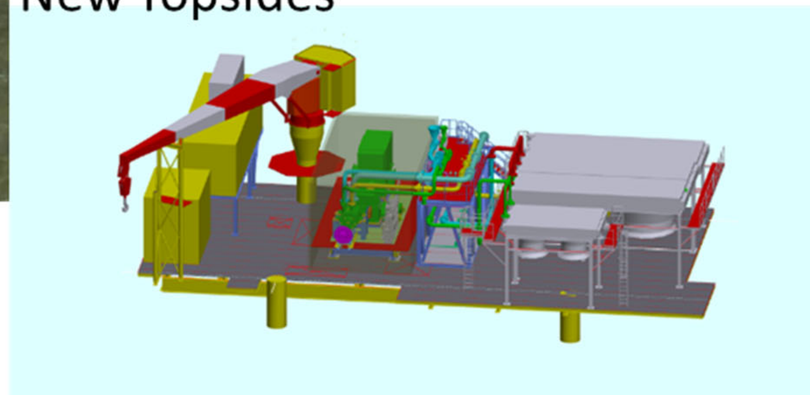
Project Delivery / Execution

- Major Brownfield activities
  - Destruct scope
  - Module heavy lift

Destruct scope

- Time-sensitive cable lay

New Topsides



- “Hot” market for subsea cables

Benefits and Trade-offs

- Significantly improve the energy efficiency and robustness of the production system
- Eliminate offshore emissions (end of life 2035)
  - 130 T/yr of NOx; 62 kT/yr of CO_2
- Increase gas sales by eliminating fuel gas and recycling consumption
  - Increased availability of compression by replacing GTG with e-motor
- Reduced HSE risk with fewer visits/activities (No GT); transformer oil vs. GT oil risk
- Sustain relationships with local stakeholders by aligning with the sustainability ambition of the Island of Ameland

- Cable / grid capacity limits options to drive compressor
- Limited / no load growth possible

Benefits and Trade-offs; SWOT summary for the project

Strengths

- Significant reduction of carbon and NOx footprint
- Lower offshore maint (Opex) vs GTGs; fewer moving parts
- Higher efficiencies with e-motors
- Control without compressor recycle
- Inherently safer design (less fuel gas/diesel; less maint/lifts)
- Better working conditions: lower noise, vibration, pollution

Weaknesses

- Single point of failure for power supply (but route to shore is per single pipeline routing)
- Hot market for subsea cables and installers
- Dependent on heavy lift contractor
- Solution for weak grid means more equipment

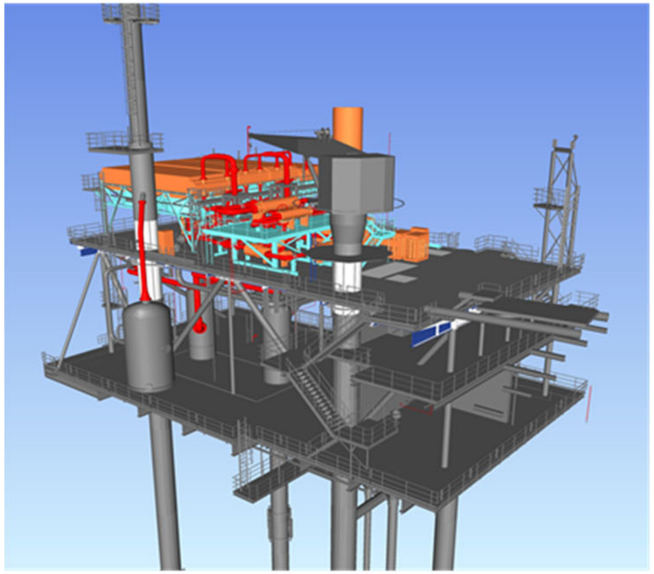
Opportunities

- Supply with 100% renewable-generated electricity
- Tie-ins to offshore wind, other facilities
- Voltage / other grid support with AFE drive
- Facilitates future de-complexing

Threats

- Permitting process
- Multi-faceted non-technical risks; stakeholder management
- Visible cable laying activities
- Spark-spread

Outcome



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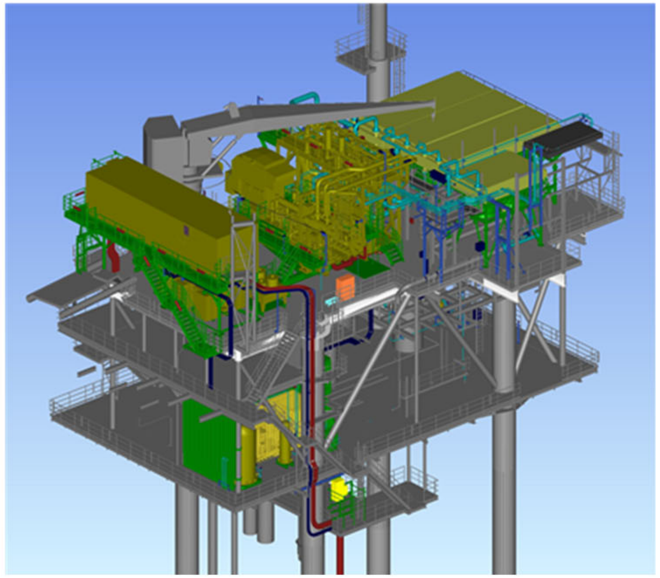
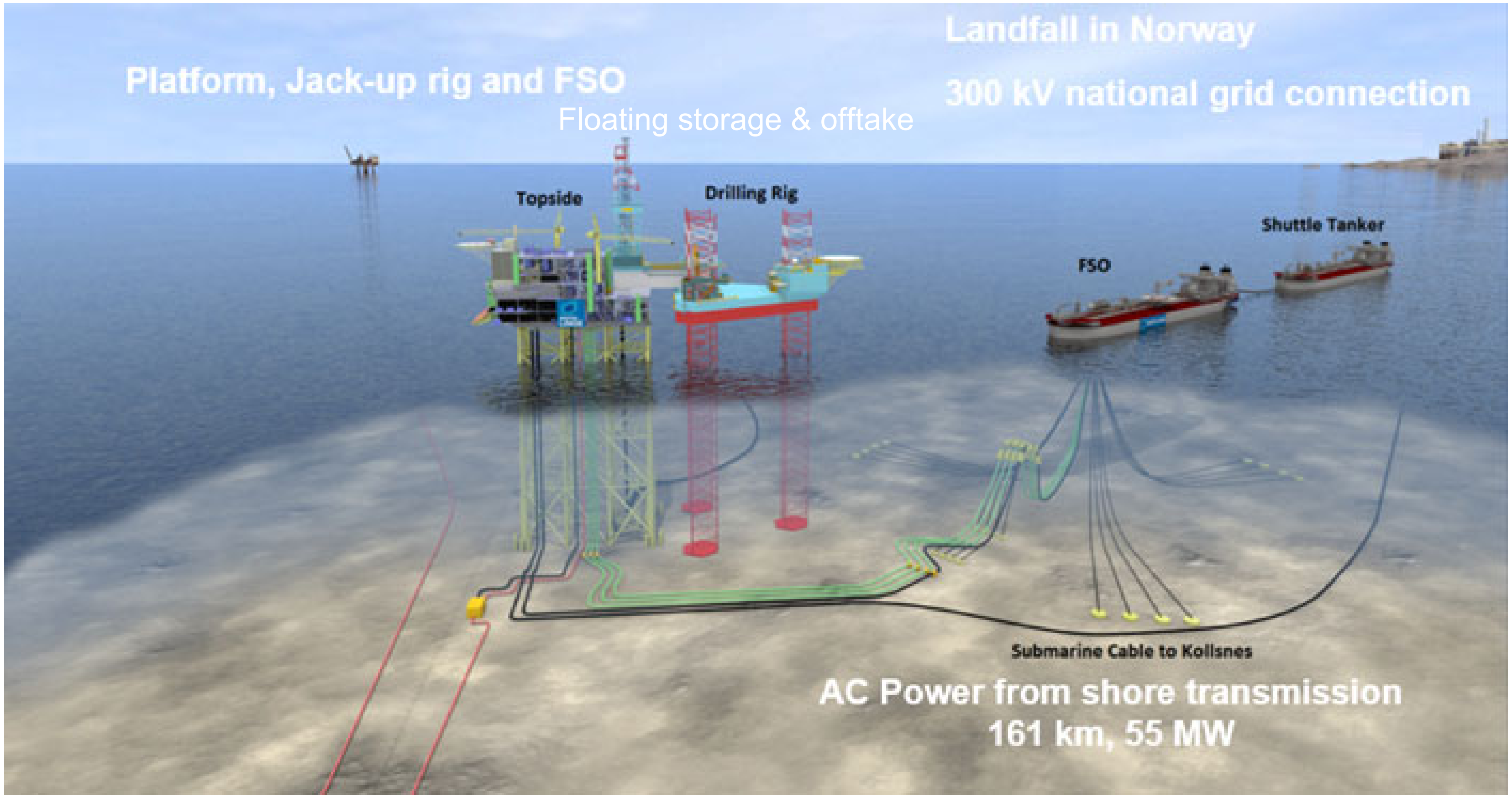


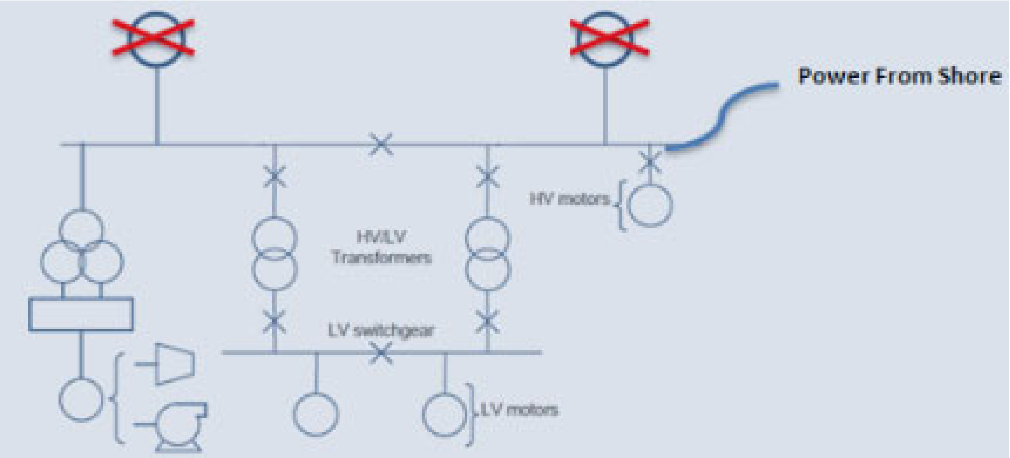
Examples

Long step-out power from shore project

Long step-out power from shore project



Electrification Project Scope



Power from shore selected for :

- Weight issue regarding offshore Gas Turbine installation
- Strong regulatory incentive for Power From Shore
- Economically equal to offshore gas turbines
- Regularity of power
- Reduced local emissions
- Increased sales volumes
- Reduced maintenance

Project Challenges, key decisions

- AC or DC?

161 kms, 55 MW

1st choice would have been to consider a DC transmission

DC issues for the project

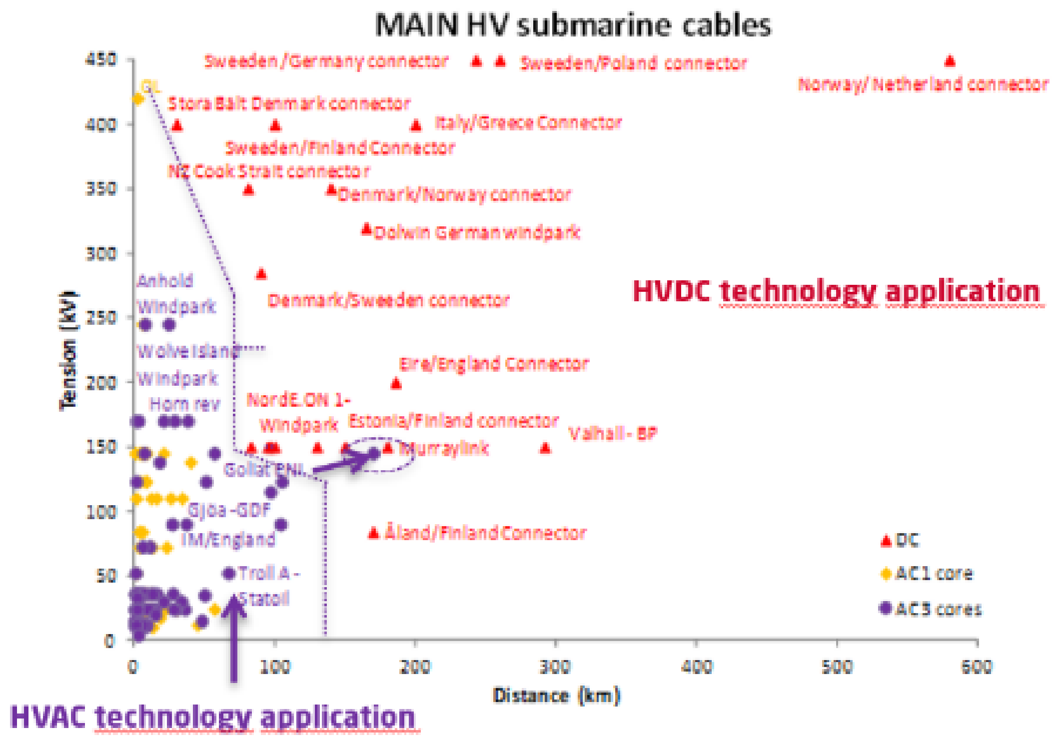
DC not feasible with existing layout

-> showstopper

But there were AC issues for the project

High voltage variation, resonances, cable reactive power

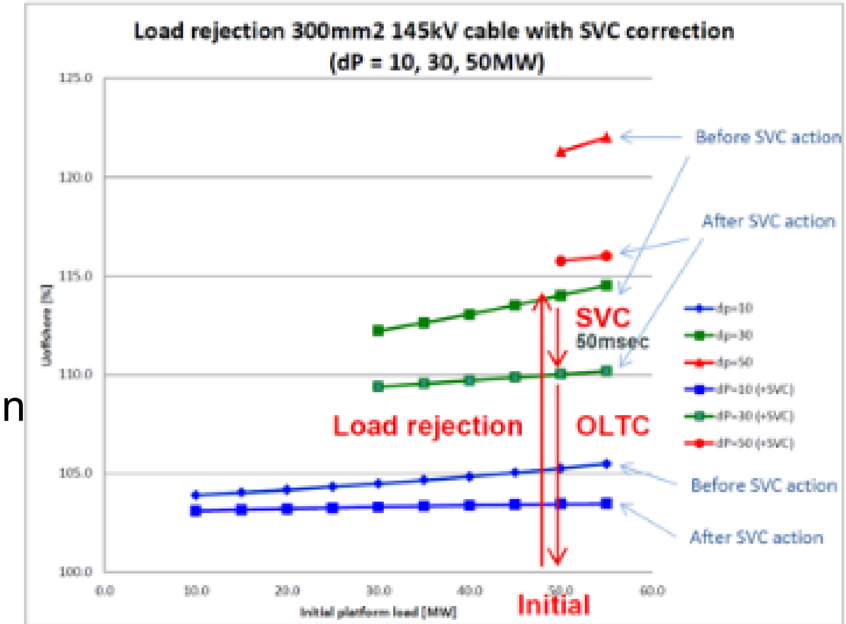
AC studies conducted -> Yes, we can !

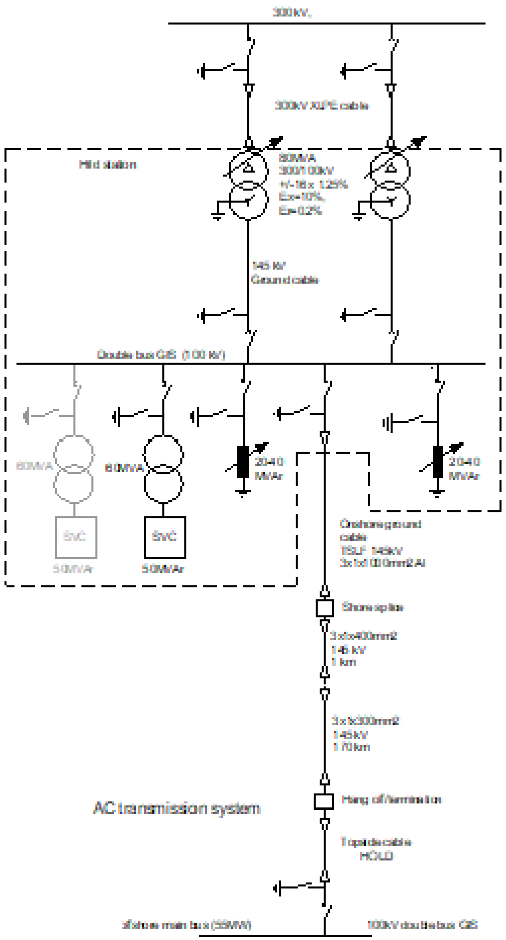


Power Transmission Challenges and Solutions

<u>Onshore Reactor</u>

- Oil filled reactor for fixed reactive power compensation



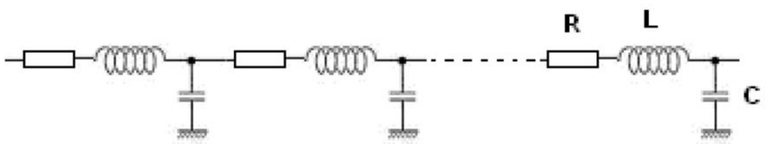


<u>Onshore SVC</u> Static VAr Compensation

- Dynamic reactive power compensation
- Grid power factor regulation
- Voltage control during transient

Power from shore design

Cable energizing associated with a large inrush current and voltage transient



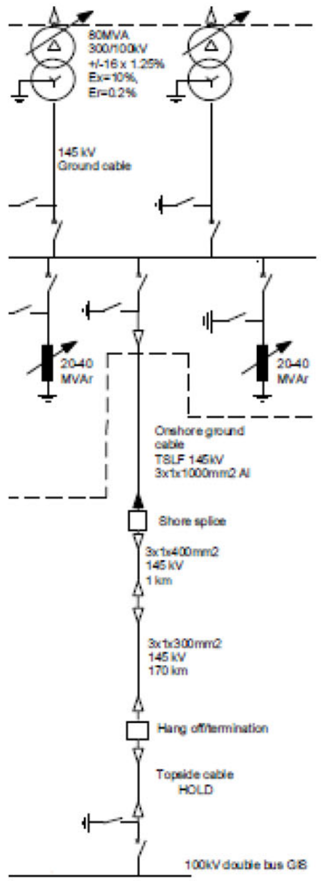
Cable ≈ 75 MVAR capacitor

Mitigations:

•Energizing of the cable at 80% of rated voltage

•Single pole closing

Gas Insulated Switchgear feeder



Submarine Cable

- Longest AC cable in world - 161km
- Manufacturer – ABB (now NKT Cable)

- Consisting of:
  - Landfall 500mm^2 (lower ampacity)
  - Subsea 300mm^2

- Installed in two sections (one subsea joint)

- Highest load is under no-load condition

Cable design

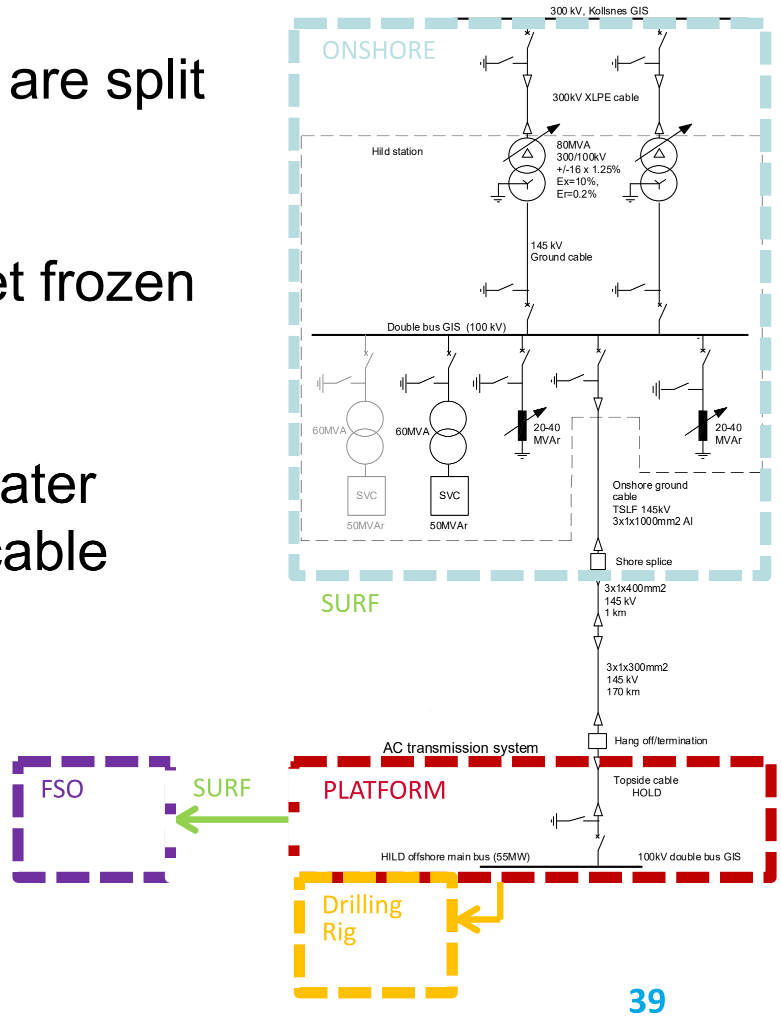
Power From Shore system design and performances (e.g. voltage variation, losses, resonances, reactive power) depend on cable data (i.e. provisional!)

Recommendations:

- Agreement on cable guaranteed value (R, L, C) prior to the contract award
- Target for a capacitance tolerance better than IEC 60840 (<8%)
- Take advantage of the manufacturing of the first cable length/batch to adjust capacitance with cable insulation thickness
- Guaranteed values shall be verified during the factory cable tests

Project Development / Execution Challenges

- System approach and performance when scopes are split in several parts with different contractors
- Early order of cable when system design is not yet frozen due to long lead time of cable (26 month in 2014)
- Qualification of infield dynamic cable in shallow water with no international standard available for such cable
- Installation risks in North sea (crossings, trawling protections)
- Complex Offshore cable HV testing programme

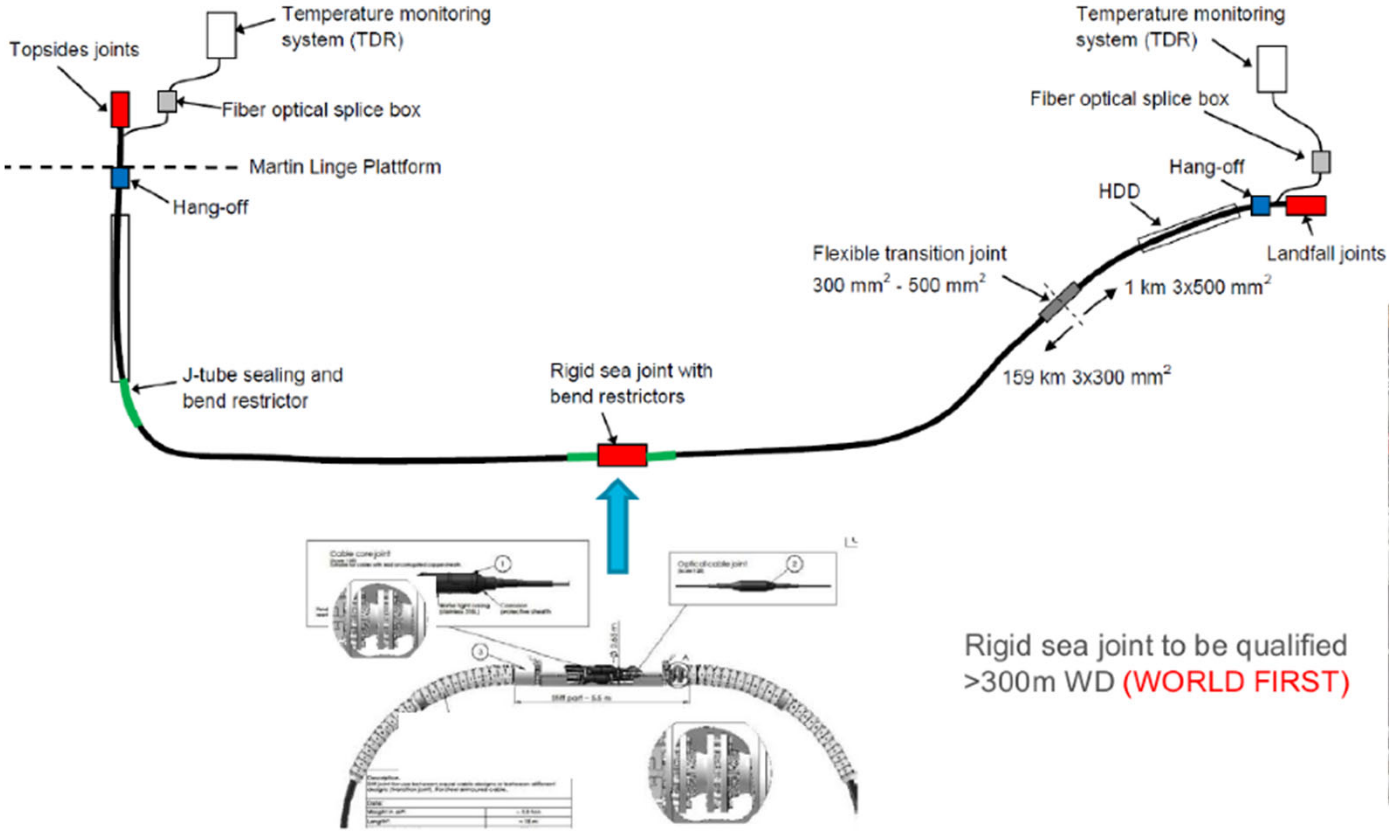


Subsea Cable Manufacturing

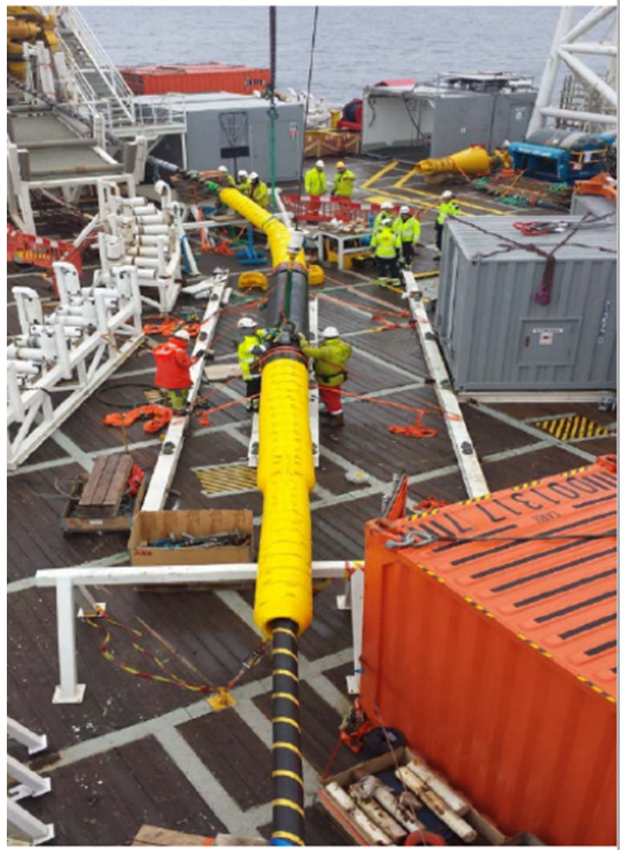
More than one year of manufacturing

Cable installation

- Midline splice operation in 6 days
- Load out speed at 250 m/h



Offshore Joint before deployment



Project summary

- Having multiple contractors involved -> greater effort on interfaces from end client
- Performance requirements are key in ensuring competitive power from shore studies by equipment manufacturers
- Invest in conceptual and pre-project definition
- Establish a good working relationship with grid company
- Be prepared for numerous data requests from contractors.

IOGP Recommended Practice - conclusions

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- Every electrification project will yield different strength, weakness, opportunities, and threats. It is useful to envisage these in the form of a SWOT summary.

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Strengths

- Significant reduction of carbon and NOx/SOx footprint
- Lower offshore maint (Opex) vs GTGs; fewer moving parts
- Higher efficiencies and availabilities with e-motors
- Inherently safer design, requires fewer people
- Better working conditions: lower noise, vibration, pollution

Weaknesses

- TRL for some projects (extreme depth, DC, dynamic, turrets)
- Single point of failure for power supply (but route to shore is per single pipeline routing)
- Hot market for subsea cables and installers
- Hot market for grid connections
- Solution for weak grid means more equipment

Opportunities

- Supply with 100% renewable-generated electricity
- Tie-ins to offshore wind, combination with other facilities
- Voltage / other grid support with AFE drive
- Facilitates future de-complexing
- Better use of the resource

Threats

- Permitting process
- Multi-faceted non-technical risks; stakeholder management
- Grid GHG intensity progress
- Brownfield process complications (waste gas, heat)
- Electricity prices – so-called Spark-spread
- Grid disconnection

Questions?


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