Statoil

Technical Innovation for Floating LNG

Bengt Olav Neeraas & Jostein Pettersen, Statoil ASA

3rd Trondheim Gas Technology Conference, 4-5 June 2014

Table of contents

Relevant know how for FLNG

FLNG concept development

Technology development & innovation

Conclusions

Snøhvit LNG barge
A precursor to FLNG

Extending current skills
Combining the experience

Snøhvit LNG - Hammerfest

- Process facilities built on floating barge – an FLNG precursor
- Compact layout
- Modularized and prefabricated facilities

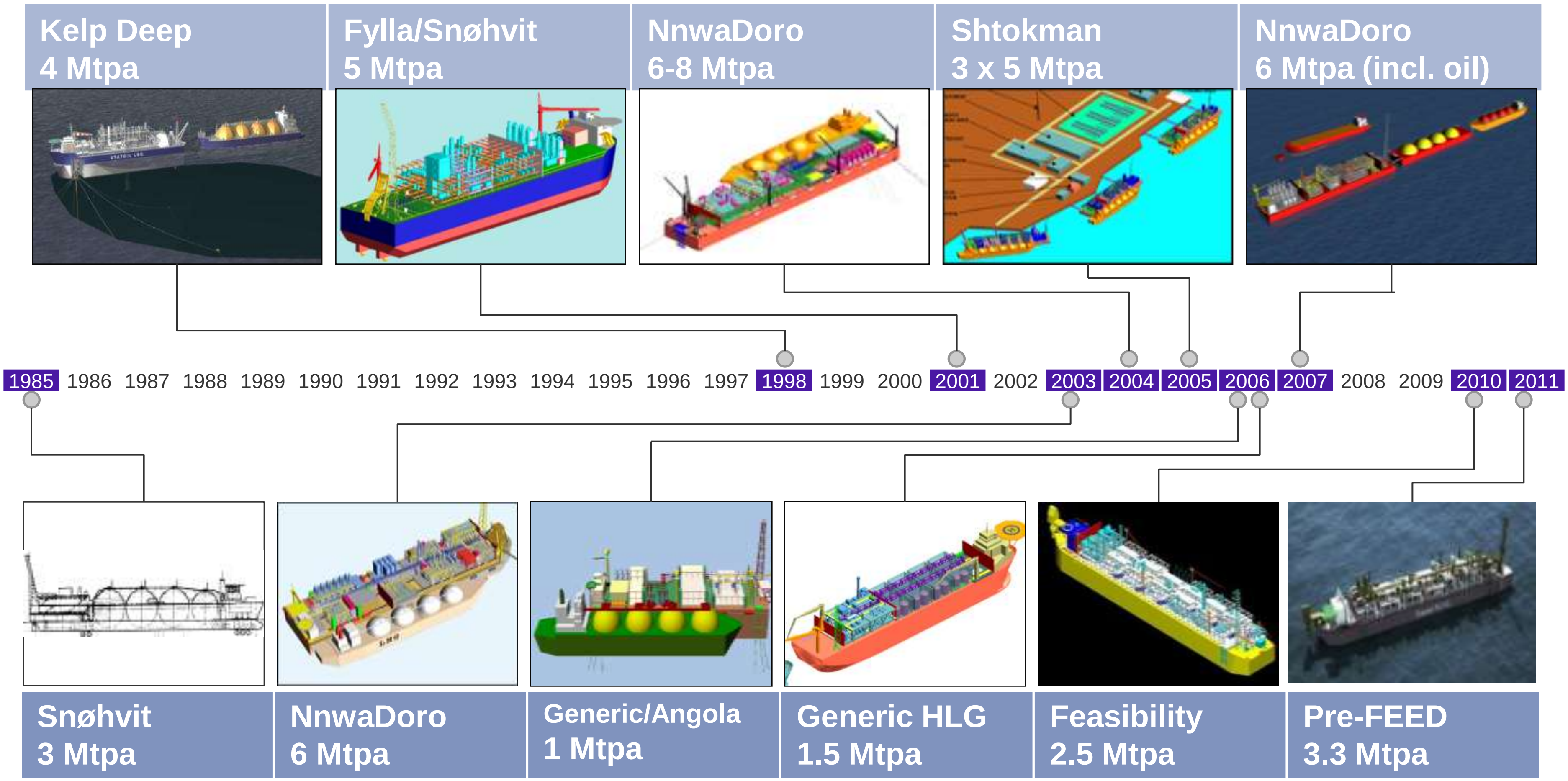
Global floating production operations

- Floating production units in operation worldwide
- Offshore offloading in harsh conditions
- Gas processing and acid gas removal on floating unit

Snøhvit technology learning
Supporting FLNG development

- Snøhvit field development and Hammerfest plant – a full LNG value chain
- Direct feed to LNG plant from subsea wells
- Use of LM6000 aero derivative gas turbines
- Reinjection of CO_2 from feed gas
- Mixed refrigerant liquefaction process with sea water cooling
- Operation in harsh environment

Statoil FLNG concept development history



Statoil FLNG

- Developed to pre-FEED level
- Varying feed gas composition
- DMR liquefaction process with mechanical compressor drivers
- Side-by-side or tandem offloading
- External or internal turret
- Alternative lay-outs
- Developed in cooperation with major engineering contractor
- Supplier group participation

LNG Capacity	3.0 - 3.5 Mtpa
Overall length	425 m
Beam	65 m
LNG storage	225 000 – 275 000 m^3

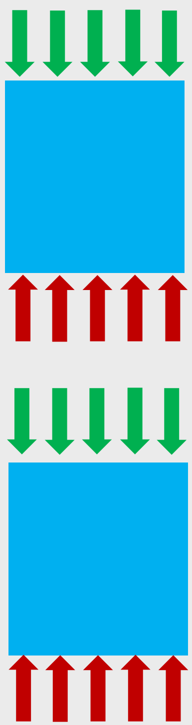
Acid gas removal

Sensitive to tilt and motions

Specification:
< 50 ppm CO_2 in treated gas

Ideal situation

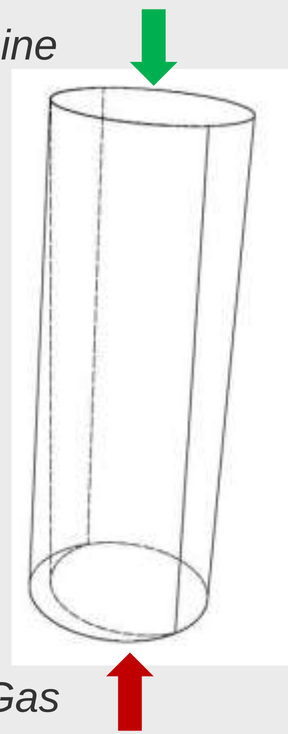
Amine



Gas

Tilted situation

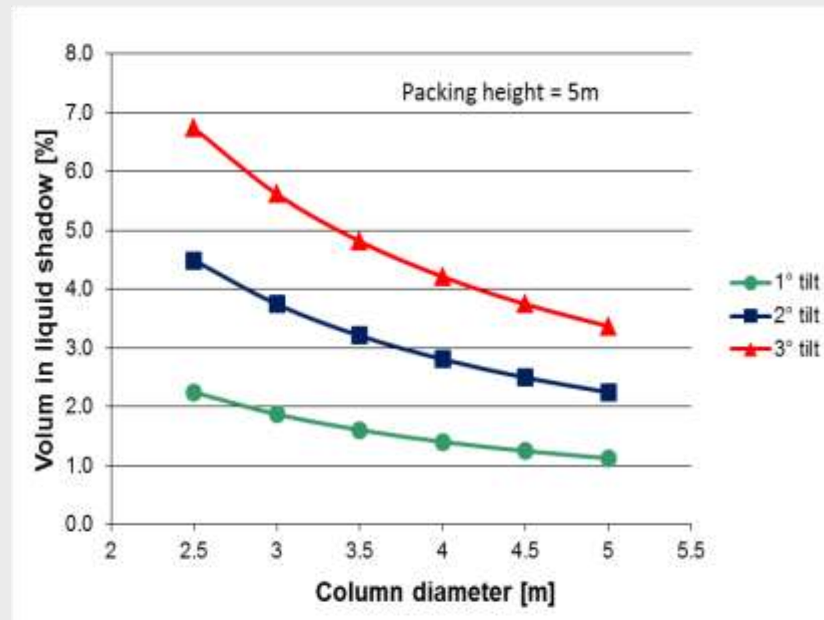
Amine



Gas

Example:

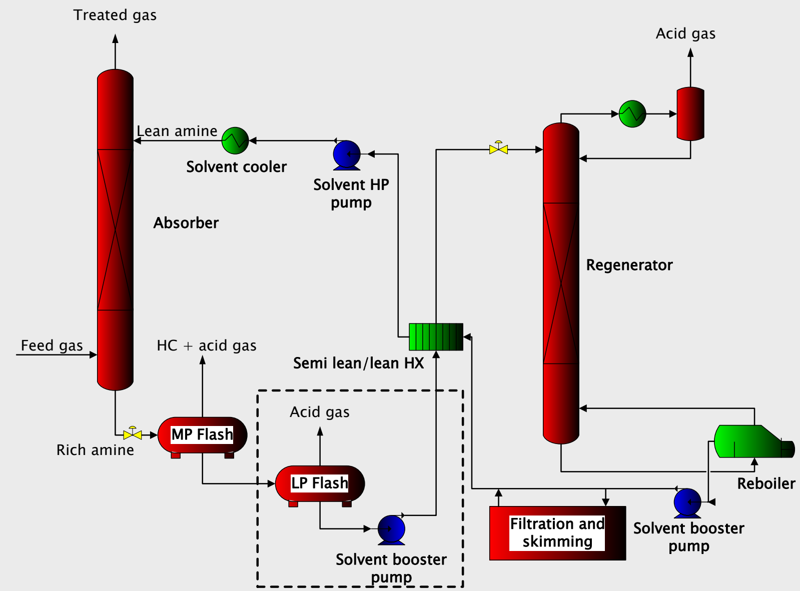
- 10 mole % CO_2 in the feed gas
- Bypass of more than 0.05% of gas flow gives off spec composition



Statoil

Acid gas removal
Statoil safeguarding solution for FLNG

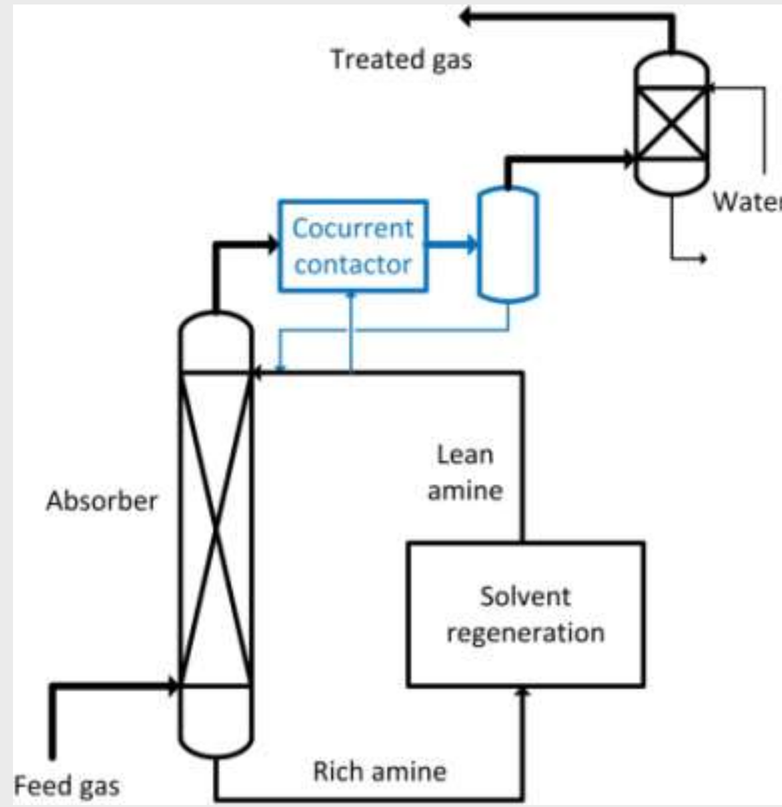
Standard Amine plant



Typical design margins for FLNG

- Increase amine circulation
- Increase absorber diameter and height
- Increase number of beds

Safeguarding solution (patent pending)



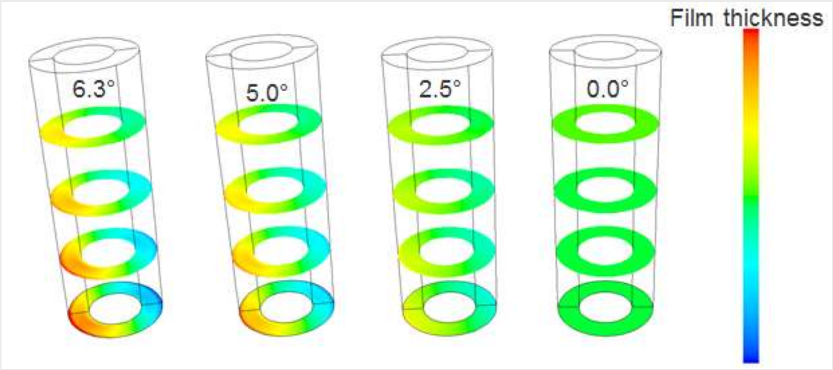
Cryogenic LNG heat exchanger

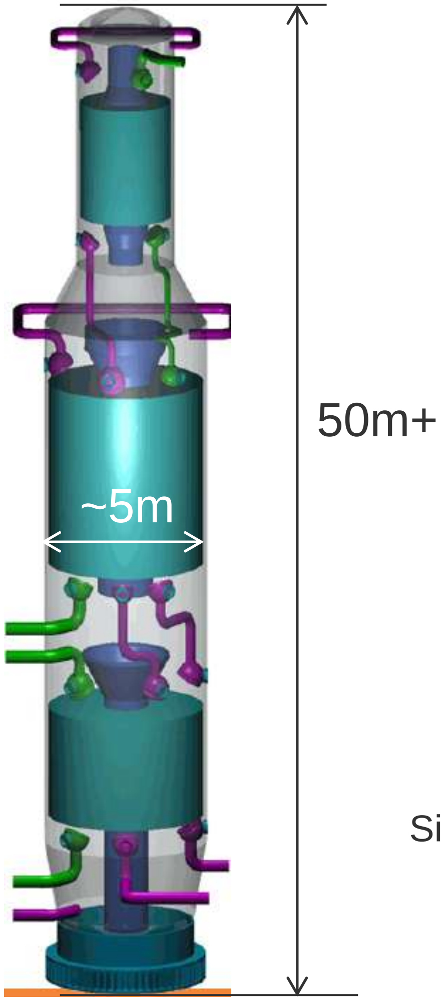
Sensitivity to tilt and motions

How will the heat exchanger performance be affected by tilt and motions ?

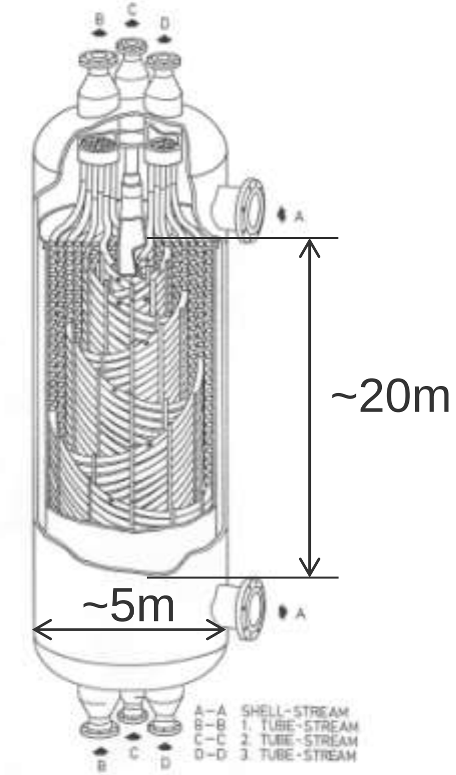
Test program performed in co-operation with Linde Engineering 2003-2007

CFD model developed





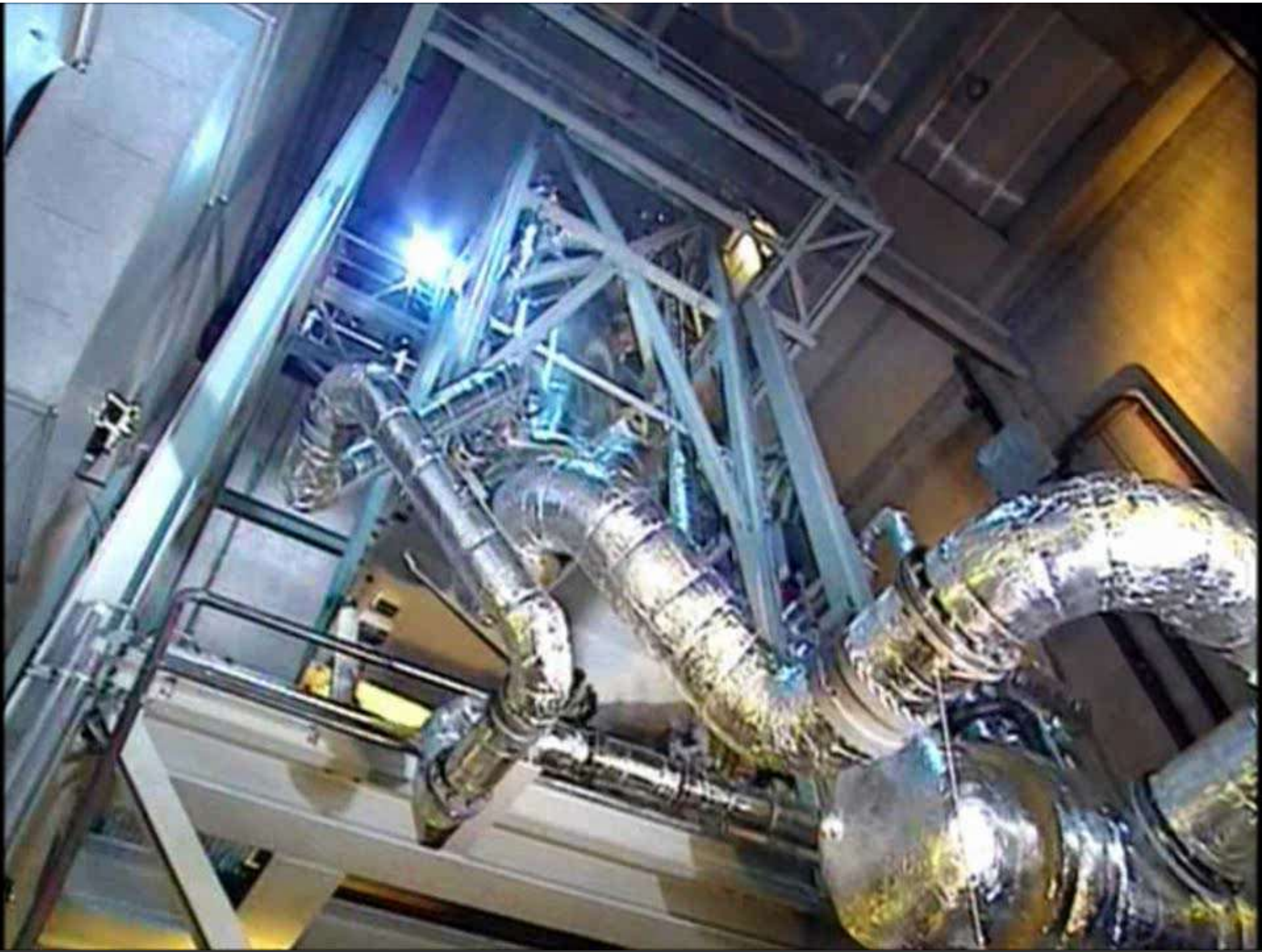
Multiple bundle heat exchanger**



Single bundle heat exchanger*

* Courtesy of Linde Engineering
** Courtesy of Air Products

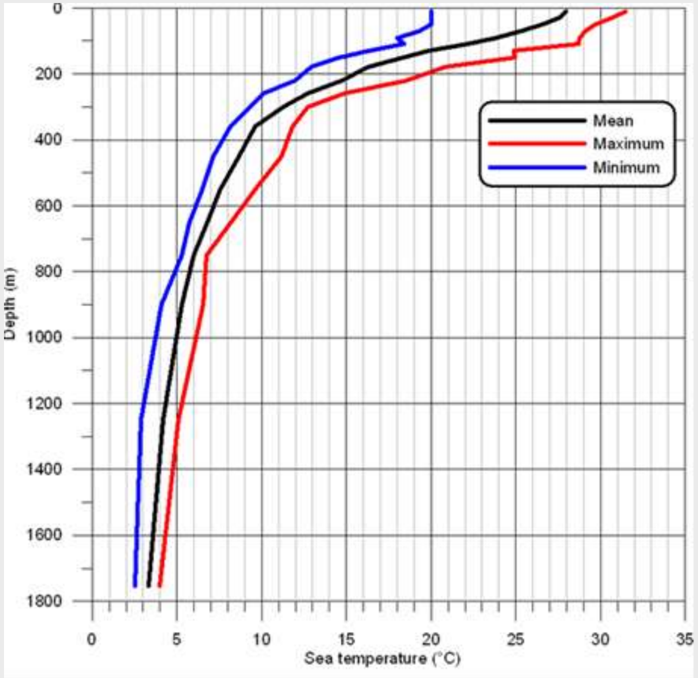
Video - Test heat exchanger in oscillation



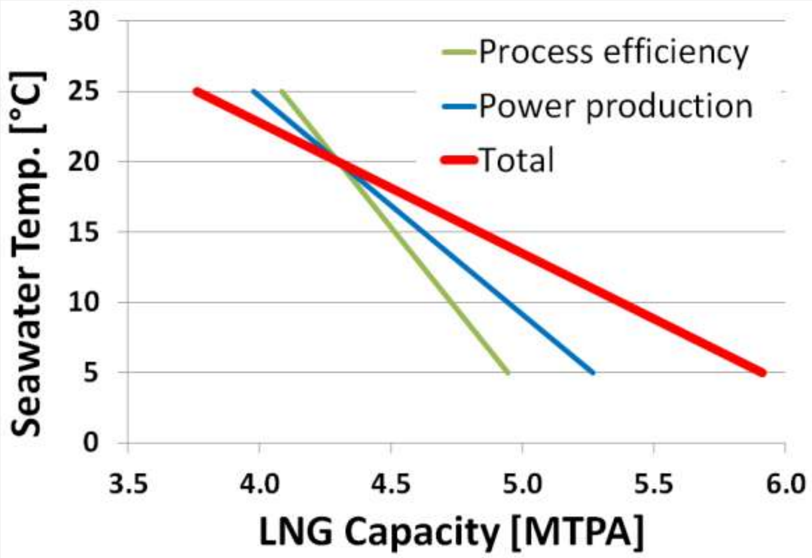
Deep sea-water intake systems
Beneficial with low temperature cooling water

- Increased process efficiency
  - ~1% increased production/°C

Typical SW temperature profile



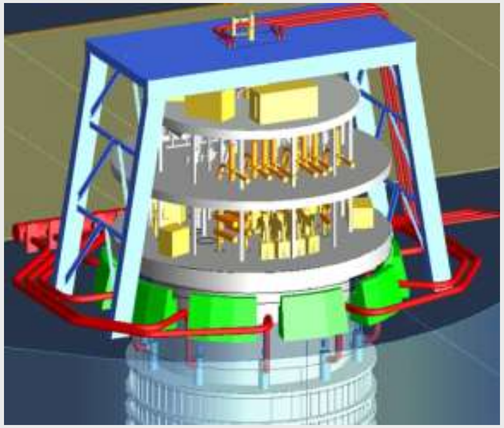
- Increased gas turbine power
  - Cooling of intake air
  - ~1,5% increased power/°C

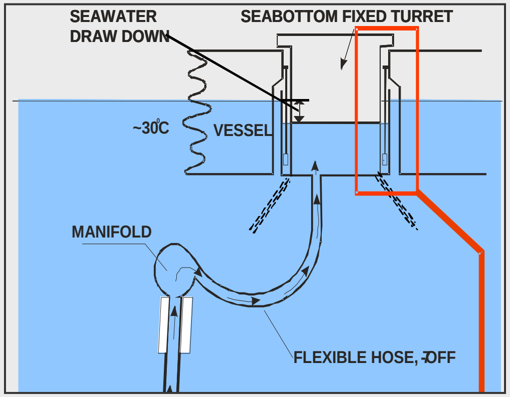


Deep sea-water intake systems

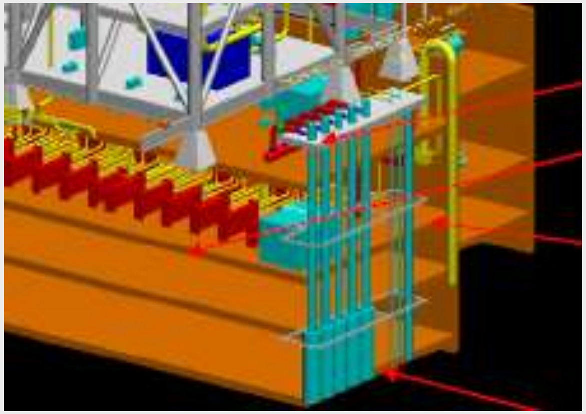
Principle system configurations

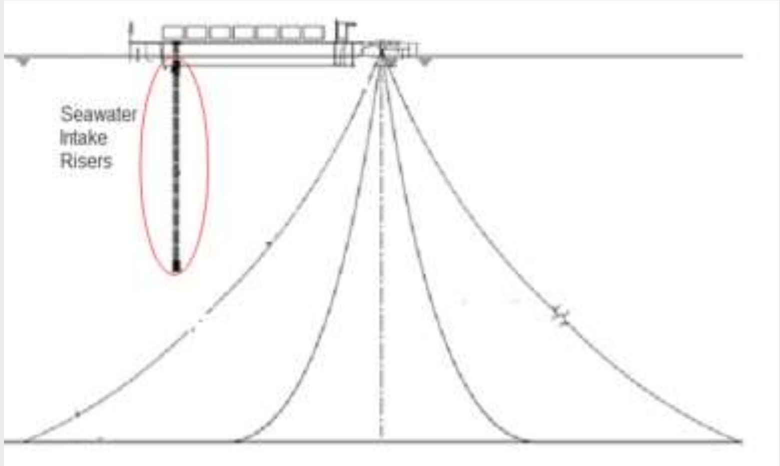
SW risers through turret





Free hanging SW risers

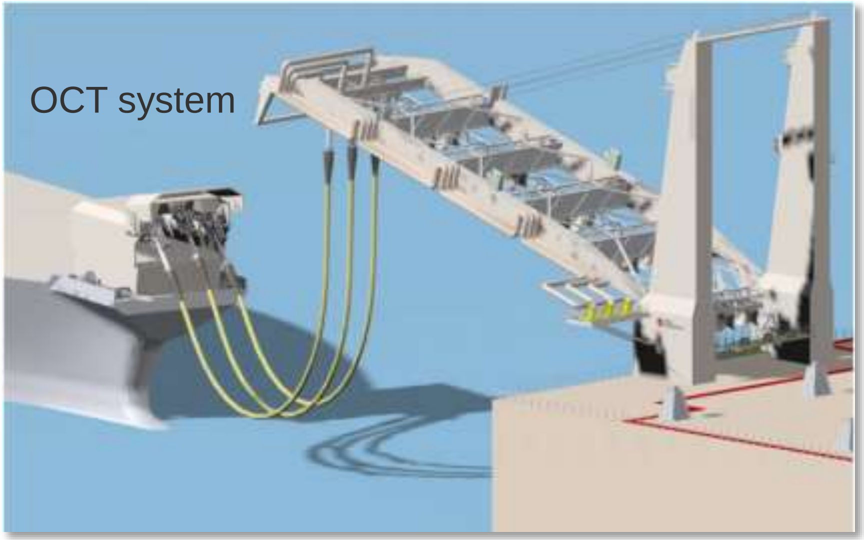




Statoil

LNG tandem offloading

Based on Statoil patents, licensed to OneSubsea



DET NORSKE VERITAS

CERTIFICATE OF FITNESS FOR SERVICE

OCT-Offshore Cryogenic Transfer system for the Santos Basin

Statement no.: SFS 2011/12RIGES-4

DNV

DET NORSKE VERITAS

CERTIFICATE OF FITNESS FOR SERVICE

This is to confirm that qualification of the

CRYODYN Pipe

has been conducted in accordance with DNV RP-A203, Qualification Procedure for New Technology /1/ Sections 5, 6, 7, 8, 9 and 10, as reported in DNV Technical Report 2011-0025 /3/. DNV considers the technology documented as fit for service, as defined in /2/.

Technology owner:	Nexans Deutschland GmbH
Name of technology:	CRYODYN Pipe
Description:	The CRYODYN technology is a flexible, vacuum insulated pipe for the transfer of liquefied natural gas or other cryogenic liquefied gases
Application:	The Certification of Fitness for Service covers the CRYODYN pipe when used for LNG offshore ship-to-ship loading in tandem configuration with an aerial use of the CRYODYN pipe
Involvement:	DNV has taken active part in and verified the design basis formulation, technology assessment, failure mode identification and risk ranking, planning and execution of the qualification programme and reliability assessment of the PoS of the above technology as reported in /3/
Limitations:	Main limitations and reference to report /3/
Reference documents:	/1/ DNV-RP-A203, Qualification Procedure for New Technology, September 2001 /2/ DNV-OSS-401, Technology Qualification Management, December 2003 (Draft) /3/ DNV Technical Report No. 2011-0025 Rev 0 "Technology Qualification Report – CRYODYN – Pipe for LNG transfer in tandem", January 10, 2011

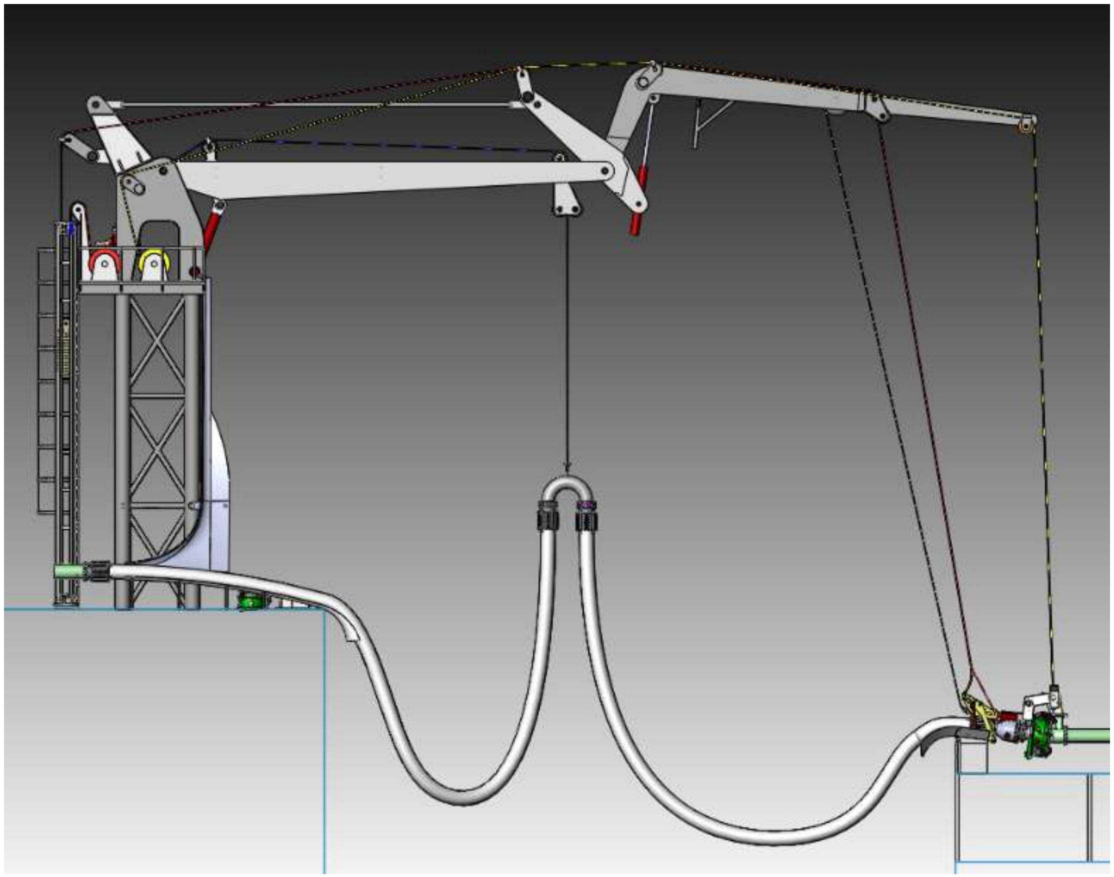
Høvik, January 10 2011
for Det Norske Veritas AS

Frank Børre Pedersen	Carl Sixtensson	Gunnhild Bækken
Head of Department	*Project Manager*	*Verifier*

Det Norske Veritas AS . Veritasveien 1, N-1322 Høvik, Norway . Tel: +47 67 57 99 00 . Fax: +47 67 57 99 11

LNG side-by-side offloading

Based on Statoil idea – Development by MacGregor Pusnes & Statoil



DET NORSKE VERITAS

STATEMENT OF FEASIBILITY

SBS Transfer System of LNG with Flexible Hoses

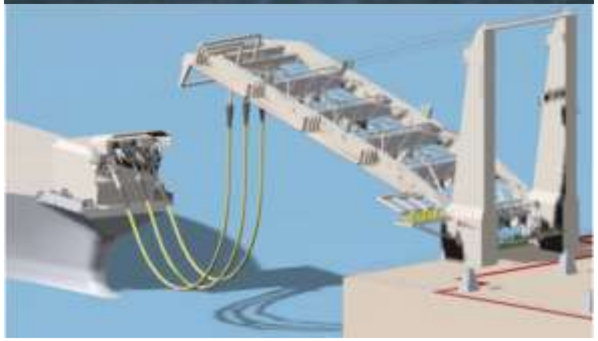
DET NORSKE VERITAS

ENDORSEMENT OF QUALIFICATION PLAN

SBS Transfer of LNG with Flexible Hoses

Conclusions

- The realization of FLNG requires fit for purpose technologies
- Important focused technologies;
  - Cryogenic heat exchangers
  - Acid gas removal
  - LNG offloading
  - Deep sea water intake
  - Layout, process selection and safety
- FLNG concept development has been matured and a basic concept is selected



There's never been a better time for good ideas

Technical Innovation for Floating LNG

Bengt Olav Neeraas
Principal Researcher
bone@statoil.com
Tel: +4790881743

www.statoil.com