Technology Status and Challenges for Floating LNG

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  - Nitrogen expander
- Status of FLNG projects

What is a Floating LNG unit?

Illustration: Höegh LNG

No FLNG unit built so far!

Advantage of FLNG

- Numerous stranded and remote gas fields
- Cheaper and faster in-yard construction than greenfield onshore
- No pipeline to shore, only riser required
- Also for fields where onshore development is undesired

- Why no FLNG at this point?
  - Easy fields developed with other solutions
  - First mover risk

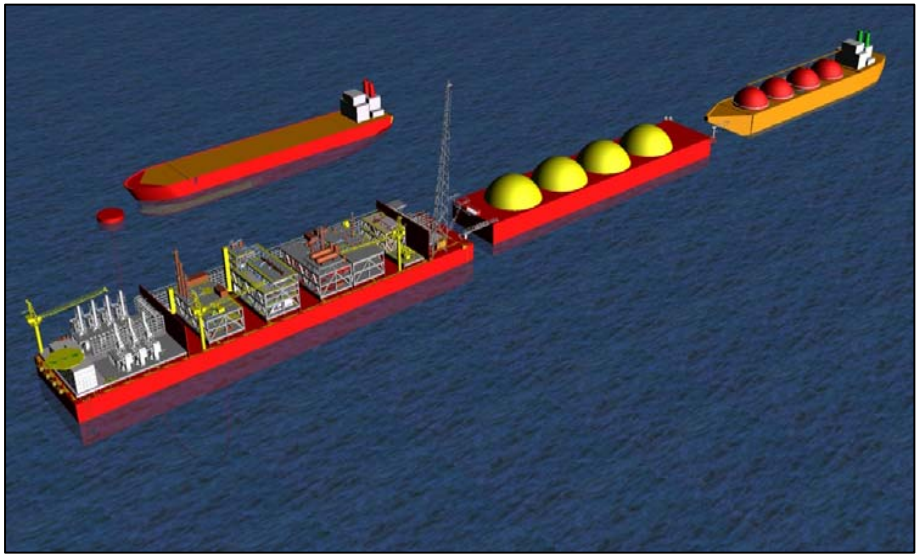


Illustration: Flex LNG

Main technical challenges

- Effect of movement and tilt on critical equipment
  - Absorption/fractionation columns
  - Main cryogenic heat exchangers
  - LNG sloshing in storage tanks
- LNG transfer/offloading
- Safety/Safety distances
- Deep water sea-water intake and riser systems

Columns

- CO_2 absorber
  - Only very small gas bypass will give off-spec CO_2 level (50 ppm)
  - Offshore CO_2 absorber at Åsgard B performs satisfactorily – not relevant for LNG
  - Onshore CO_2 absorber experience from Hammerfest LNG
    - > No experience in “moving CO_2 absorber” for 50 ppm spec.
  - Special design will be needed for FLNG
  - Final CO_2 removal could be done in subsequent water adsorption system
- Fractionation/condensate stabilisation
  - StatoilHydro have experience with Condensate Stabilization column at Åsgard B
- A more systematic review on columns is needed

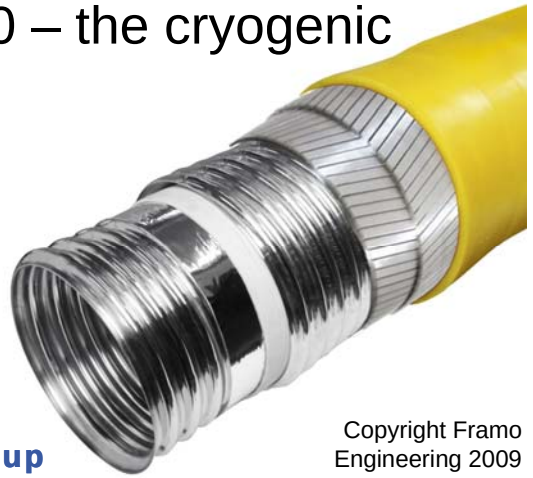
Main cryogenic heat exchanger

- StatoilHydro has pre-qualified the Spiral Wound Heat Exchanger (SWHE) for floating applications.
- Unique knowledge of SWHE and Plate-Fin Heat Exchanger from Hammerfest LNG
- Effect of tilt in liquid distributors need to be addressed

LNG offloading

- Tandem offloading by aerial pipe
  - Flexible pipes, Offshore Cryogenic Transfer (OCT)
  - Currently being developed in a JIP together with ExxonMobil, Shell, Chevron, Petrobras and StatoilHydro
  - Vacuum insulation
  - 16” inner pipe
- Other offloading concepts include
  - Traditional Chiksan (smooth sea only)
  - Floating hoses
  - Aerial composite hose

Cryodyn 500 – the cryogenic flexible pipe



The OCT Group

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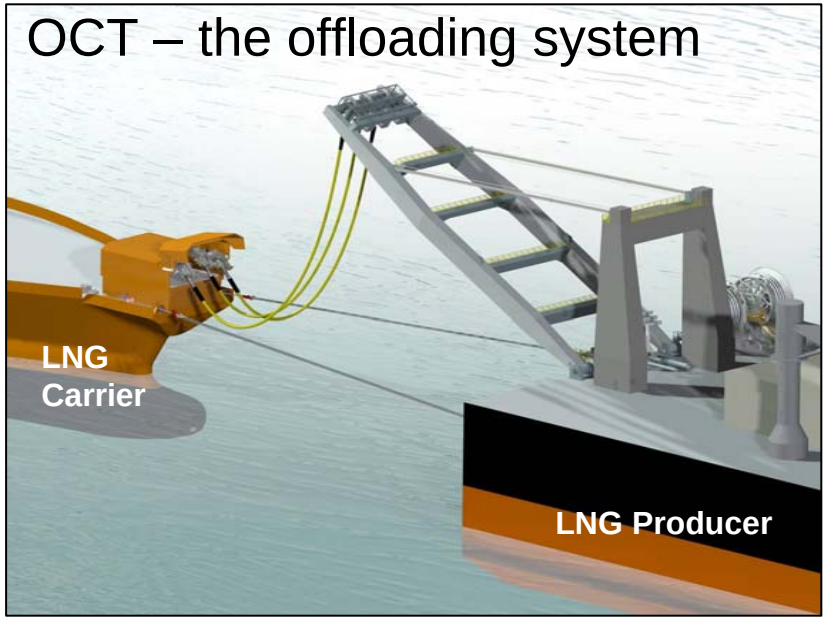
OCT – the offloading system



Liquefaction process selection

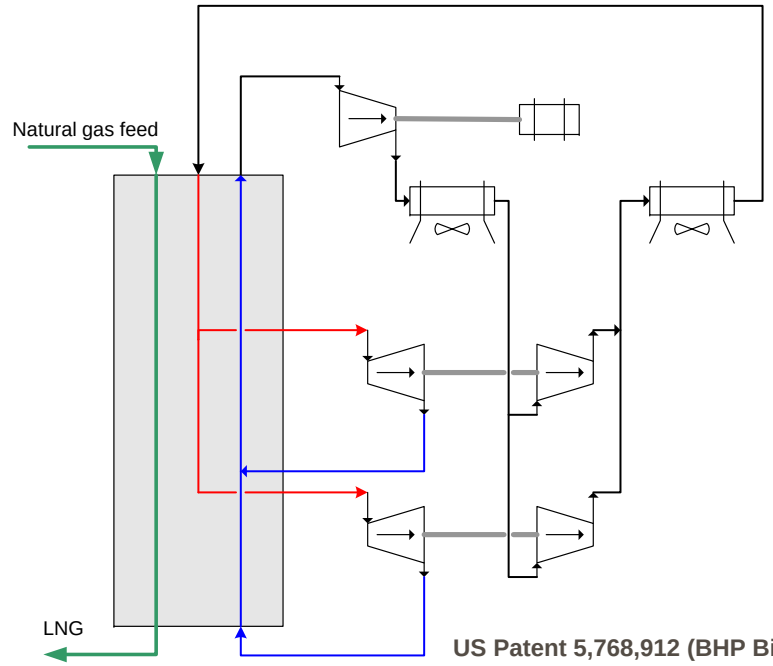
Type	Principle	Pros and cons
Gas expander cycles	Gas heating at linear gliding temperature and constant pressure	• Simple and compact • Nitrogen not flammable and easy to produce • Low sensitivity towards movement regarding two-phase flow refrigerant
		• Lower efficiency, equipment in parallel
Cascade cycle	Pure refrigerants boiling at constant temperature at different pressure	• No issues with refrigerant distribution
		• Extensive equipment count • Flammable refrigerant + ethylene import
Mixed refrigerant cycle	Mixed refrigerant boiling at gliding temperature at constant pressure	• High efficiency • Lower volume flow of refrigerant
		• Requires refrigerant make-up of many components • Refrigerant distribution in SWHE

Processes can also be combined

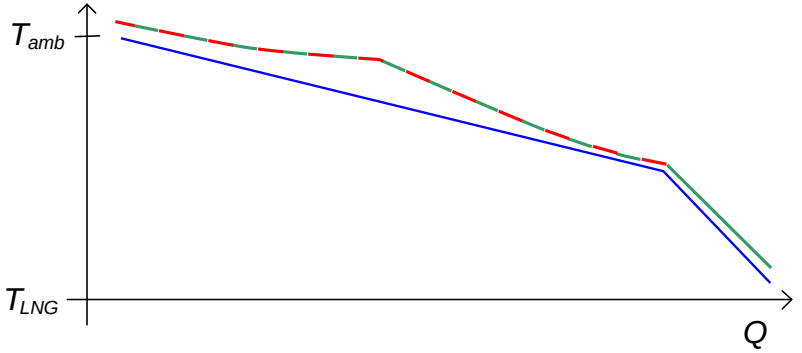
Advantages with expander processes

- Equipment
  - Simple and compact
  - Few parts and low CAPEX
- Distribution of refrigerant
  - No maldistribution issues as for two phase flow
  - Small or no sensitivity towards orientation or movement
- Refrigerant
  - Nitrogen not flammable and easy to produce
- Regularity
  - Simple design and automated operation
  - Fast start-up

Good alternative for smaller sized units



US Patent 5,768,912 (BHP Billiton)



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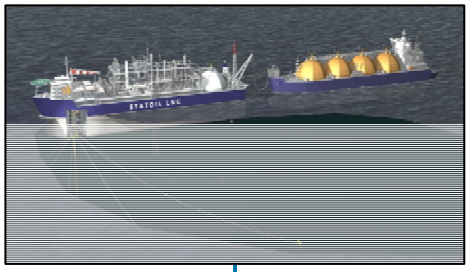
StatoilHydro FLNG concept history

4 MTPA



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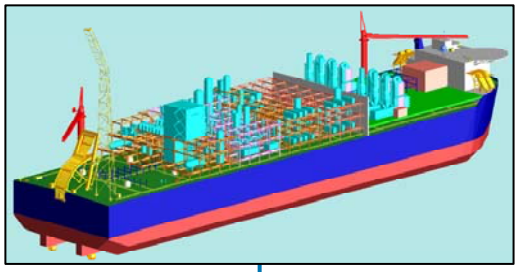

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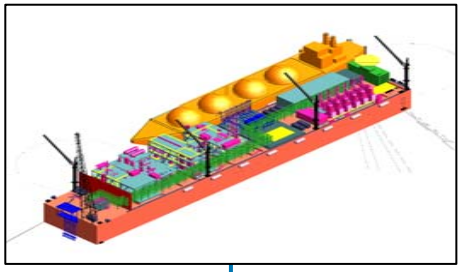

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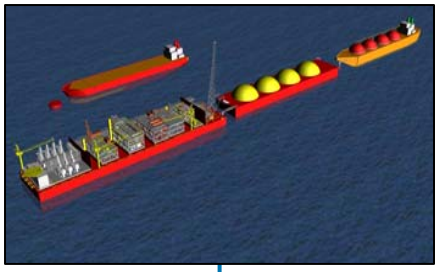

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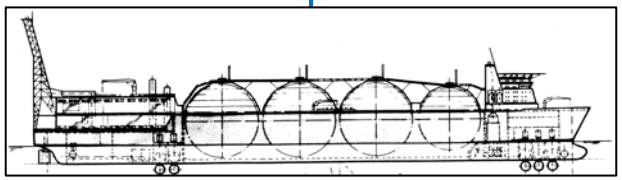

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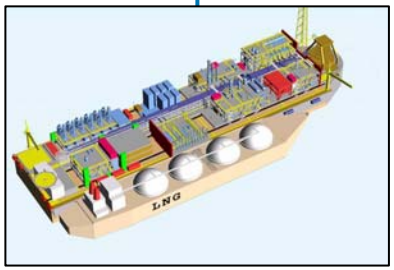

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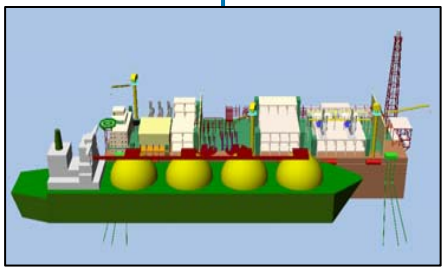

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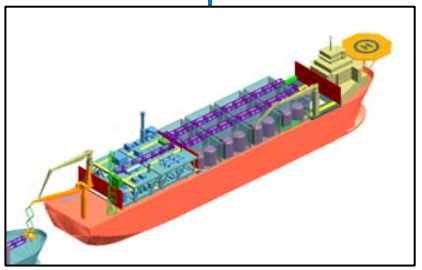

1.5 MTPA

MTPA = million tons per annum

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Other published FLNG concepts

Source: Internet

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Project status

- Many concepts have been suggested, but no steel has so far been cut
- Most promoted concepts (all in FEED-status):
  - Shell/Technip/Samsung (has money and fields, recently announced FLNG off shore Australia, barge is 470 x 70 m)
  - Flex/Samsung (ship hull, generic + field specific modules)
  - Linde/SBM (strong player with Linde's process and SBM's FPSO experience)
- Technical challenges remain, but none considered show stoppers

Depletion of close-to-shore fields will force the development of more remote fields using FLNG