



AA feasibility work for water temperatures below 0 degC

(Presentation for the Force webinar: Hydrate Management Strategies For Unlocking Production from Marginal Subsea Tiebacks)

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Shell’s net-zero emissions target

Shell’s operating plan and outlook are forecasted for a three-year period and ten-year period, respectively, and are updated every year. They reflect the current economic environment and what we can reasonably expect to see over the next three and ten years. Accordingly, the outlook reflects our combined Scope 1 and 2 target, NCI target and our oil products ambition over the next ten years. However, Shell’s operating plan and outlook cannot reflect our 2050 net-zero emissions target, as this target is outside our planning period. Such future operating plans and outlooks could include changes to our portfolio, efficiency improvements and the use of carbon capture and storage and carbon credits. In the future, as society moves towards net-zero emissions, we expect Shell’s operating plans and outlooks to reflect this movement. However, if society is not net zero in 2050, as of today, there would be significant risk that Shell may not meet this target.

Forward-Looking non-GAAP measures

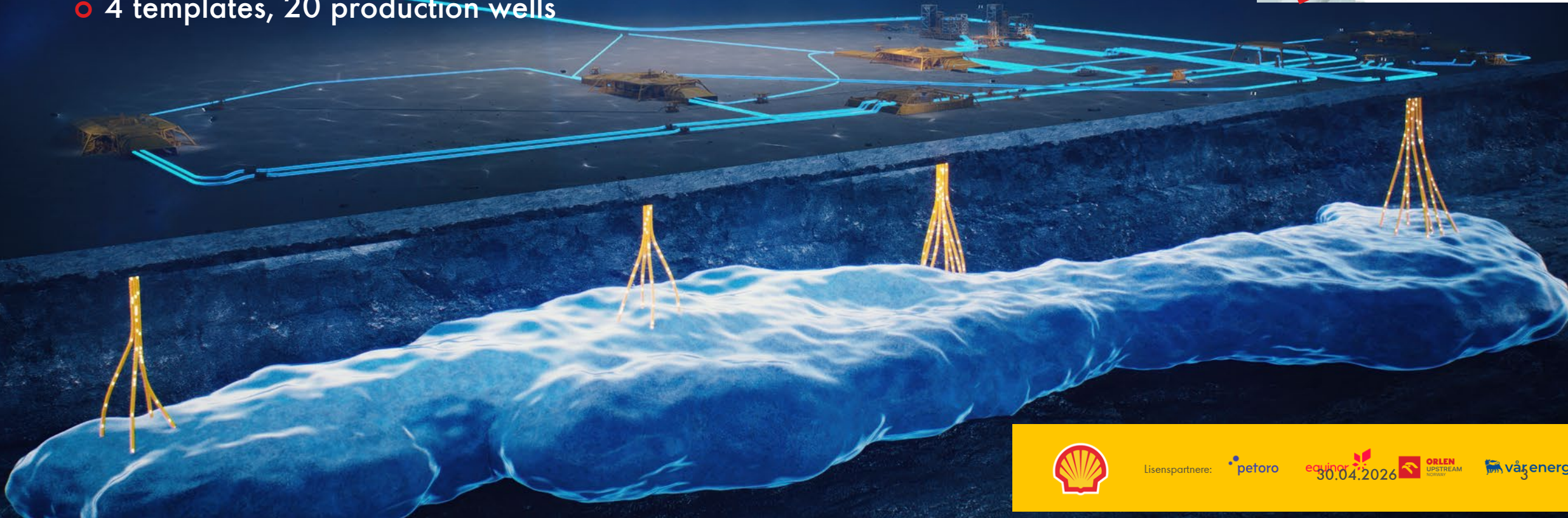
This content may contain certain forward-looking non-GAAP measures such as free cash flow and underlying operational expenses. We are unable to provide a reconciliation of these forward-looking non-GAAP measures to the most comparable GAAP financial measures because certain information needed to reconcile those non-GAAP measures to the most comparable GAAP financial measures is dependent on future events some of which are outside the control of Shell, such as oil and gas prices, interest rates and exchange rates. Moreover, estimating such GAAP measures with the required precision necessary to provide a meaningful reconciliation is extremely difficult and could not be accomplished without unreasonable effort. Non-GAAP measures in respect of future periods which cannot be reconciled to the most comparable GAAP financial measure are calculated in a manner which is consistent with the accounting policies applied in Shell plc’s consolidated financial statements.

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Ormen Lange – Norway's 2nd biggest gas discovery

- Mature, high performing asset since 2007. Average +98 % reliability
- 120 km tie-back to Nyhamna, 2x30"
- ~1000m water depth
- 4 templates, 20 production wells



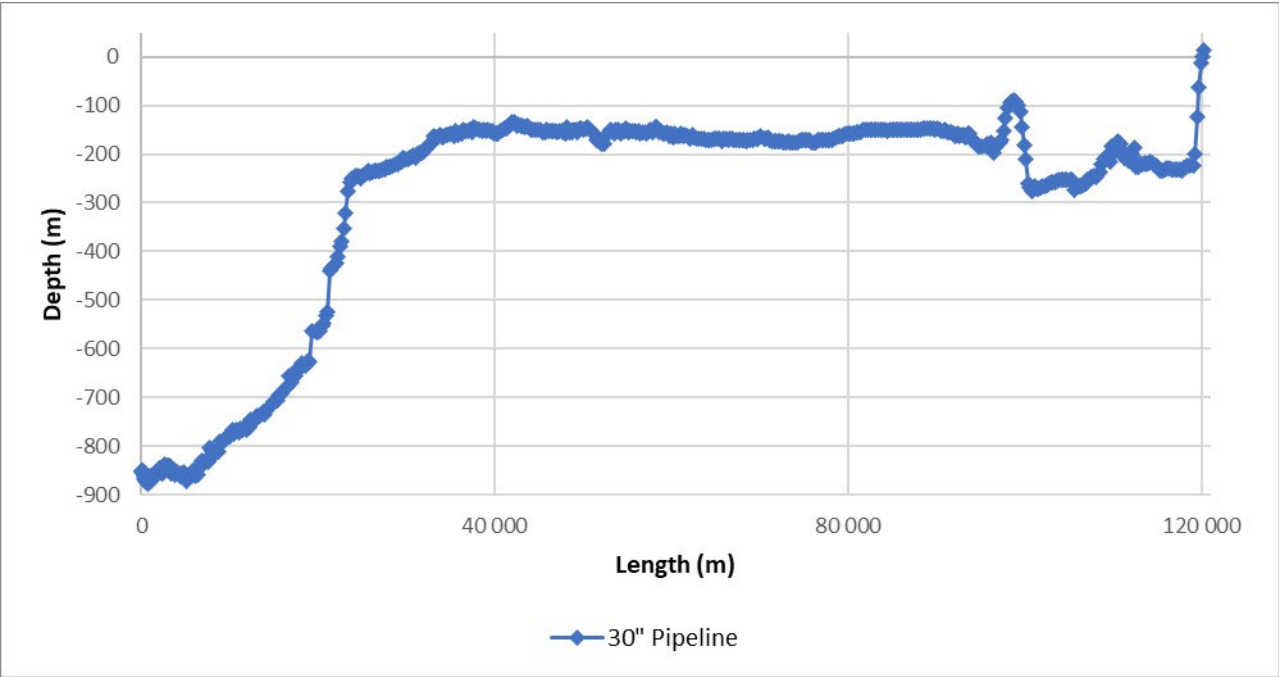
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Pipeline profile

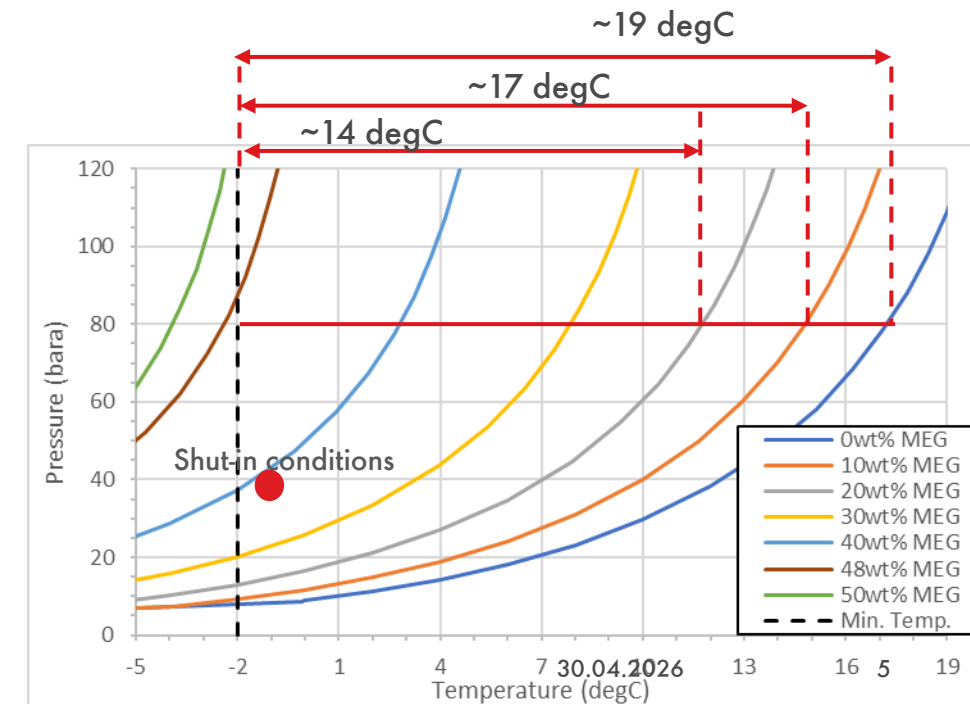


Ambient sea water temperatures (deg C)

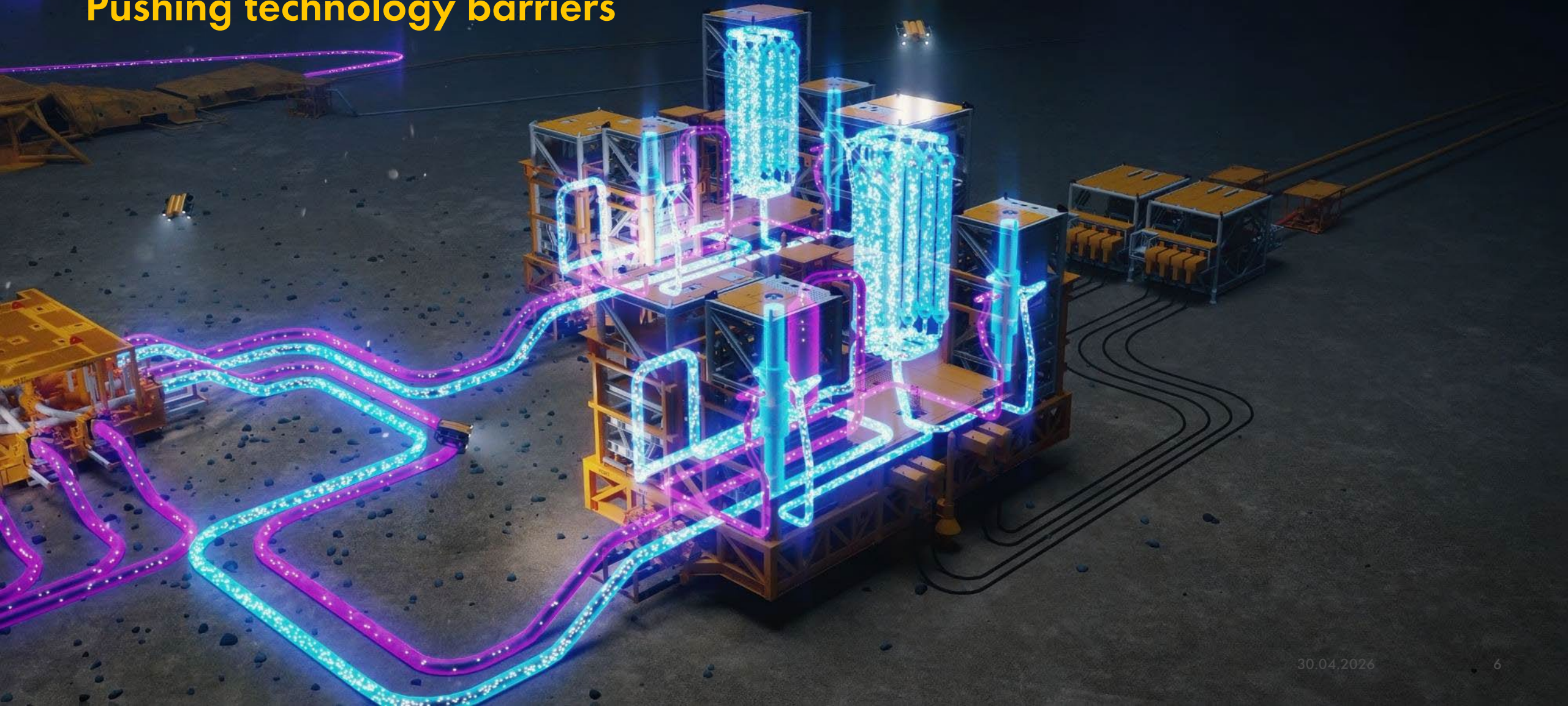
	All Year Ave
sea surface	10.2
	7.7
mid-depth	6.7
	2.9
near seabed conditions	-0.8

Ormen Lange conditions

- Pressure: 15 - 112 bara (112 bar is trip pressure subsea compressor, normal max.)
- Temperature: -2 °C (ambient -1 °C + JT cooling)
- CGR: 25-50 m³/Msm³
- Watercut: 30-50% (during a shut-in, an increased watercut may accumulate in dips of the pipeline)
- Subcooling at 80 bara → Hydrate Equilibrium temperature is ~17 degC
 - 0wt% MEG = 19 degC
 - 10wt% MEG = 17 degC
 - 20wt% MEG = 14 degC
 - ~48wt% MEG is fully dosed

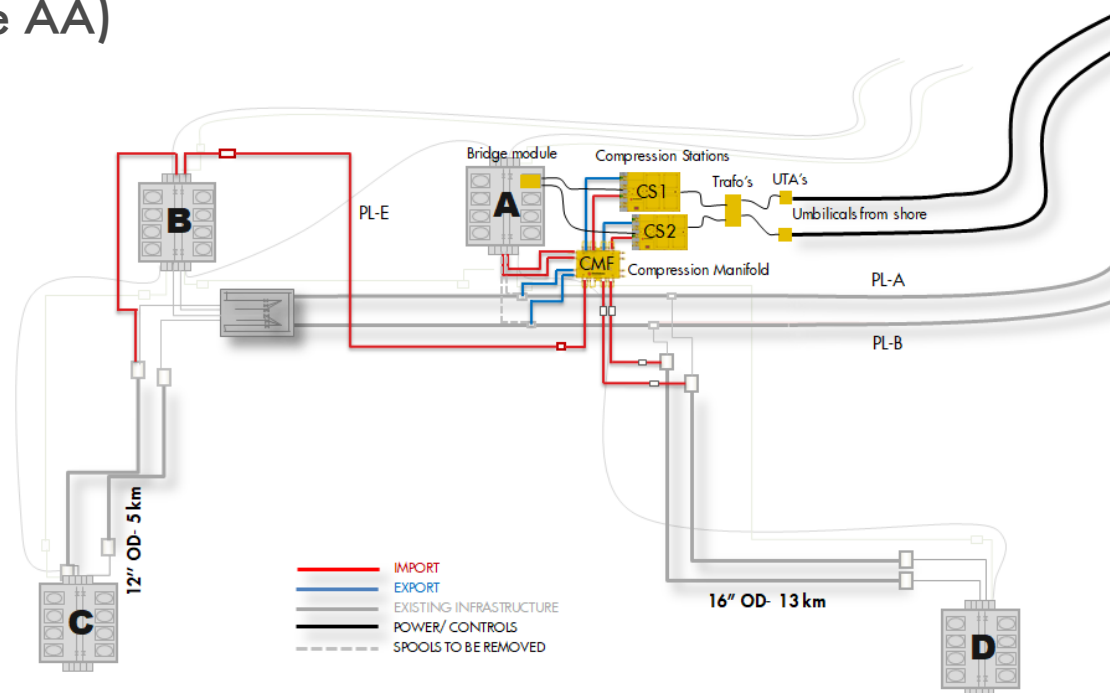


**Phase 3: Unlocking value, increasing output without increasing emissions.
Pushing technology barriers**



MEG injection line

- Lean MEG injected to prevent hydrates
 - Lean meg concentration is 90wt% MEG and 10wt% water
- 2 MEG injection lines from shore (line A and B) → no separate umbilical available for injecting other chemicals → all chemicals are injected onshore and are injected at the wellheads (e.g. CI, SI and potential future AA)



AA

- Current hydrate management strategy is using 60 wt% MEG → resulting in a high MEG rate → high pressure drop in the pipeline
- Business case for switching to AA + 10wt% MEG → reduce MEG injection → reduce hydrostatic head in the pipeline (needs to be produced from ~900m water depth) → reduce backpressure on the wells by a few bar → increase the gas production
- Option of using a low dosage hydrate inhibitor (LDHI) will reduce the MEG rate
 - Anti Agglomerants (AA) do not prevent hydrate formation itself but rather prevent the dispersed crystals from agglomerating and causing pipeline blockages.
 - Kinetic Hydrate Inhibitor (KHI): prevent the growth of hydrate crystals for a certain time, subcooling < 10degC
- Due to the temperature below 0 degC there is a risk for ice formation in the pipeline → 10wt% MEG is required to prevent ice

AA

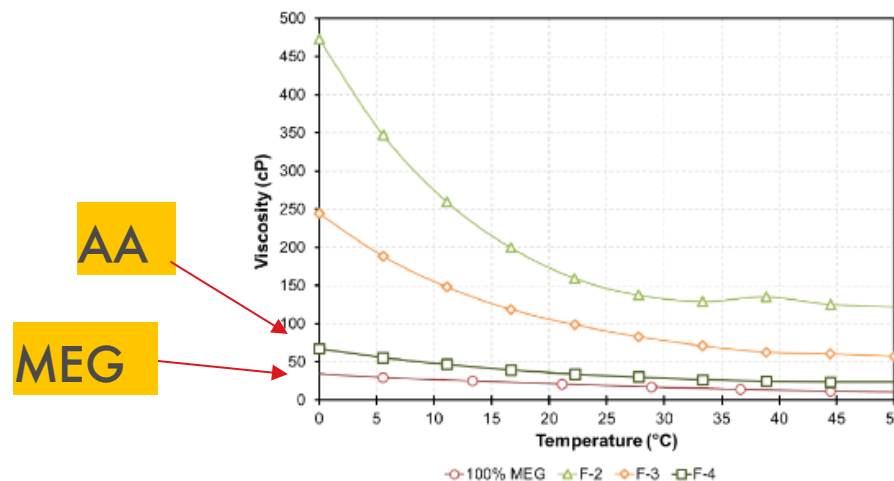
- New green AA developed by Clariant (HTDF 19512A ECO)
 - On the market since Q1 2024
 - Successfully used in another Shell asset
 - Subsea tie-back
 - Water is overboarded
 - Not in combination with MEG
- Difference with other Shell asset and Ormen Lange:
 - Ormen Lange needs AA which is compatible with glycol → glycol required to prevent ice
 - Need to go through subsea compressor (max. trip temperature 110 degC)
 - Need to go through MEG regeneration system
 - AA needs to be injected in the MEG (no separate umbilical available for AA injection)

AA compatibility with MEG

- HTDF 19512A ECO was insoluble in MEG → forms 2 phases

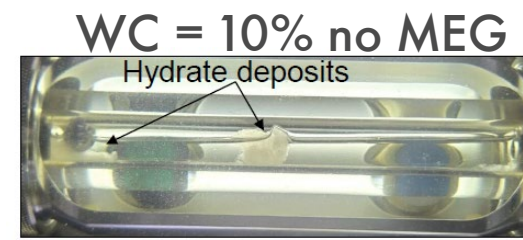


- AA adapted by Clariant to make it compatible with MEG → Solubility & compatibility tests done
- New product has the same active ingredient as HYTREAT DF 19512A ECO and HYTREAT DF 19630A ECO
- 3 formulations tested with different viscosities → formulation with the lowest viscosity used for further testing

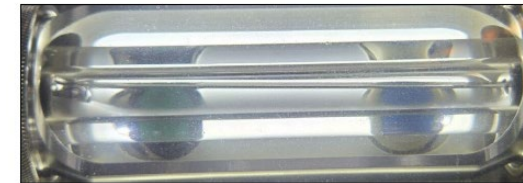


AA rocking cell testing

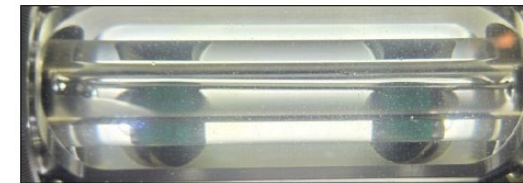
- Autoclave and rocking cell testing
- Testing was done with a similar subcooling as is seen in the field
 - Cells were filled with: Ormen Lange condensate, water with AA and Green Canyon gas
- Dosages from rocking cells are most likely to be roughly 50% lower in the field (2:1 ratio from Rocking cells to field/autoclave)
 - Pass 7.5% in rocking cell and 3.7% autoclave with 50% watercut
- Results:
 - Higher dose rate required for higher watercuts
 - Beter AA performance in combination with MEG



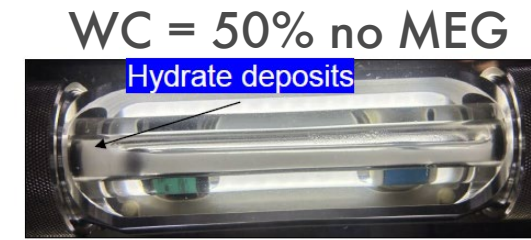
AA = 1.5% (Fail)



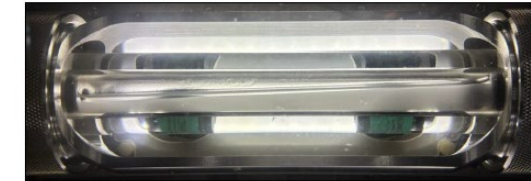
AA = 2% bvwt (Pass)



AA = 3% bvwt (Pass)



AA = 6% bvwt (Fail)



AA = 7.5% bvwt (Pass)



AA = 8% bvwt (Pass)

		No MEG	10wt% MEG	20wt% MEG
	Watercut %	MED %	MED %	MED %
Rocking cell	10	2	1.5	
Autoclave	30	1		
Rocking cell	50	7.5	6	
Autoclave	50	3.7	3.7 (not optimized)	
Autoclave	85		6 (borderline)	6

MED = Minimum Effective Dose - HYTREAT DF 20539A ECO

Results from Shell A'dam with different AA

Ormen Lange conditions

- Cooldown to -2.5 degC
- Small nicely dispersed particles, start-up is OK

Blanc WC=20%, MEG=30w%

- Hydrates formed during cooldown
- Ball stuck by hydrates on wall and ball



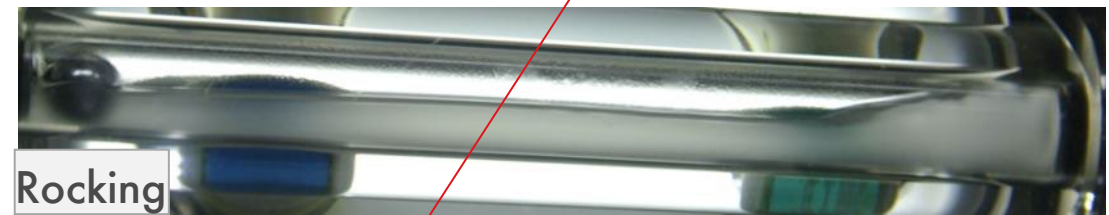
4% AA, WC=50%, MEG=10w%

- Hydrates formed during cooldown
- During shut-in (48 hrs), hydrate slurry in layer below condensate,



3% AA, WC=30%, MEG=5w%

- Hydrates formed during cooldown
- During shut-in (48 hrs), hydrate slurry in layer below condensate



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Further work

- Investigate transport properties of the hydrate slurry in flowloop experiments
- Onshore/offshore:
 - Check AA partitioning between oil and condensate in the main separator
 - Check AA partitioning in the MEG reboiler
 - Check fouling risk for MEG reboiler
 - Corrosion management at lower MEG concentration & compatibility
 - Any impact on the existing production chemicals (CI – SI) because of the AA
 - Impact of fines

