Hydrate management – How to cut down cost

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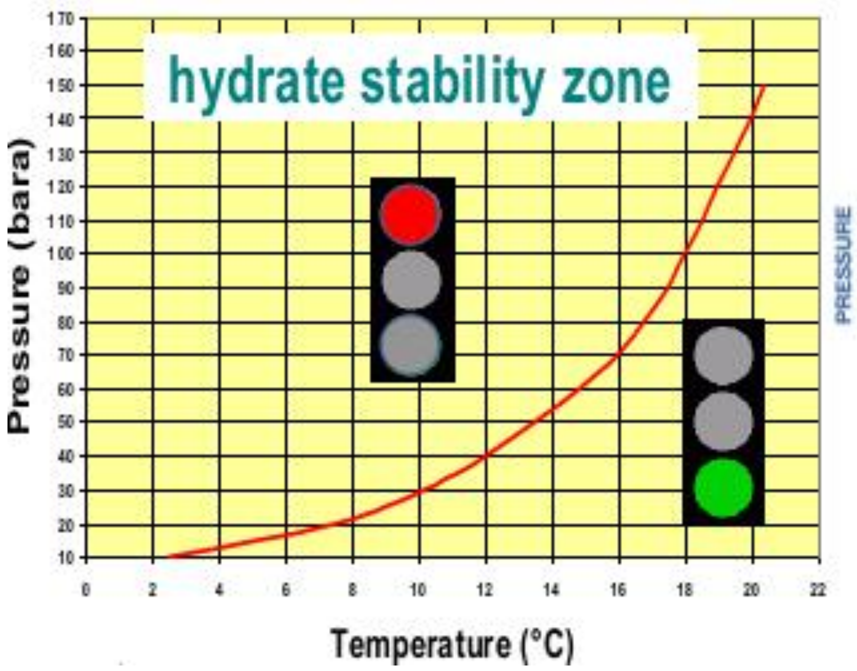
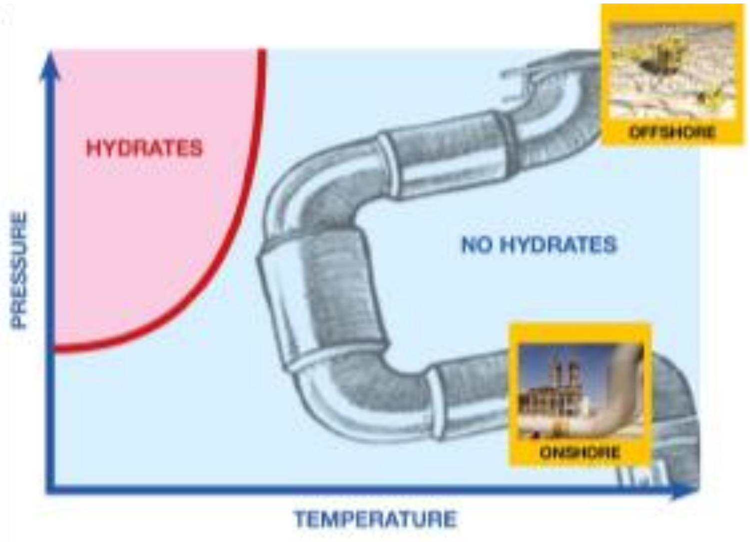
Current hydrate management strategy

- Production outside the hydrate zone
- Requirements
    - Thermal insulation
    - Massive injection of THI* (MeOH or MEG)
    - Heating devices e;g. Electrical
    - Complex operating procedures e.g. Dead oil preservation



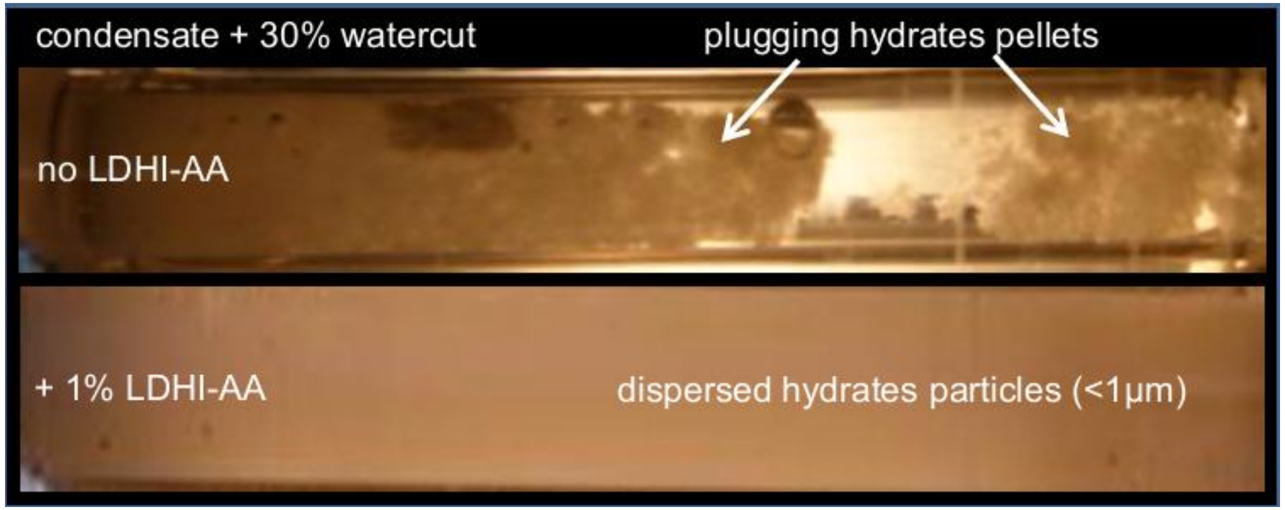


*:THI = Thermodynamic Hydrate Inhibitor

AA-LDHI: a way to produce inside the hydrate zone

- AA-LDHI: Anti-Agglomerant Low Dose Hydrate Inhibitor
  - Injection dose: ~ 1% / hydrate phase to be compared with ~ 50% / water phase for THI*
- Formation of a slurry of fine hydrate particles dispersed in the suspending liquid phase (no agglomeration, no deposit formation)
- Limitation in terms of slurry viscosity

$$\mu = \mu_L \frac{1-\phi_{hyd}}{\left(1-\frac{\phi_{hyd}}{\phi_M}\right)^2} \quad ; \quad \phi_{hyd} < \phi_M \approx 60\%$$



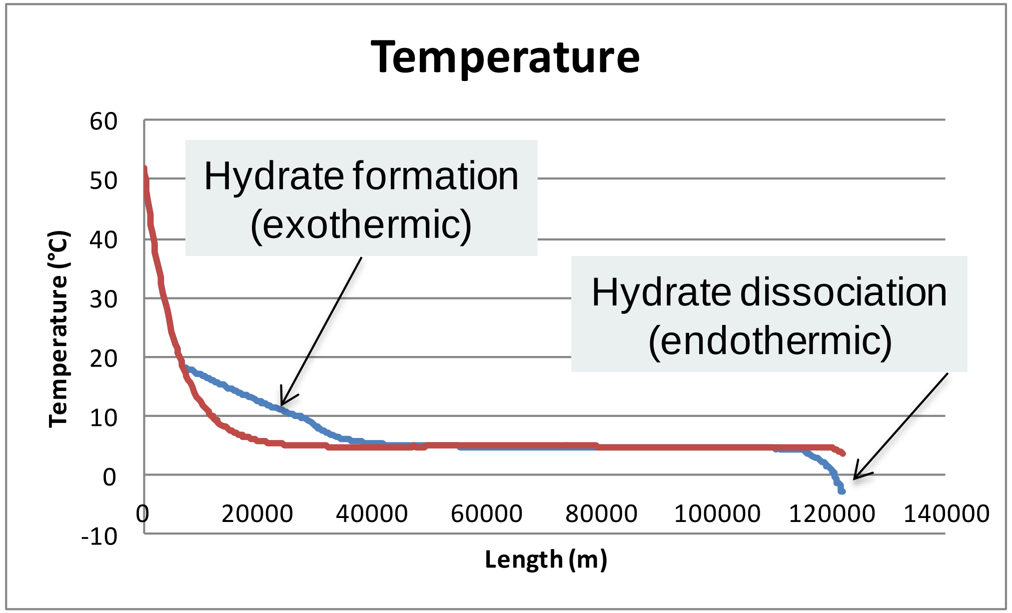
*:THI = Thermodynamic Hydrate Inhibitor

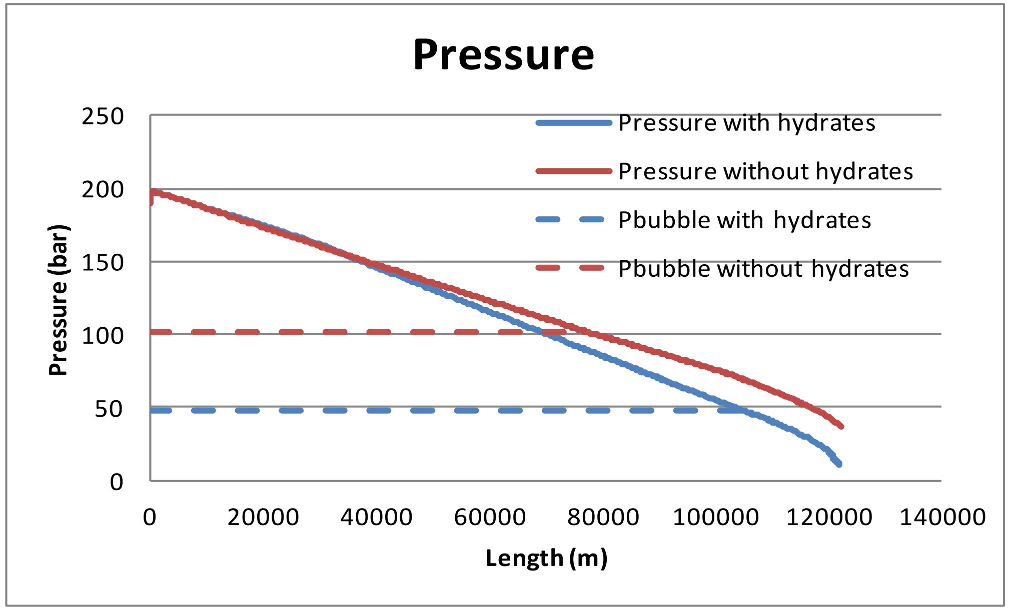
Development of an in-house simulator

- A predictive tool to handle formation and flow of hydrate slurries
- Main hypotheses
  - Steady state 2-phase flow conditions
  - Thermodynamic equilibrium (no kinetics – conservative approach)
  - Compositional calculation
  - Slurry viscosity = viscosity of a dispersed suspension
  - Exothermicity of hydrate formation considered in thermal calculations

Development of an in-house simulator

- Example
  - single liquid flow with a condensate saturated with gas at 150 bar and at WC=20%

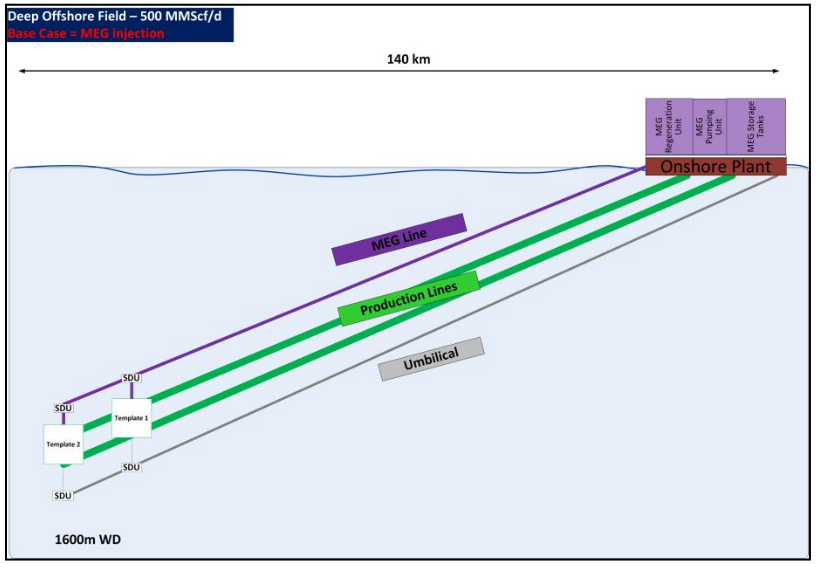


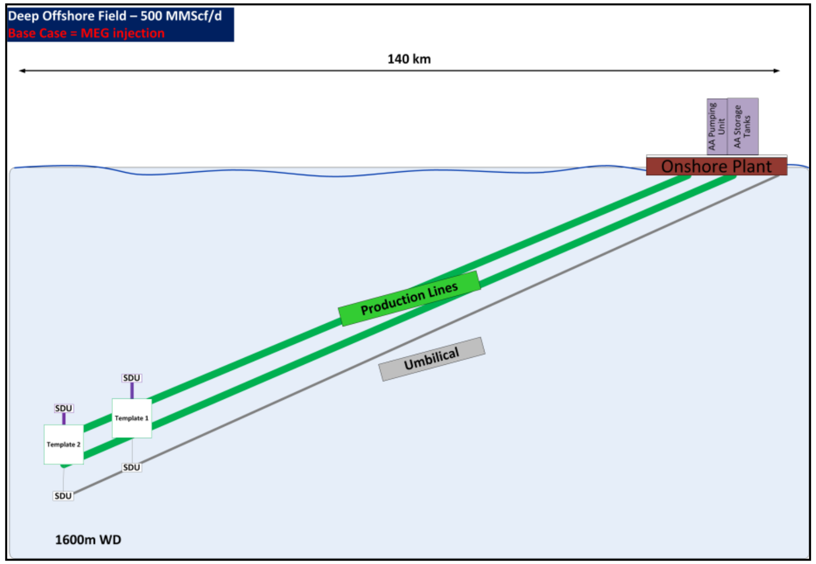


Application to subsea gas fields

- New architecture concept for gas field developments
  - ~~1x6" pipe for MEG transport~~ → AA-LDHI in existing umbilical (~1 bbl/d)
  - ~~MEG regeneration unit at onshore~~

Cutting CAPEX ~ 400 M$

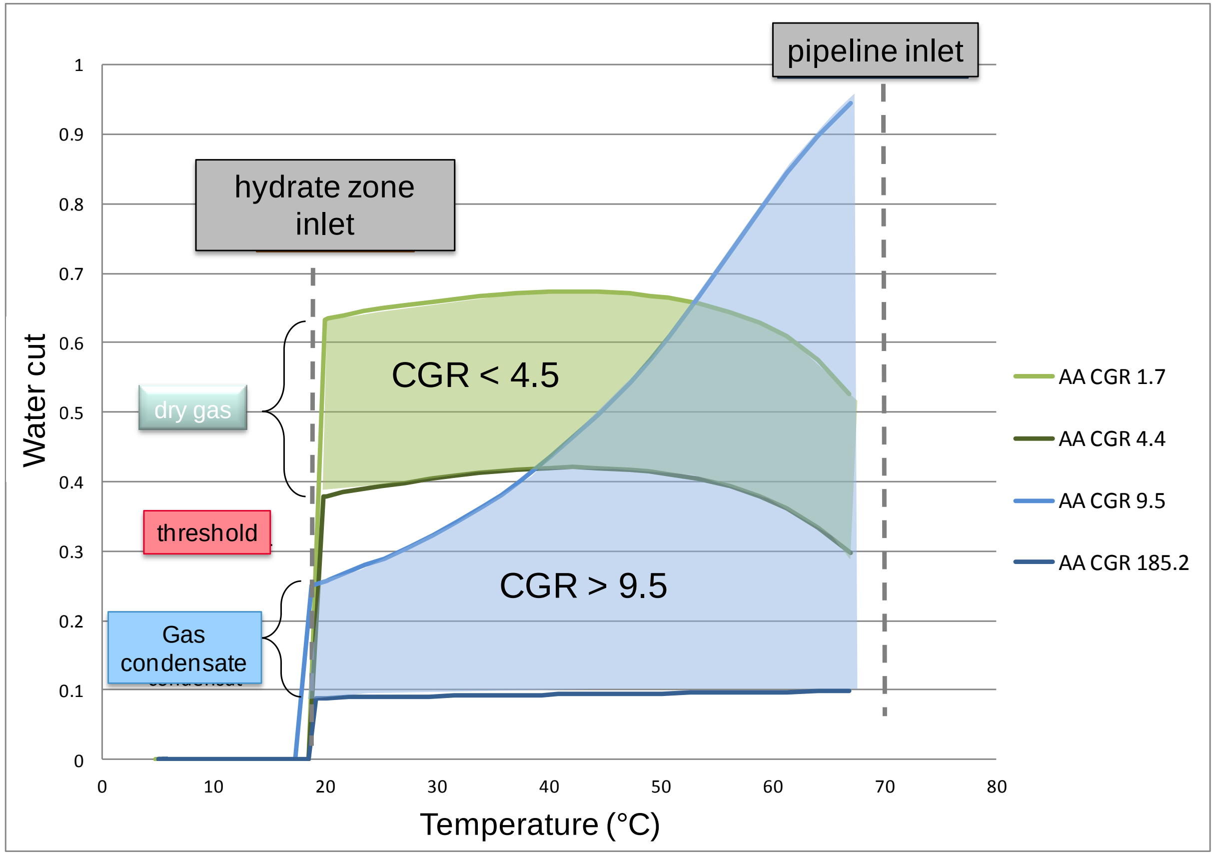




- Additional possible cutting CAPEX
  - Lower liquid content → lower hydrodynamic turndown
  - ~~2~~ production lines → 1 production line

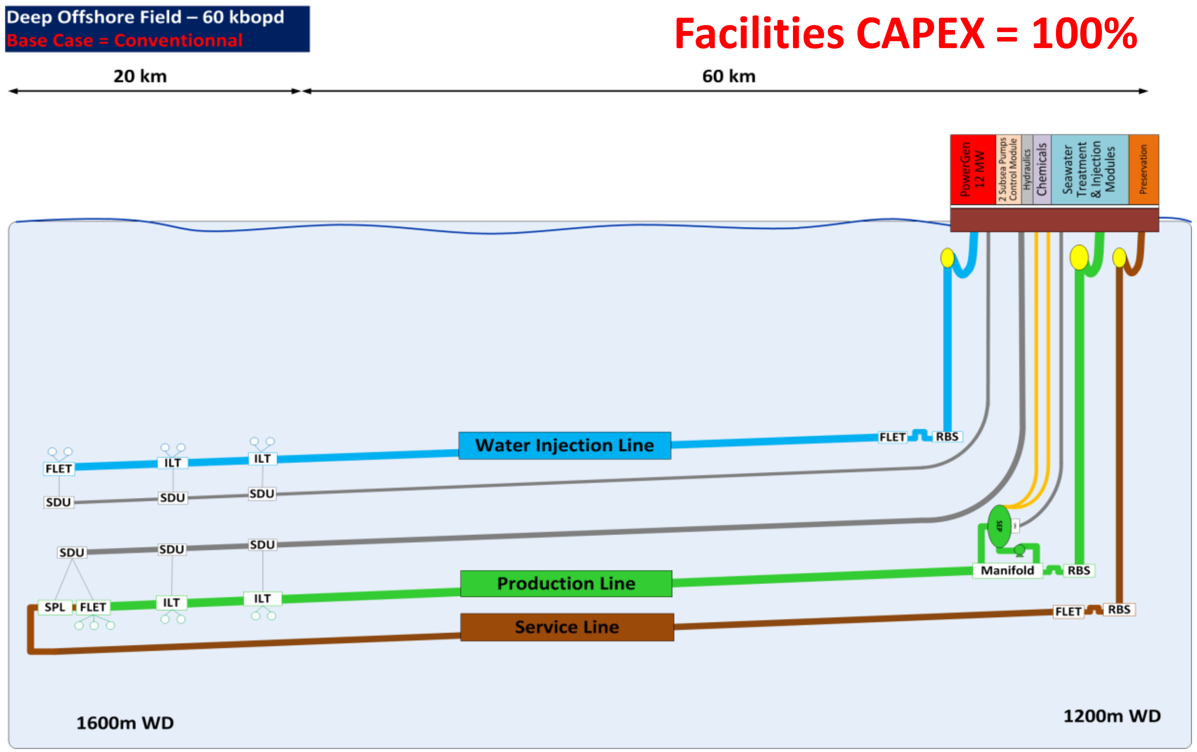
Application to subsea gas fields: Operational envelop

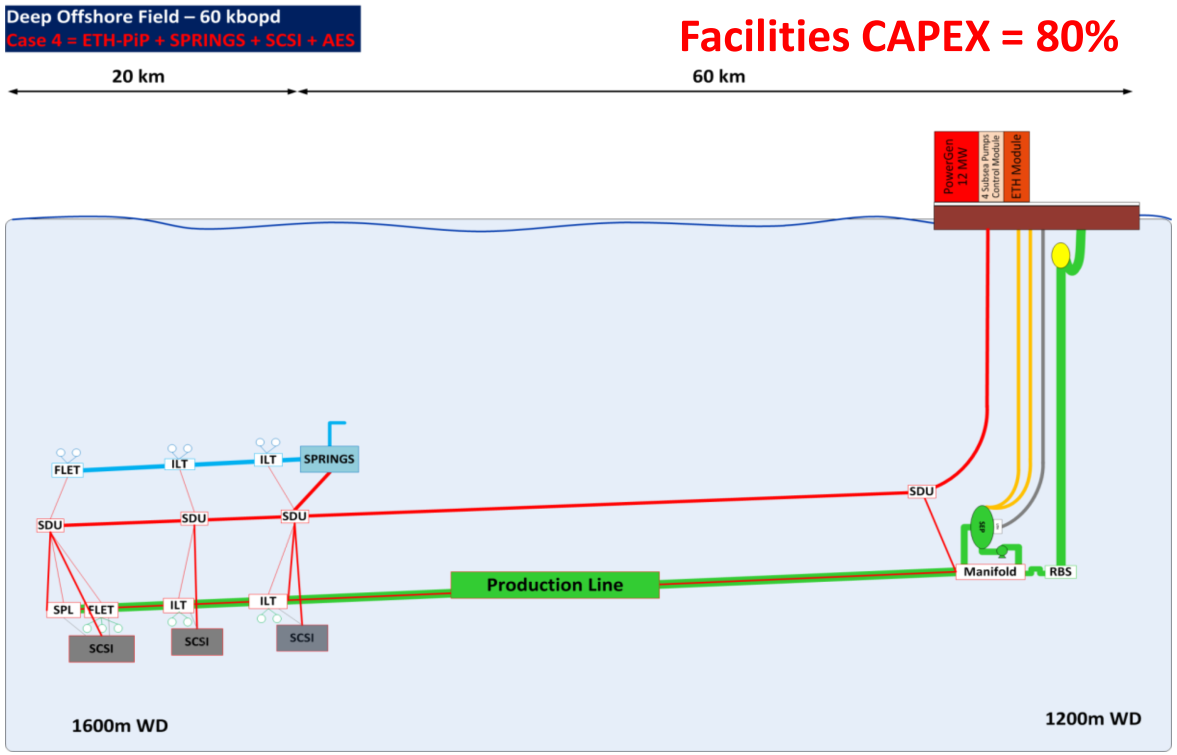
- **Only condensed water is considered**
  - All the water phase is transformed into hydrate
  - No salt
- Key point: WC at the entrance of the hydrate zone
- CGR is the main relevant parameter for hydrate transportability
- CGR threshold: ~ 4 – 10 SMm^3/Sm^3
  - Can vary depending on the pressure in the line
  - Might be higher in case of production of reservoir water



Application to satellite subsea oil fields

- Production line + service line → ETH*-PiP + Subsea systems + all elec.





Adapted from L. Riviere MCEDD Pau 2016

*:ETH = Electrical Trace Heating

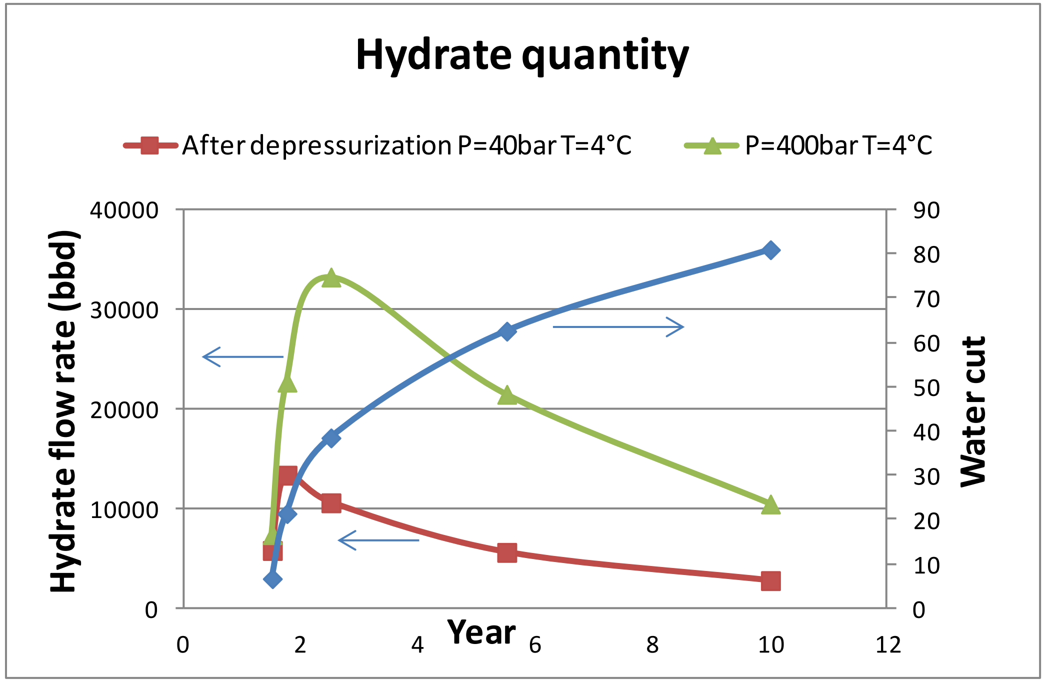
Application to satellite subsea oil fields

- **Another gain step can be reached by replacing the 12”/18” ETH-PiP by 14” wet insulated pipe**
  - CAPEX 80% → CAPEX 62% (*according to L. Riviere MCEDD Pau 2016*)
- Batch injection of AA-LDHI for degraded flow conditions and planned shutdowns (makes feasible subsea storage)
- Risk of hydrate formation during long unplanned shutdowns and restarts
  - Depressurization at the SSU*: may be not enough
  - Continuous injection of AA-LDHI for unplanned shutdowns management might result in high OPEX

* SSU = Subsea Separation Unit

Application to satellite subsea oil fields

- A case-by-case risk assessment is required by considering:
  - Maximum quantity of hydrate that can form
    - Thermodynamic conditions
    - Limited by GOR and salinity of produced water

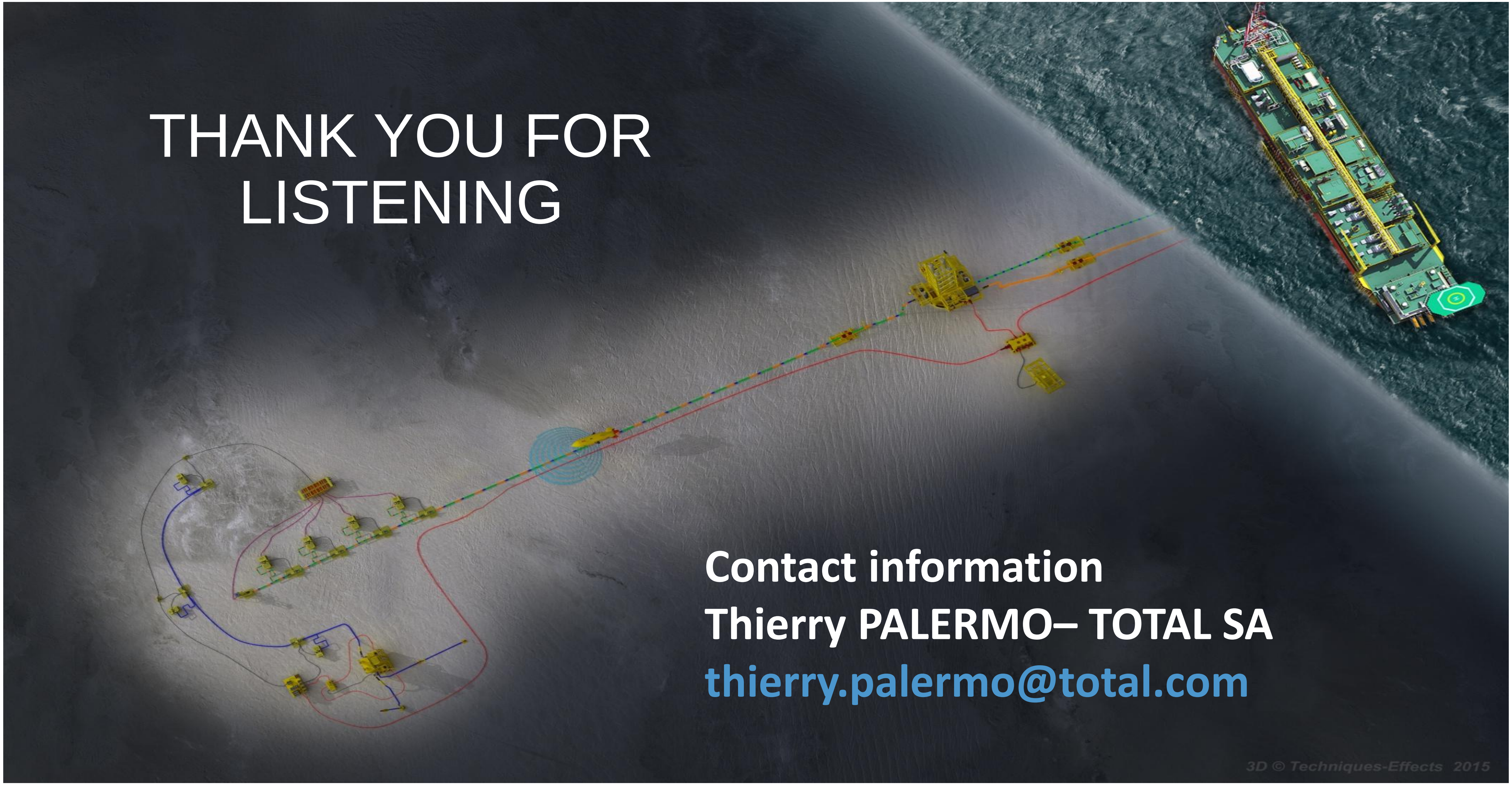


  - Actual quantity of hydrate that can form
    - Kinetics effect
  - Natural AA properties of the oil
    - May enable to drastically reduce the quantity of AA-LDHI be continuously injected

Conclusions

- Subsea gas fields
  - Large cutting CAPEX by replacing MEG with AA-LDHI
  - Can be applied to low CGR cases
- Satellite subsea oil fields
  - In addition to the simplified ‘single line’ architecture, AA-LDHI can offer an another significant cutting CAPEX.
  - Batch injection of AA-LDHI to manage degraded conditions and planned shutdowns
  - A case-by-case risk assessment is required for long unplanned shutdowns
    - Continuous injection of AA-LDHI may be lead to high OPEX
    - Should depend on oil properties

THANK YOU FOR LISTENING



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BACK-UP

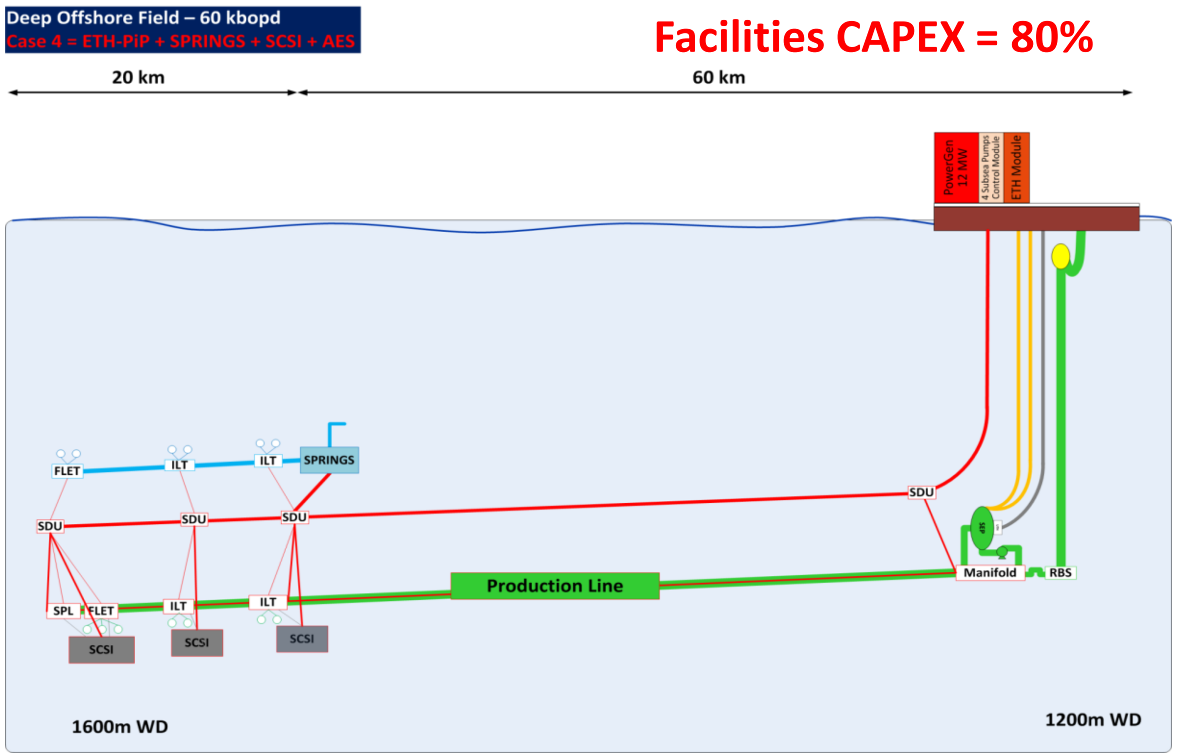
CGR and WC definitions

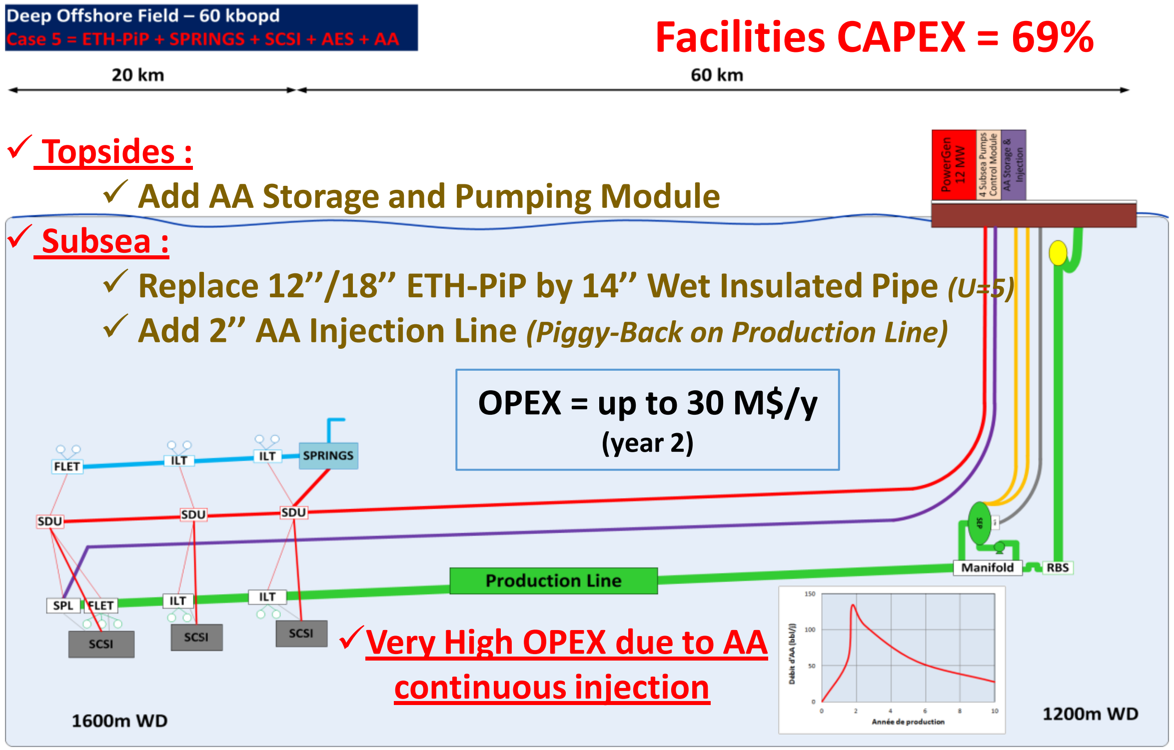
- Pseudo-process considered to calculate CGR and WC:

	1st step	**2d step**	**3rd step**	**4th step**	**5th step**
P (bar)	45	60	60	45	15
T (°C)	20	6	1.5	1	1

Application to satellite subsea oil fields

- ETH-PiP → wet insulated line + continuous AA-LDHI injection





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