

Saturn Cold Flow

by

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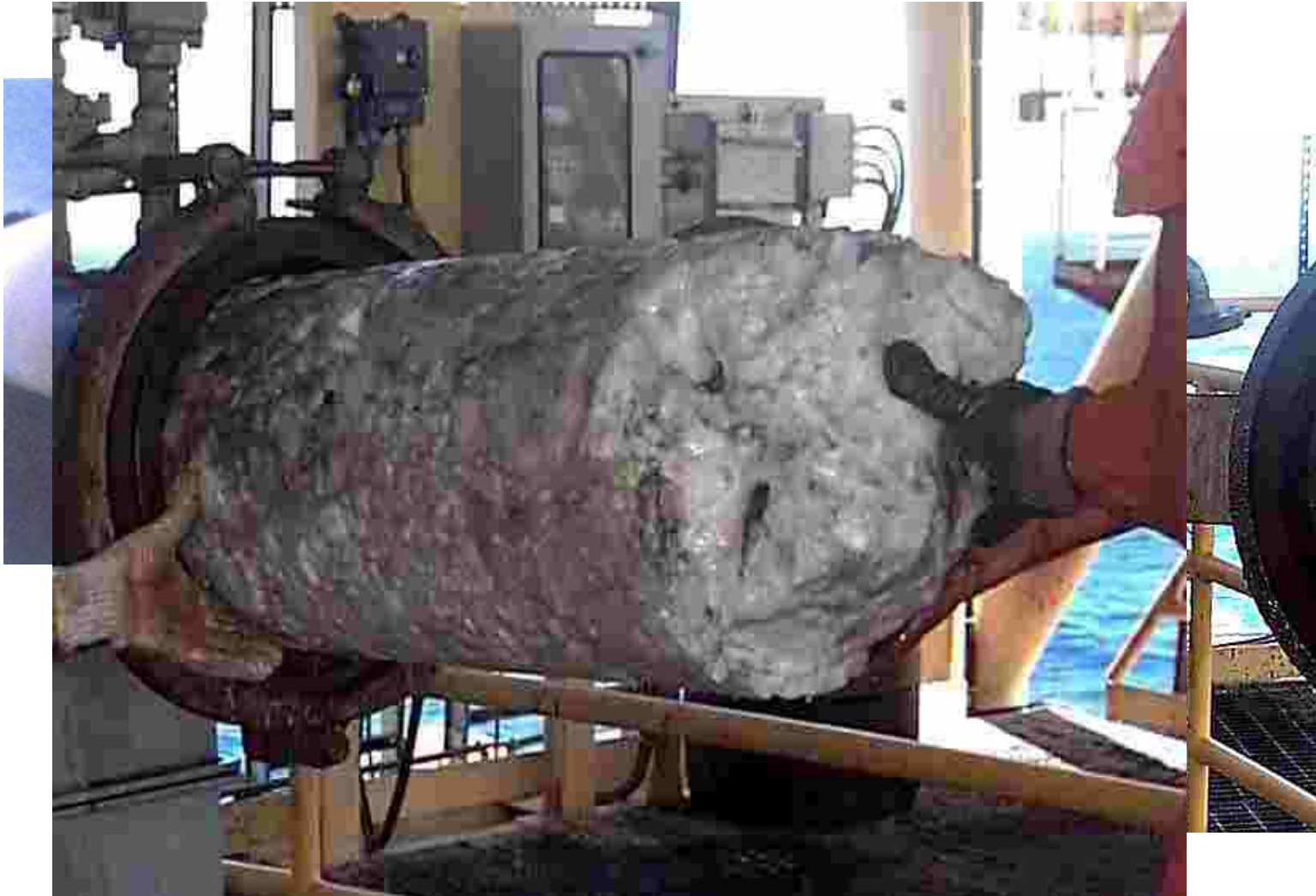
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Major flow assurance problem: Gas Hydrates

- Ice-like crystals – gas in H₂O cavities
- May exist up to 25-30 °C
- Requirements:
 - light hydrocarbons (C1-C4)
 - free water
 - “low” temperature (offshore: <20 °C)
 - “high” pressure (offshore: >20 bar)

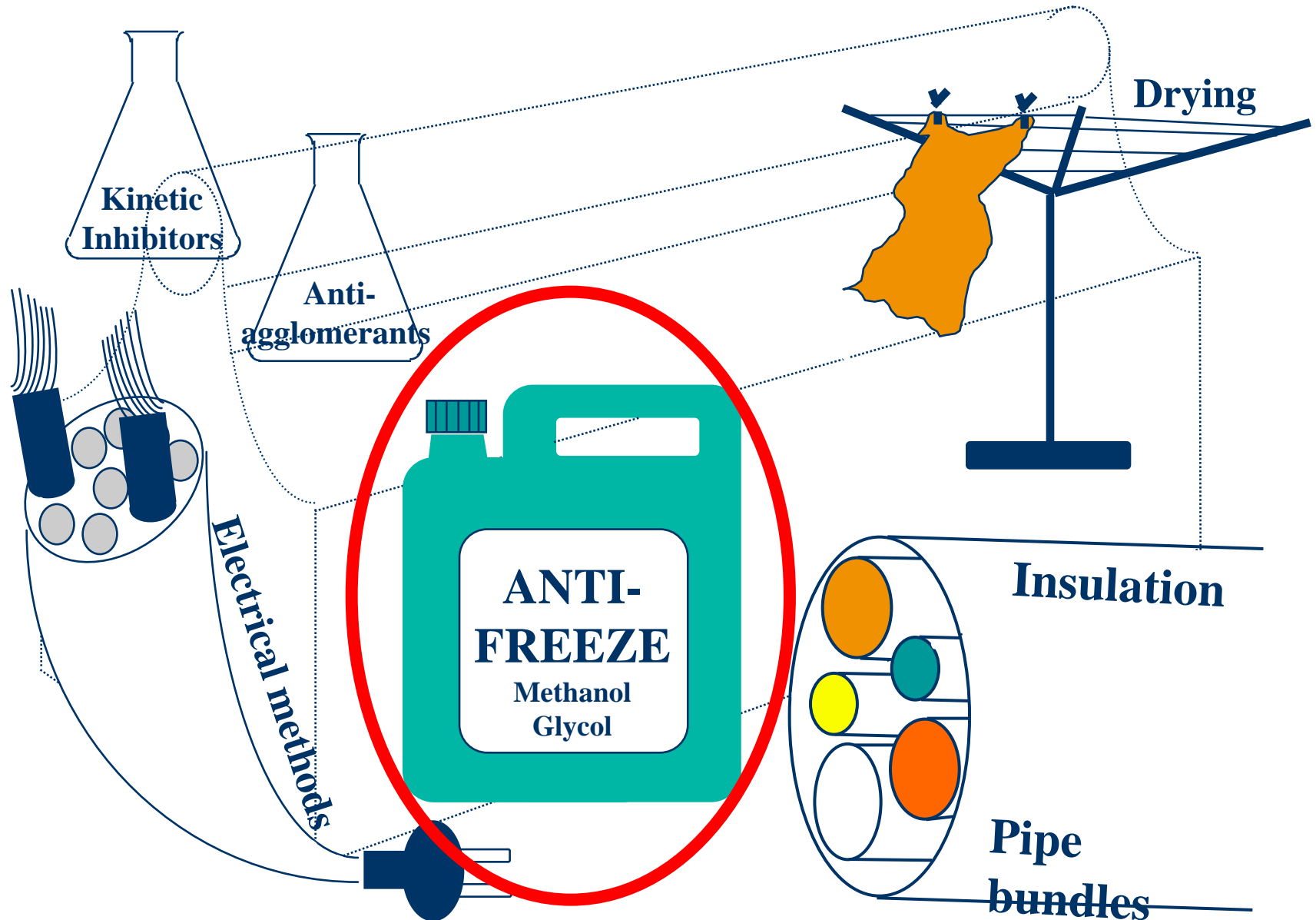


Pipeline Plugging



Pictures from P-34 FPSO platform, in Campos Basin - courtesy of Petrobras

Traditional Tool Chest



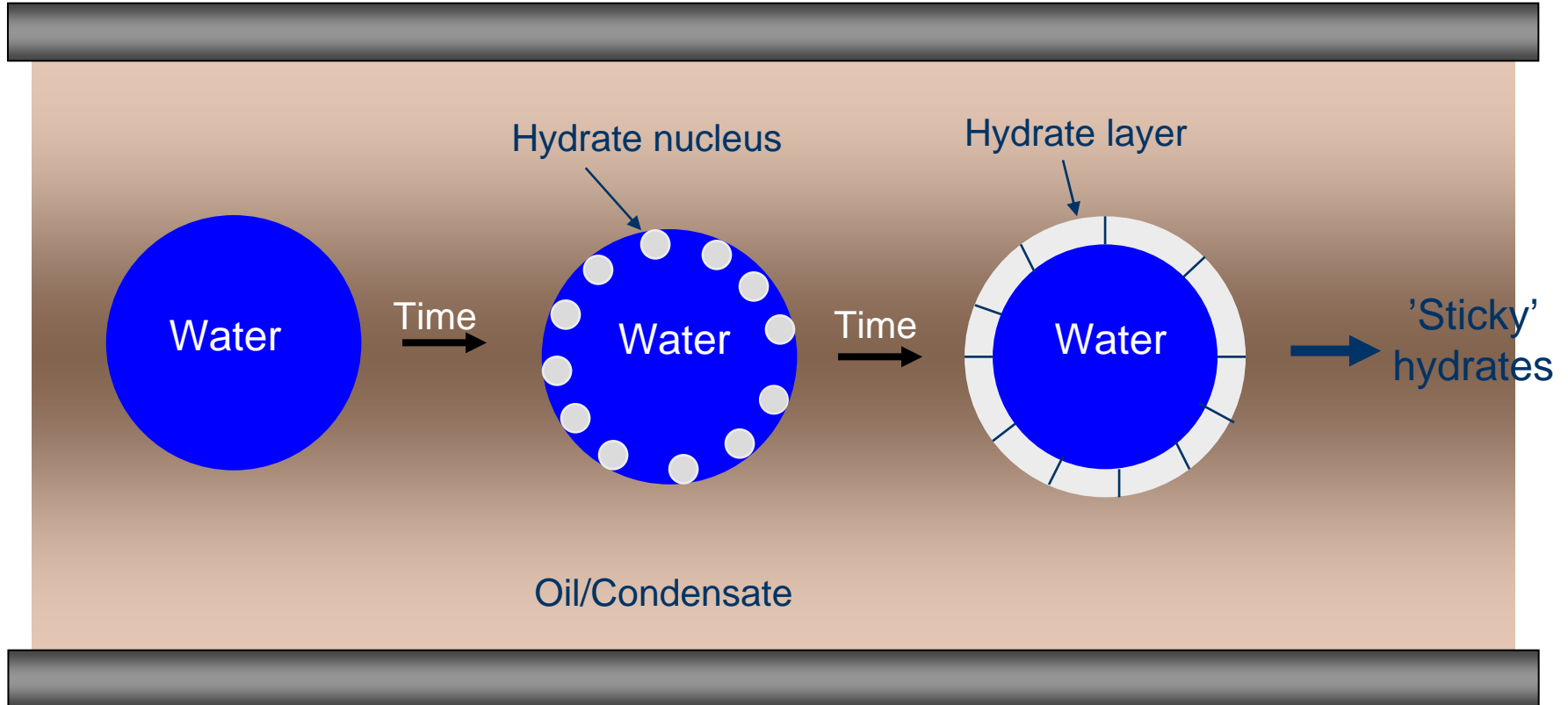
What is Cold Flow ?

Transport of production fluids at conditions in thermal equilibrium with the surroundings, with hydrates and waxes precipitated – no extreme temperatures needed!

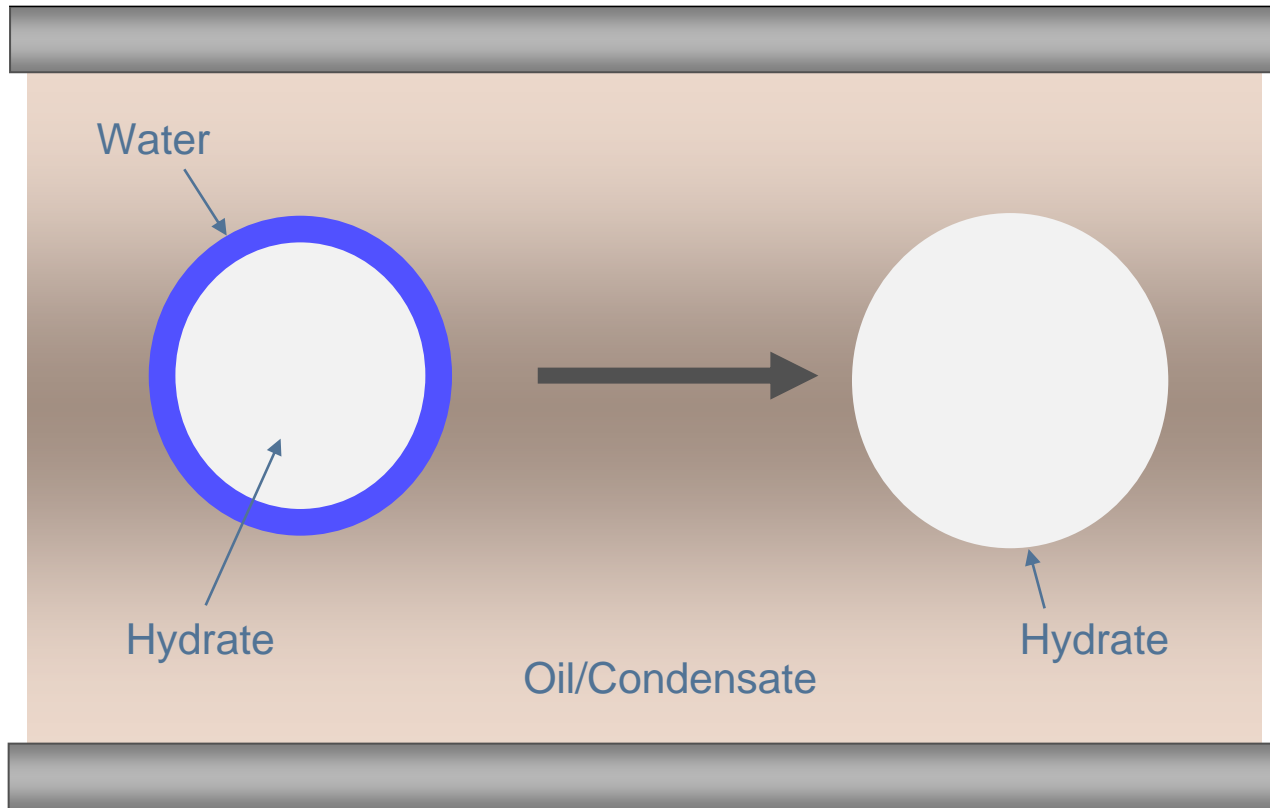
Our definition also requires:

- **NO** chemical solids inhibition, and - in particular no ‘anti-agglomerant’ hydrate slurry producers,
 - **NO** pipeline or component heating,
 - **NO** pipeline insulation,
- just bare steel pipelines, exposed to sea, with a slurry that is easily transportable, able to go through long-lasting shut-ins, re-dispersing at restart, etc.

Hydrate growth - standard



Hydrate growth – "improved"



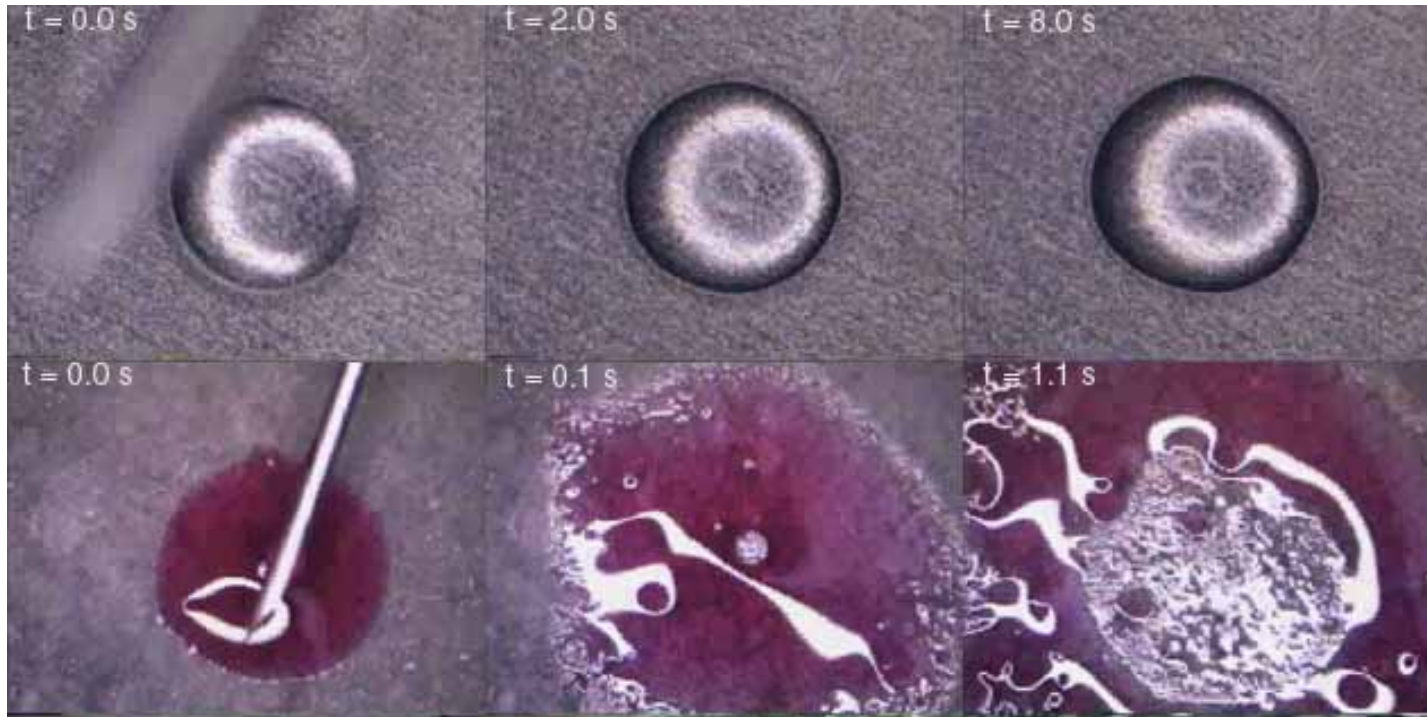
Dry, inert, easily flowable hydrate powder

A striking experiment...



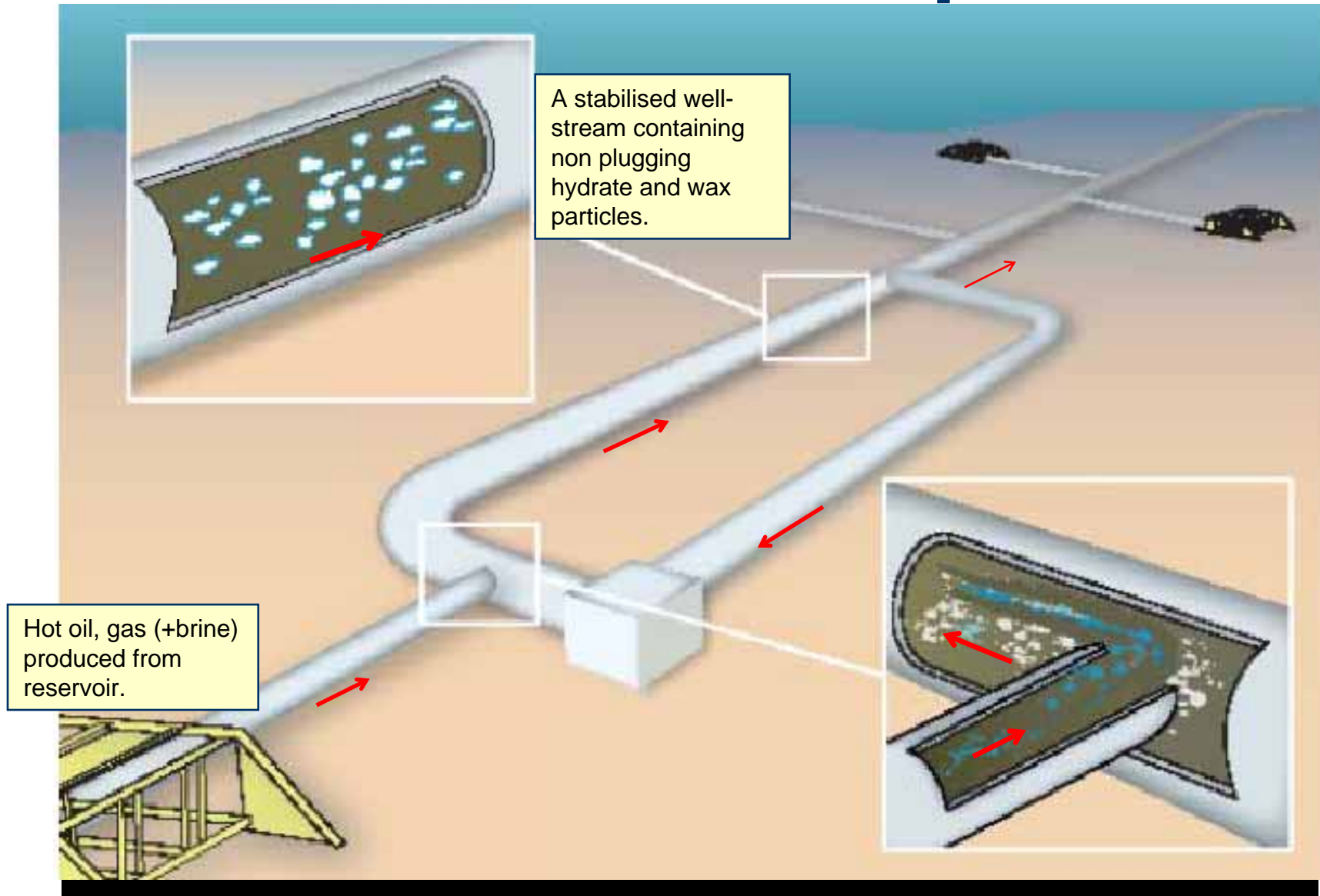
Water spreading on steel, ice, and hydrate

Video backup...

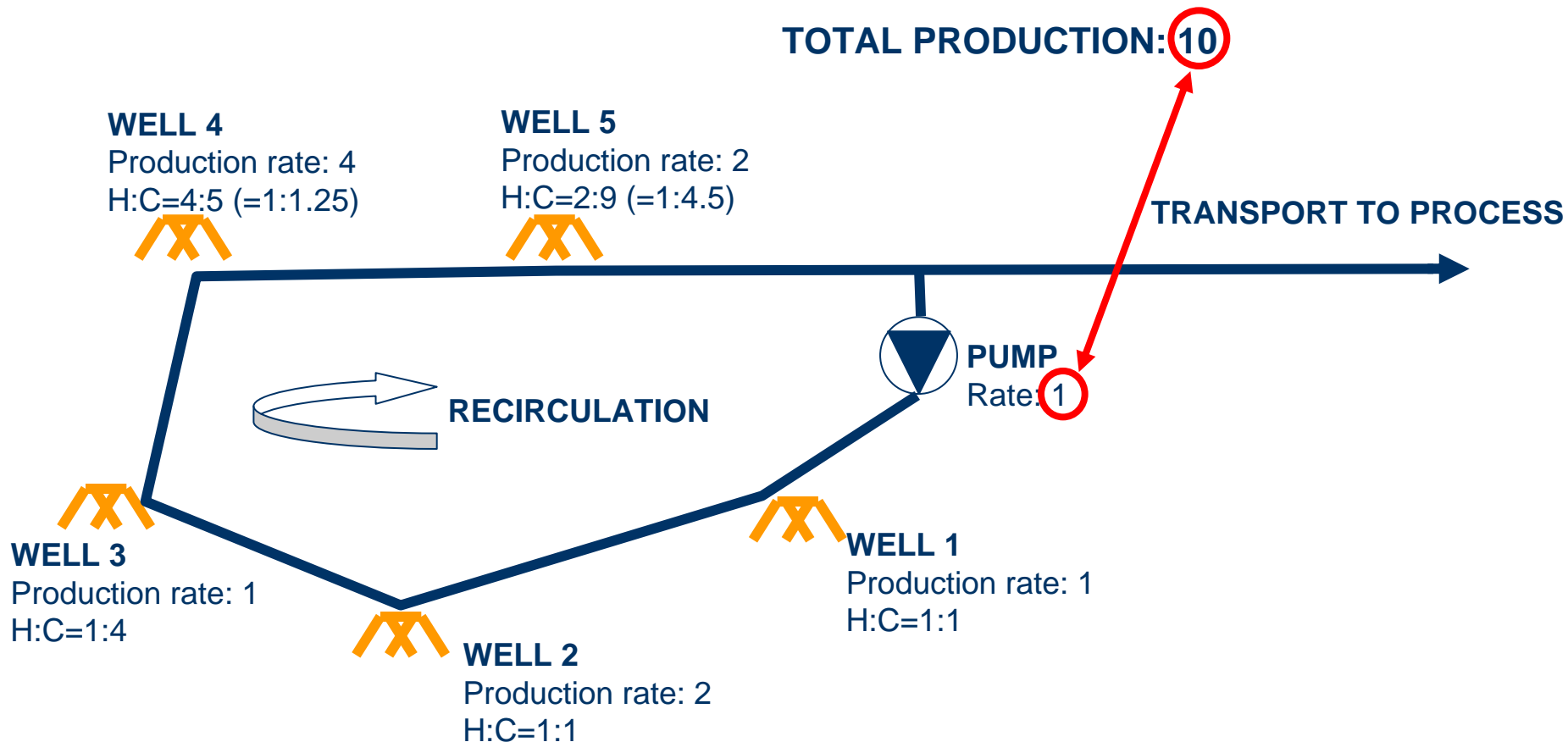


Water spreading on steel (top), and hydrate (bottom)

The Cold Flow Principle



Recirculation needs

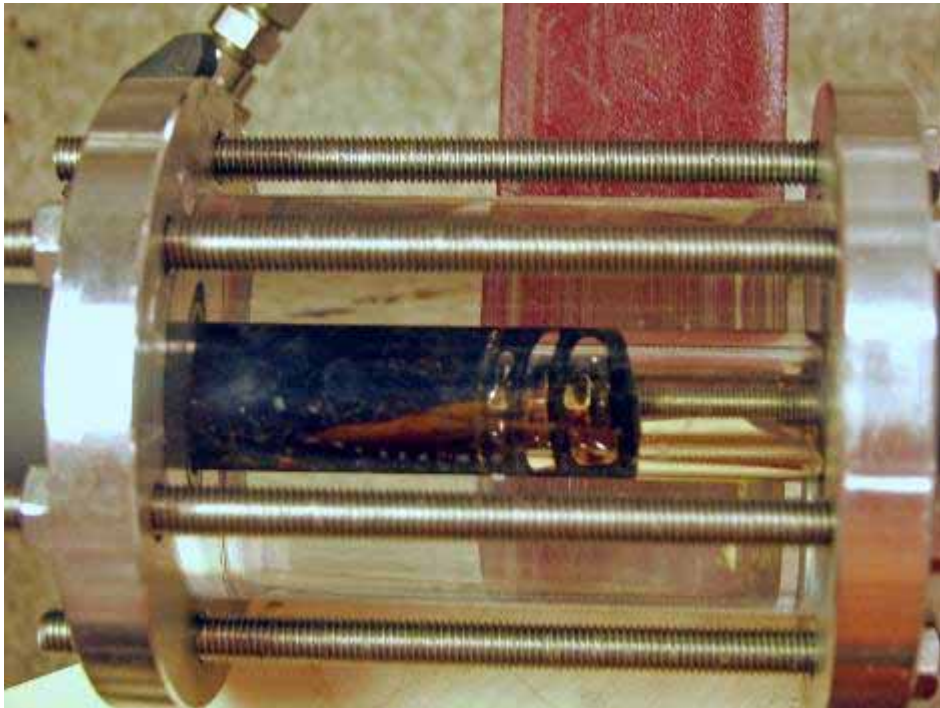


H = 'hot', warm rate
C = 'cold', cold rate (recirc)

What about wax?



Wax deposition effects



Pigging test rig with rubber disc pigs



With the Cold Flow process

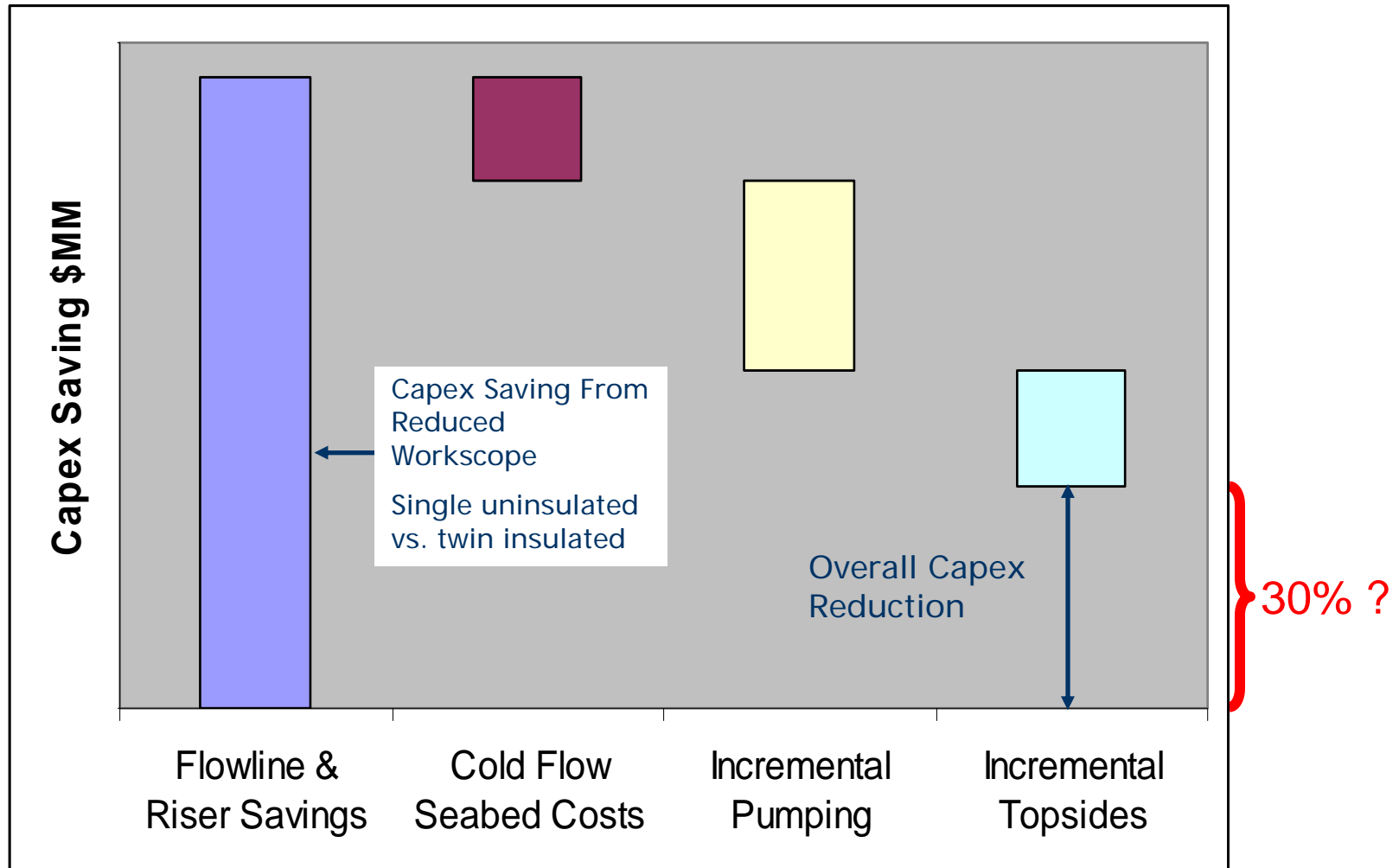


Without the Cold Flow process

Reduced CAPEX with Cold Flow

- Lower cost tie-backs; ~\$100 million reduction compared to conventional designs (BP)
- Eliminates high cost passive and active insulation / heating solutions – *single bare steel pipelines*
- Long tie-backs to shallow water host
- Eliminate deepwater surface-piercing structures
- Easier deepwater installation
- Produce directly from subsea to shore

Main Source of Business Value – Capex Reduction



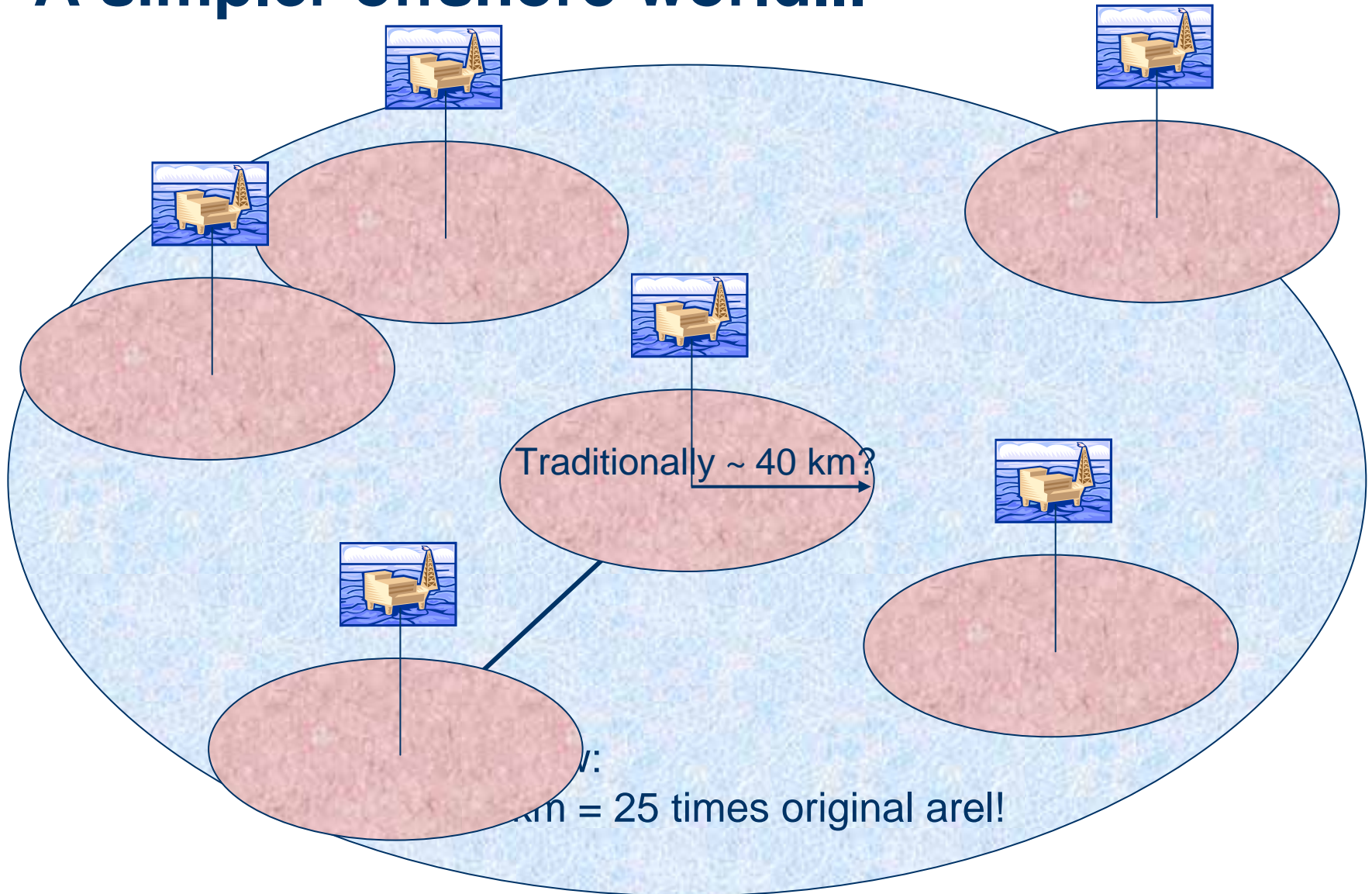
Reduced OPEX with Cold Flow

- Eliminates or reduces need for chemical injection (MeOH, MEG...)
- Less need for platform personnel
 - Long tie-backs to shallow water host
 - Eliminate deep water surface-piercing structures
 - Production directly from subsea to shore
- Improved production
 - Removes hydrate / wax blockage risk
 - Might reduce corrosion due to water being locked up as hydrate
 - Simpler operation, steady operation, low maintenance

Improved HSE with Cold Flow

- Lower numbers of offshore personnel – reduced risk
- Fewer surface-piercing offshore structures
- Removes hydrate / wax blockage risk with potential personnel risk
- Reduced usage / handling of harmful chemicals
- Reduced / zero emission of harmful chemicals to sea (methanol, glycols, LDHI etc.)
- Reduced energy input for heating pipelines (and thereby reduces CO₂ emissions)

A simpler offshore world...



Main conclusion

Cold Flow is a potentially revolutionary technology for safer production and transport of liquid-dominated hydrocarbons, both for new developments in 'mature' regions, and for new challenges in deep water and in harsh or vulnerable areas (e.g. arctic)

The road ahead

■ Main remaining challenges:

- Continuous operation over long time (months)
- Testing of shear (deposition conditions) vs. turbulence (heat transfer)
- Needs large and advanced test facility (diameter/length/temperature control)

■ Future:

- Assessment phase now: what is needed for qualification and commercialisation?
- Research Council/Demo2000 support, as well as industry, but so far challenging to fully finance the next steps
- Field test (onshore?) on our wish list

SATURN COLD FLOW

