October 27-29, 2014
Petrochemistry and Chemical Engineering

Thermodynamic and Kinetic Hydrate Inhibition Performance of MEG Solution and its Synergistic Inhibition with PVCap

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Research Purpose

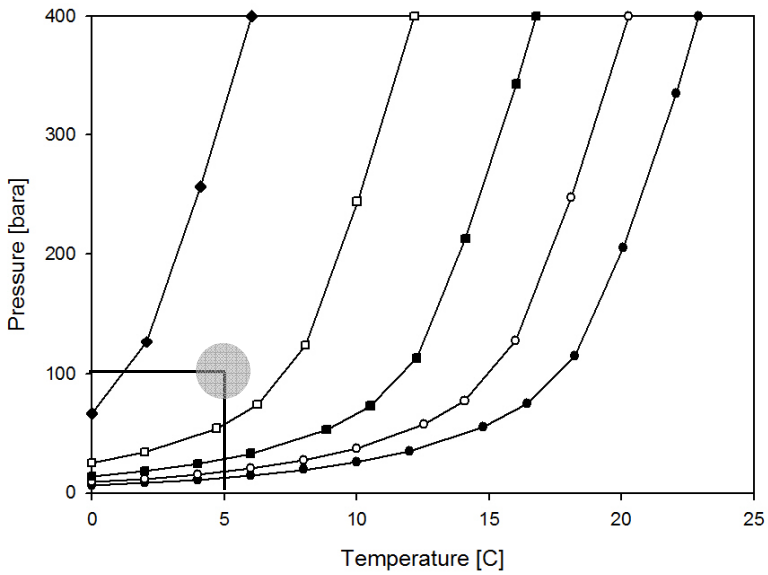
- The methodology to determine the MEG concentration that can avoid the hydrate blockage is developed by using both simulation and experimental results.
  - To determine the MEG concentration based on conventional techniques and investigate the required hydrate delay time enough to avoid the hydrate onset
  - To understand the hydrate formation kinetics in the presence of MEG
  - To evaluate the inhibition performance of under-inhibited system
  - To study the amount of hydrate that is formed at studied MEG concentrations in order to confirm its fraction is less than 10 % in liquid phase

System Description

- Compositions

Component	mol %
Water	3.34
Methane	86.98
Ethane	5.80
Propane	2.91
n-Butane	0.97

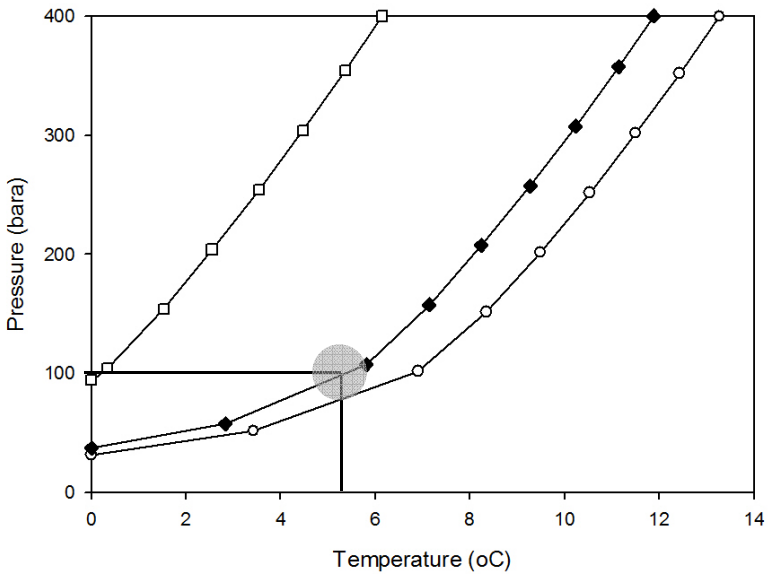
- Hydrate equilibrium curve



- Pure water (●), MEG 10 wt% (○), 20 wt% (■), 30 wt% (□), 40 wt% (◆), 50 wt% (◇)

Required MEG Injection Rates

- Based on worst conditions



○ = MEG 40 wt%

□ = MEG 50 wt%

- Shut In Flowline Pressure = 100 bar
- Ambient temperature = ~ 5.0 ℃
- Required hydrate inhibitor concentration

  = **43 wt%** (◆)
- The volume of water per 1 MMscfd of dry wellstream

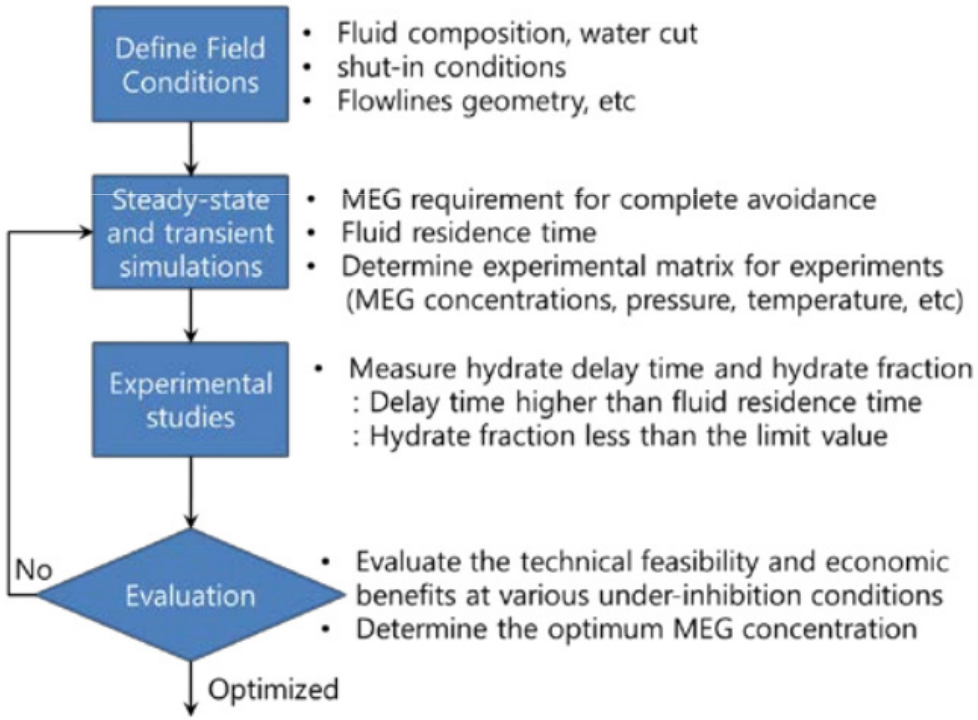
  ≒ **5 bbl of water / MMscfd of dry wellstream**
- Production rate = 400 MMscfd
  - The amounts of condensed water

    = 2,000 bbl/day
  - **Required MEG**

    = ~ 237,000 kg/day (MEG 90wt% solution)

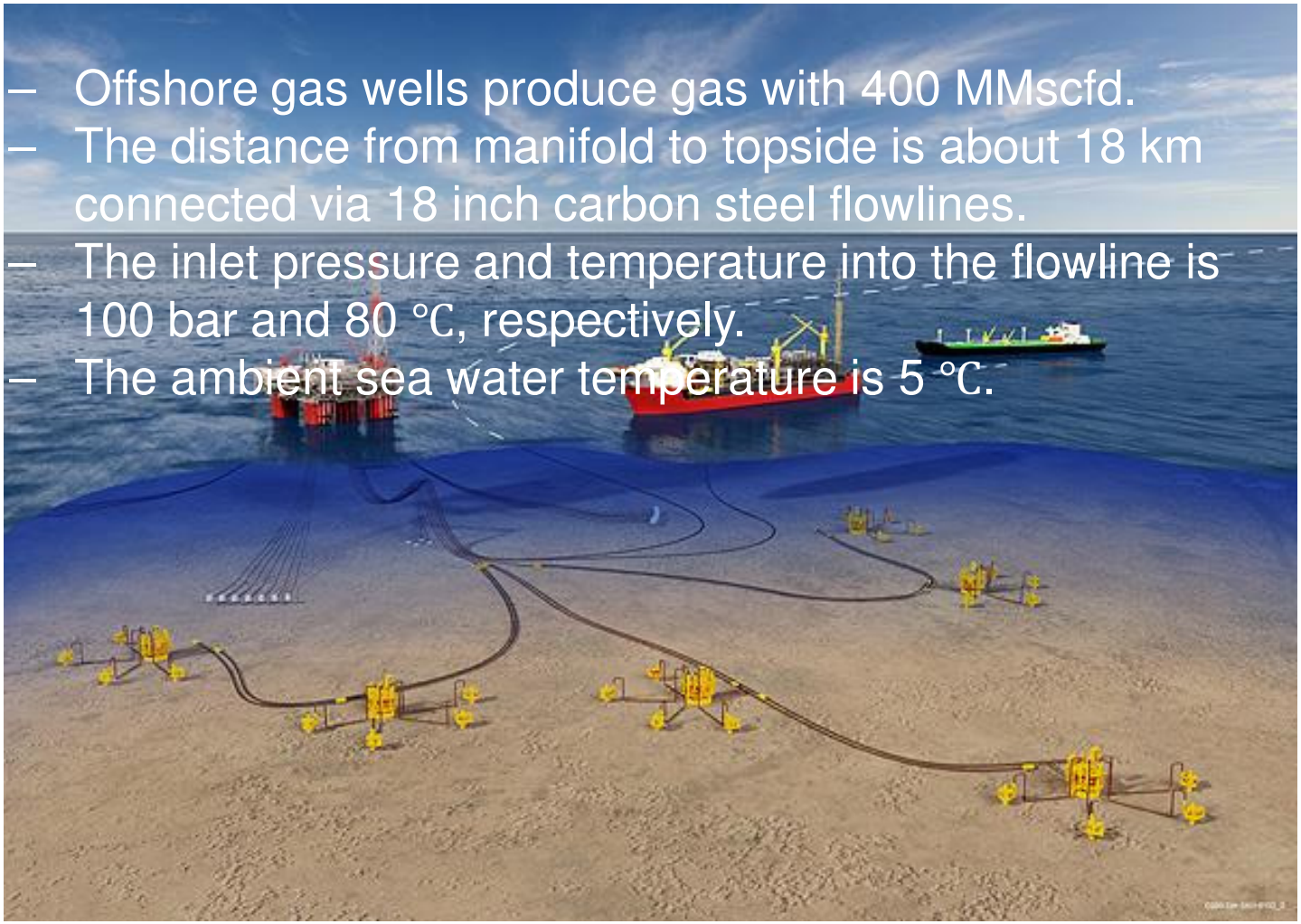
Applying the under-inhibition concept

- Purpose: Evaluate the feasible MEG concentration to avoid hydrate plugging risks
- Step 1: Scenario developments by multiphase simulation tool such as OLGA
- Step 2: Experiments to evaluate the performance of MEG solution
- Step 3: Evaluation of the hydrate management strategy



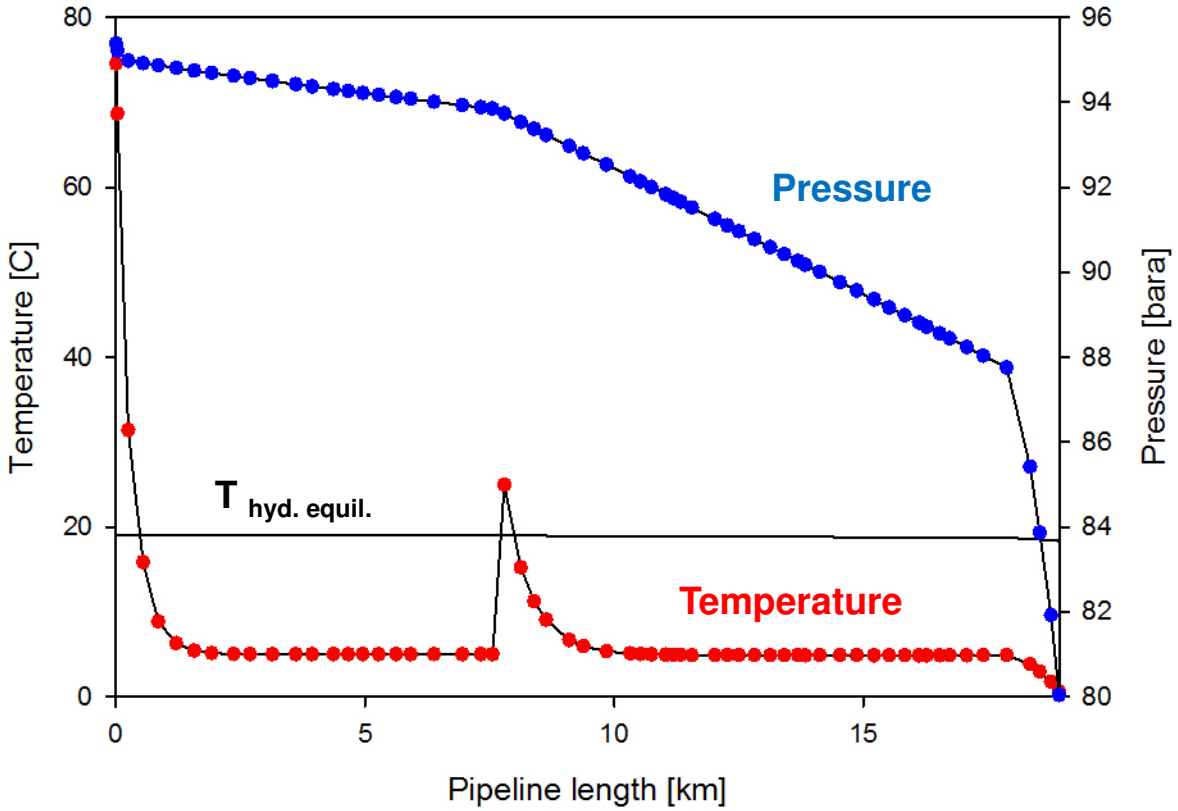
Step 1: Define the case

- Simplified field layout



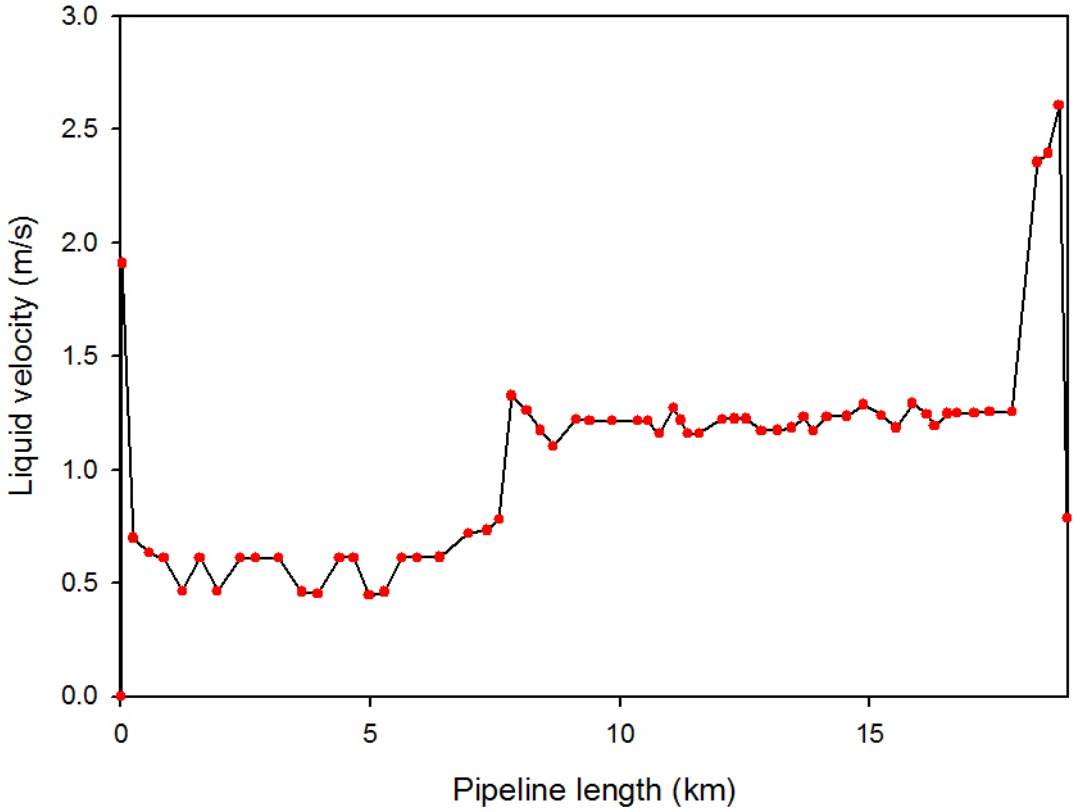
Step 2: Multiphase simulation

- Steady state simulation – No insulation



Liquid Phase Fluid Velocity

- Steady state simulation – No insulation



Liquid Phase Residence Time

- The liquid velocity
  - Minimum: 0.5 m/s
  - Average: 1.6 m/s
  - cf) Average gas velocity: 6 m/s

- Stratified flow

- From this low liquid velocity, the fluid residence time is expected to be about 288 min.

- In order to incorporate the under-inhibition concept, target hydrate delay time set to be 320 min (10 % margin with actual fluid residence time, 288 min) and the hydrate delay time in the experiments should be longer than this target value.

Step 3: Experiments for optimizing inhibition strategy

- Experimental matrix

MEG concentration (wt%)	PVCap concentration (wt%)	Target temperature (℃)
0, 20, 30	0, 0.2	5

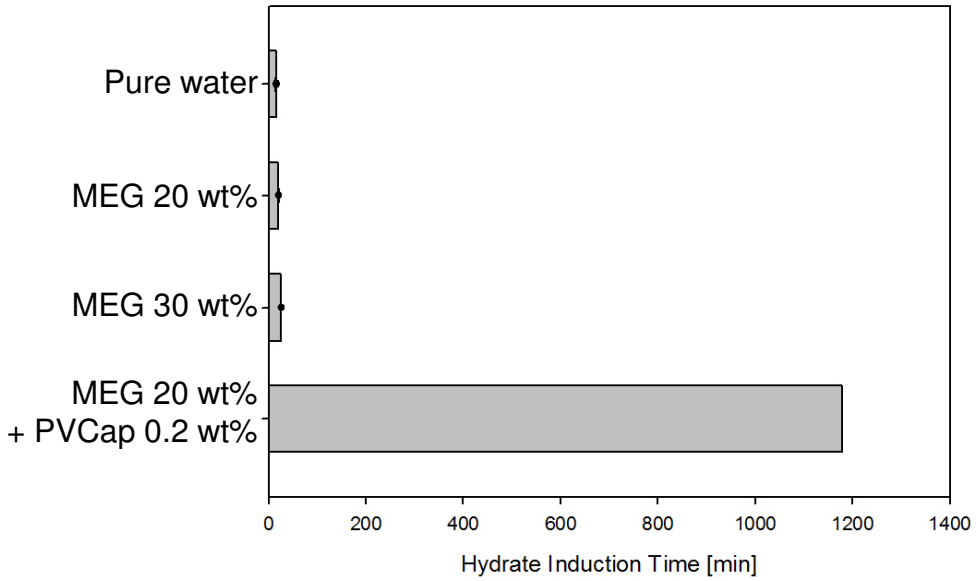
- Initial condition: 23 ℃ and 120 bar
- The constant cooling method
- 80 ml liquid volume
- Stirring at 600 rpm
- Measurement the volumetric consumption rate of the gas mixture while monitoring the change of pressure and temperature

Results – Hydrate Onset

	Induction time [min]	Subcooling temperature [℃]
Pure water	15.7 ± 0.7	4.6
MEG 20 wt%	20.8 ± 1.3	5.3
MEG 30 wt%	26.0 ± 0.5	5.8
MEG 20 wt% + PVCap 0.2 wt%	1179	10.9

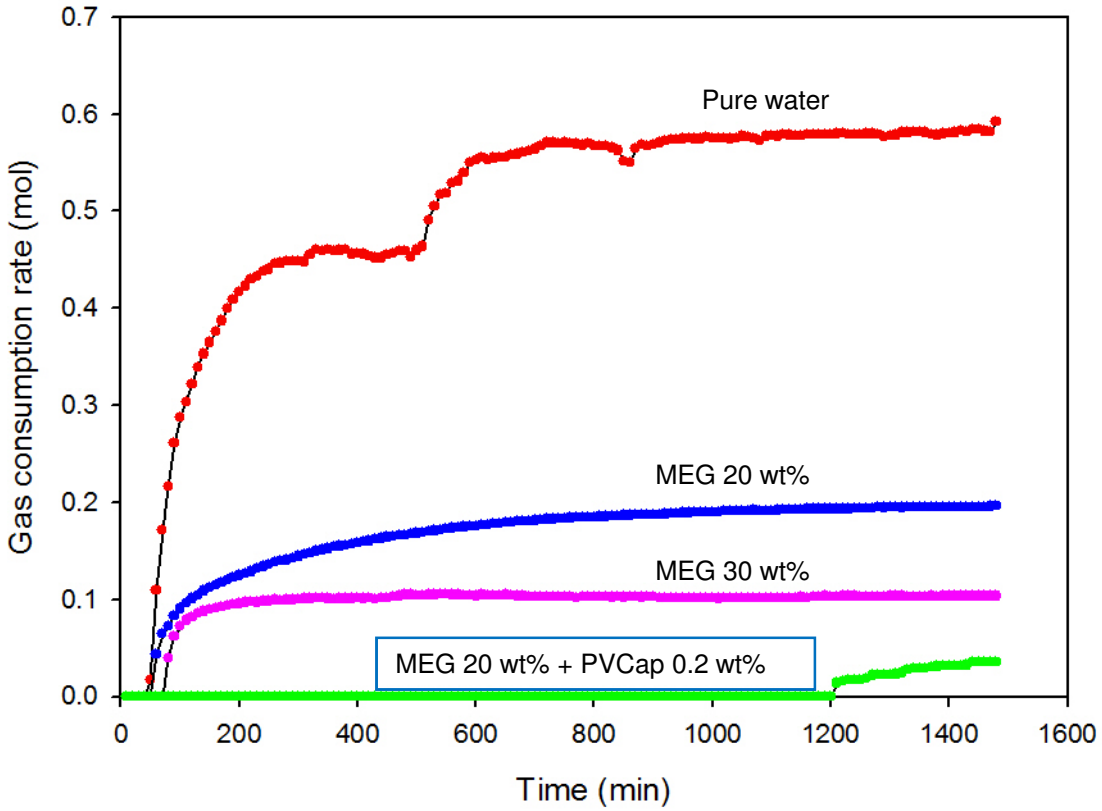
- Induction time

System	Induction time
Pure water	15.7 min
MEG 20wt%	20.8 min
MEG 30wt%	26.0 min
MEG 20wt% + PVCap 0.2wt%	1179 min



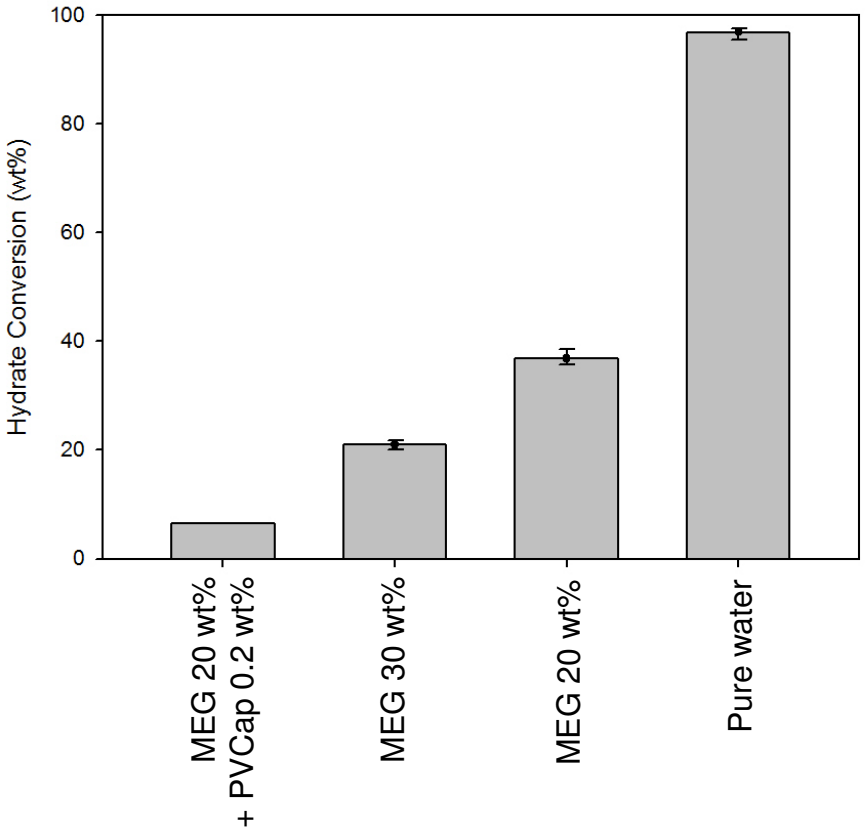
Results – Hydrate Growth

- Target temperature = 5 ℃



- Hydrate conversion

System	Del P (bar)	Conversion (wt%)
Pure water	29.8	0.97
MEG 20wt%	11.2	0.37
MEG 30wt%	5.8	0.21
MEG 20wt% + PVCap 0.2wt%	0.7	0.07



Comparison of experimental results

- Best option – MEG 20wt% with PVCap 0.2wt%

System	Hydrate delay time (min)	Hydrate fraction (measured)	Hydrate fraction (predicted)
Pure water	15.7 ± 0.7	0.97	1.0
MEG 20wt%	20.8 ± 1.3	0.43	0.72
MEG 30wt%	26.0 ± 0.5	0.25	0.49
MEG 20wt% + PVCap 0.2wt%	**1179**	**0.08**	**0.72**

Conclusions

- In this work, the evaluation of under-inhibited system is carried out to identify the possibility of hydrate blockage formation using multiphase flow simulation tool and accompanying hydrate kinetics experiments.
- For offshore gas wells which produce gas with 400 MMscfd, steady state simulation indicates the liquid velocity is the minimum in flowline section, 0.5 m/s resulting the residence time of liquid about 288 min.
- In order to incorporate the under-inhibition concept, target hydrate delay time set to be 320 min (10 % margin with actual fluid residence time, 288 min).

Conclusions

- By introducing the under-inhibition, we confirmed that the MEG concentration can be reduced to 20 wt% with the addition of synergist 0.2 wt% of PVCap. Hydrate kinetics experiments suggest that the hydrate delay time is 393 min, which is higher than the limit value of 320 min, and hydrate fraction is 0.08, which is less than the limit value of 0.10.
- The daily saving of OPEX by reducing MEG injection rate from 237 ton/day to 118.5 ton/day can be USD 118,500.
- It can be concluded that saving of both capital and operational cost as well as the saving of topside spaces by using smaller facilities would impact the economy of offshore field development.

Acknowledgement

- This works was supported by the Global Leading Technology Program of the Office of Strategic R&D Planning (OSP) funded by the Ministry of Knowledge Economy, Republic of Korea (10042424) and also supported by the Technology Innovation Program (10045068) funded by the Ministry of Knowledge Economy, Republic of Korea.

Discussion

