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Evaluation of Scenarios Associated to Subsea Gas-liquid Separation in Pre-Salt Fields: Opportunities and Technological Challenges

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SUMMARY

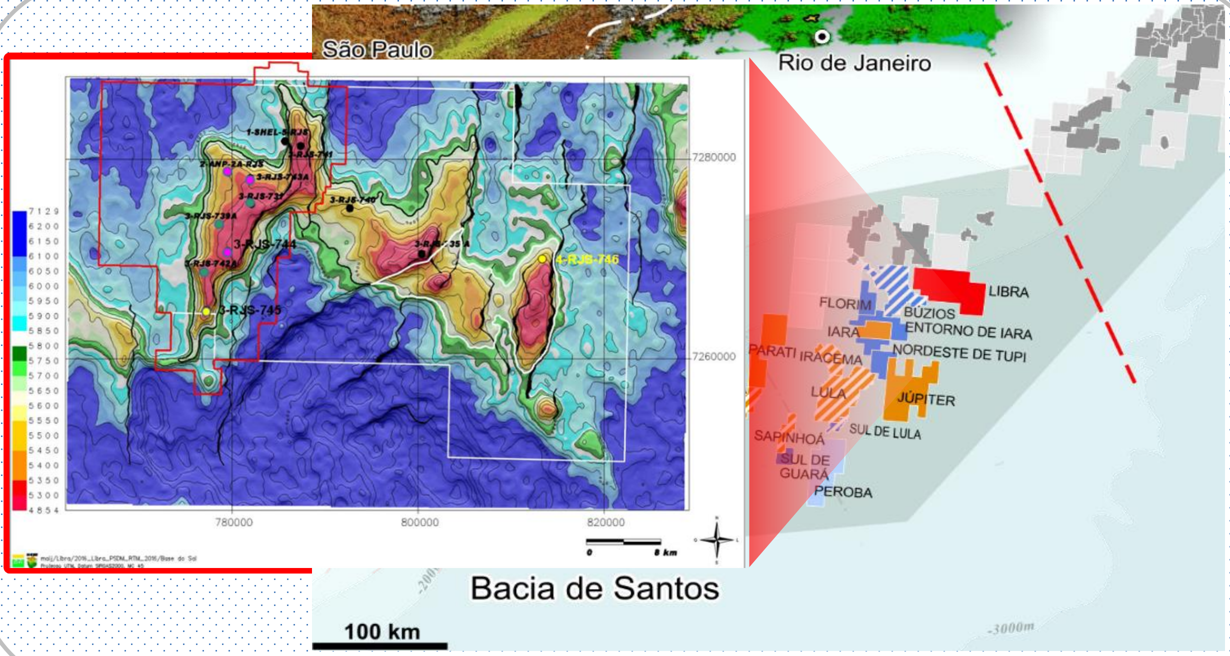
- WORK MOTIVATION
- MAIN CASE STUDY
- OPPORTUNITIES AND CHALLENGES
- CONCLUSIONS

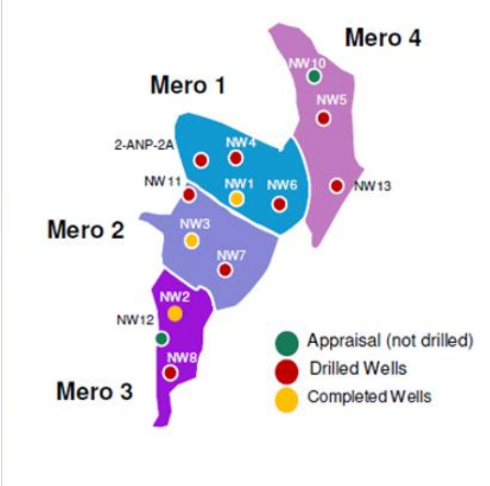
WORK MOTIVATION

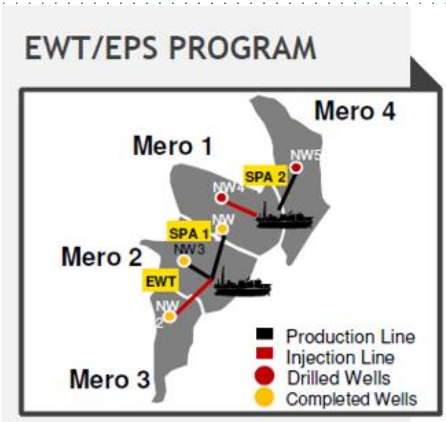
- High productivity wells and high original GOR → gas processing plants as a limiting factor for oil production, due to its occupied physical area and weight.

- Concept alternatives to deal with high gas flow rates → different scenarios of gas management like subsea separation system and or gas reinjection into the aquifer or gas export.

MAIN CASE STUDY: MERO FIELD







MERO FIELD NW:

→ 170 km from coast;

→ 11 drilled wells;

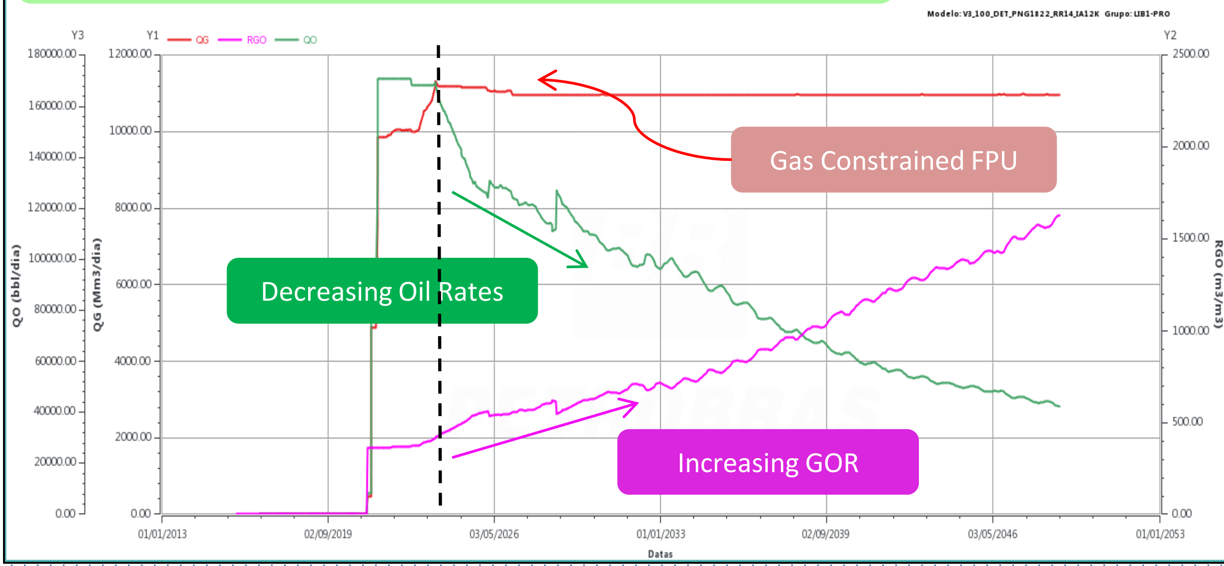
→ 3 completed wells.

MAIN CASE STUDY – BASE CASE

- Satellite production and injection wells;
- Production wells connected to FPSO by 8” ID production lines and 4” ID service lines (pressure rating of 5.000 psi);
- Injection wells connected to FPSO by 6” ID injection lines (pressure rating of 9.000 psi). Loop for each 2 injection wells, connected by a jumper between their annular side at X-tree;
- Total gas reinjection into the reservoir zones.

MAIN CASE STUDY – BASE CASE

Increasing GOR will constrain oil production



Investigate ways to better manage the gas and optimize recovery

Investigate Gas Behavior and derisk Gas Management alternatives

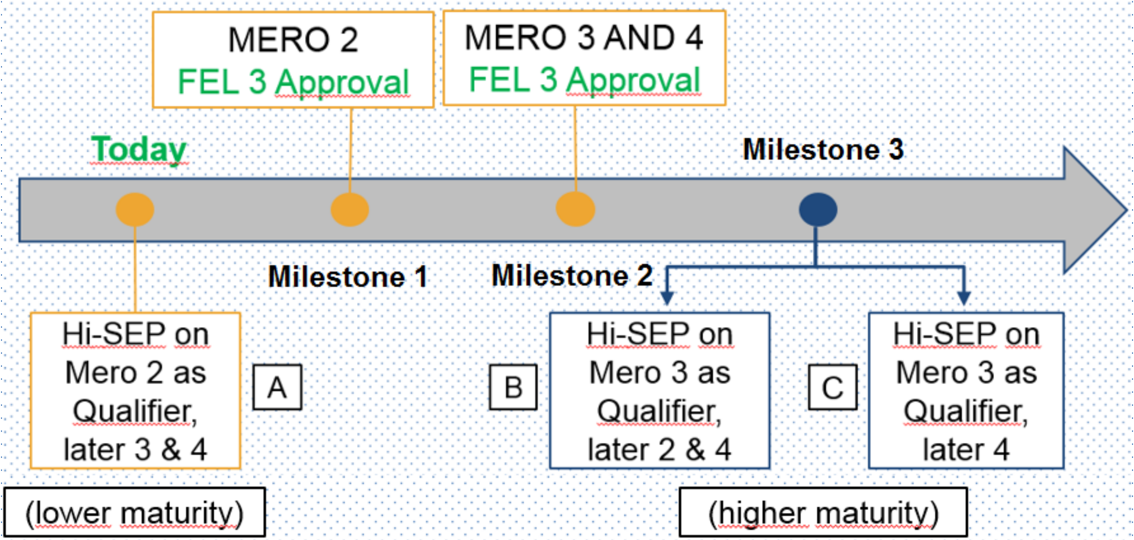
MAIN CASE STUDY – ALTERNATIVES

→ *Gas Management scenarios*: Increase of oil production due to the reduction of gas flowrates at FPSO through:

- Partial gas reinjection into the aquifer;
- Partial gas export through FPSO + first option;
- Gas export (produced gas) to a gas hub;
- **G/L subsea separation** (1 system per FPU) sending the gas to a gas hub;
- **G/L subsea separation** (1 system per FPU) reinjecting directly the separated gas into an injection well.

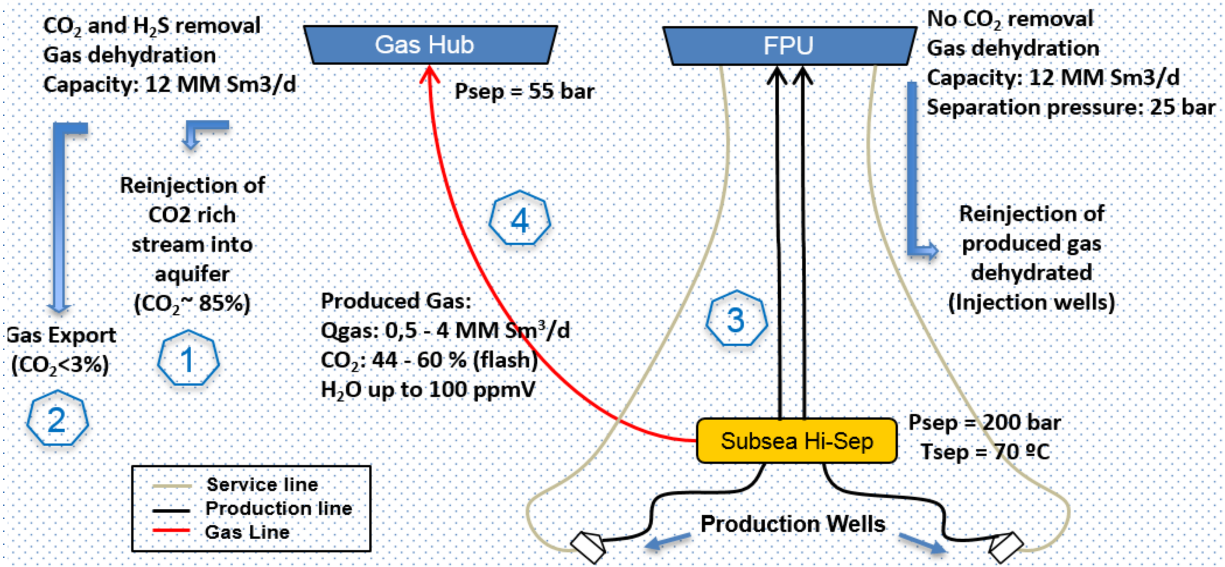
MAIN CASE STUDY – ALTERNATIVES

→ 12 reservoir scenarios for Hi-Sep
(No aquifer inj.↔ aquifer inj. / Well optimization or not)



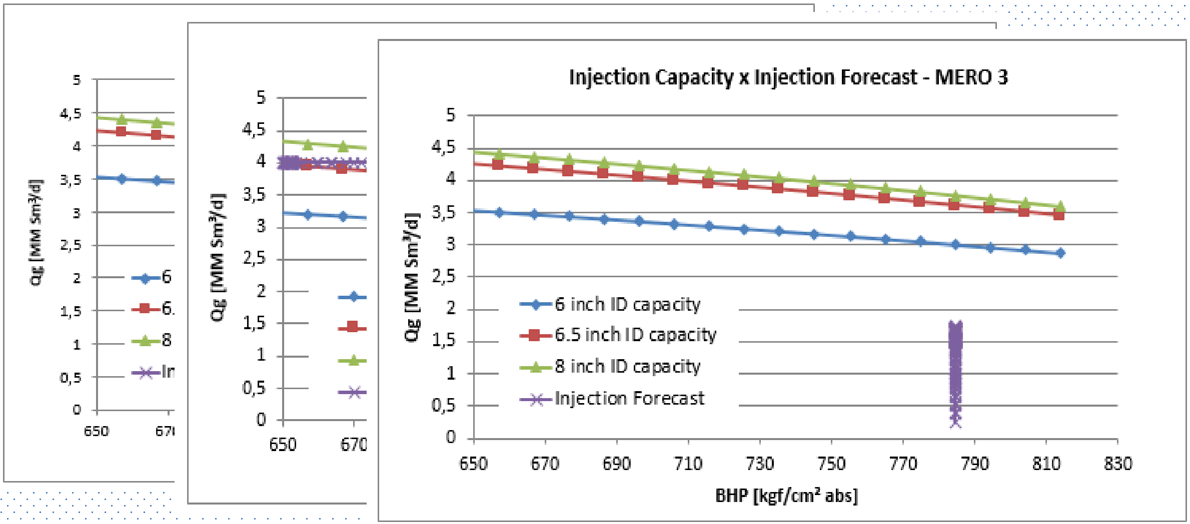
MAIN CASE STUDY – ALTERNATIVES

→ *SUBSEA GAS/LIQUID SEPARATION TO A GAS HUB:*



MAIN CASE STUDY – ALTERNATIVES

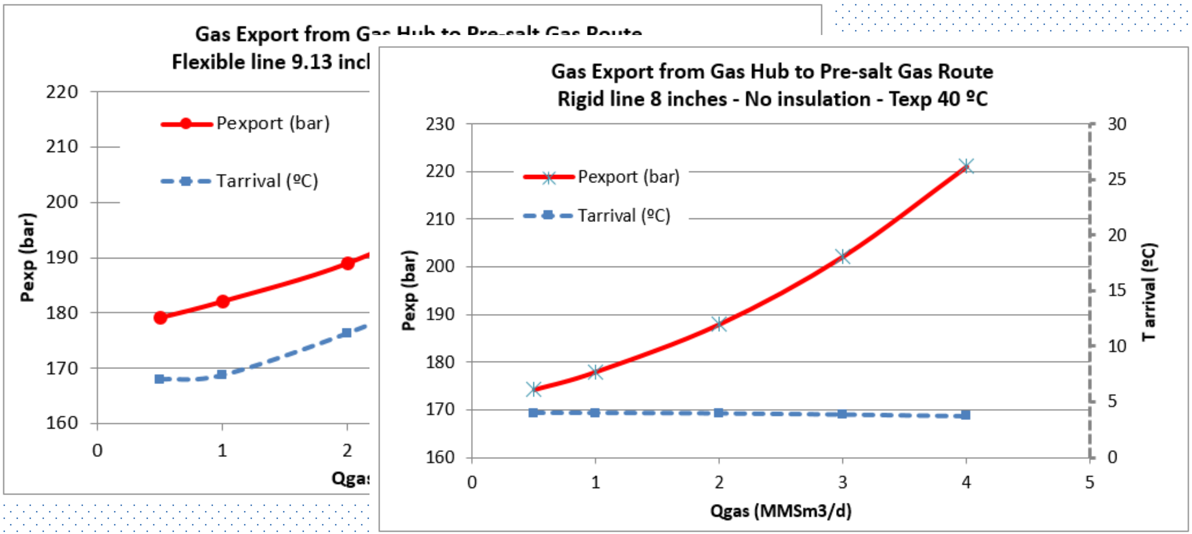
1 Gas injection into aquifer from gas hub (rich CO_2 stream)



6” and 8” – flexible line / 6.5” – rigid line
Flowline length: 13 and 21 km

MAIN CASE STUDY – ALTERNATIVES

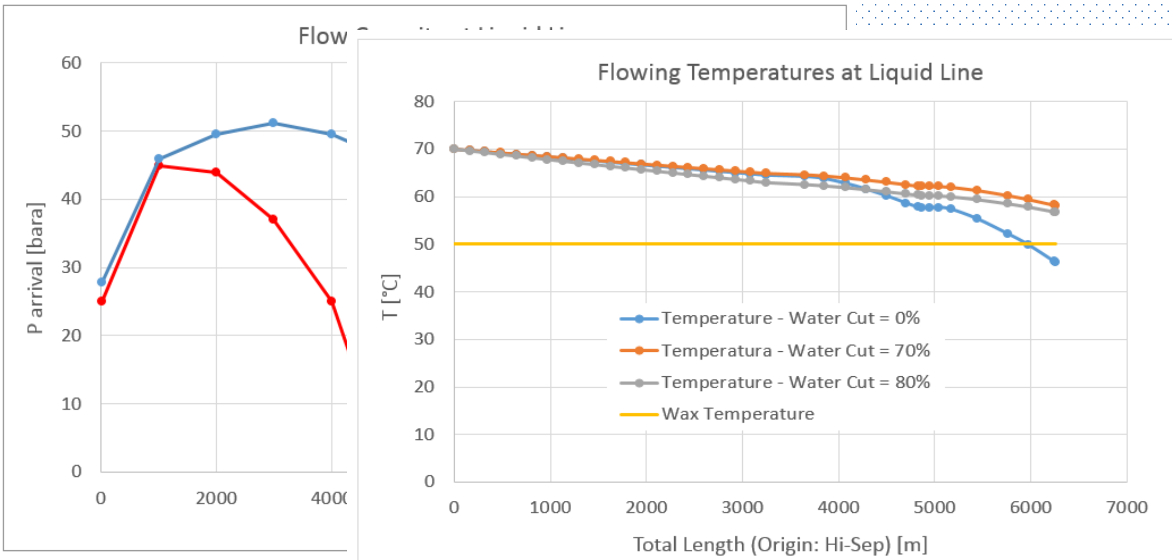
2 Gas export from gas hub to a pre-salt gas route (treated gas)



Flowline length: 20 km

MAIN CASE STUDY – ALTERNATIVES

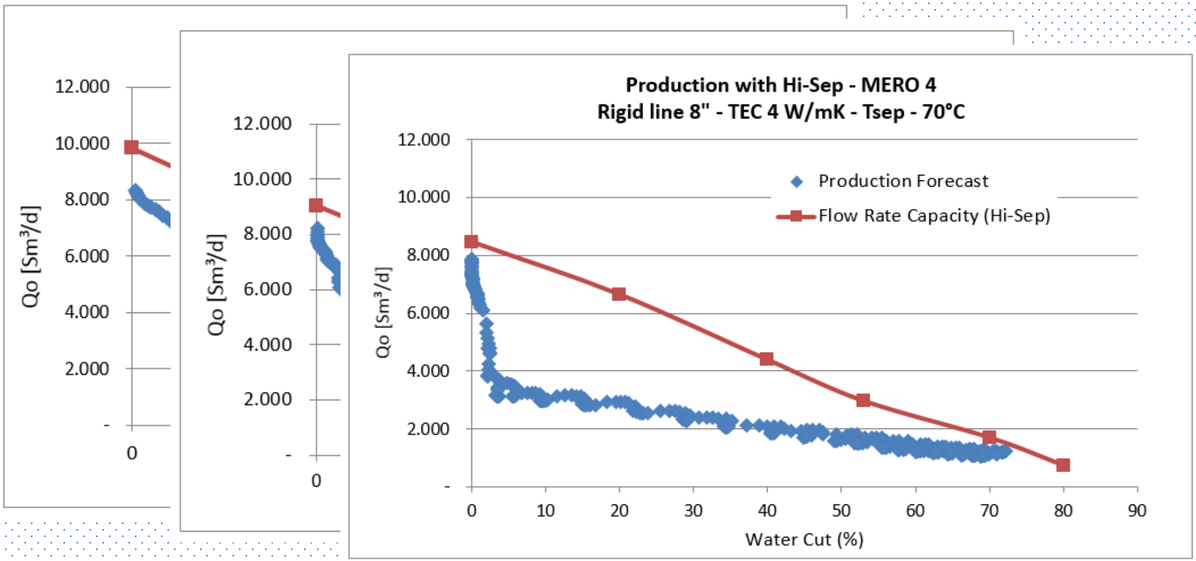
3 Liquid production from Hi-Sep to FPU



Flowline length: 5 km

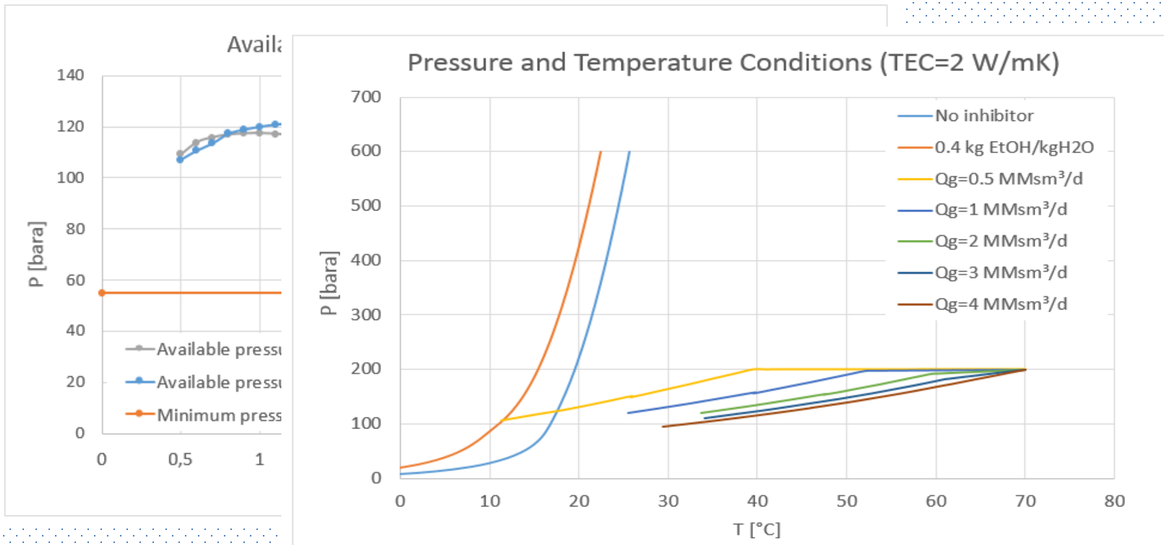
MAIN CASE STUDY – ALTERNATIVES

3 Liquid production from Hi-Sep to FPU



MAIN CASE STUDY – ALTERNATIVES

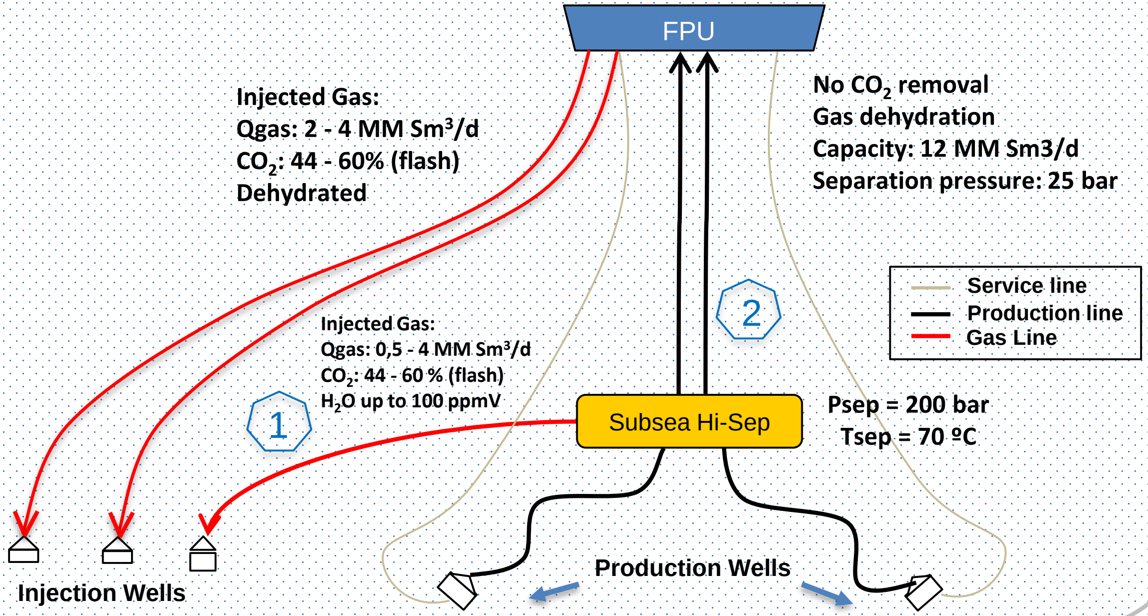
4 Gas flow from Hi-Sep to gas hub



Flowline length: 7 km

MAIN CASE STUDY – MERO FIELD

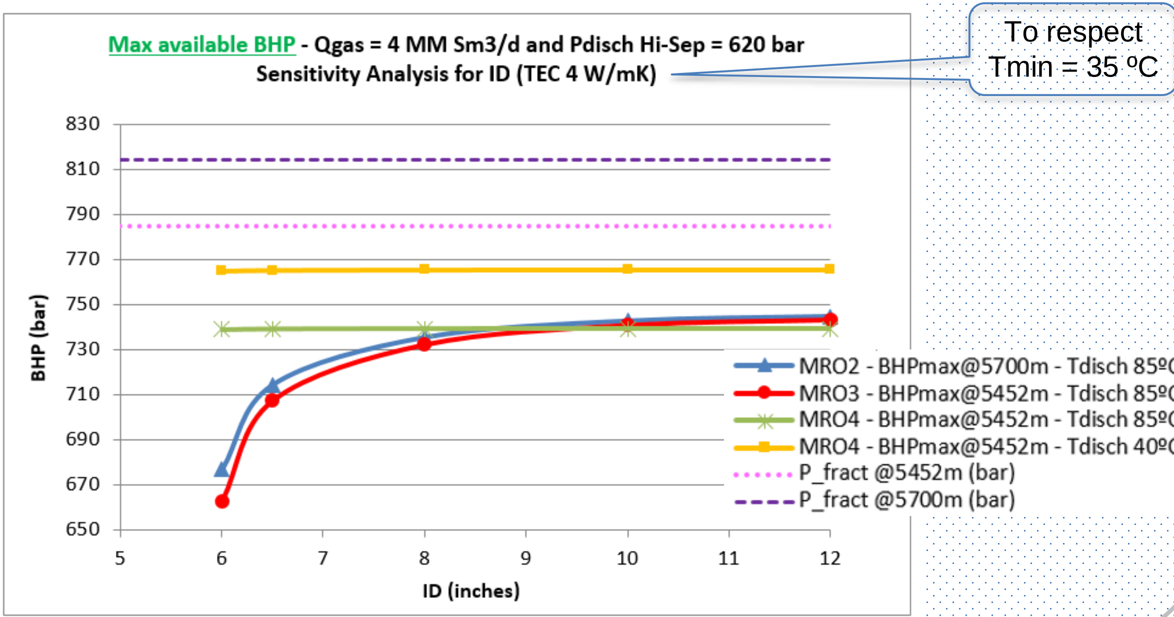
→ SUBSEA GAS/LIQUID SEPARATION & GAS REINJECTION:



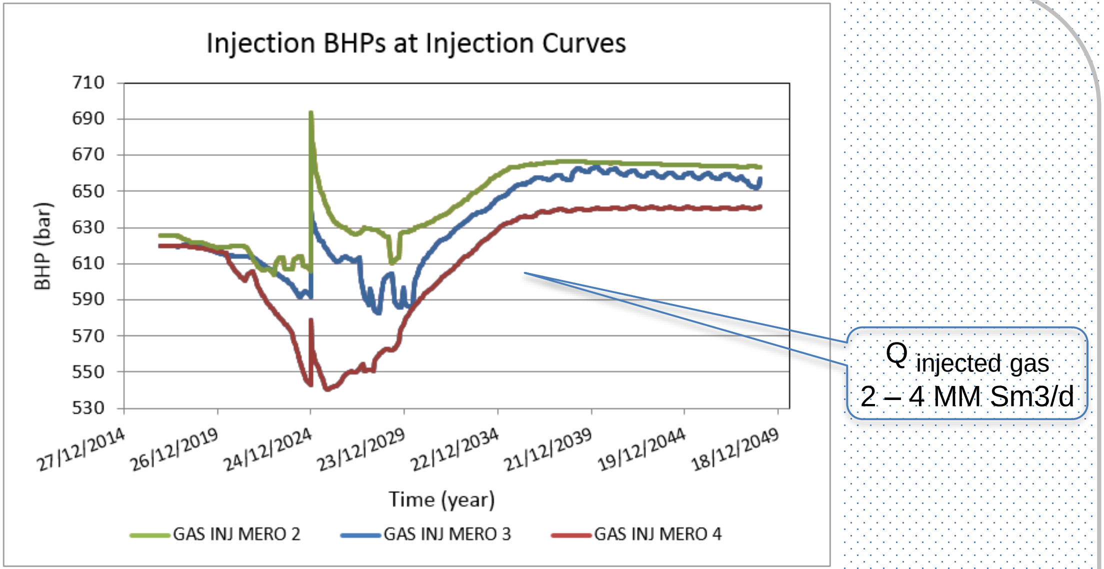
MAIN CASE STUDY – MERO FIELD

1 Gas injection into aquifer from Hi-Sep (separated gas)

To respect Tmin = 35 ºC



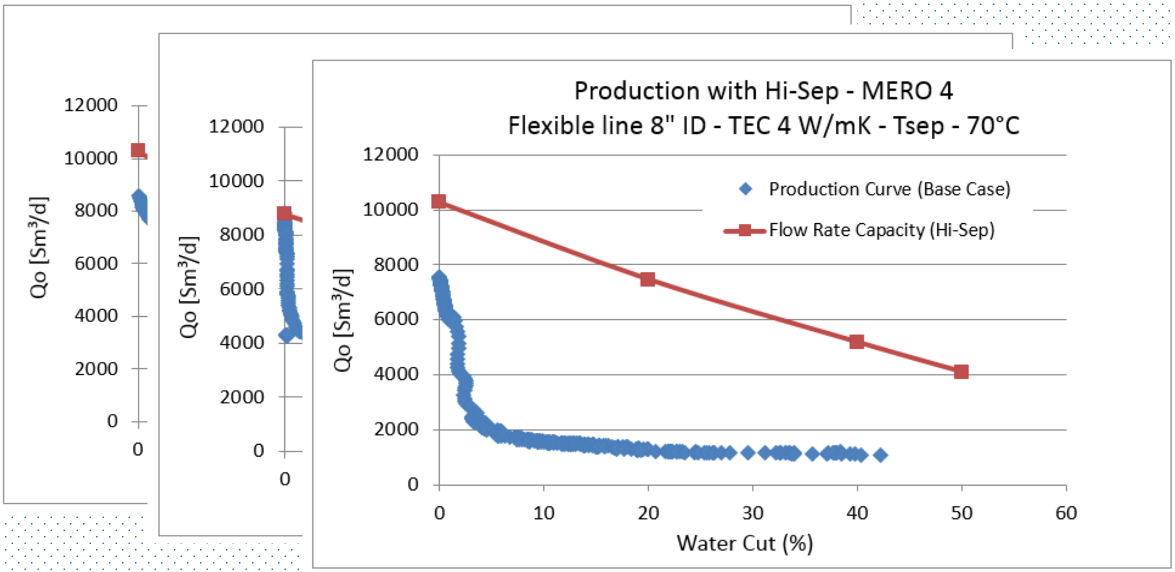
MAIN CASE STUDY – MERO FIELD



Hi-Sep Injector	Distance (m) Hi-Sep ↔ X-tree	Reference depth (m)	P_fract at reference depth (bar)
MRO2	3463	5700	814
MRO3	4150	5452	785
MRO4	30	5452	785

MAIN CASE STUDY – MERO FIELD

2 Liquid production from Hi-Sep to FPU

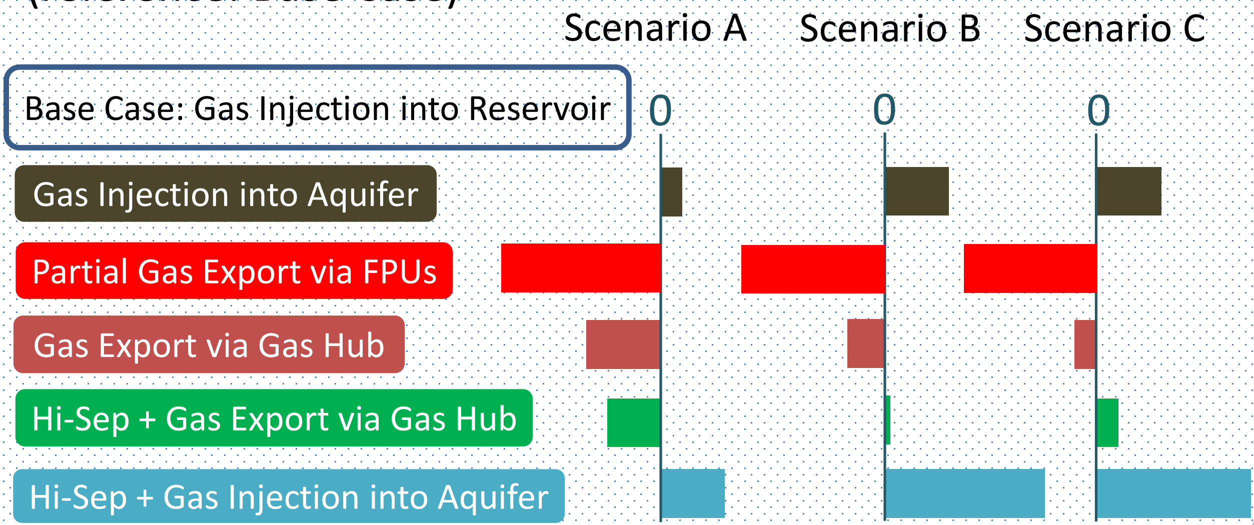


Flowline length: 5 km

OPPORTUNITIES AND CHALLENGES

NPV GAINS
(reference: Base Case)

Oil and Gas Prices



OPPORTUNITIES AND CHALLENGES

→ Reservoir

- Uncertainties about injectivity into aquifer.
- Investigation of gas behavior from injector wells to producers wells.

→ Topsides

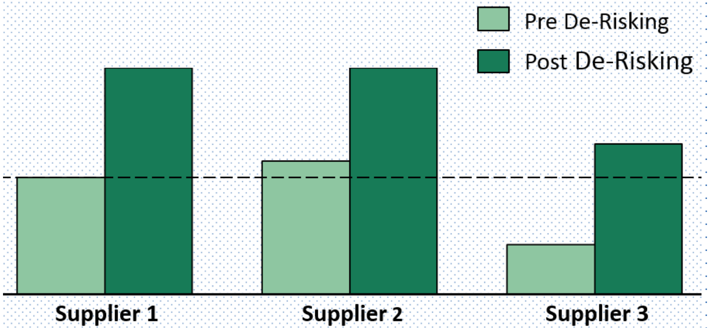
- Technical solution to supply extra power demand at FPUs.
- Gas hub: limitation on gas capacity due to the high gas inventory with high CO_2 content, weight increment and higher lead time.

OPPORTUNITIES AND CHALLENGES

→ Maturity degree of Hi-Sep Components

- Most of the components: TRL = 7
- Some of the components: 3 < TRL < 6

TRL Scale	
0	Unproven / Ideal Concept
1	Concept Demonstrated
2	Concept Validated
3	Prototype Tested
4	Technology Qualified for first use
5	Technology Integration Tested
6	Technology Installed and Performing
7	Proven Technology



Probability Of Success (PoS)

CONCLUSIONS

→ *Technical View (1/2):*

- Gas injection lines: the adoption of 8" ID commits with the maximum discharge pressure at Hi-Sep, not achieving the fracture pressure, for the base case scenario of injectivity index.

- For a pessimistic scenario of injectivity index (mainly into aquifer), the oil production gains may be reduced due to the limited gas reinjection flow rates (higher BHPs).

- Need of LDHI continuous injection for gas injection / export lines (hydrate prevention during shutdowns), product that still depends on experimental analysis for validation.

CONCLUSIONS

→ *Technical View (2/2):*

- Possibility of optimization on reinjection capacity considering the reducing of temperature discharge at Hi-Sep (some gain in scenarios when the equipment is closed to injection X-tree).
- Urcertainties must be mitigated regarding the aquifer injectivity.
- Maturity degree of some subcomponents for Hi-Sep is low and depends on the successful de-risking phase.
- Technical solution has to be developed to supply extra power demand at FPUs.

CONCLUSIONS

→ *Strategic View (1/2):*

- Reducing gas production uncertainties at Mero field scale via field production is a must to validate all FPUs forecasts and the production gains associated with gas management.

- Gas injection into aquifer is an attractive alternative, due to its oil gains for providing gas debottlenecking, compared to current base case scenario.

- Hydrocarbon gas export scenarios, evaluated over a wide range of oil production gains and economic parameters, showed erosion of value when compared to gas reinjection.

CONCLUSIONS

→ *Strategic View (2/2):*

- Gas liquid subsea separation reinjecting the produced gas, which implementation depends on its maturation, has the highest gas debottlenecking impact on oil production leading to significant gains and value creation.

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Thank You!

Questions?

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