Society of Petroleum Engineers

SPE workshop

IOR/EOR Practices for Enhanced Efficiency in the Evolving Carbon-Conscious Environment

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Maximizing Recovery and Sustainability:

Challenges and Innovations in Offshore Polymer Flooding Deployments

Maxence RUIZ

INTRODUCTION – CURRENT CONTEXT

- Oil should remain the main source of energy by 2050
- Challenge = Increasing oil production while reducing the environmental footprint of oil extraction and remaining cost-efficient
- Polymer EOR is developing widely
  - Easy deployment
  - Field proven, > 300 references
  - Cost effective, 3 to 6 $/bbl of incremental oil
- Sustainable, 50 to 80% CO_2 emissions reductions compared with WF
- Projects ramping up from pilot to full field

« Production from existing fields declines at a rate of 8% per year in the absence of any plausible fall in global demand» - IEA (2020)

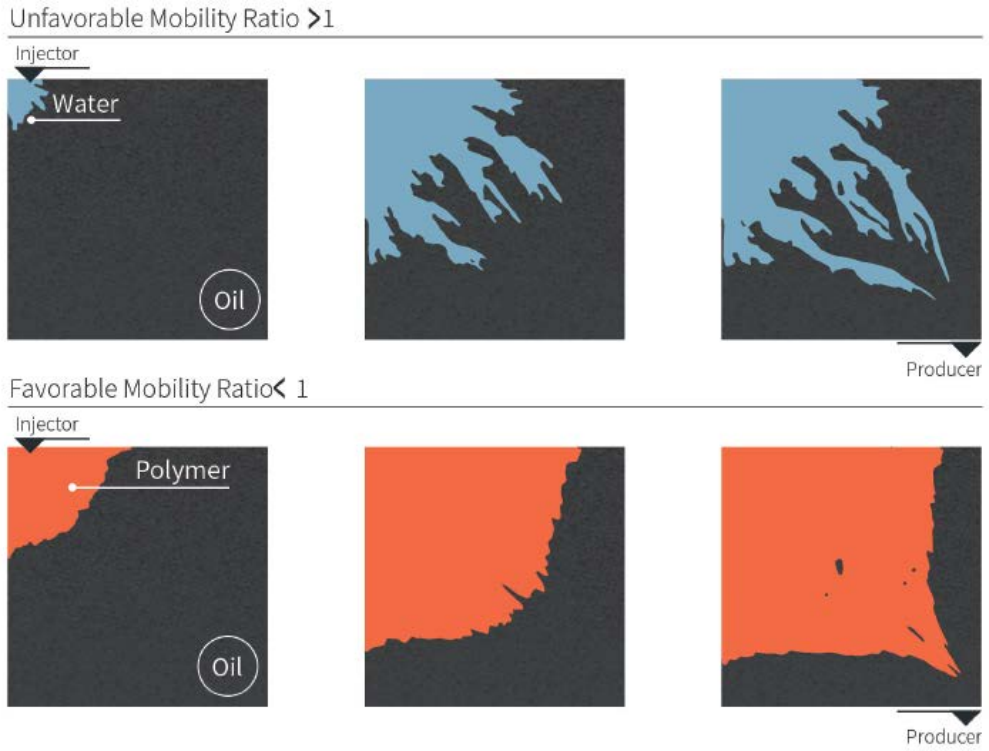
« There are almost no reservoir which are not appropriate for polymer flooding or at least giving serious consideration to polymer » - Ken Sorbie (HWU - 2021)

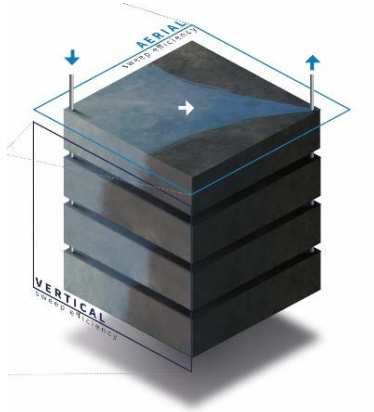
AGENDA

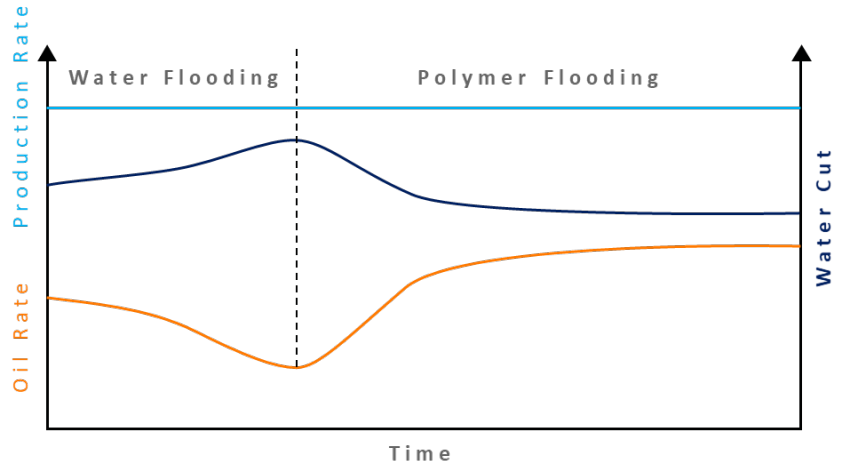
1. What are we talking about?
2. Deploying polymer flooding offshore – Main challenges
3. Addressing the challenges and project figures
4. Case studies

WHAT ARE WE TALKING ABOUT ?

POLYMER FLOODING – NOTHING BUT A VISCOUS WATER FLOOD

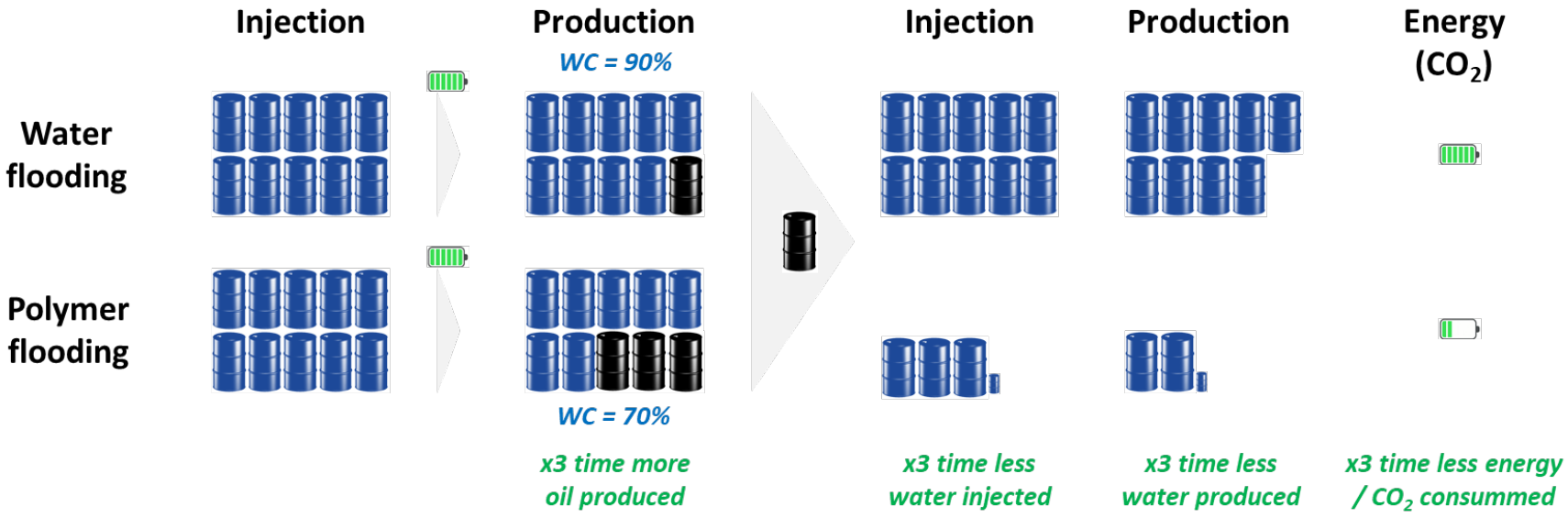






WHAT ARE WE TALKING ABOUT ?

A SUSTAINABLE SOLUTION



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MAIN CHALLENGES FOR POLYMER FLOODING OFFSHORE

- Limited footprint/height
- Limited weight (total/per unit)
- Limited power load
- Chemical logistics between port and platform
- Possible large well spacing
- Polymer chains shearing equipment
- Existing production and WT facilities
- …

MAIN CHALLENGES FOR PF OFFSHORE

Offshore Limitations	Will it be ok?
➢ Limited footprint/height	
➢ Limited weight (total/per unit)	
➢ Limited power load	
➢ Chemical logistics between port and platform	➢ How the logistics for polymer can be solved ? What is the best choice?
➢ Possible large well spacing	➢ Does the technique require significant investment before positive impact?
➢ Shearing equipment (subsea choke valves)	➢ Any solution to avoid viscosity degradation and higher chemical consumption?
➢ Existing production and Water Treatment facilities	➢ How existing production and WT facilities can deal with potential residence time impact?
	➢ Does the Injection facility design fit / suitable for the the existing platform?

ADDRESSING THE CHALLENGES

		
Form	Liquid	Granular Solid
Handling	Pump transfer	Pneumatic or mechanical transfer
Active Content	50%	90%
Storage Volume	-	+
Preparation Facilities	+	-
OPEX	-	+

ADDRESSING THE CHALLENGES

- Limited footprint and height
- Limited weight (total or per unit)
- Limited power load

ADDRESSING THE CHALLENGES

➢ Chemical logistics between port and platform

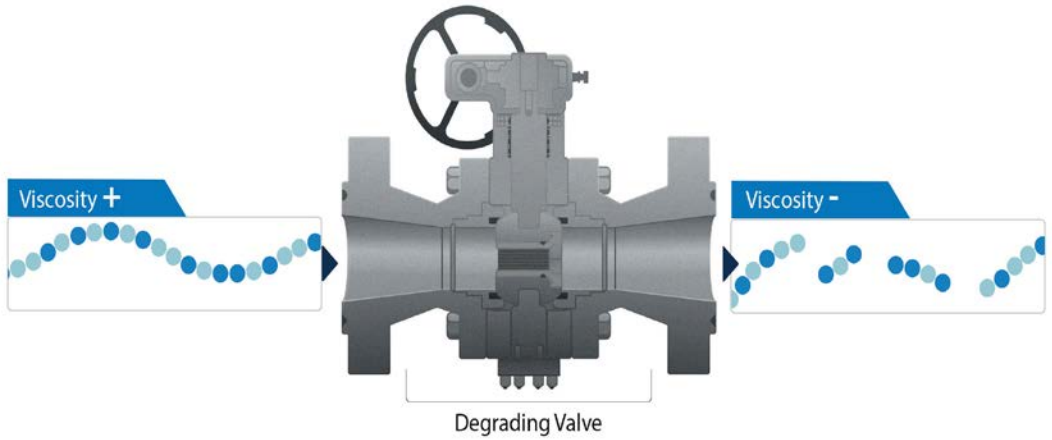
Type	IBC	Floquip TT	Isotank	Supply boat
Capacity	1000 kg	1 to 10 T	25	100 to 1000 T
Visual				

Type	Bags	Big-bags	Bag-in-box	Tilting C20	Transit Hopper	Supply boat
Capacity	25 kg	750 kg	20 T	20 T	5 to 10 T	100 to 1000 T
Visual						

Bulk pneumatic delivery: new double container horizontal bulk silo and dissolution unit general outside appearance

ADDRESSING THE CHALLENGES

- **Shearing equipment for polymer chains**



ADDRESSING THE CHALLENGES

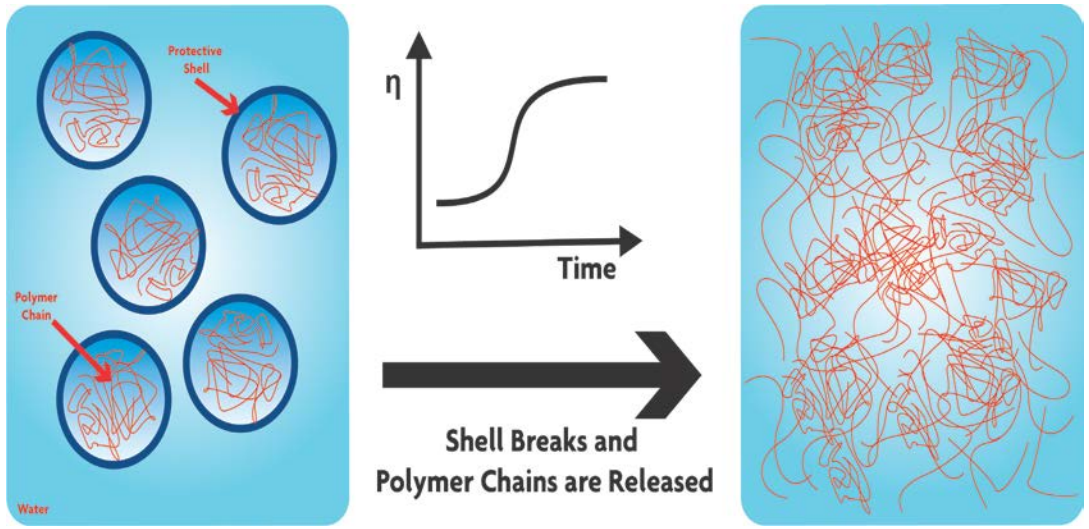
➢ Polymer non-shearing choke valves

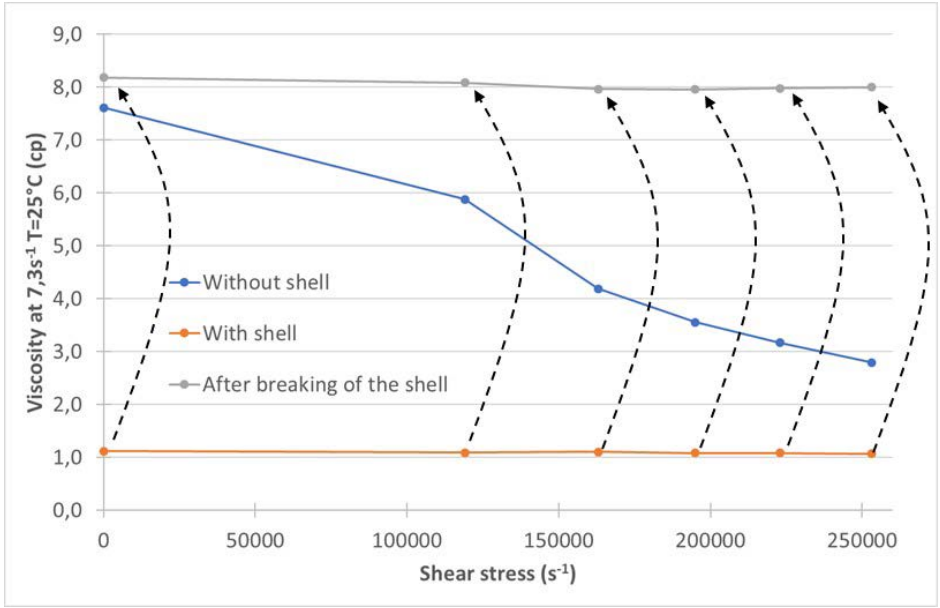
- Designed to control injection pressure or injection flow of polymer solution without inducing significant degradation
- Different technologies depending on process conditions
- Very compact unit
- Patented

ADDRESSING THE CHALLENGES

- **Shearing equipment for polymer chains**

Delayed Viscosifying Polymers (DVP)





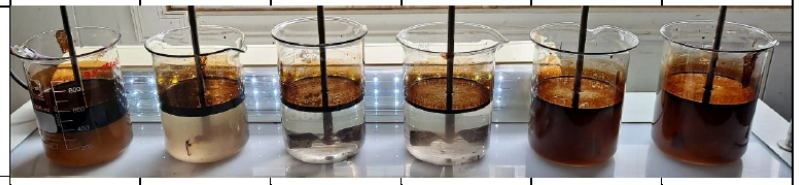
ADDRESSING THE CHALLENGES

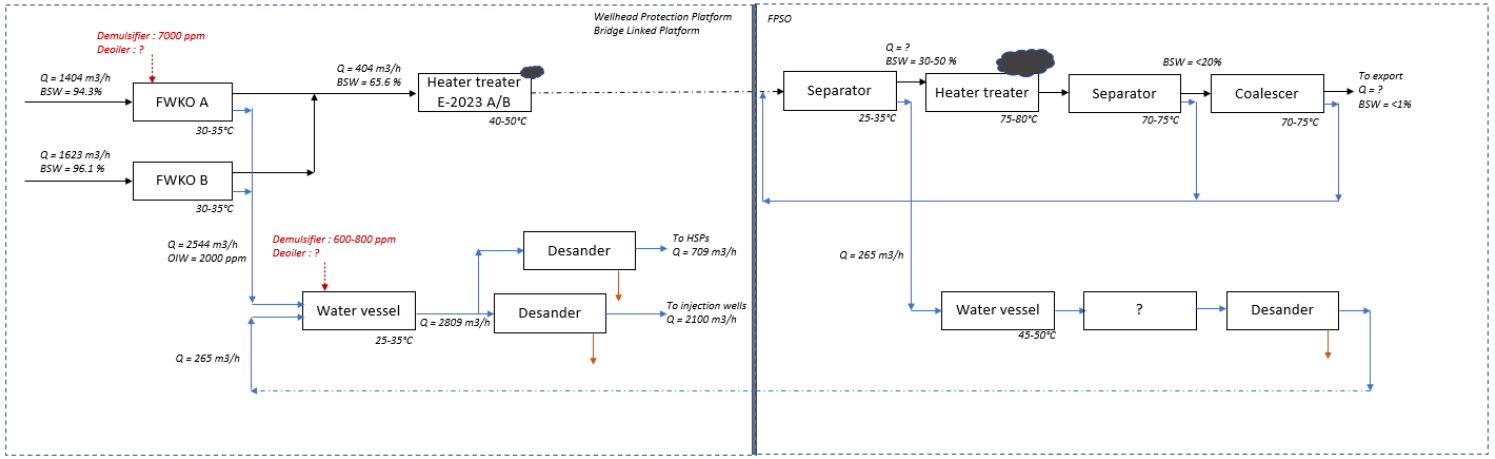
➢ Existing production and WT facilities

Potential issues can be anticipated controlled and mitigated but it requires a multidisciplinary approach

To be adapted per context (regulations, performances, power, footprint, …)

→ Combined Mechanical + Process + Chemical review

	J1	J2	J3	J4	J5	J6
Polymer (ppm)	100-150	100-150	100-150	100-150	100-150	100-150
+						
Floctreat 12 (ppm)	0	5	7	9.6	0	0
Bozefloc AE 533 (ppm)	0	0	0	0	0.4	2
Water phase clarification						
Flocs	X	Floating Small and not sticky	Floating Small and not sticky	Floating Small and not sticky	X	X



CASE STUDY #1 – SHENGLI Offshore China / POWDER

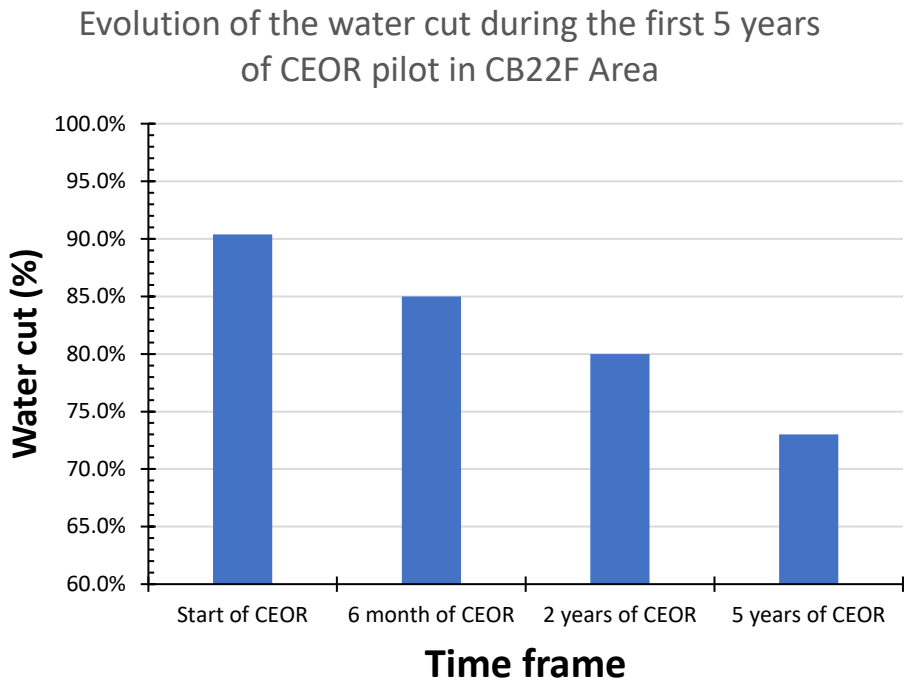
Reservoir area (km^2)	2.86	Reservoir depth (m)	1,344 – 1,455
Net thickness (m)	25.4	Median grain size (mm)	0.14
STOIIP (MMstb)	67.7	**Oil in situ viscosity (cp)**	**30-70**
Porosity (%)	33.3	Live oil in situ density (g/cm^3)	0.9066
Original oil saturation (%)	63	Dead oil viscosity at surface (cp)	264
Dykstra – Parsons coefficient	0.5	Stock Tank crude oil density (g/cm^3)	0.9387
Original reservoir temperature (°C)	65	Initial reservoir pressure (bars)	134
Formation Volume Factor (Bo)	1.06	Bubble point pressure (bars)	102
Average permeability (mD)	**1,397**	Bubble point pressure difference (bars)	32

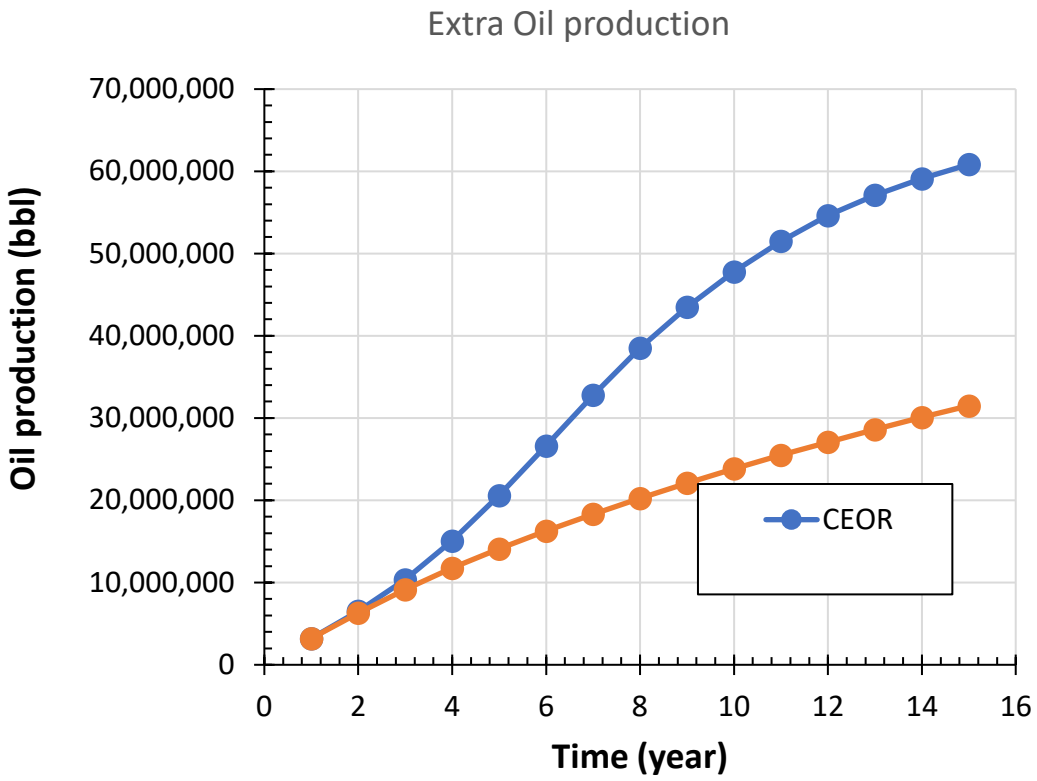
- STOIIP: 67.7 MMstb
- Average remaining oil saturation : 51%
- EOR project sanctioned in 2019, started end of 2020
- More platforms to develop

Ref. paper : "OTC-31527 - Offshore Large Scale Polymer Flood Implementation at Chengdao Field" Offshore Technology Conference Asia, Kuala Lumpur, Malaysia, March 2022.

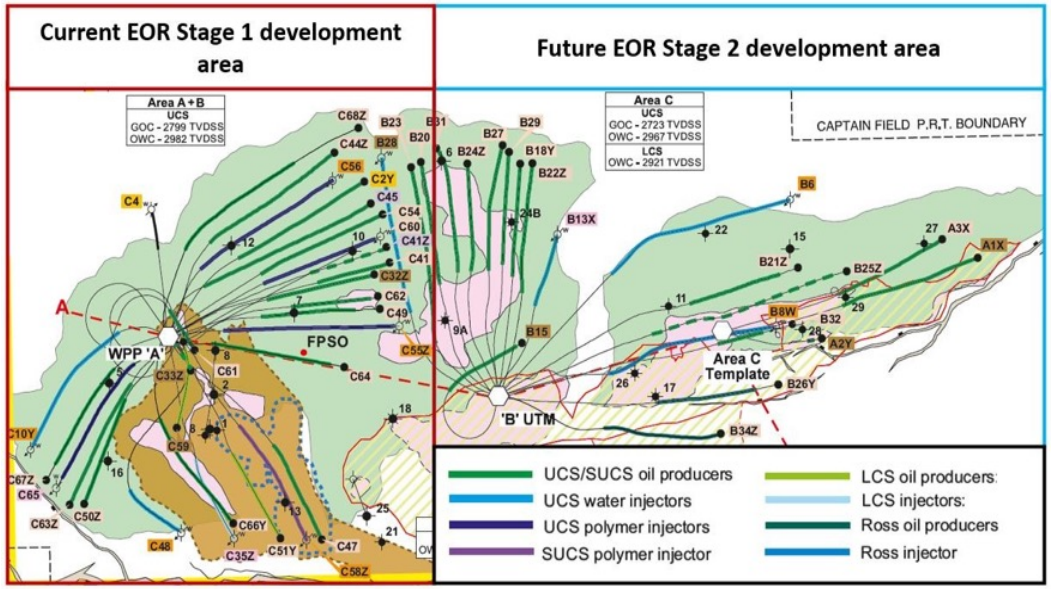
CASE STUDY #1 – SHENGLI Offshore China / POWDER

- After 15th years of polymer injection : Planned oil production increases by **29 340 744 bbl**
- Acceleration in oil recovery = **8 years**
- At iso-oil production : **- 6 500 000 mT of CO_2 (-52,6%)**





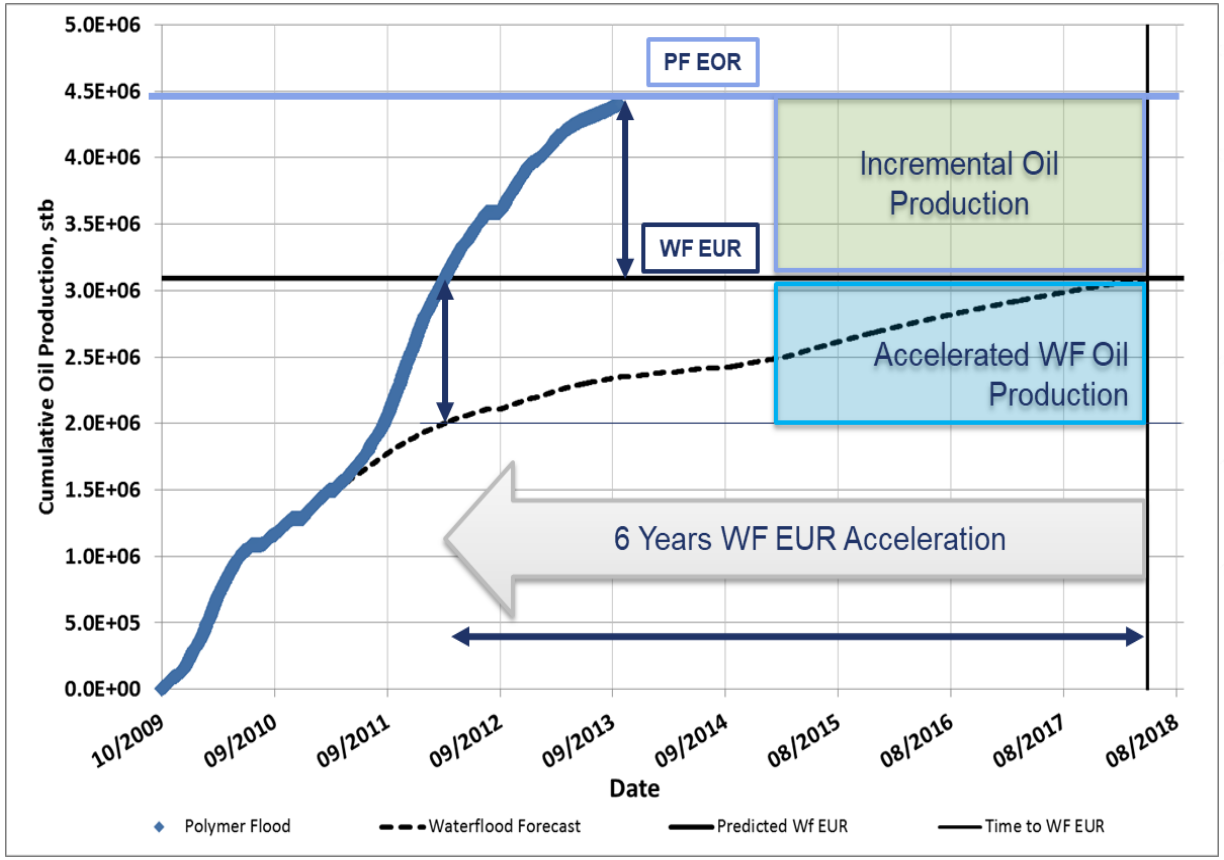
CASE STUDY #2 – ITHACA Offshore North Sea / EMULSION

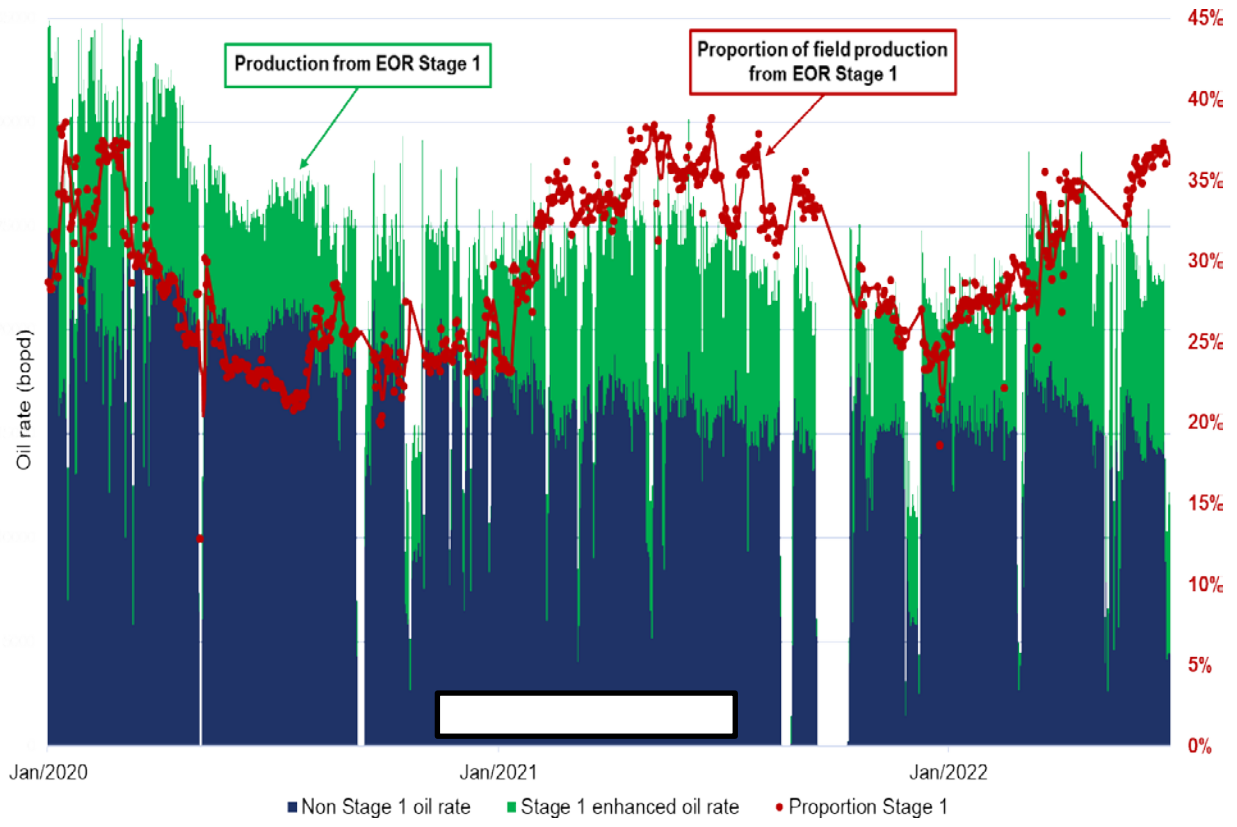


- Operated by Ithaca Energy (UK) Ltd (85%) with Dana Petroleum (E&P) Limited (15%)
- Offshore UK North Sea
- Discovered 1977, 1st production 1997
- 1 billion barrels STOOIP
- Sea depth 350ft

- 3 - 11 Darcy sandstones
- Temperature = 31˚C
- Pressure = 1,270psi
- Oil 40 - 140 cP
- End-point mobility Ratio for Waterflood ~40
- Produced Water Re-Injection
- 94% watercut

CASE STUDY #2 – ITHACA Offshore North Sea / EMULSION





Ref. paper : "SPE 215559 – Creating New Economic Reserves Using Enhanced Oil Recovery Within a Mature Offshore Field- G. Johnson - 2023

TO CONCLUDE

- ✓ Challenges for PF Offshore **can be addressed** provided the platform and operating limitations are well identified

- ✓ Results of Offshore Polymer Flooding are very good
- ✓ Quick and large development of existing projects + New developments in Asia

- ✓ CO_2 consumption reduced: technique effectiveness, less water, more oil

- ➢ **Green signal !**

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