
Technology Collaboration Programme
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IEA EOR TCP
// STAVANGER 2022
ANNUAL EVENT
21 – 24 Nov
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Enhanced Oil Recovery

Meet the Net-Zero Target while Ensuring Sustainable and Affordable Energy Supply The Role of Chemical EOR

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IEA EOR TCP workshop and joint EOR/GOT-symposium
21 – 24th of November 2022
Stavanger, Norway

Workshop: Oil and gas in the context of energy security and clean energy transitions

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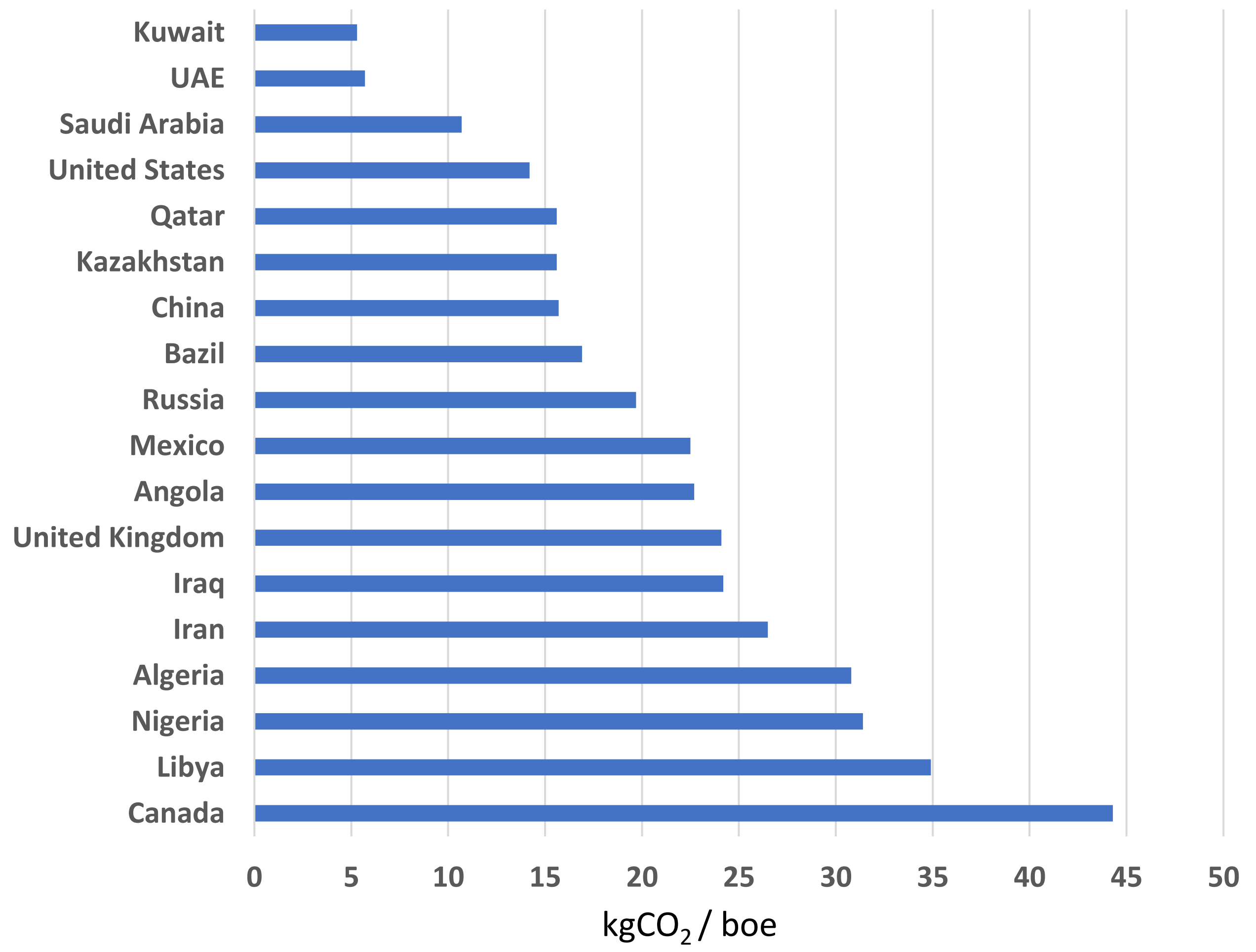
IS NET ZERO POSSIBLE WITH OIL AND GAS PRODUCTION?

Average carbon intensity of oil production by country, 2019



- **Increasing climate policies** incentivize reduction in the carbon intensity of oil
- Acknowledge the need for **substantial reductions in the production of fossil fuels across** the industry by 2050
- Net Zero targets have been established
- Oil and gas operating and service companies have set a **target to be Net Zero by 2050**

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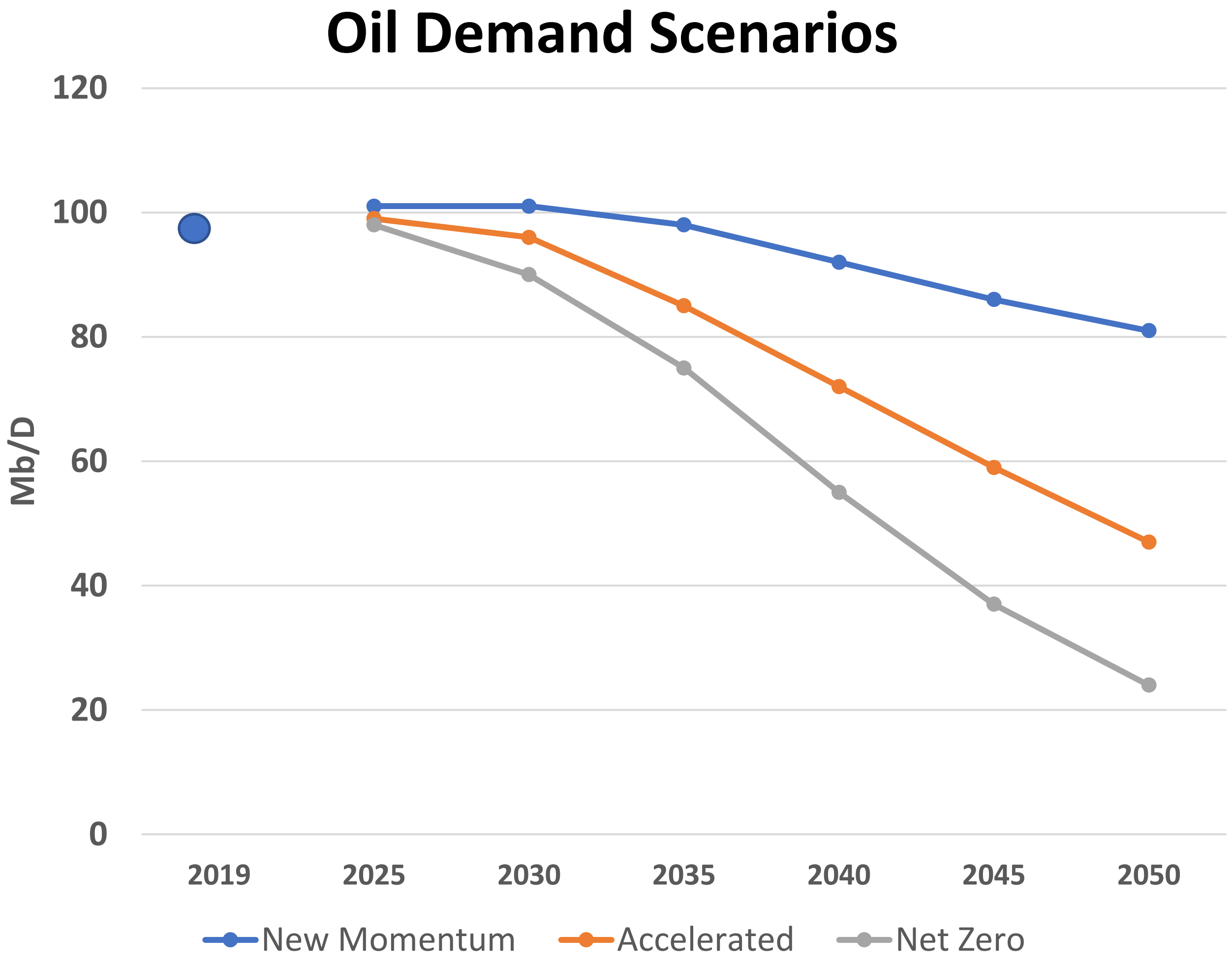
Source: Rystad Energy

OIL DEMAND



- **Oil demand increases** to above its pre-COVID-19 level in all three scenarios
- Boosted by rebound in economic growth. **Oil consumption peaks in the mid-2020s**
- Global oil demand is projected to peak around **104 MMb/d** in the next two to five years
- Oil consumption in **Accelerated** and **Net Zero** falls substantially → declines in oil demand in **New Momentum** are slower and less marked

Overview | Energy economics | Home (bp.com)

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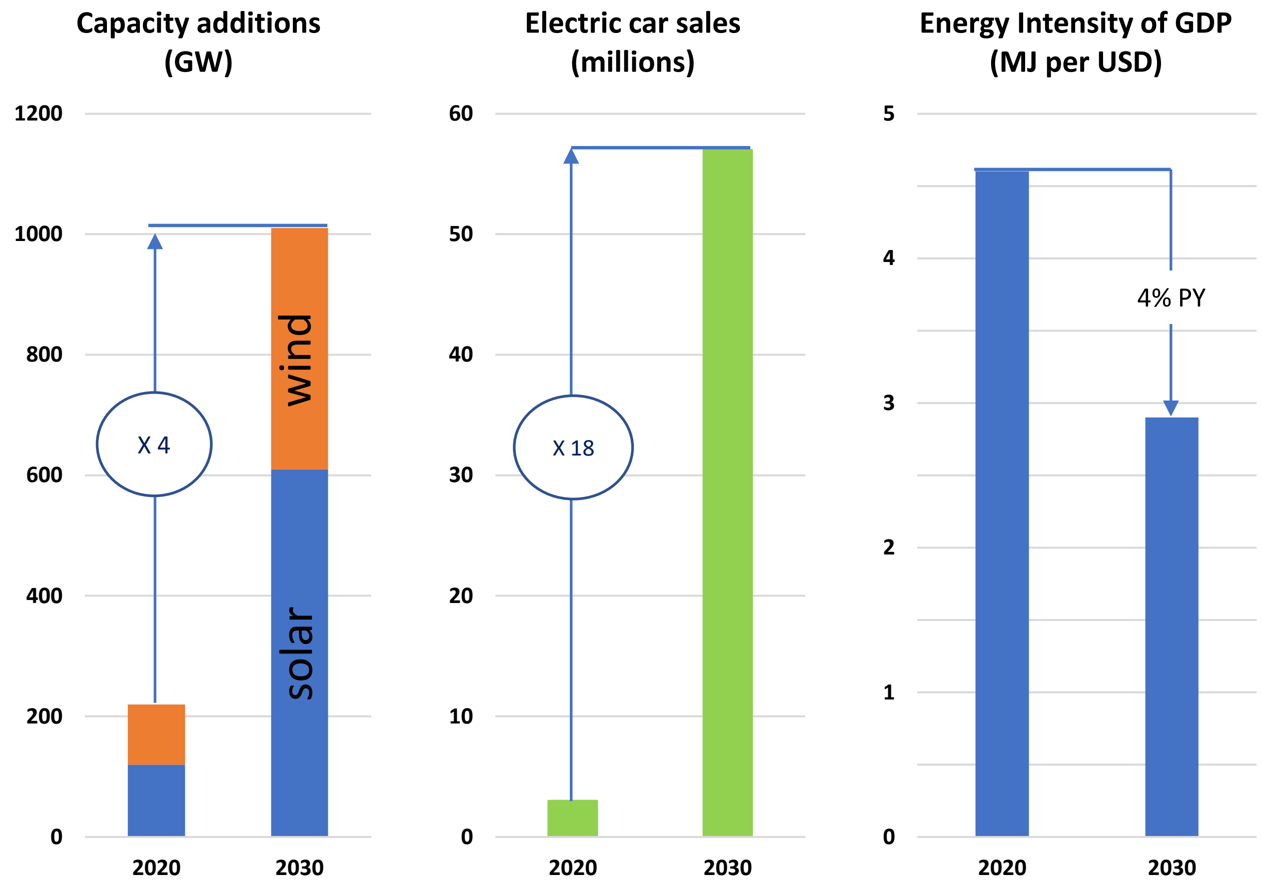
CLEAN TECH RAMP TO NET ZERO



- Most of the global reductions in CO_2 emissions through 2030 in our pathway come from technologies readily available today
- But in 2050, almost half the reductions come from not developed yet
- Reaching net zero by 2050 requires further rapid deployment of available technologies
- **Investment is increasing but not at the required rate to achieve targets**

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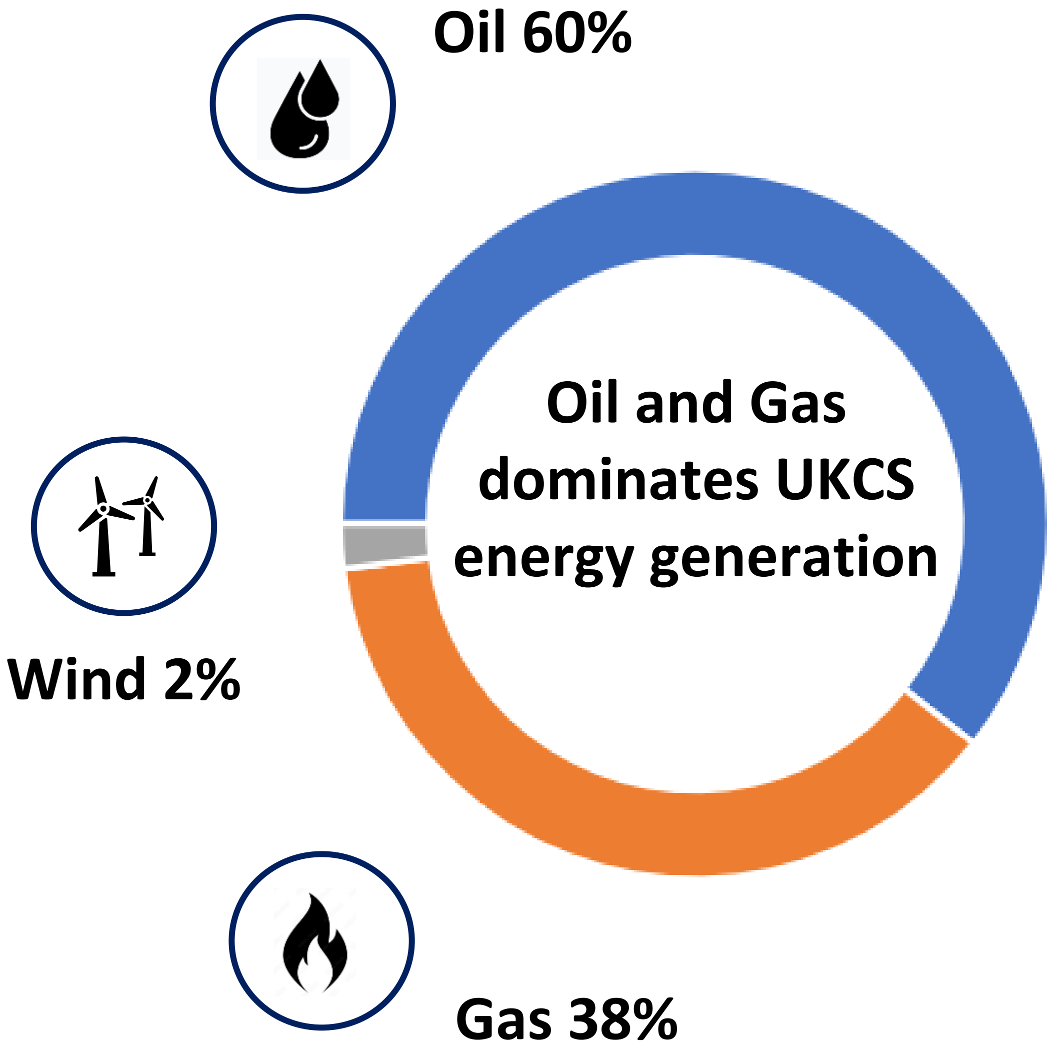
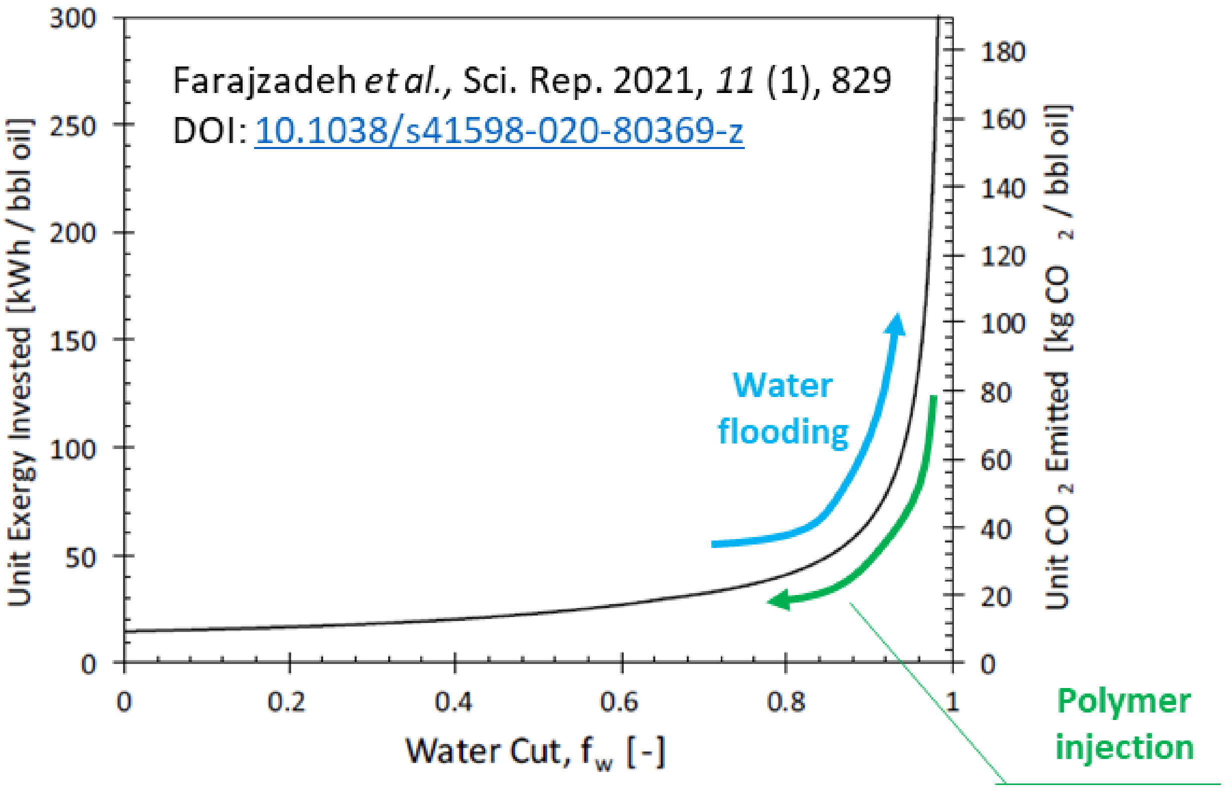
Source: IEA

IS NET ZERO POSSIBLE WITH OIL AND GAS PRODUCTION?



- Emissions from oil and gas operations, make up about **5.2 billion tonnes of carbon-dioxide equivalent**
- Amount to **about 15%** of the energy sector's total GHG emissions.
- **The global economy will still need oil and gas – so how to balance net zero targets and still produce?**

HOW DOES POLYMER EOR REDUCES CO_2 EMISSIONS?



60% of the reservoirs are under water injection

- Above 80%-90% of water CO_2 emissions increase massively

Polymer improves Sweep effiency

- Decrease of water cut
- Increase of oil production

Less water required, less water being produced , less energy consumption, les CO_2 emissions

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POLYMER FLOODING PRINCIPLE

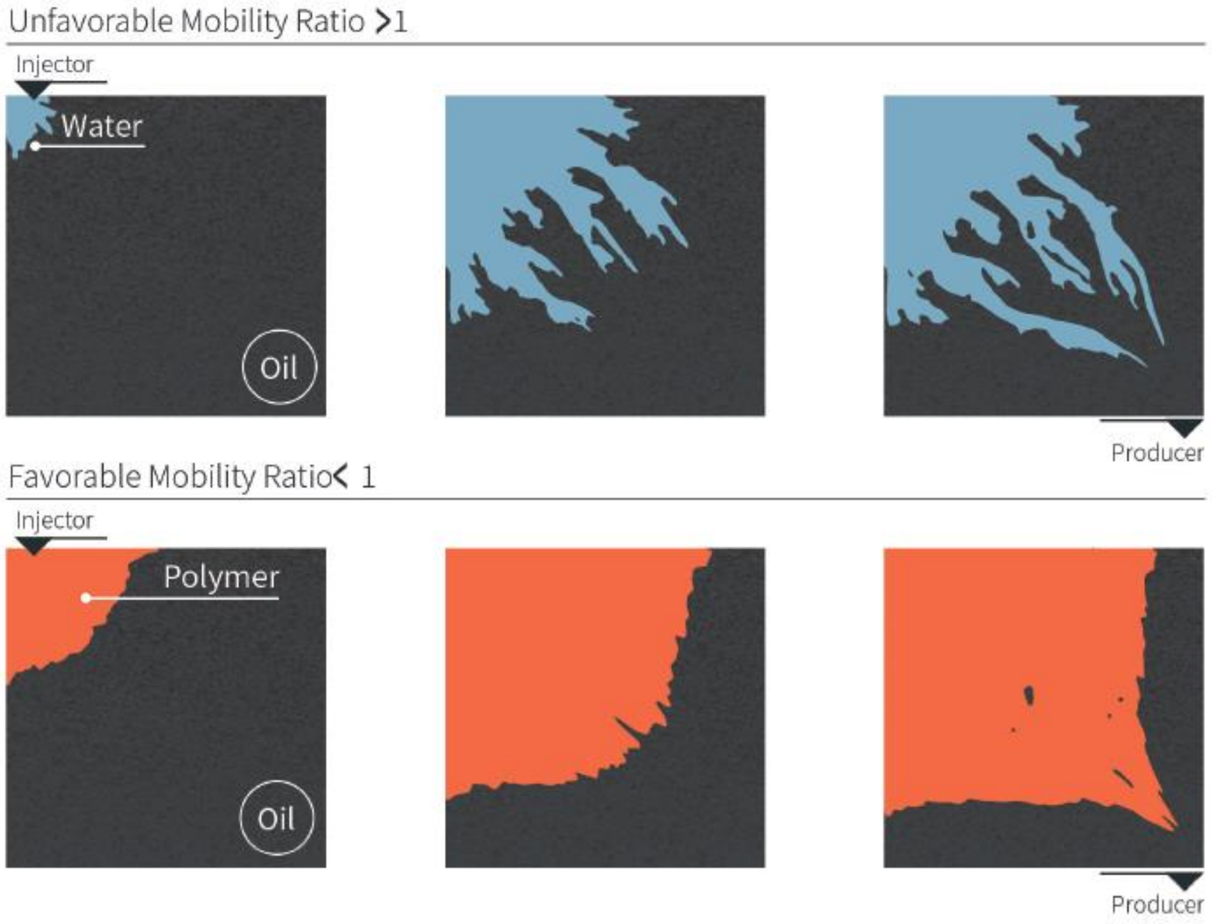
Proven EOR technology with more than 300 applications worldwide

- Improves reservoir sweep efficiency
- Improves mobility control
- Limits, prevents or corrects fingering
- Promotes viscous crossflow accelerating oil production beyond what is usually predicted

Easy deployment

- Compact units specifically designed for onshore and offshore requirements

Cost limited to $4 to $6 per incremental barrel (SPE 177254)



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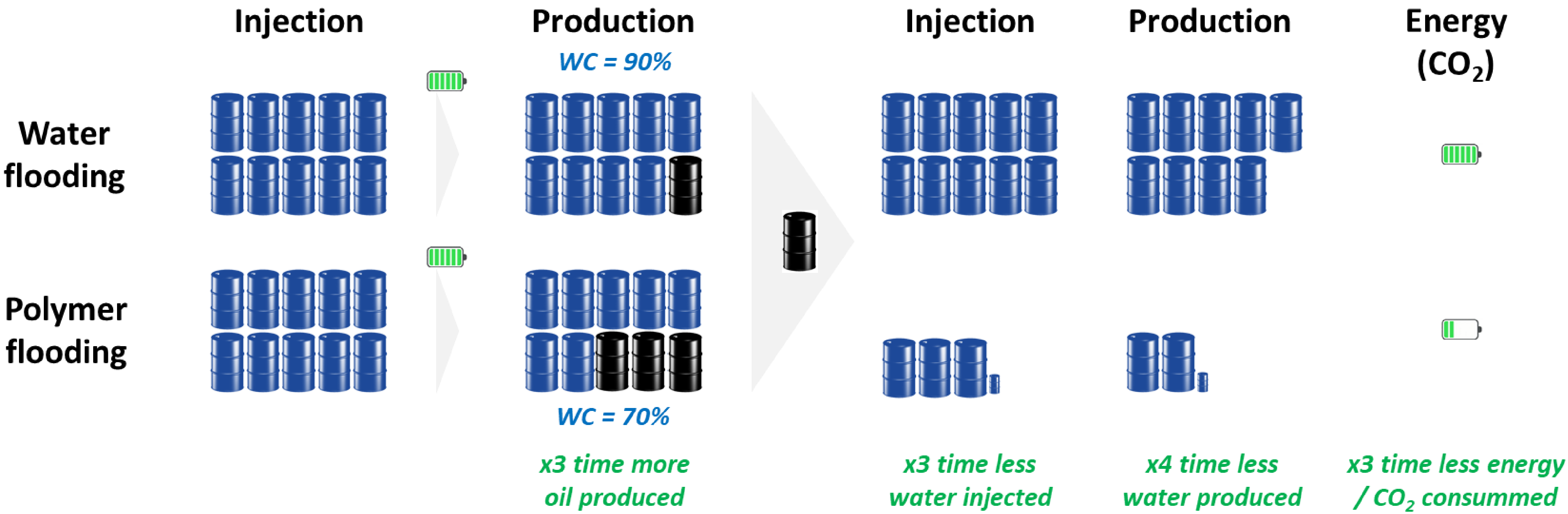

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ASSESS CO_2 FOOTPRINT

Define the system boundaries

- Identify the main CO_2 emission contributors
- Establish the assumptions to narrow down the comparison scope

Determine the Emission Factors (EF)

- Define the emission
- Estimate the EF: oil field chemicals (OFC) *vs* polymer
- Transport EF: from local transport policies
- Energy consumption of each element (depend on the country)

Apply to field cases

Compare the associated EF between waterflooding and polymer flooding

Assess for the environmental impact of Polymer Flooding vs Water Flooding

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THE GREENHOUSE GASES PROTOCOL

STANDARDIZED FRAMEWORK FOR MEASURING AND MANAGING EMISSIONS

Scope 1

- Polymer powders = 300 to 430 $kgCO_2/mT$
- Oil Field Chemicals = about 800 $kgCO_2/mT$

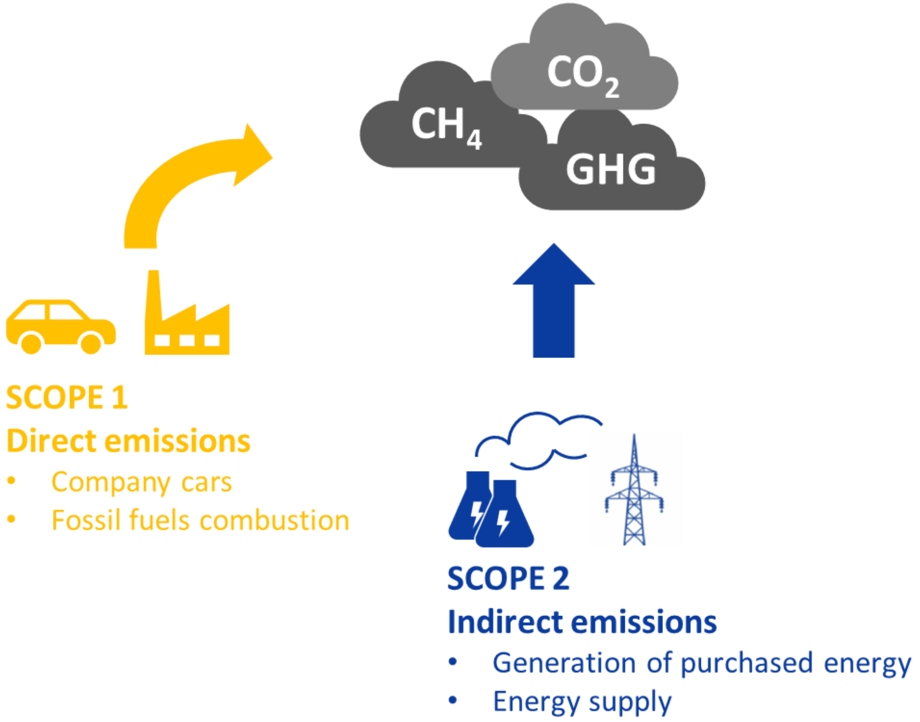
Scope 1 + 2

- Polymer powders = 550 to **700 $kgCO_2/mT$**
- Oil Field Chemicals = about **1600 $kgCO_2/mT$**

Polymer Scope 1 + 2: Depend on chemistry and factory location
(electricity-related emission factor)

Country	Emission Factor *
China	0,623 $kgCO_2/kWh$
India	0,743 $kgCO_2/kWh$
France	0,047 $kgCO_2/kWh$
UK	0,277 $kgCO_2/kWh$
US (state specific)	0,40 to 0,47 $kgCO_2/kWh$

* Carbon footprint county specific electricity grid greenhouse gas emissions factors; 2019 Grid Electricity Emissions Factors v1.0; 2019.



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HANDPRINT OF POLYMER FLOOD

CO_2 EMISSIONS CALCULATIONS

Ideal → full access to operator data

- Energy, fuel and water consumptions
- Oil, gas and water production data
- Flaring, venting, gas leak information

» ongoing efforts

Estimations from information available in the literature + internal data

- Field case papers, press releases, corporate reports…
- Technical information exchanged around project design and execution
- Polymer emissions factors (direct access)
- Emission factor related to transport mode

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HANDPRINT OF POLYMER FLOOD

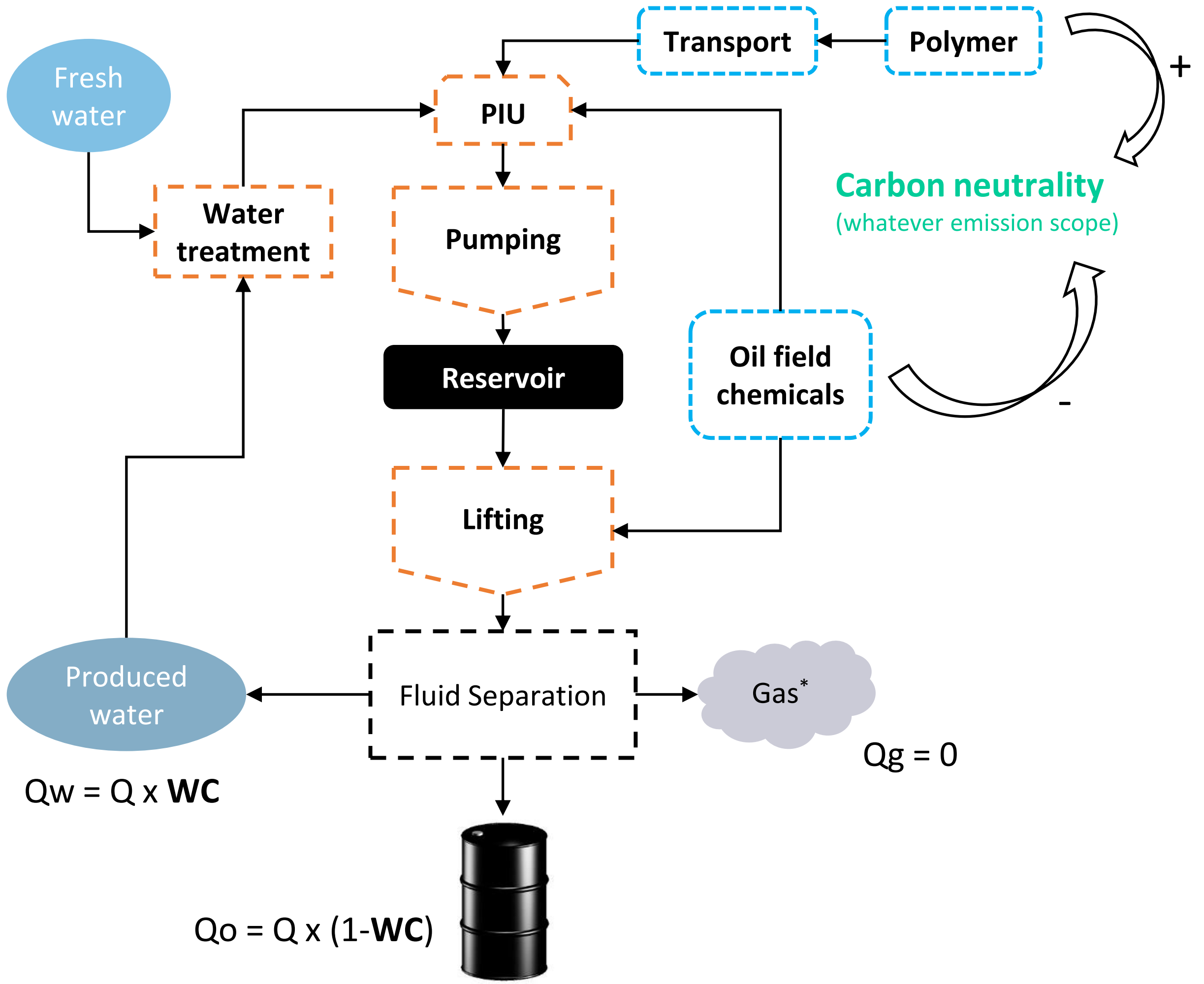
SYSTEM BOUNDARIES

Calculation of

- **Energy consumption** → conversion into emission factor (via local energy emission factor)
- **Direct emission factor**

Hypothesis

- No emissions from water source
- Injection rate = production rate
- No gas production
- Same energy consumption for fluid separation and water treatment
- Produced fluid recycling not considered



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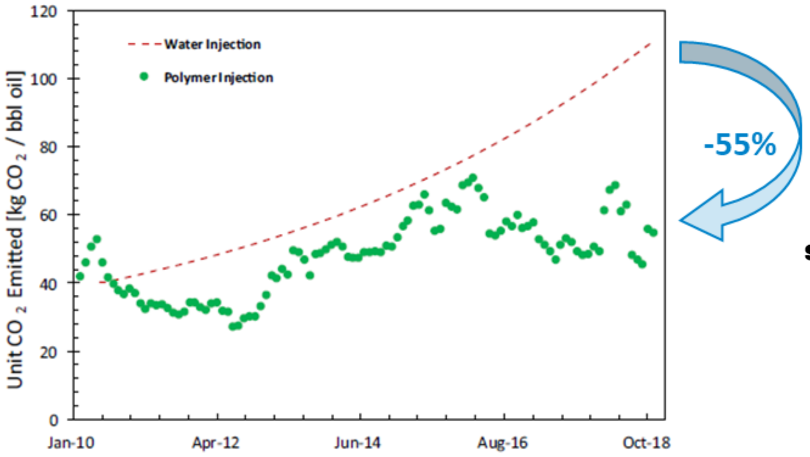
POLYMER FLOODING CONTRIBUTING TO NET ZERO

In the North Sea, **polymer flooding** could contribute **reducing CO_2 emissions by 40%** *vs* water injection

In line with data already published in the literature



Marmul (PDO, Oman)

www.nature.com/scientificreports

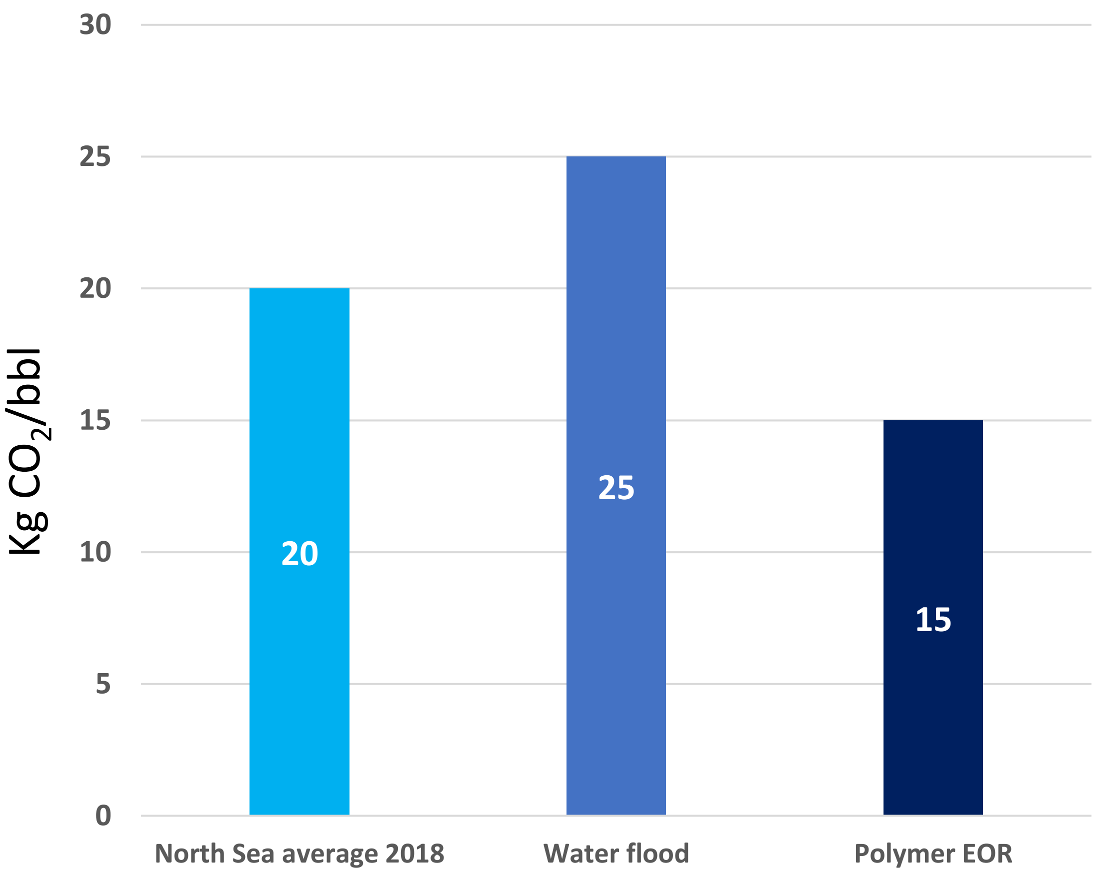
scientific reports

Check for updates

OPEN Chemical enhanced oil recovery and the dilemma of more and cleaner energy

Rouhi Farajzadeh[1,4], Siavash Kahrobaei[2], Ali Akbari Eftekhari[3], Rifaat A. Mjeni[4], Diederik Boersma[2] & Johannes Bruining[1]

Figure 8. History of CO_2 emitted for field B in the Middle East from the start of the project in January 2010 until October 2018. The calculations are based on the data from one injection pattern in the field.



Estimates from Crondall emissions reduction exercise

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CAPTAIN FIELD CASE

Main achievements of Captain polymer pilot vs waterflooding baseline

- Dramatic acceleration of oil recovery (F) → -6 years
- Incremental recovery = +45% vs water injection (J vs G)
- Water handling reduction = -88,7%

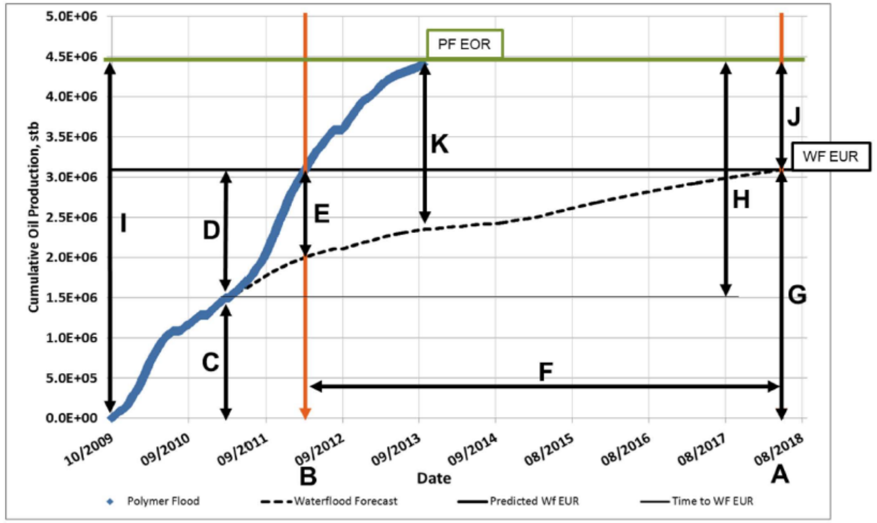

Figure 10—Captain EOR Pilot production and EOR terminology designations to report chemical flood performance

SPE 190175 – Chevron, Captain (UK)

Acceleration		Figure 10 designation
Date of expected waterflood EUR	May 2018	A
Date of waterflood EUR reached (actual)	March 2012	B
Waterflood cumulative production at PF start, MMSTB	1.5	C
Remainder of WF EUR produced by PF, MMSTB	1.6	D
Waterflood accelerated oil production by PF (at WF EUR), MMSTB	**1.1**	E
Acceleration (PF less time to reach WF EUR)	**6 years**	F
Incremental Oil Recovery		
Waterflood EUR, MMSTB	3.1	G
Polymer flood production, MMSTB	3.0	H
Cumulative oil production, MMSTB (actual)	4.5	I
Incremental oil production (above WF EUR), MMSTB	**1.4**	J
Enhanced Oil Recovery		
Enhanced oil production (at end of PF injection), MMSTB	2.5	K
Water Handling Reduction		
Cumulative water production @ WF EUR, MMSTB	28.4	
Cumulative water production @ WF EUR under PF, MMSTB	3.2	
Water handling reduction (PF less water production), MMSTB	**25.2**	

Water handling reduced by 88,7%

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CHENGDAO CASE STUDY

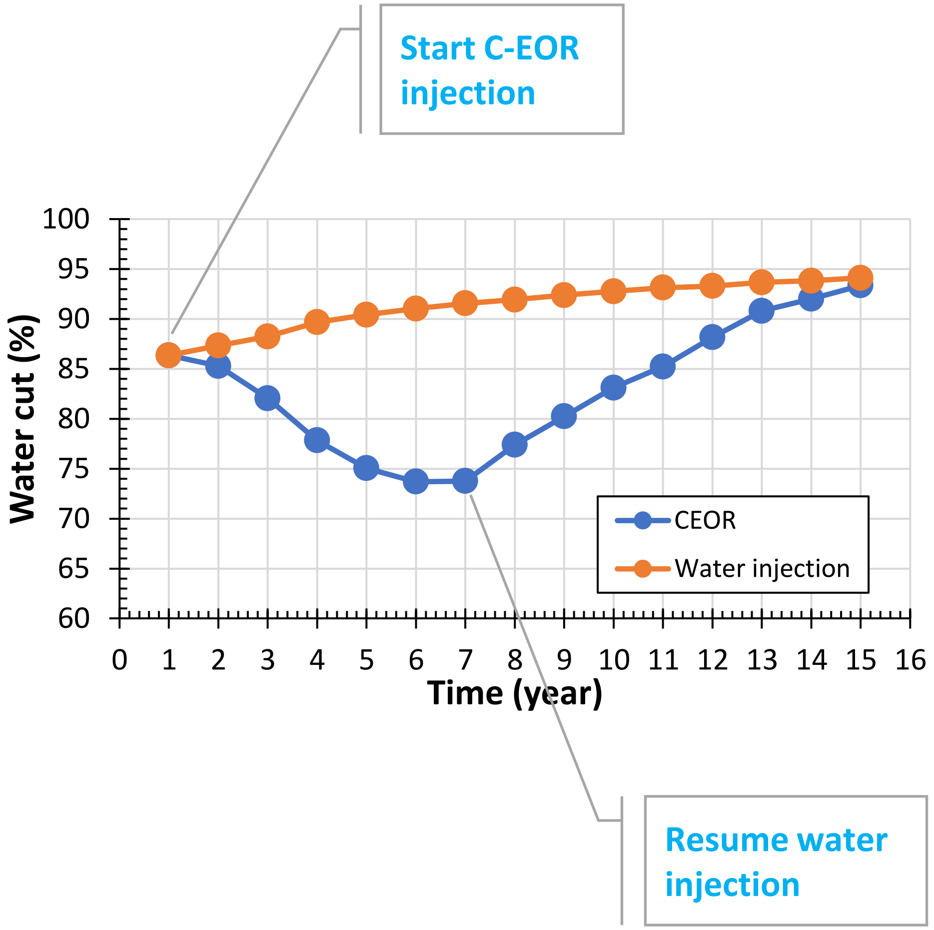
C-EOR project started in Chengdao oilfield (offshore China) → 44 injection wells

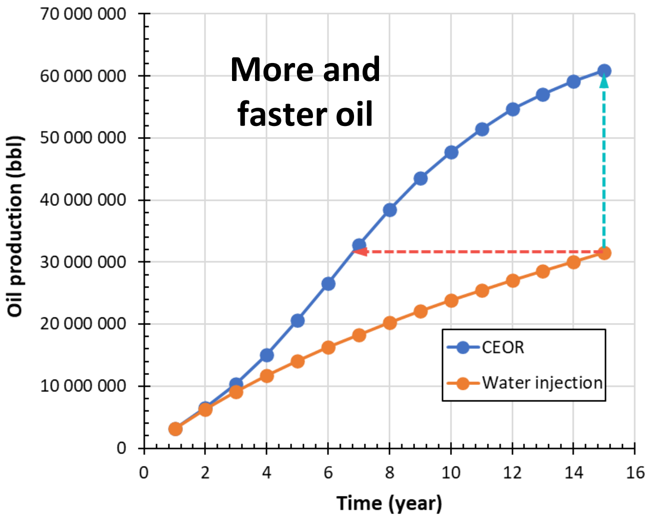
General information

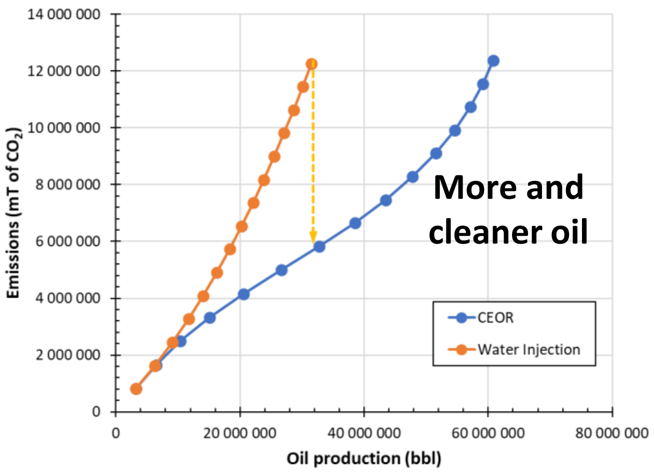
- Stable fluid production = 8 996 mT/d
- Energy consumption increased by less than 1%

Results from simulation study

- **Drop of water cut from 87% to 74%**
- Current performances following predictions







SUMMARY OF FIELD CASES

Calculations based on field case data from the literature

- Water intensity reduced by 40% to 90%
- CO_2 emissions reduced by 30% to 82%

- More information available :

IOR 2021 EAGE

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Using Polymer EOR to Reduce Carbon Intensity While Increasing Oil Recovery

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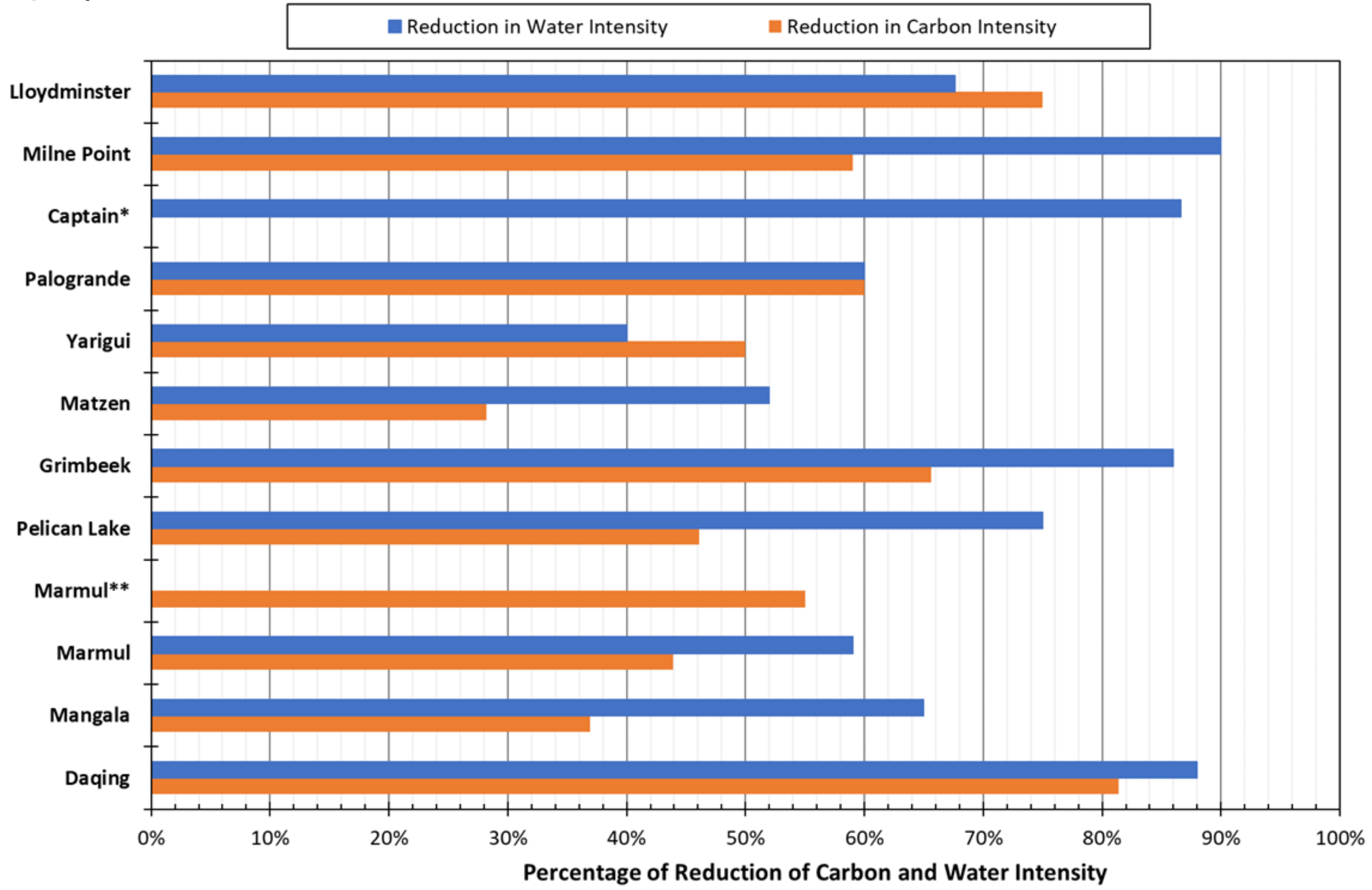
[1] SNF

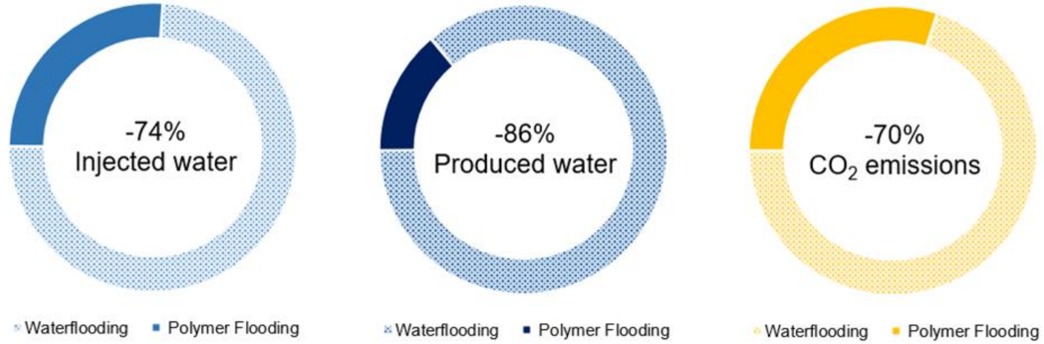


CONCLUSIONS

- Public policies engaged a shift away from fossil fuels
- Long process impacted by several external parameters (geopolitical events, pandemia)
- Oil production is declining with less discovery and lower budgets

- **Where to find the oil to buffer the transition? → Role of EOR technologies**
- **Polymer flooding = the easiest and most implemented EOR technique**
  - The concept is known, more than 300 projects, low risk and high return on investment
  - applied in large variety of field conditions

- Additional benefits = improving the energy balance sheet → use less to produce more
  - On average \$4 to \$6 per incremental barrel
  - Accelerated oil recovery
  - 4 to 6 times less water per barrel
  - 2 to 6 times les CO_2 emissions *vs* WF



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THANK YOU!

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