



cEOR developments in the current oil price environment- Start or Stop

Tibor István Ördög
MOL Hungary

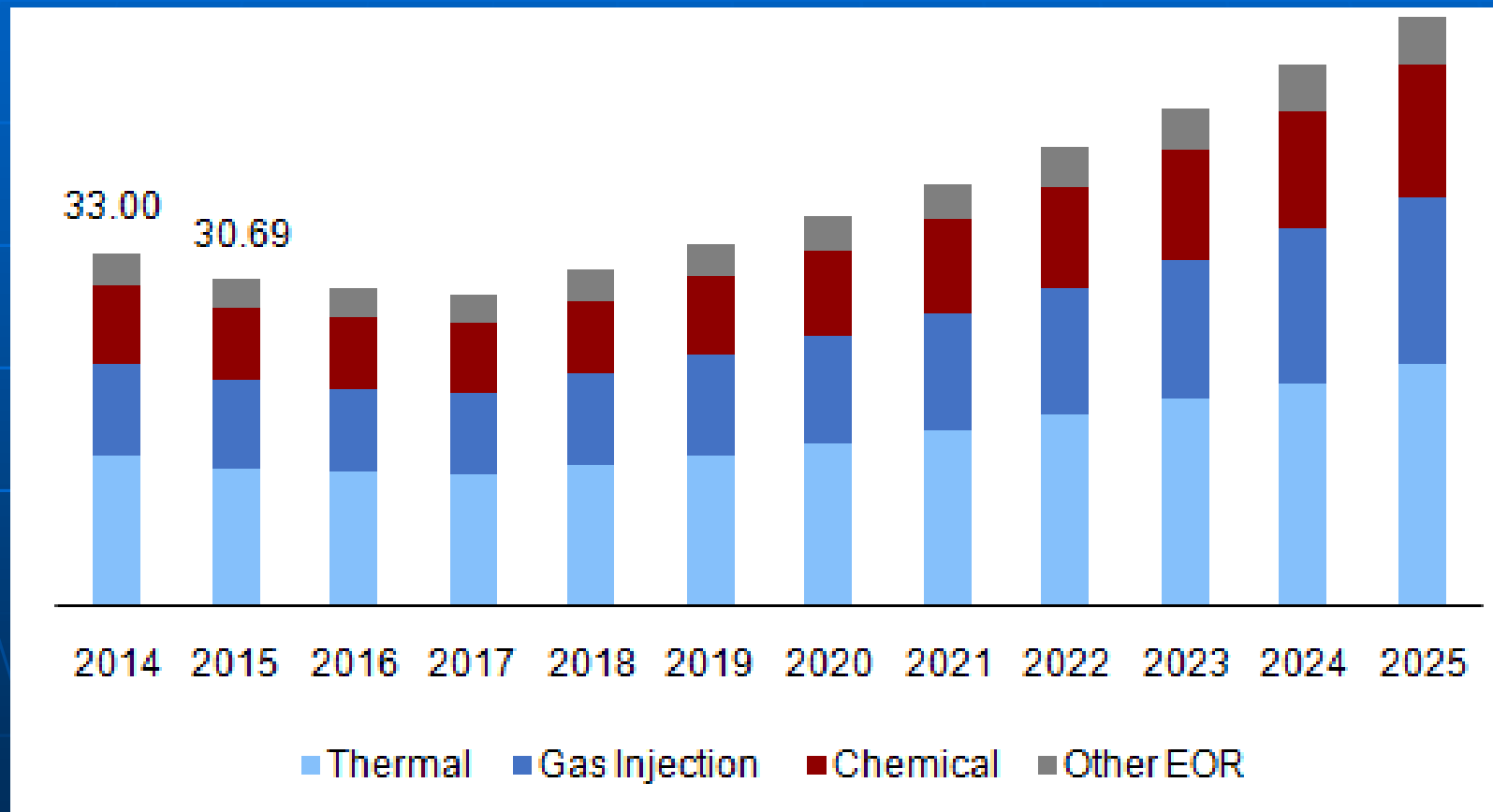
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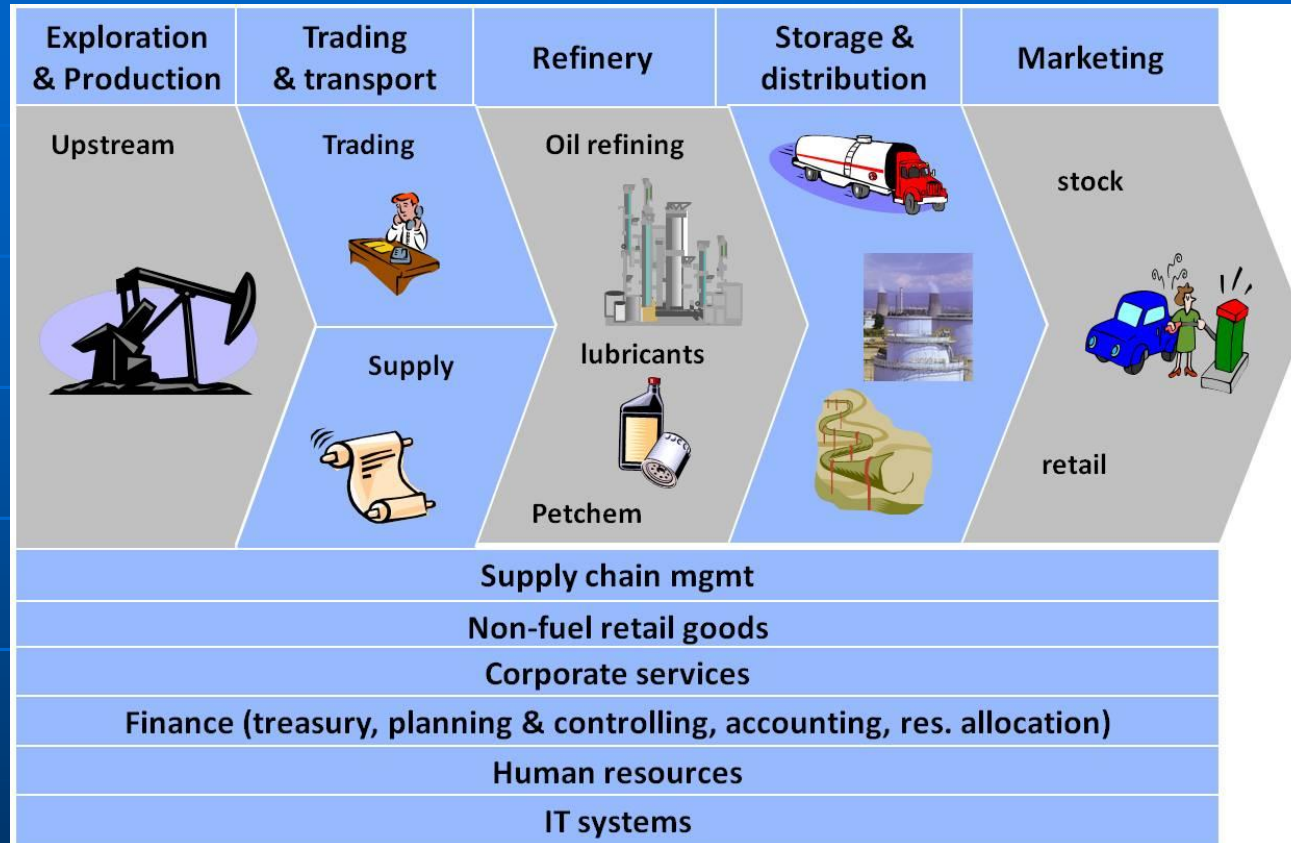
Agenda

- Global EOR market
- Global cEOR market
- cEOR future
- cEOR economics
- Project economics
- Summary

Global EOR market revenue, by technology, 2014 - 2025 (USD Billion)



Value chain in petroleum industry



Traditional value chain, where **oilfields** and **chemical production technologies** and **sales of chemicals** available in different segments

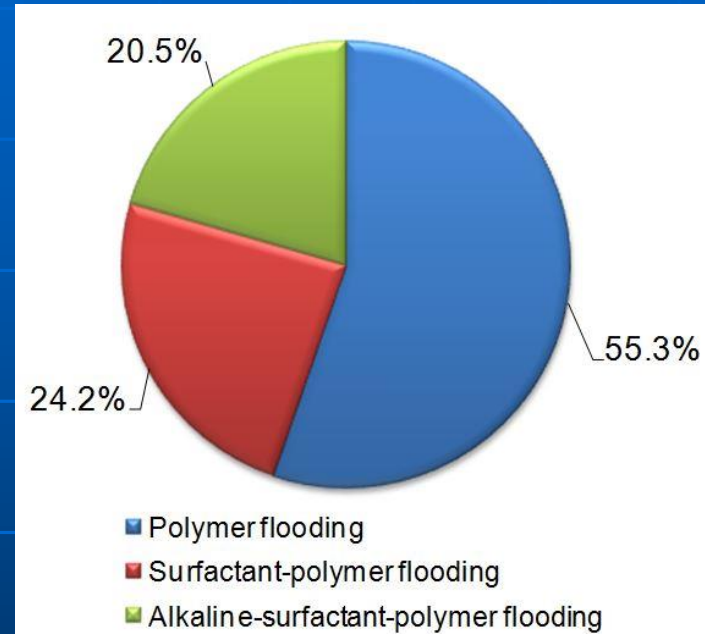
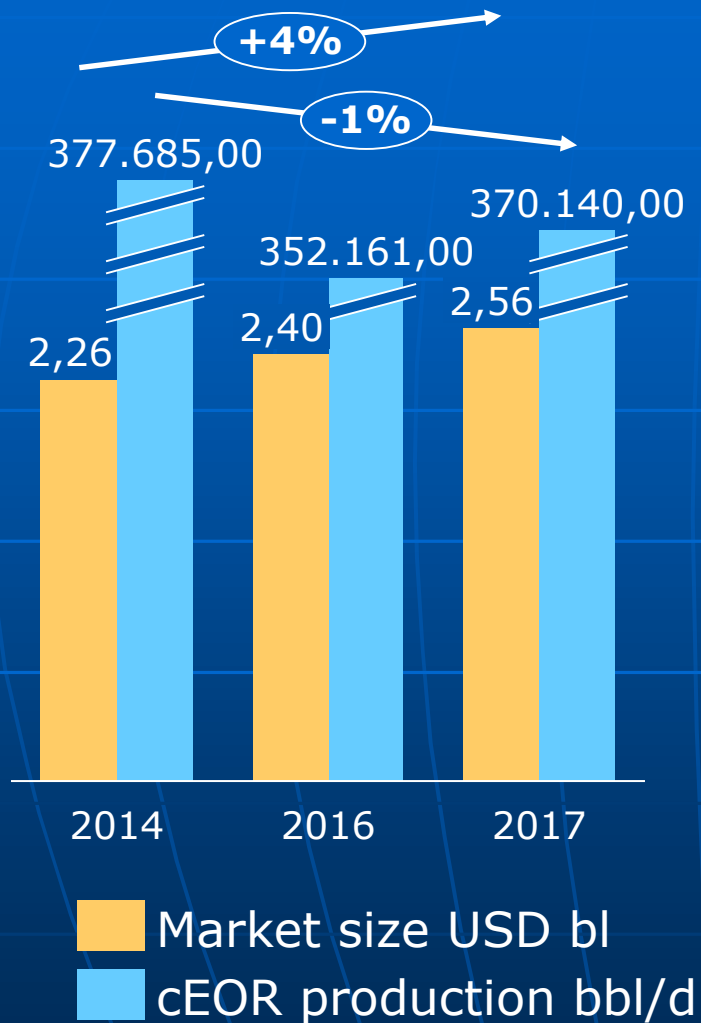
General Understanding

- Polymer flooding (PF): A mature EOR process
- Polymer gels: Used successfully in water shut-off and profile modification in selected reservoirs
- Surfactant-polymer (SP): Effective but, expensive
- ASP: Effective, less expensive, but requires extensive treatment of injection/produced fluids

What has changed since the 70s and 80s

- Surfactants and polymers with both higher performance and better characteristics are now available
 - Detergent manufacturing has greatly improved so the quality of the commercial product is better
 - The cost of HPAM polymer has actually decreased by a factor of 3 in real terms
 - Reservoir modeling is vastly better and faster
- Numerous commercial chemical floods have been done in recent years so we have a lot more field experience to guide us in terms of what works best
- Reservoir characterization and other enabling technologies have improved
 - Polymer injectivity can be vastly increased by the use of horizontal wells
 - Recent laboratory results show surfactant performance in dolomite reservoir rock just as high as in sandstones using the same low cost anionic surfactants as we use for sandstones

cEOR market review



Percent of revenue by chemical flooding type in EOR chemicals market in the United States and Europe in 2012

(Source: Frost & Sullivan)

Chemical EOR Global Status

- China and USA have most field experiences
- US has focused on improvements in chemicals, lab studies, and simulators
- Increased chemical EOR mechanistic understandings and field activities in US and world-wide in recent years
- Oman, Russia and India next „hot” countries

CHEMICAL EOR OPPORTUNITIES

- Two trillion bbl of oil remain in depleted or abandoned wells
- Chemical floods offer the only chance in many depleted & water flooded reservoirs
- Chemical EOR must be re-evaluated based on current technical & economic conditions
- Minimal or no remediation is necessary, minimizing environmental constraints
- Trained personnel are available locally

COST OF CHEMICALS

	1980	2006
Polymer ¹	\$3-4/lb	\$1/lb
Surfactant ²	\$0.40-0.60/lb	\$0.60-1.2/lb
Alkali ³	\$0.12/lb	\$0.20-.040/lb
Crude Oil	\$12/bbl	\$50-70/bbl
Incr. Cost/bbl	\$8-15	\$0.50-\$5

¹ Some processes eliminate need for polymer

² Surfactant concentration has been reduced by 10

³ Alkali has been reduced by 50% or in some cases is not needed at all

(Source: Gary Pope UT&A)

ENLARGED FIELD CHEMICAL FLOOD

Raw Material Supply

- Source (local or import)
- Availability (quantity, quality)
- Alternative suppliers
- Storage

Capital Investment

- Up-front investment
- Operational cost
- By-products

Manufacturing Location

- Foreign, domestic, on-site
- Shipping, tax, etc.
- Storage and distribution
- Flexibility

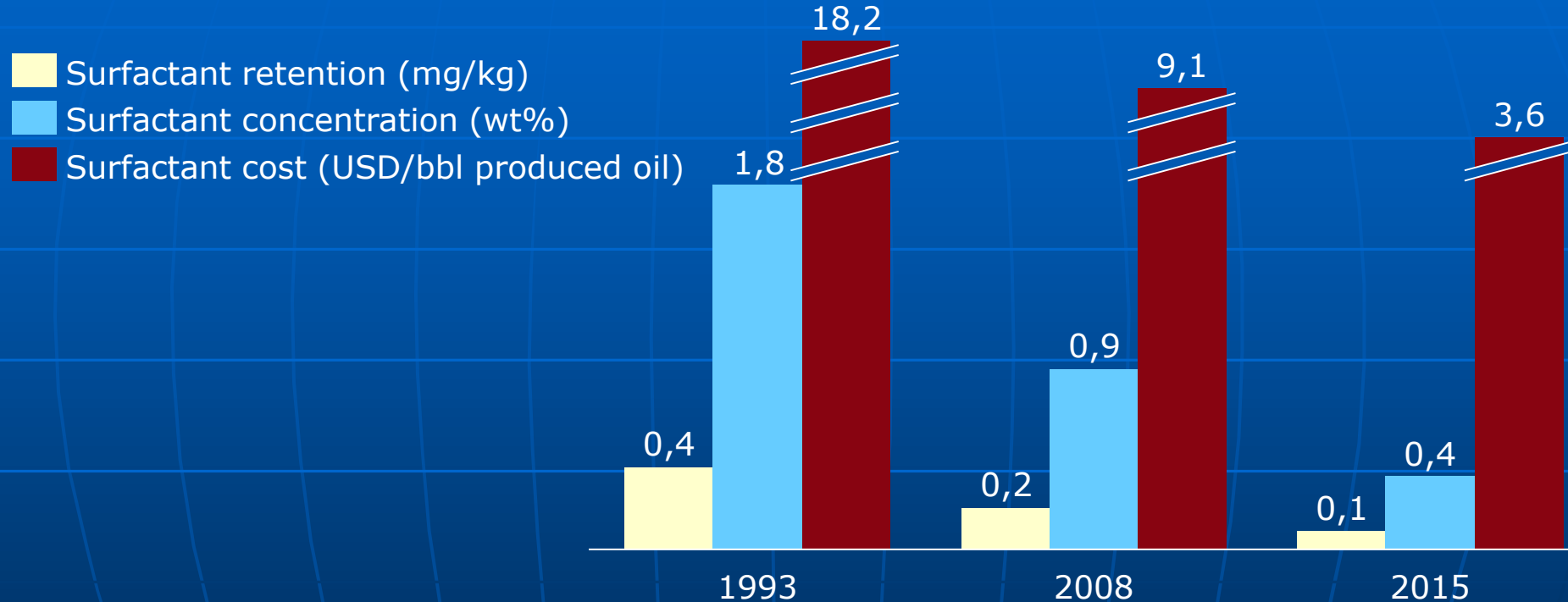
CHEMICAL EOR - THE FUTURE

- New processes use less surfactant (up to 10 times less)
- Extensive lab evaluations support the feasibility of chemical flooding
- Field data proves chemical flooding is an effective way to recover residual oil
- Cost of chemicals have not increased in proportion to price of crude oil

cEOR –Potential is vast

- cEOR will remain the **smallest segment** of the **EOR** market for the **immediate future**.
- **Potential** for cEOR is **vast** in terms of both size and regional scope.
- Chemical EOR already **surpasses** both **thermal and gas EOR** methods in terms of the number of countries with active projects (14), while double-digit spending growth is anticipated over the next five years as pilot projects are set up and expanded.
- cEOR is set to **emerge from the shadow** of its rival EOR methods to become an important technology on the global scale.

cEOR –Economic Significance of Reduced Retention

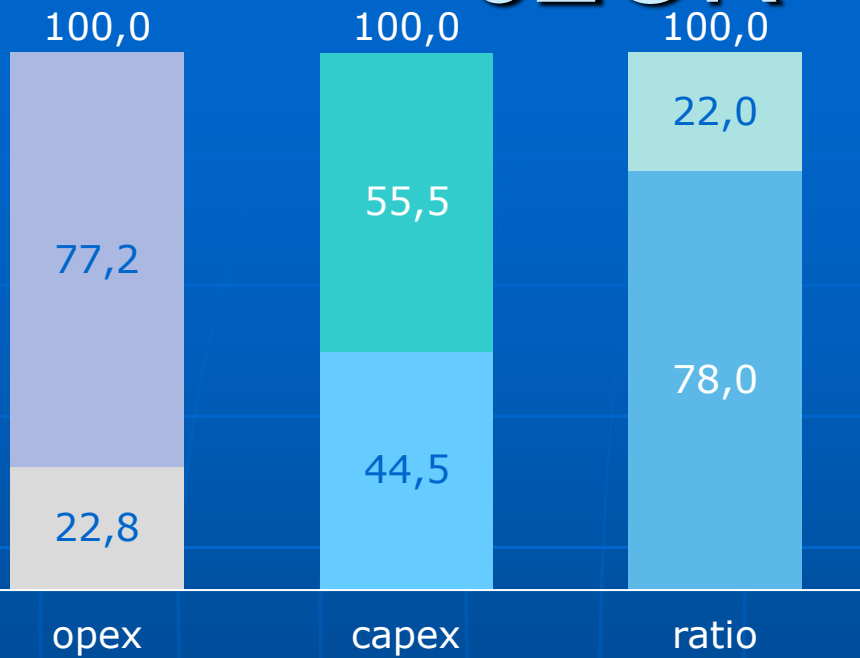


References • Wang (1993), Flaaten (2008)

Assumptions:

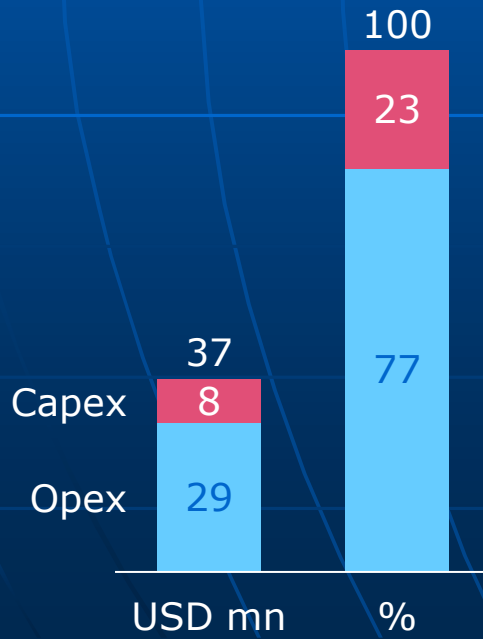
- Porosity: 20%
- Recovery Factor: 25% OOIP
- Size of Chemical Slug: 0.3 PV
- Surfactant to Co-solvent

cEOR – Example



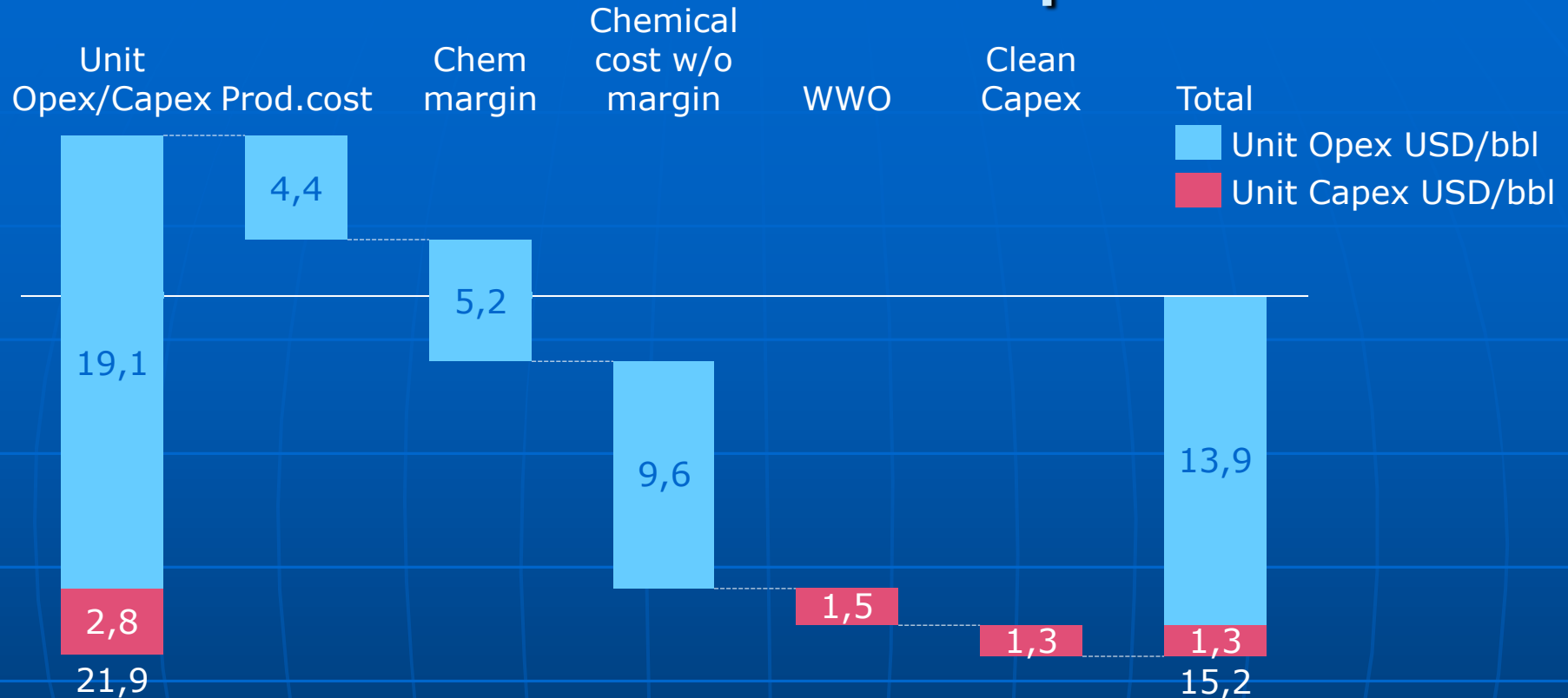
- Well construction
- Injection plant construction
- Chemical cost
- Operation cost
- capex
- opex

- 56 % of cEOR project CAPEX is spent on WWO
- CAPEX is 22 % of total budget



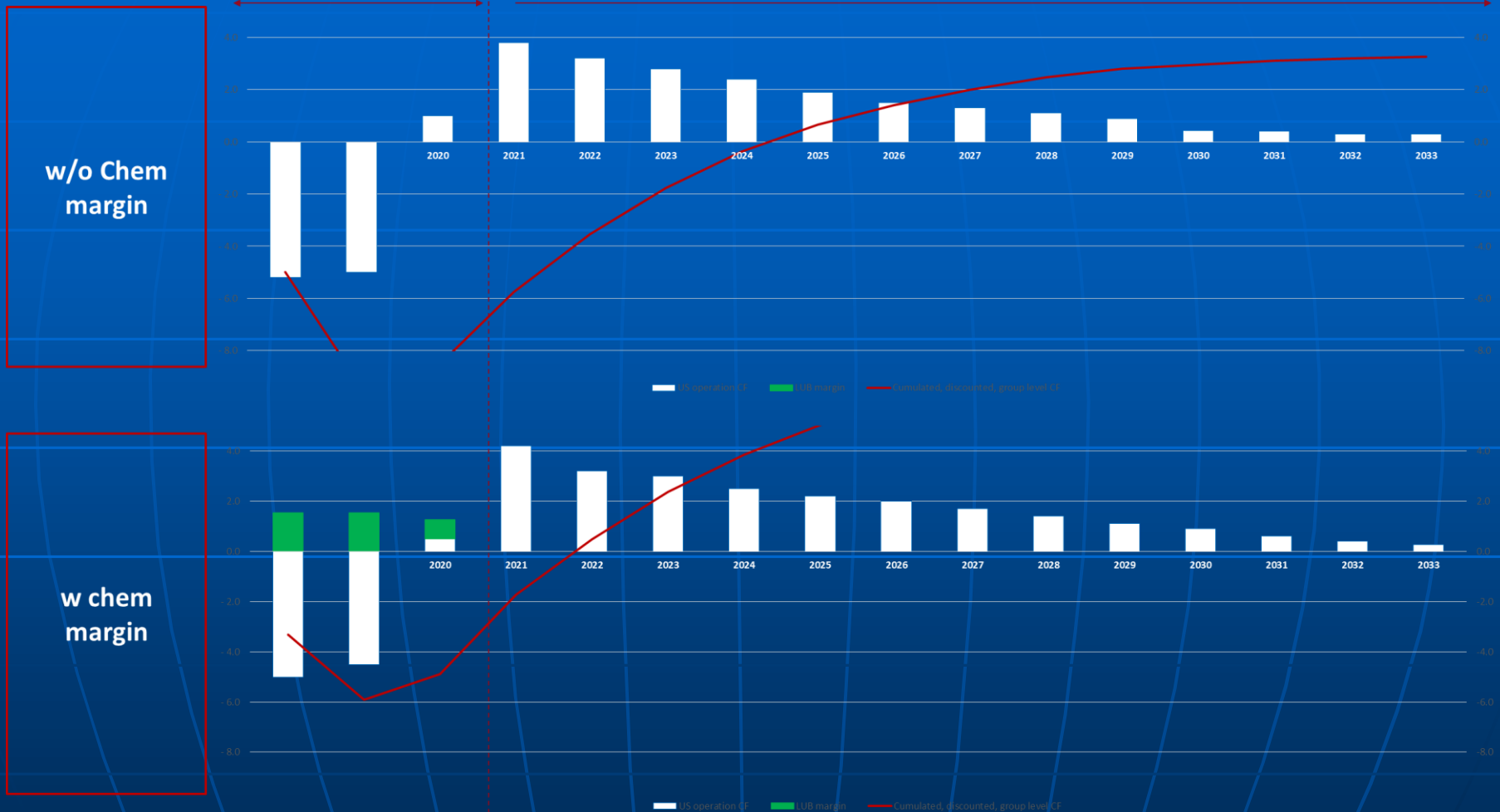
- cEOR project OPEX is almost 80% of total budget
- CAPEX is 23 % of total budget

cEOR –Example



- Chemical product margins vary between 35-200%
- WWO activity is not part of budget in standard case
- OPEX can be decrease between 27-58 % in case of 35-200% chemical product margin scenarios
- CAPEX can be decrease by 46% w/o WWO
- All in all total 30-58 % cost reduction can be achieved based on chemical product margin scenarios

cEOR –CF curves



- Surfactant production in-house margin can help a lot during the injection period
- Later on the incremental crude production drive CF

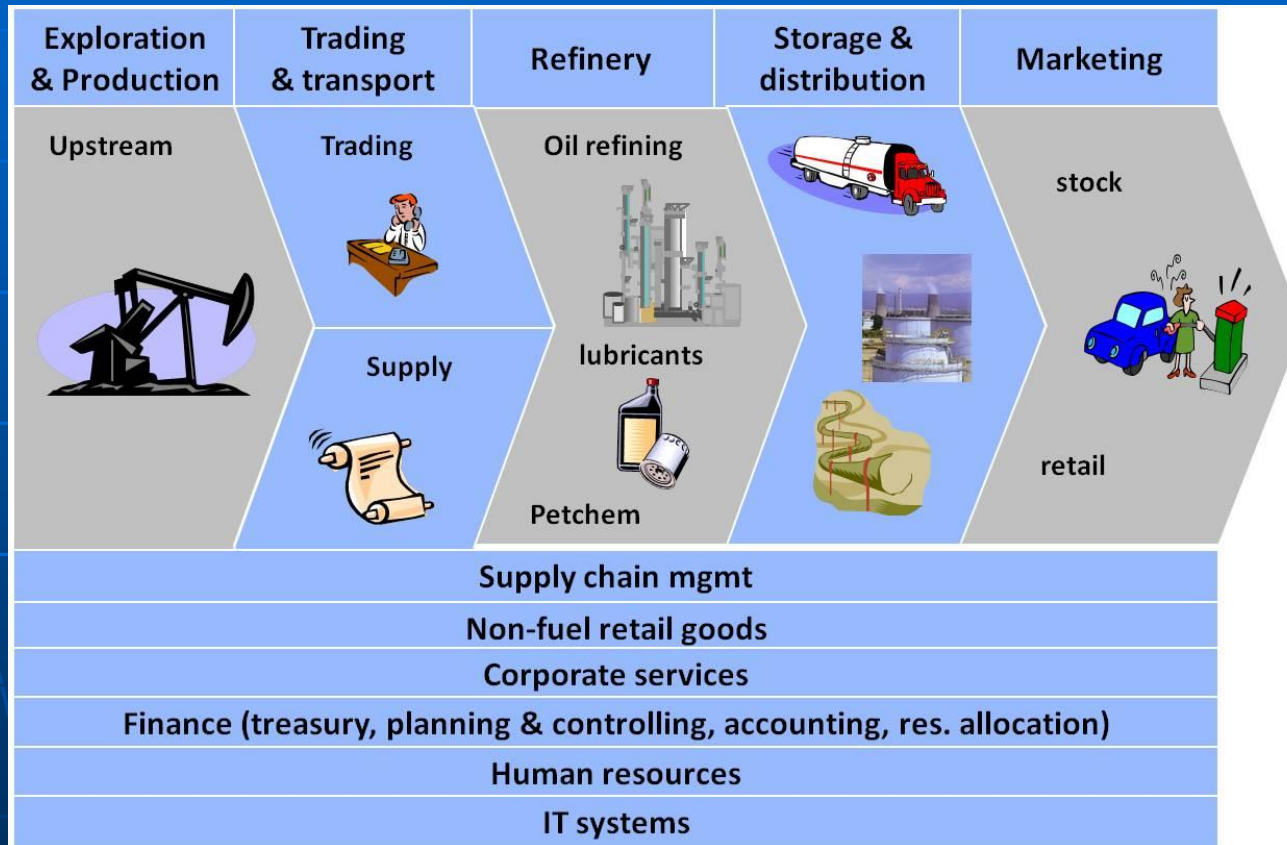
Summary and Conclusions

- Chemical EOR technology is dramatically better than 30 years ago due to more experience, better understanding, better modeling, better enabling technologies and better chemicals at lower cost adjusted for inflation
- Chemical EOR is a very complex technology requiring a high level of expertise and experience to successfully implement in the field
- At current oil prices, oil companies can make a high rate of return using chemical EOR methods

cEOR –Take Home

- The combined impact of all of the new Chemical EOR and oilfield technology is a game changer
- New and better chemicals at lower real cost
- Increased performance at lower cost per Bbl oil
- Better models are available to design and predict field performance by new SWs
- In-house chemical production is game changer
- But it's still complex technology and geology still matters, and so do people

Value chain in petroleum industry





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Thank You for your kind attention!

Q&A

Contact: tordog@mol.hu