ConocoPhillips

CO2 for EOR

Ekofisk CO2 Study

FORCE - EOR Competence Building Seminar
November 2013

ConocoPhillips

Cautionary Statement

The following presentation includes forward-looking statements. These statements relate to future events, such as anticipated revenues, earnings, business strategies, competitive position or other aspects of our operations or operating results. Actual outcomes and results may differ materially from what is expressed or forecast in such forward-looking statements. These statements are not guarantees of future performance and involve certain risks, uncertainties and assumptions that are difficult to predict such as oil and gas prices; refining and marketing margins; operational hazards and drilling risks; potential failure to achieve, and potential delays in achieving expected reserves or production levels from existing and future oil and gas development projects; unsuccessful exploratory activities; unexpected cost increases or technical difficulties in constructing, maintaining or modifying company facilities; international monetary conditions and exchange controls; potential liability for remedial actions under existing or future environmental regulations or from pending or future litigation; limited access to capital or significantly higher cost of capital related to illiquidity or uncertainty in the domestic or international financial markets; general domestic and international economic and political conditions, as well as changes in tax, environmental and other laws applicable to ConocoPhillips' business and other economic, business, competitive and/or regulatory factors affecting ConocoPhillips' business generally as set forth in ConocoPhillips' filings with the Securities and Exchange Commission (SEC).

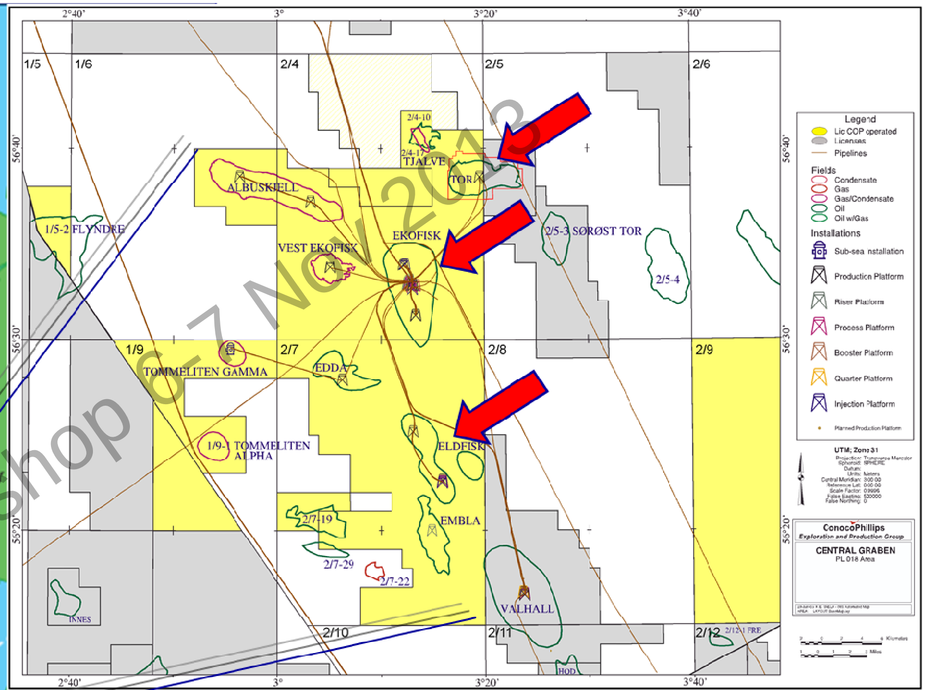
Use of non-GAAP financial information - This presentation includes non-GAAP financial measures, which are included to help facilitate comparison of company operating performance across periods and with peer companies. A reconciliation of these non-GAAP measures to the nearest corresponding GAAP measure is included in the appendix.

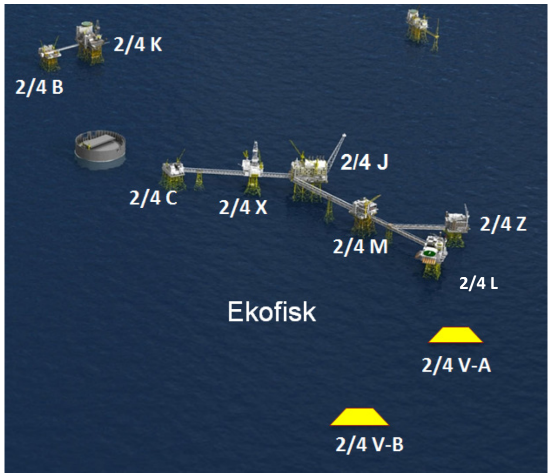
Cautionary Note to U.S. Investors – The SEC permits oil and gas companies, in their filings with the SEC, to disclose only proved, probable and possible reserves. We use the term "resource" in this presentation that the SEC's guidelines prohibit us from including in filings with the SEC. U.S. investors are urged to consider closely the oil and gas disclosures in our Form 10-K and other reports and filings with the SEC. Copies are available from the SEC and from the ConocoPhillips website.

Agenda

- Introduction Ekofisk
- CO_2 Mechanisms Subsurface
- CO_2 Scenario Studies
- Summary

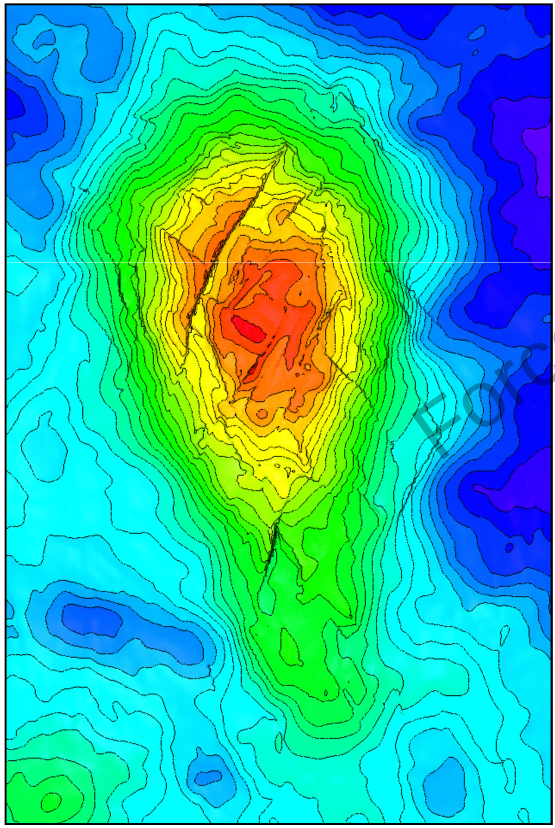
Ekofisk Field





Facts Ekofisk

LOCATION: CENTRAL GRABEN, NORWEGIAN NORTH SEA
DISCOVERED: 1969
START-UP: 1971
OOIP: 7.1 MMMSTB
PRODUCED: 3.7 MMMSTB



0 1 km

RESERVOIR:

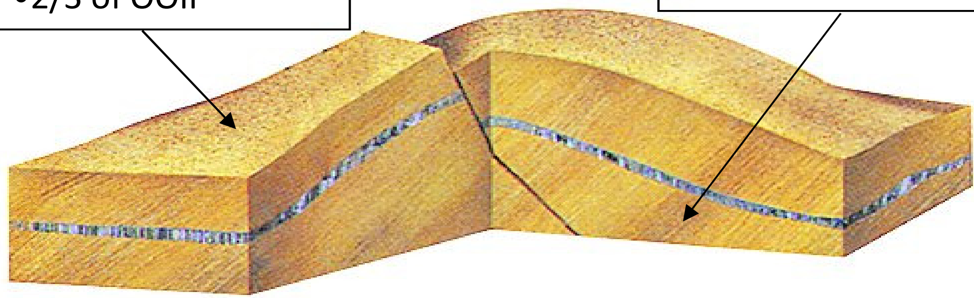
FRACTURED CHALK

- EKOFISK FM: DANIAN (EARLY PALEOCENE)
- TOR FM: MAASTRICHTIAN (LATE CRETACEOUS)

PAY THICKNESS: 1000 feet
DEPTH: 9500 - 10800 feet
POROSITY: 25 - 40%
PERMEABILITY: Matrix: 3 - 10 mD
Effective: 3 - 100 mD

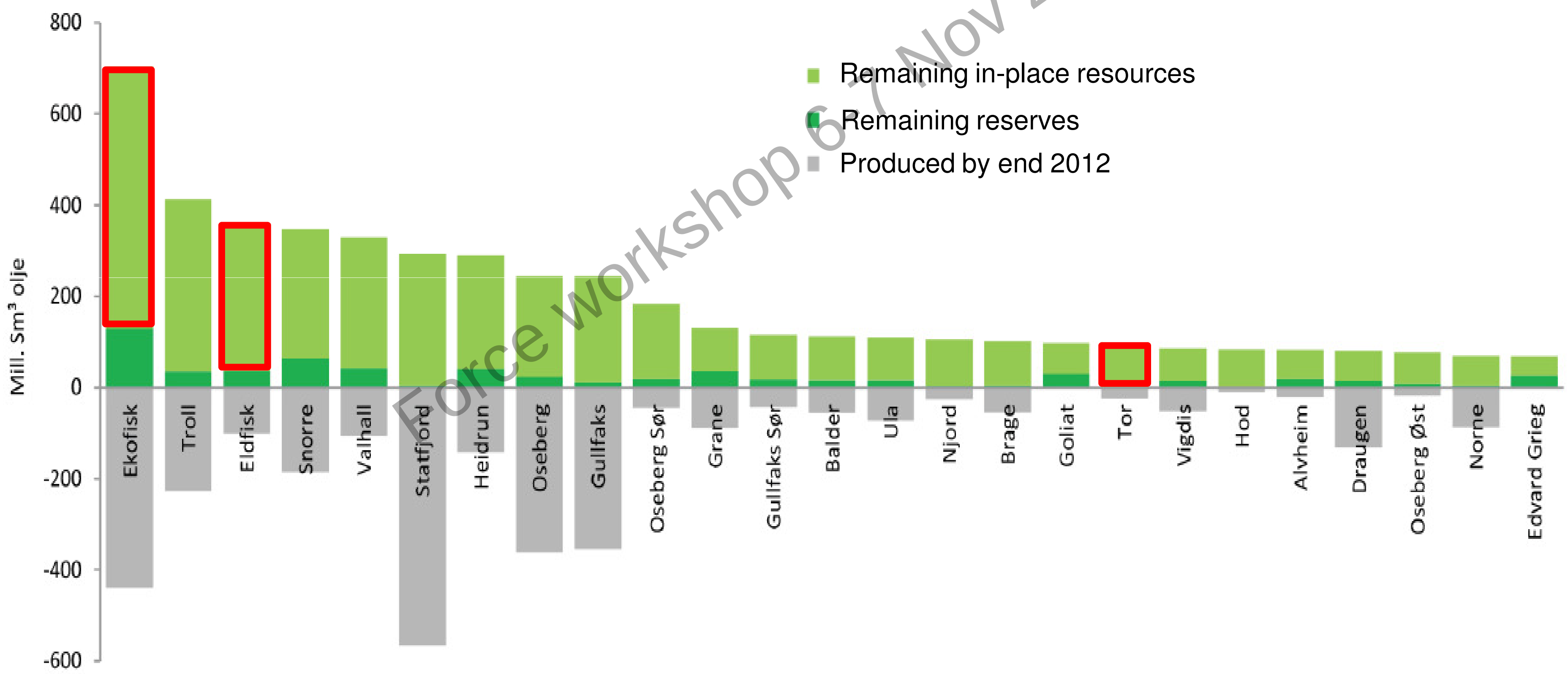
Ekofisk Formation
- 300 - 500 ft thick
- 2/3 of OOIP

Tor Formation
- 300 - 500 ft thick
- 1/3 of OOIP



MOTIVATION - WHAT WE LEAVE BEHIND

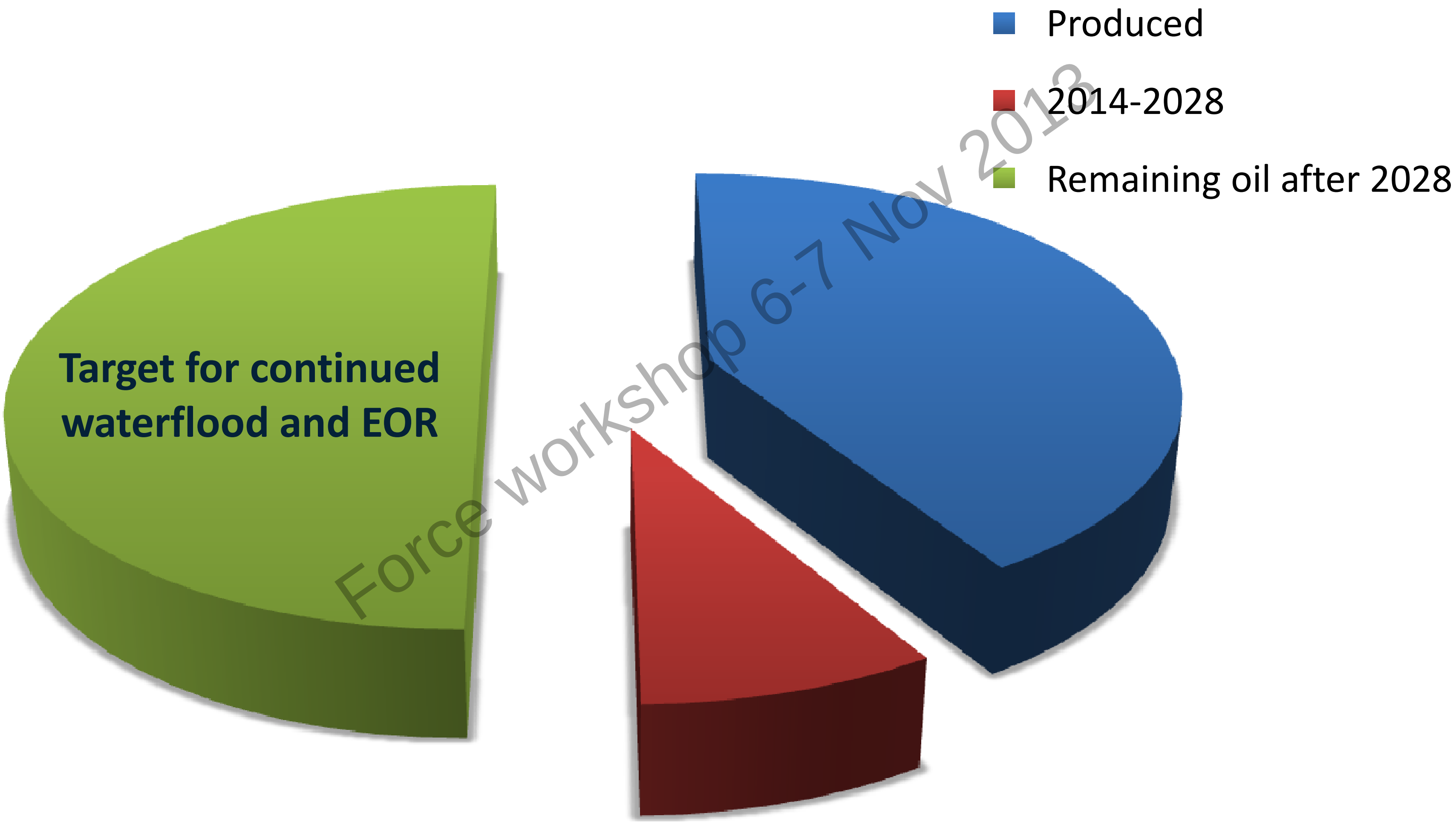
Oil Resources and Reserves in Norwegian Fields



* Source: Norwegian Petroleum Directorate

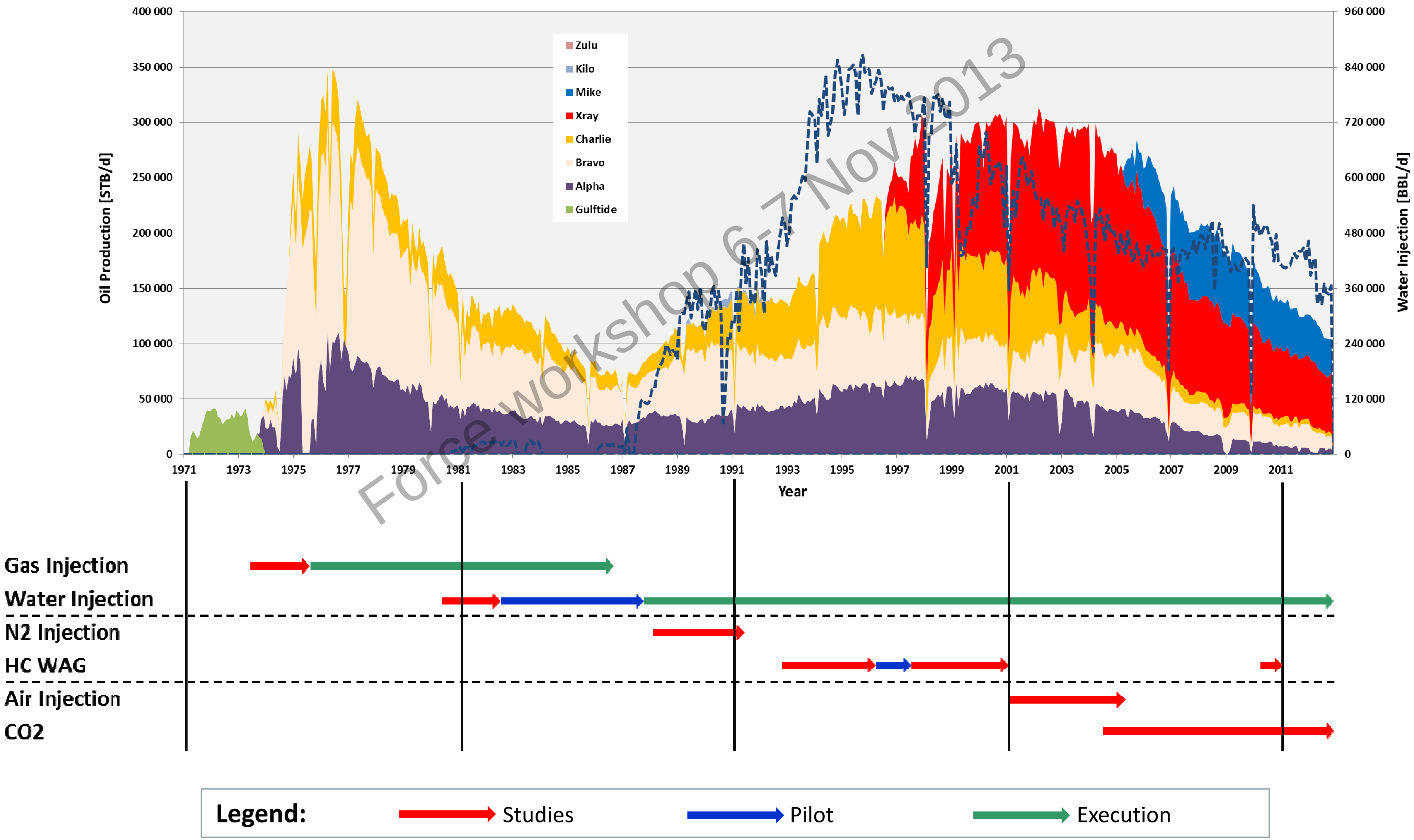
ConocoPhillips

Ekofisk EOR Target



+1% incremental RF ~ 80 MMBOE

Historical Gas Based EOR Studies



Agenda

- Ekofisk Information
- CO2 Mechanisms Subsurface
- CO2 Scenario Studies
- Summary

CO2 has been extensively studied for the past 10 years

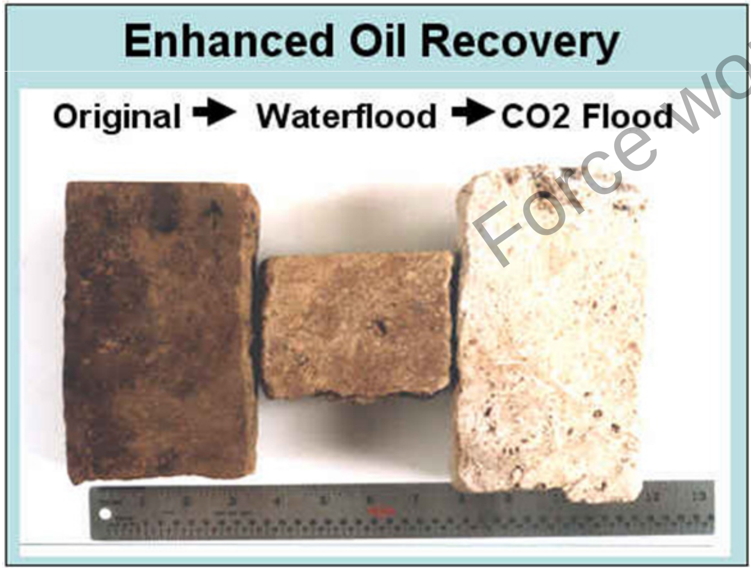
- **Subsidence & Compaction**
  - CO_2 compaction impact
  - Well failure potentials
  - Full field subsidence/compaction forecast
- **CO_2 Transport Mechanisms**
  - Injection schemes (Pure, WAG, Carbonated Water)
- **CO_2 Displacement Mechanisms**
  - Fracture/Matrix interaction
  - Diffusion, Gravity, Viscous Displacement
- **CO_2 Recovery Mechanisms**
  - Swelling, Vaporization, Miscibility
- **Other Issues**
  - CO_2 Solubility in Water
  - Asphaltene formation
  - Hydrate Formation
- **Res. Simulation**
  - Model Mechanisms
  - Upscale to full field

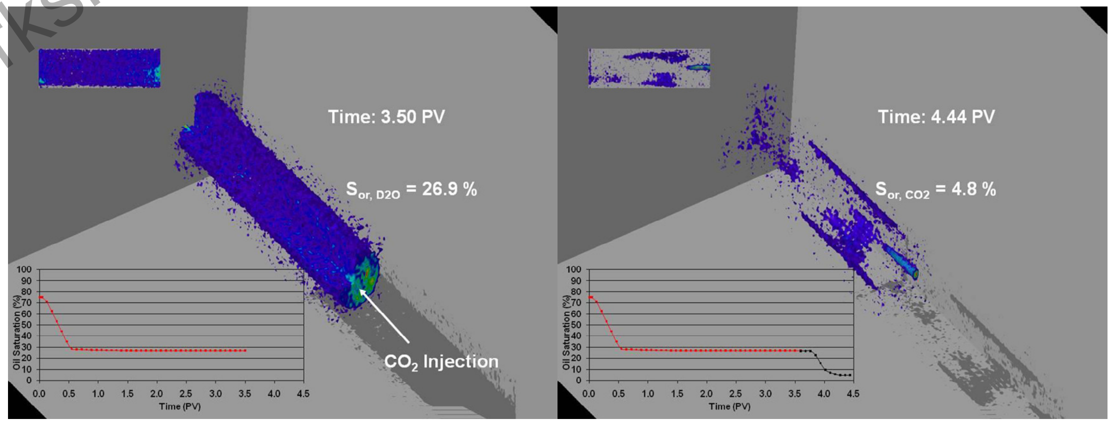
Project(s) Status:

- Completed
- Ongoing
- Need more work

CO2 as an EOR Method

- **CO2 can be a very efficient EOR method in homogeneous chalk**
  - Potential for reducing Sor to less than 10% within 1 PV CO2 injected
- **Miscible displacement can be achieved at reservoir conditions**
  - Miscibility is a bigger challenge for HC- and N2-gas





Laboratory test of waterflooded outcrop chalk with CO2 as EOR (University of Bergen)

a) Residual oil saturation after waterflood

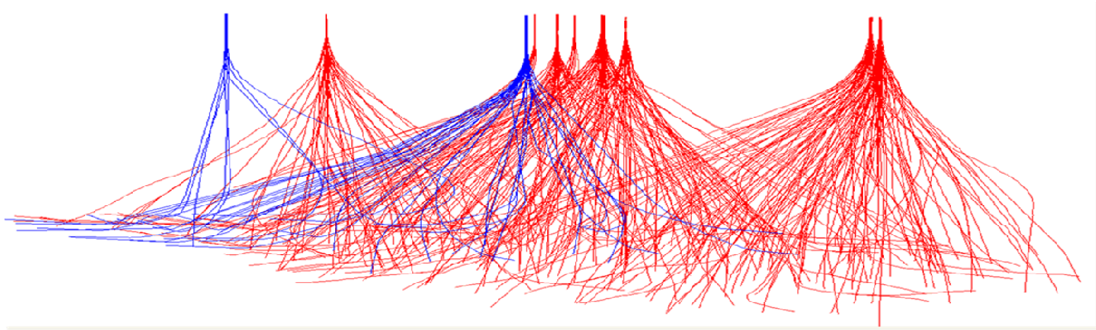
b) Residual oil saturation after CO2 injection

Challenges of CO2 in North Sea Chalk Reservoirs

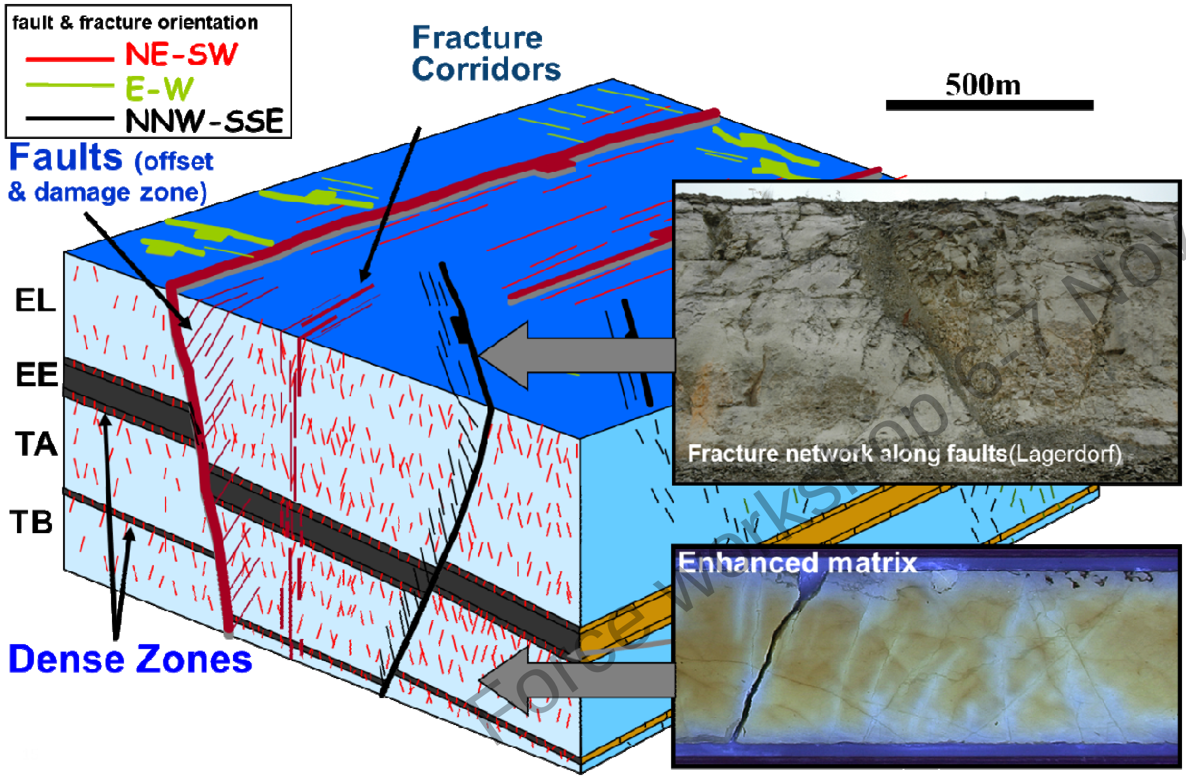
- **Most of the chalk fields are naturally fractured reservoirs**
  - Slower recovery and potentially higher Sor after CO_2 flooding
  - Early CO_2 breakthrough
    - ⇒Cycling of CO_2 - close to CO_2 self sufficient after some years
- **Injection temperature**
  - Potential risk of loosing injectivity due to hydrates

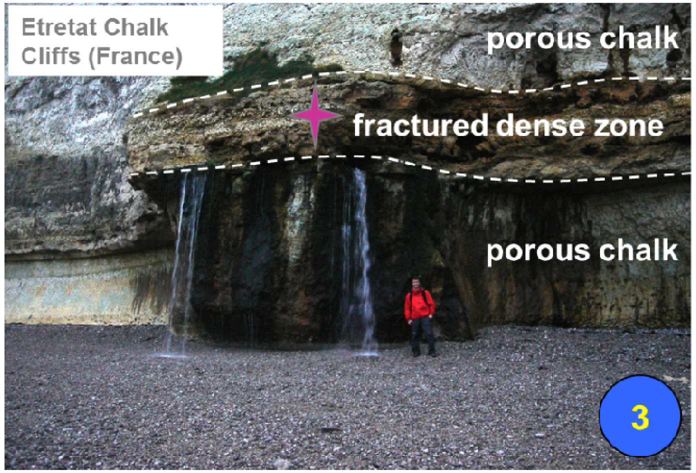
Challenges of CO_2 in North Sea Chalk Reservoirs

- **Compaction/Subsidence**
  - Potential for increased compaction/subsidence with CO_2 injection
    - ⇒Increased potential for well failures
    - ⇒Top side integrity
    - ⇒Increased risk for leakage
- **Containment**
  - More than 400 wells drilled during the 40 years of production
    - High potential for CO_2 leakage
  - Need for a safe aquifer as storage



Fractured Chalk





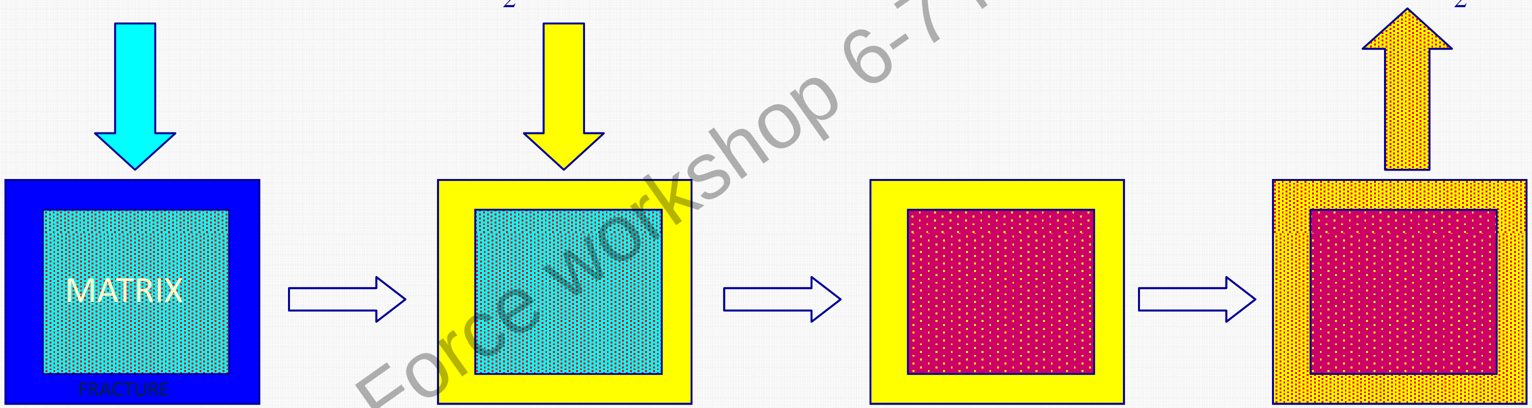
ConocoPhillips

Fractured Chalks: CO_2 Transfer Mechanisms?

Water Injection

CO_2 Injection
- Pure
- WAG
- CO_2/Water

Improved Recovery
- Oil
- CO_2/Condensate Mix
- Water/CO_2



After Waterflood
-Oil – 30%
-Water – 70%
-Waterfilled fracs

CO_2 Transport
-Displace frac. water
-CO_2 enter frac.system

Contact Residual Oil
-Diffusion
-Gravity Drainage
-Viscous Displacement

Oil Recovery
-Swelling of oil
-Vaporization of light end components
-Miscibility

Simulation Study: Premises for the Incremental Recoveries

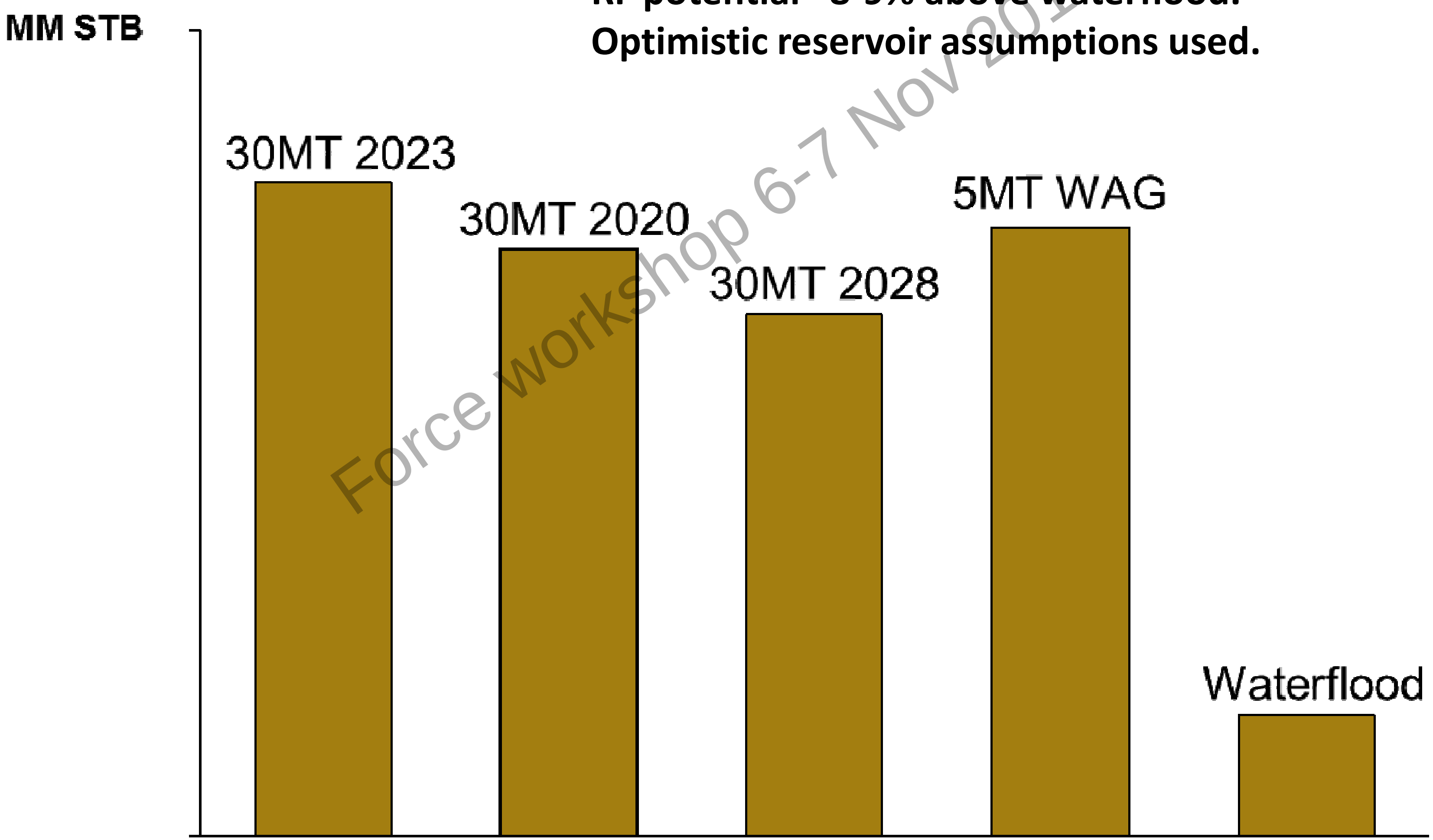
- **In 2008 a larger simulation study was conducted**
- **Full field scale CO_2 injection**
- **Two CO_2 injection scenarios where evaluated**
  - Continuous CO_2 injection – 30MT CO_2 pr year, with start-up in
    - 2020
    - 2023
    - 2028
  - CO_2 WAG scenario with start-up in 2023 – 5MT CO_2 pr year

Optimistic reservoir assumptions used in the simulation study.

Most knowledge of the fracture network and impact on recovery has been obtained in the past 5 years.

Simulation Study: Incremental Recovery above Waterflood

RF potential ~8-9% above waterflood.
Optimistic reservoir assumptions used.



Agenda

- Ekofisk Information
- CO_2 Mechanisms Subsurface
- CO_2 Scenario Studies
- Summary

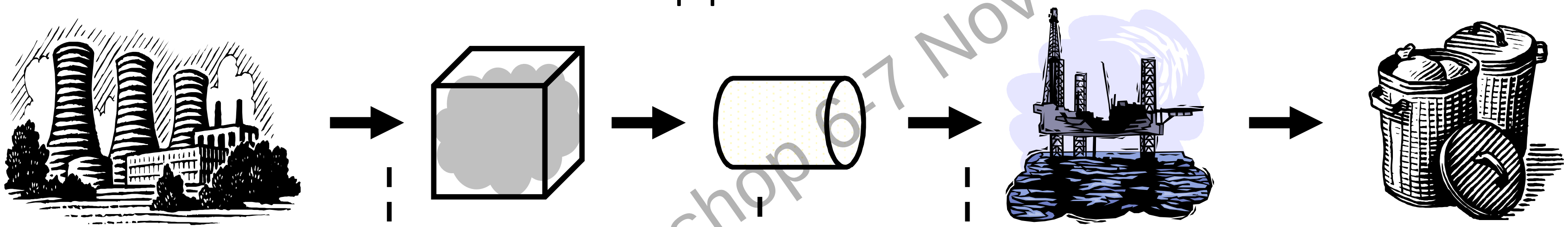
Surface related CO_2 Challenges

- **Logistics**
  - CO_2 source
  - Transportation
- **Regulatory, HSE and containment**
- **High cost due to facility modifications**
  - Compression
  - Upgrade Wells for CO_2 Service
  - CO_2 separation
  - Pipelines

  $\Rightarrow$Expected need for a full re-development of the field
- **A multi-well pilot will be required before a full field implementation**

Value chain - 3 cost scenarios for delivered CO2

European Coal Power | Carbon Capture | CO2 transport pipeline | Ekofisk CO2 EOR | Offshore CO2 sink



(1) As-is

Base Case

EOR project pays for full CO2 value chain and 'receives' carbon credits as an avoided operating cost

(2) Regulations force / incentivise power plants into CCS but they have alternative onshore storage

EOR project pays incremental transport cost to supply to Ekofisk vs onshore alternative

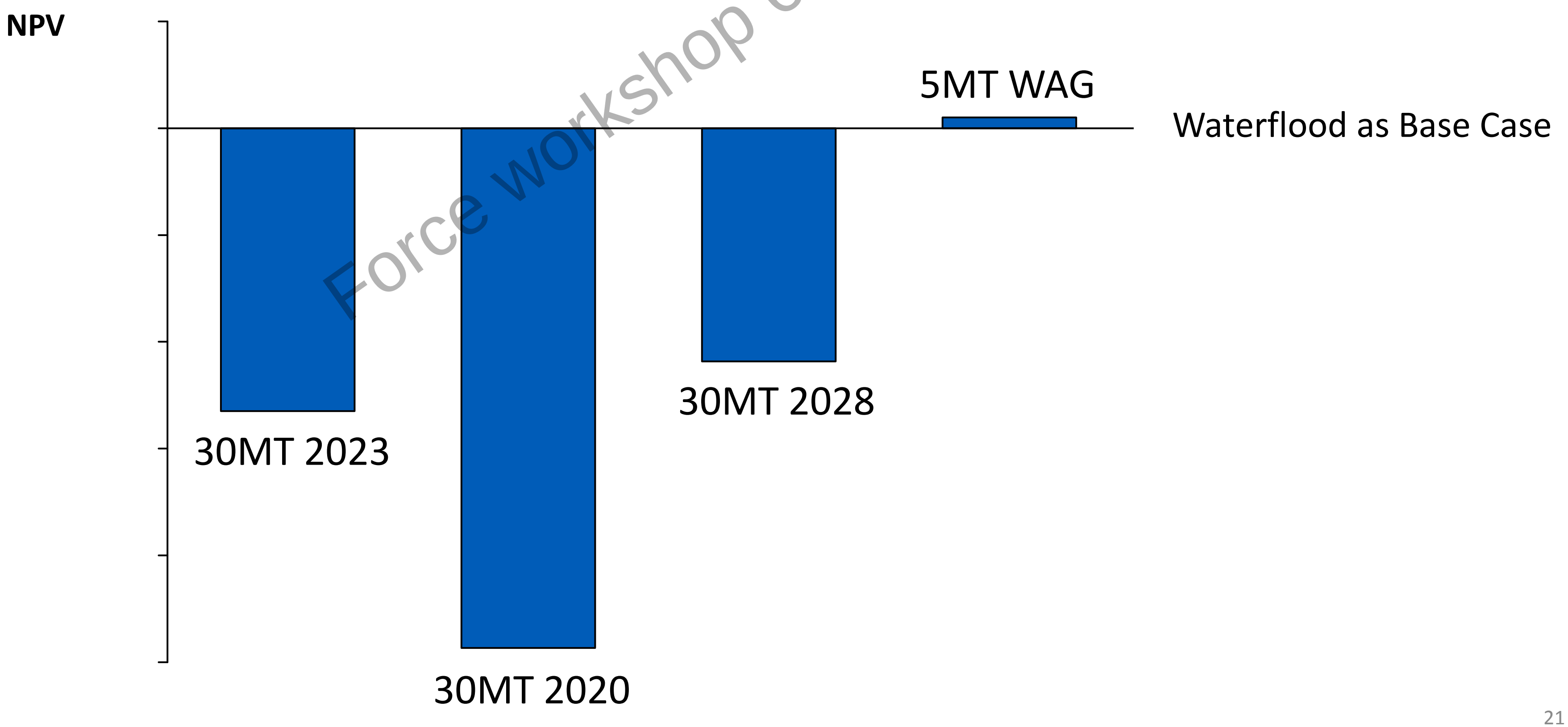
(3) Power plants are forced into CCS as above with no alternative storage available

EOR project gets free delivered CO2

Economical Screening of CO2 Scenarios

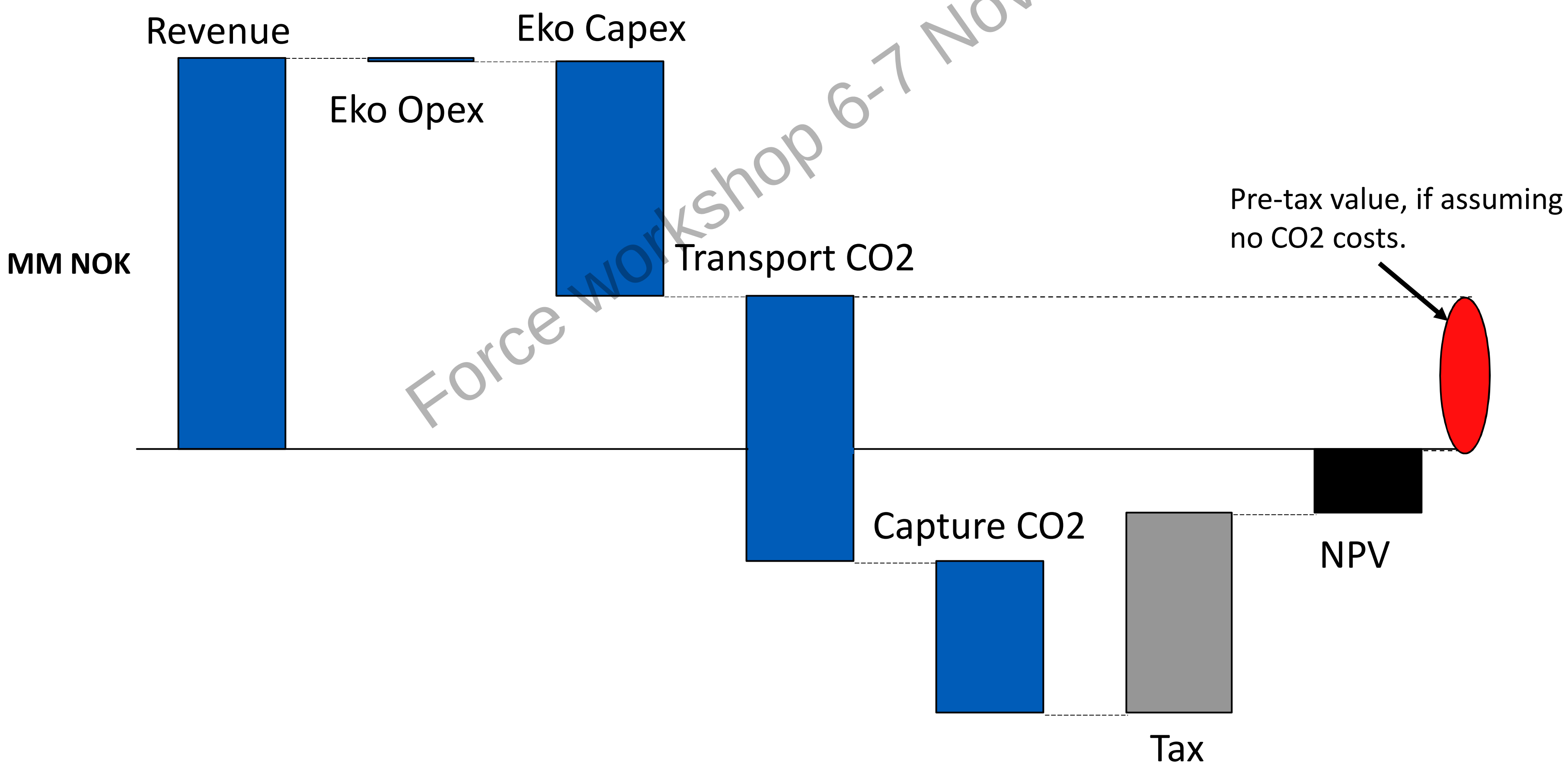
- High Upside Investments
- High Risk on Potential Recovery

Even with optimistic reservoir assumptions, screening economics are not very attractive.



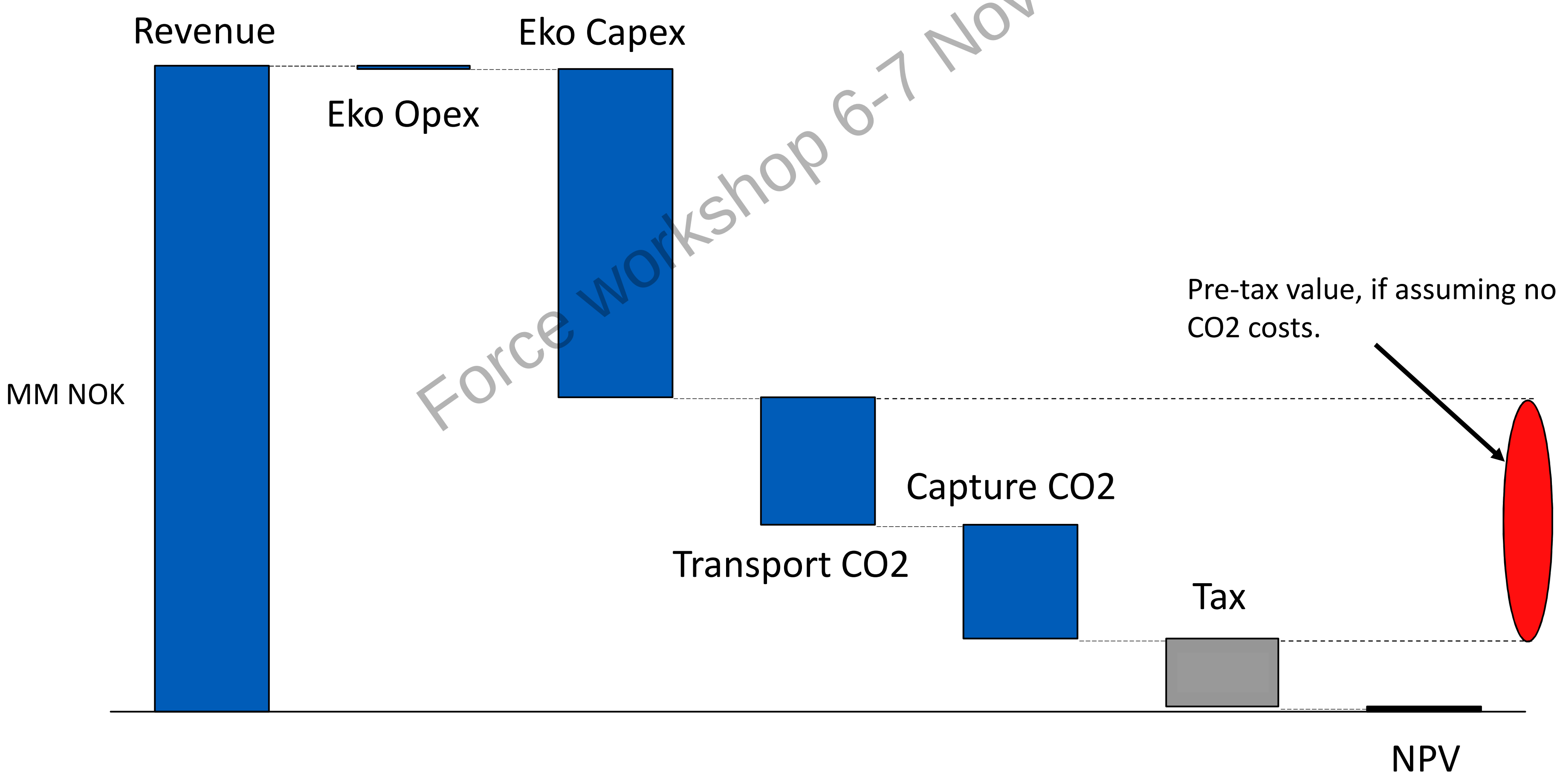
Difference in value 30MT case vs continued waterflood

The increased revenues over waterflood are not enough to pay for the CO2 costs in the 30MT case

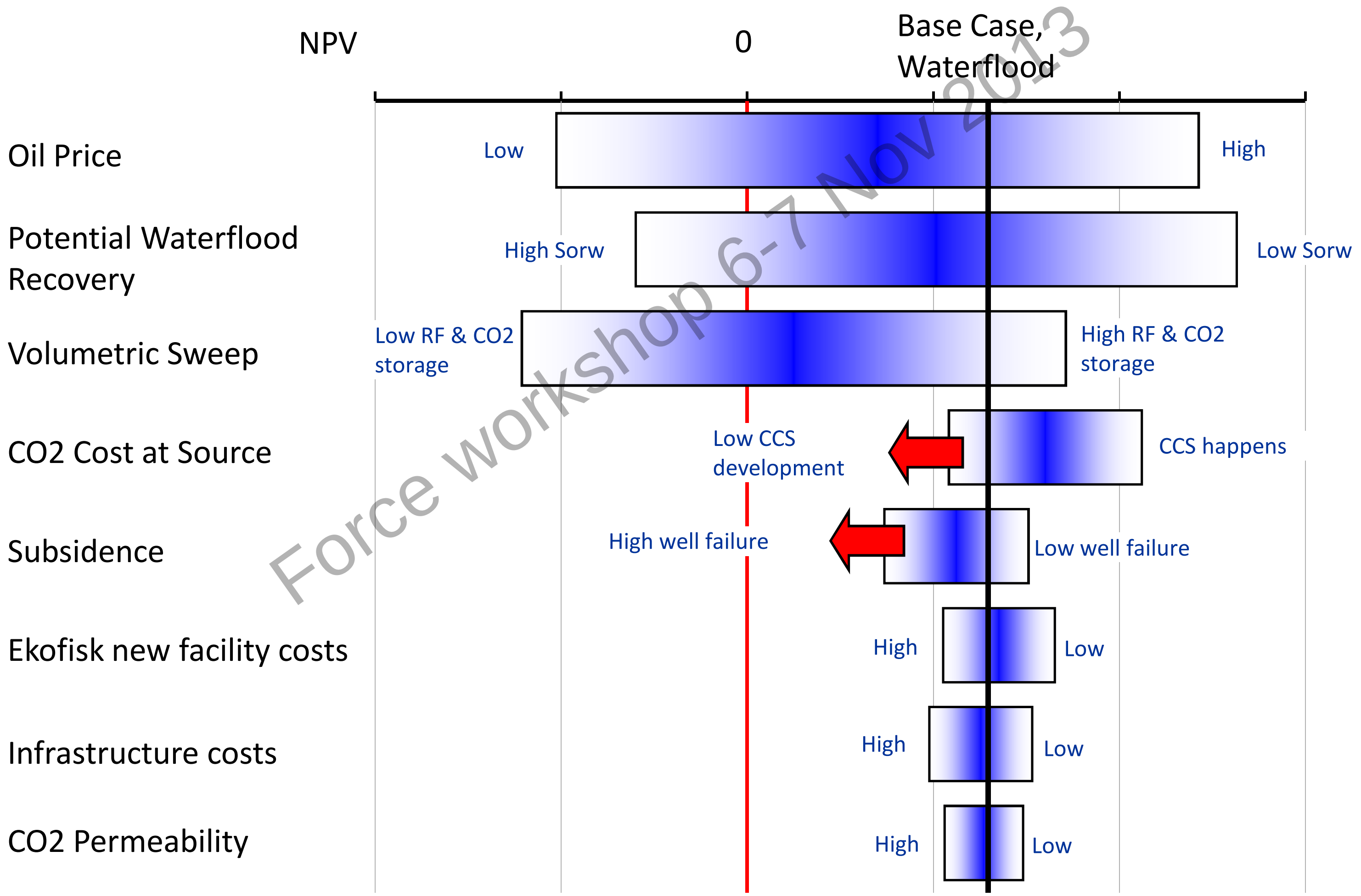


Difference in value 5MT case vs continued waterflood

Paying for the CO2 supply makes the 5MT case a marginal project under base assumptions



Difference in value 5MT case vs continued waterflood



Agenda

- **Ekofisk Information**
- **CO2 Mechanisms Subsurface**
- **CO2 Scenario Studies**
- **Summary**

Summary

- **In un-fractured chalk, CO_2 is a very effective EOR method**
- **Key challenges (potential show-stoppers) related to North Sea chalk fields**
  - Most of the chalk fields are naturally fractured reservoirs
  - Compaction/Subsidence
  - Injection temperature
  - Logistics
  - Regulatory, HSE and containment
  - High facility cost
  - A multi-well pilot will be required before a full field implementation

Summary

- **Economics**
  - Even with optimistic reservoir assumptions, screening economics are not very attractive
  - The cost of CO_2 can significantly affect the economics
  - The main economical uncertainties with base assumption of CO_2 cost are
    - Oil Price
    - The size of the EOR target
    - Volumetric sweep efficiency

Acknowledgements

Acknowledgement goes to the PL018 partnership for their support and permission to publish this presentation. This includes:

Total E&P Norge AS,
ENI Norge AS,
Statoil Petroleum AS,
Petoro AS.