CO2 for EOR in North Sea

"Fiscal Mechanisms Promoting CO2 for EOR in the North Sea"

by

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CO2 - Norway AS

Work developed in collaboration with the

CENS Project Management Team

Overview of Presentation

- Background:
  - The CO2-Capture Plant Engineering Study
  - Elsam as a Large Volume CO2-Supplier
  - The NO / UK - EOR Project Scenario
  - Description of the CENS Economic Model
- The Oil Field Operators Perspective:
  - Oil Price and IRR
  - Other Significant Factors (Tax, CO2-cost *et al*.)
  - EOR Risk Management
- The Role of Government as a Stakeholder / Underwriter:
  - Tax Income v's no project
  - Mechanisms for "Total" Project Risk Mitigation

Elsam CO2 Capture: Engineering Study

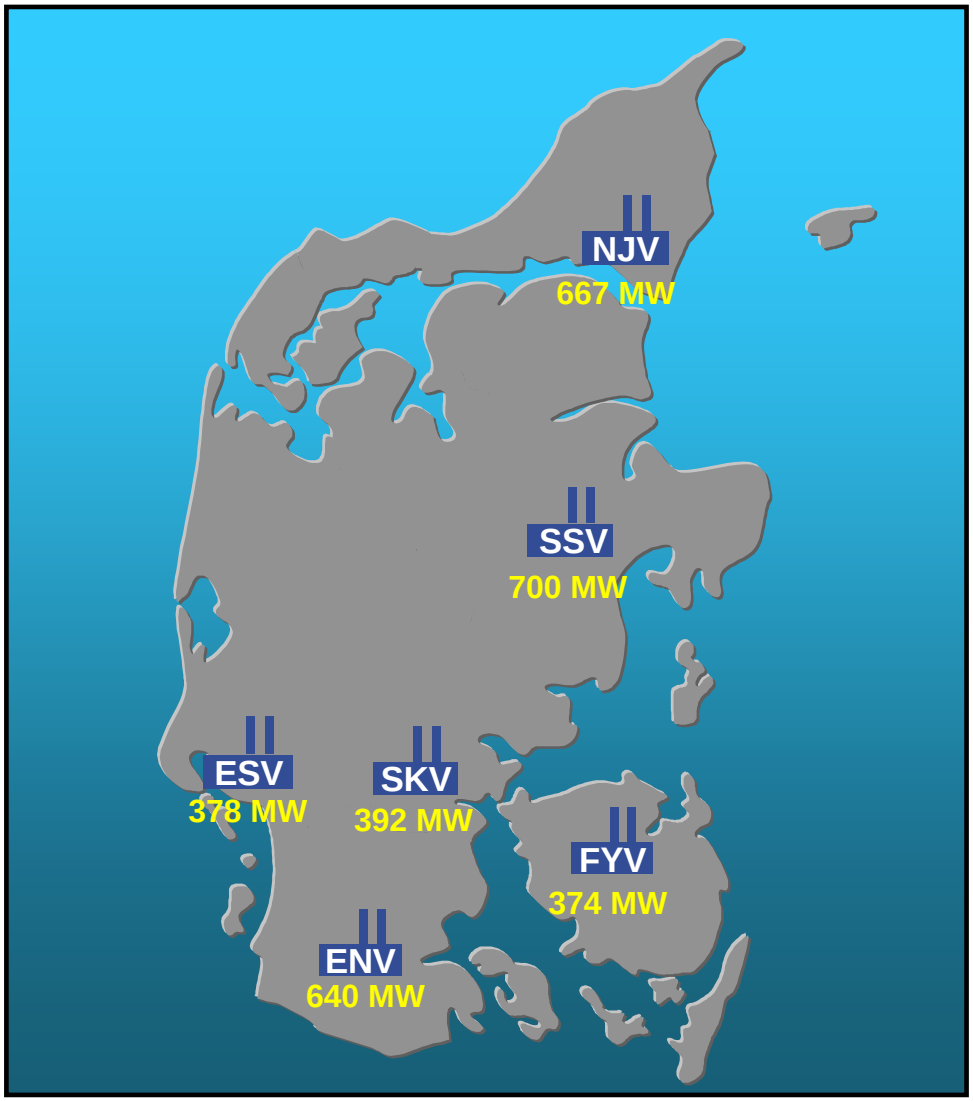
Main Objectives:

- Ensure availability of CO2 capture technology.
- Assess technology risk – scaling and cost estimation.
- Determine Capex + O&M Costs for capture plant.
- Identify area requirements and plant layout.
- Integration with Esbjerg Power Station Unit No.3

Esbjerg Plant ...with CO2-Capture

CO2 NORWAY

Elsam Coal & CHP for CO2 Capture



Combined Heat and Power Plants (central)

Total max. load	2,912 MW
Incl. overload	3,140 MW

+ district heating reserve 635 MW
(NVAB1 – SKVB1 – FYVB3)

Power Plant	Max. load
❑ - ENV	640 MW
❑ - ESV	378 MW
❑ - FYV	374 MW
❑ - NJV	667 MW
❑ - SKV	392 MW
❑ - SSV	700 MW

NB: ENV used to be 50% Preussen Elektra

Capture CO2 from Cheapest Source

Capturing 90% of the CO2 emitted from Elsam's coal-fired power plants is commercially competitive because:

- Ultra clean flue-gas with FGD and SCR are already installed.
- The flue-gas concentration is 12 - 14% CO2, which is three times the concentration for Natural Gas power plants.
- Steam at 290 bar / 580 °C minimises efficiency drop in conjunction with integration of amine capture technology.
- Integration with district heating also helps reduce loss in overall plant efficiency.
- Close proximity to North Sea CO2-Infrastructure.
- Potential production of between 10 - 15 million tonnes CO2 per year from 5 plants by 2012.

Change in Power Plant Efficiency

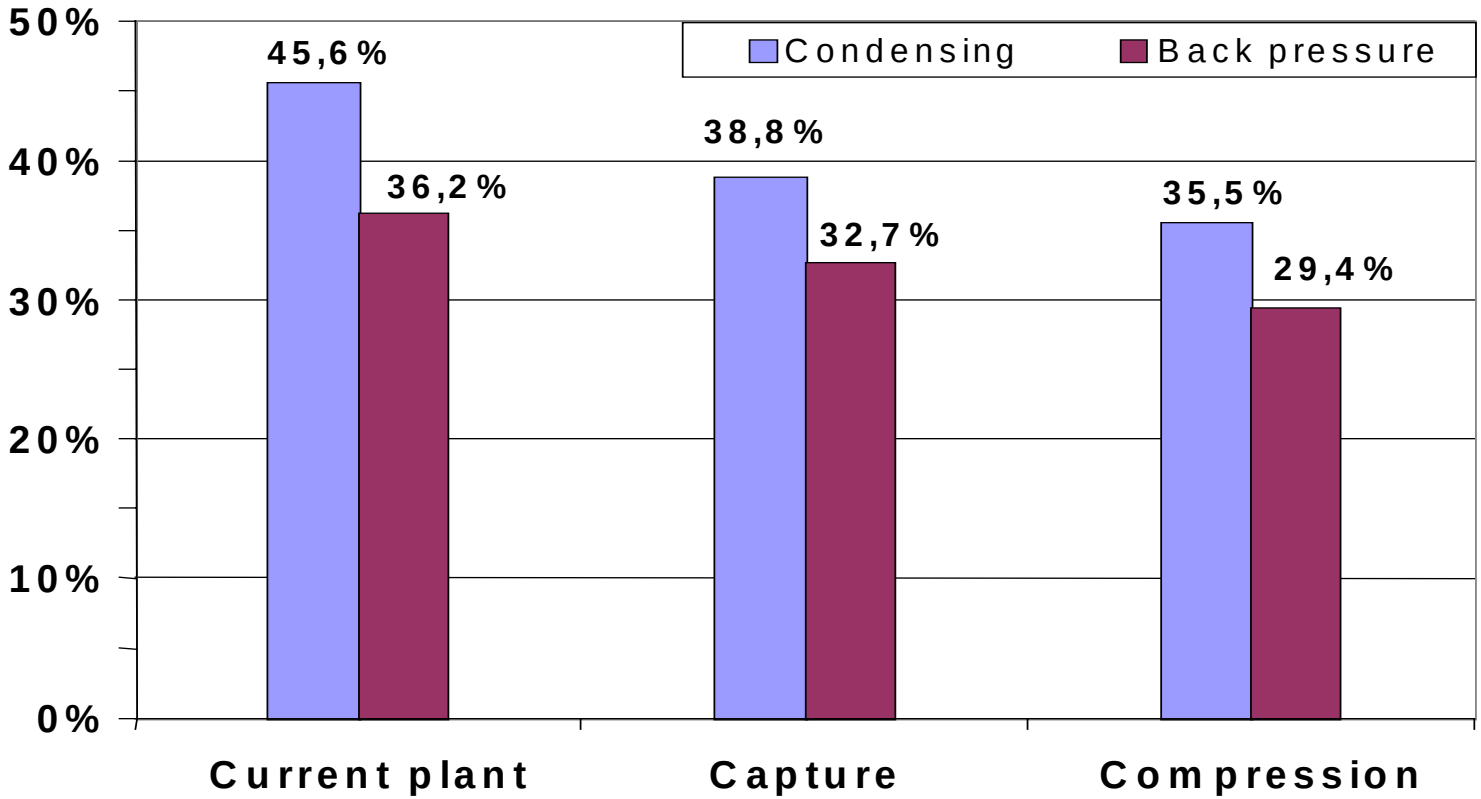
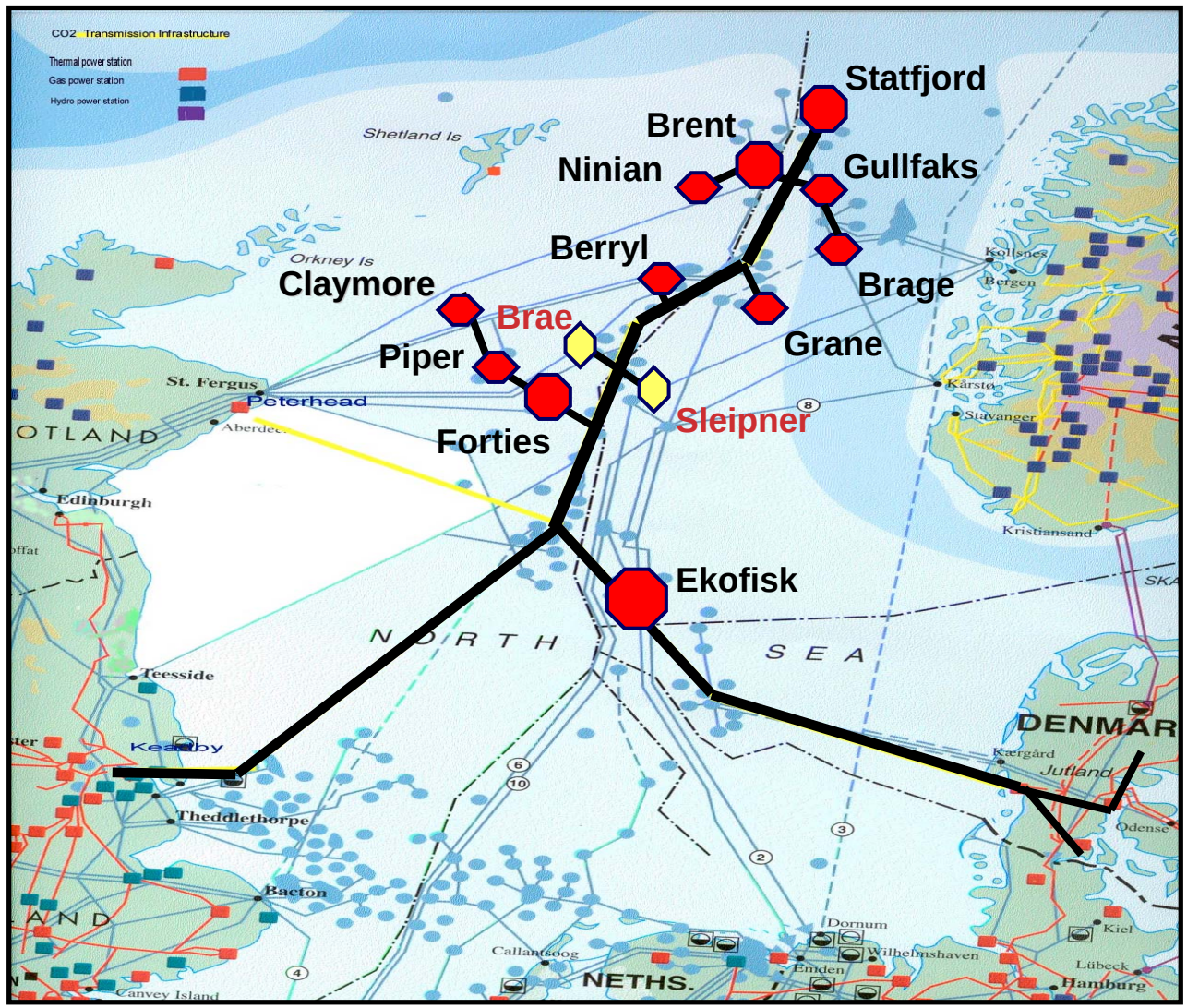


Fig. 0: *Summary of Electrical Efficiency The Esbjergværket ESV3 facility is one of the most efficient power plants in the world at 45.6% electrical efficiency in the Condensing mode. With CO2 capture and compression the electrical efficiency will be reduced by 10.1%-point to 35.5%. (Compression of CO2 to 140 bar requires ~27.5 MWe and is equivalent to 3.3%-point.) In Back pressure mode electrical efficiency is reduced by 6.8%-point to 29.4%, but with CO2 as additional by-product. This is analogous to a combined heat and power plant (CHP) that also produces less electricity but sells heat as a by-product of the generation process.*

The Offshore EOR Project Scenario

- **Potential delivery of CO2 for EOR through infrastructure at cost of ~ $35 /tCO2.**
- **Screening of the most mature EOR fields indicates potential of > 30 mtCO2/yr for +20 year period.**

† Designated fields are "potential" CO2-floods that might typically start-up during 2007 - 2013 time frame.



The CENS Economic Model (CEM)

- Assumed pipeline infrastructure supplying approx. 680 mtCO2 over 20 year period to six UK and five Norwegian fields.
- Used “Best Available” techno-economic data to evaluate overall project economics and total tax revenue for host governments.
- The CEM permits changes in all significant economic parameters.
- Project and sub-projects can be evaluated in terms of NPV and IRR.
- Total project economics can be related to a “Break-Even” oil price.
- Model permits analysis of different fiscal mechanisms that can be evaluated in order to manage project risk exposure on behalf of all project stakeholders.

Base Case Assumptions (NO / UK)

Oil Price ($/bbl)	$20
Special/PR Tax Rate %	50% / 50%
Corporate Tax Rate %	28% / 40%
Effective Tax Rate %	78% / 70%
Depreciation Term (years)	6 yr / 1 yr
Operating Cost ($/bbl)	$4.50 / $5.50
Decommissioning Costs	
– Large Fields	$450 million
– Small Fields	$150 million

Base Case Assumptions (NO / UK)

Field Capital Costs ($/incr bbl)	$2.25
Financed Debt (where applicable)	40%
Incremental Operating Cost ($/bbl)	$2.00
Incremental Pump Costs ($/t CO2)	$0.10
Incremental Production bbls/t CO2	3.2
Recovery Factor (% of OOIP)	6%
CO2 Delivered Price ($/tonne)	$35
CO2 Support Price ($/tonne)	$23
CO2 Purchased Price ($/tonne)	$12

The Basic NO / UK - EOR Project

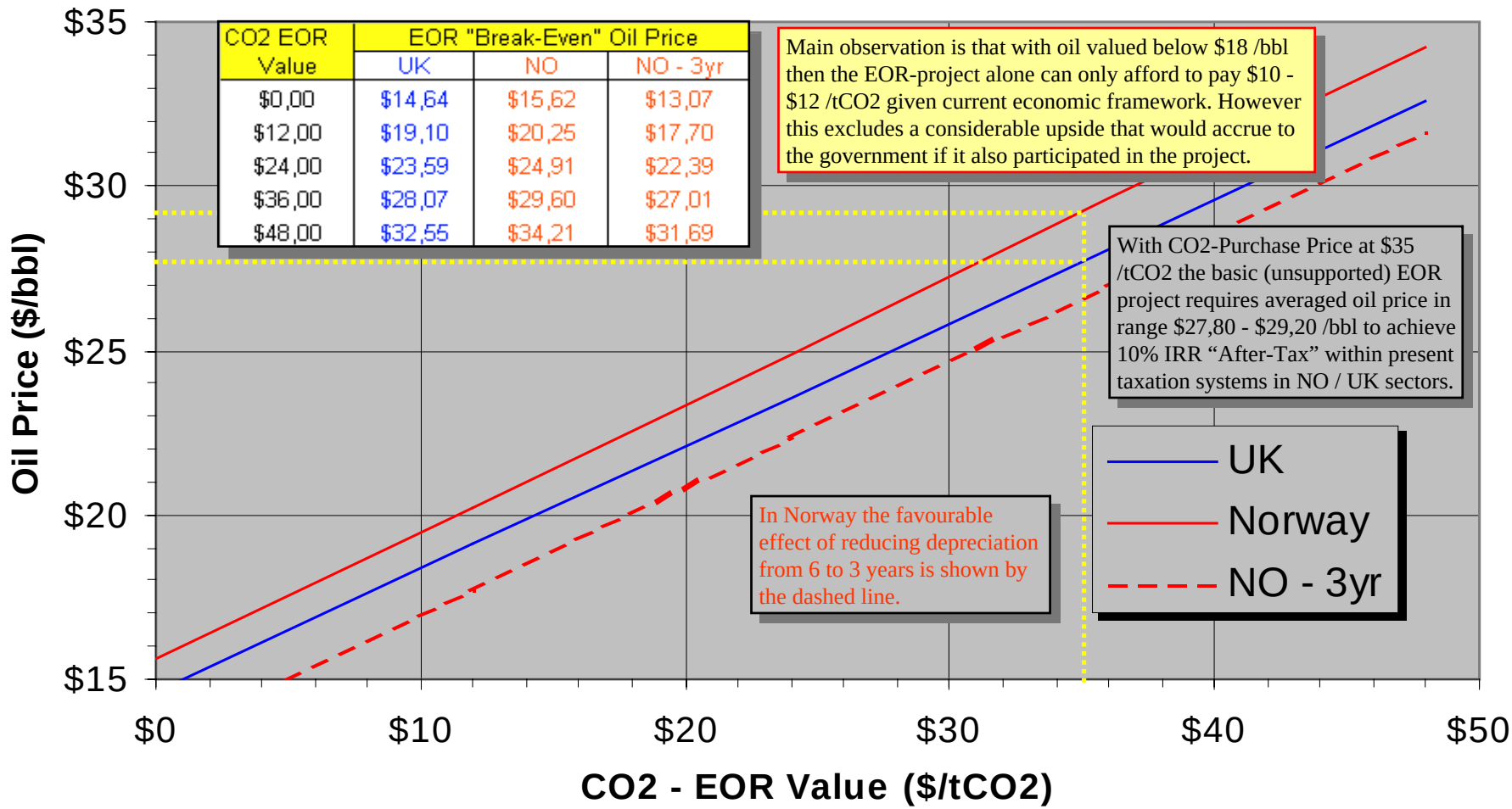
Oil Price v's CO2 - EOR Value (@ 10% IRR)

CO2 EOR Value	EOR "Break-Even" Oil Price		
	UK	NO	NO - 3yr
$0,00	$14,64	$15,62	$13,07
$12,00	$19,10	$20,25	$17,70
$24,00	$23,59	$24,91	$22,39
$36,00	$28,07	$29,60	$27,01
$48,00	$32,55	$34,21	$31,69

Main observation is that with oil valued below $18 /bbl then the EOR-project alone can only afford to pay $10 - $12 /tCO2 given current economic framework. However this excludes a considerable upside that would accrue to the government if it also participated in the project.

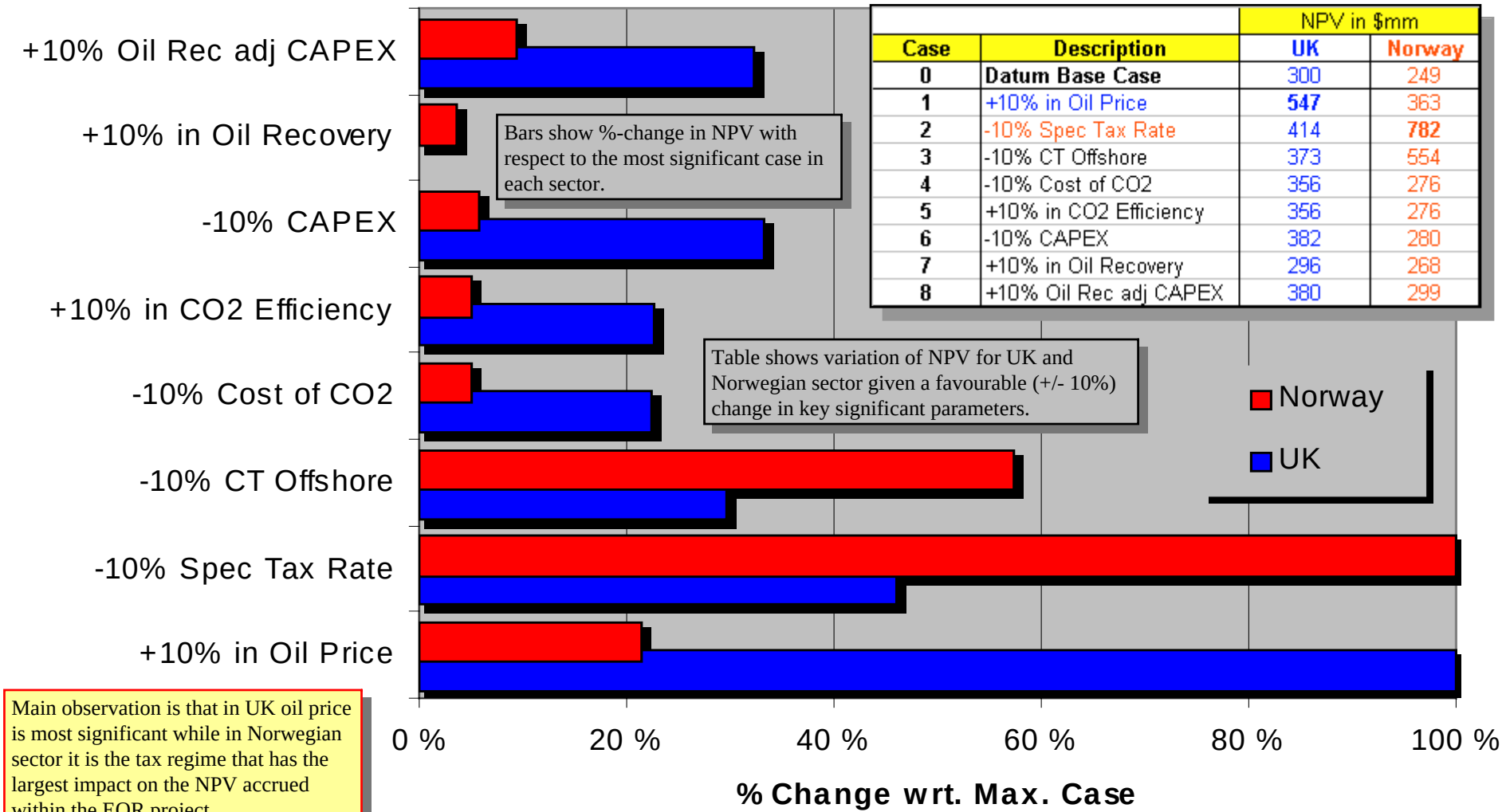
With CO2-Purchase Price at $35 /tCO2 the basic (unsupported) EOR project requires averaged oil price in range $27,80 - $29,20 /bbl to achieve 10% IRR “After-Tax” within present taxation systems in NO / UK sectors.

In Norway the favourable effect of reducing depreciation from 6 to 3 years is shown by the dashed line.



The NO / UK - EOR Project

Relative Significance with respect to Max. Case in Each Sector

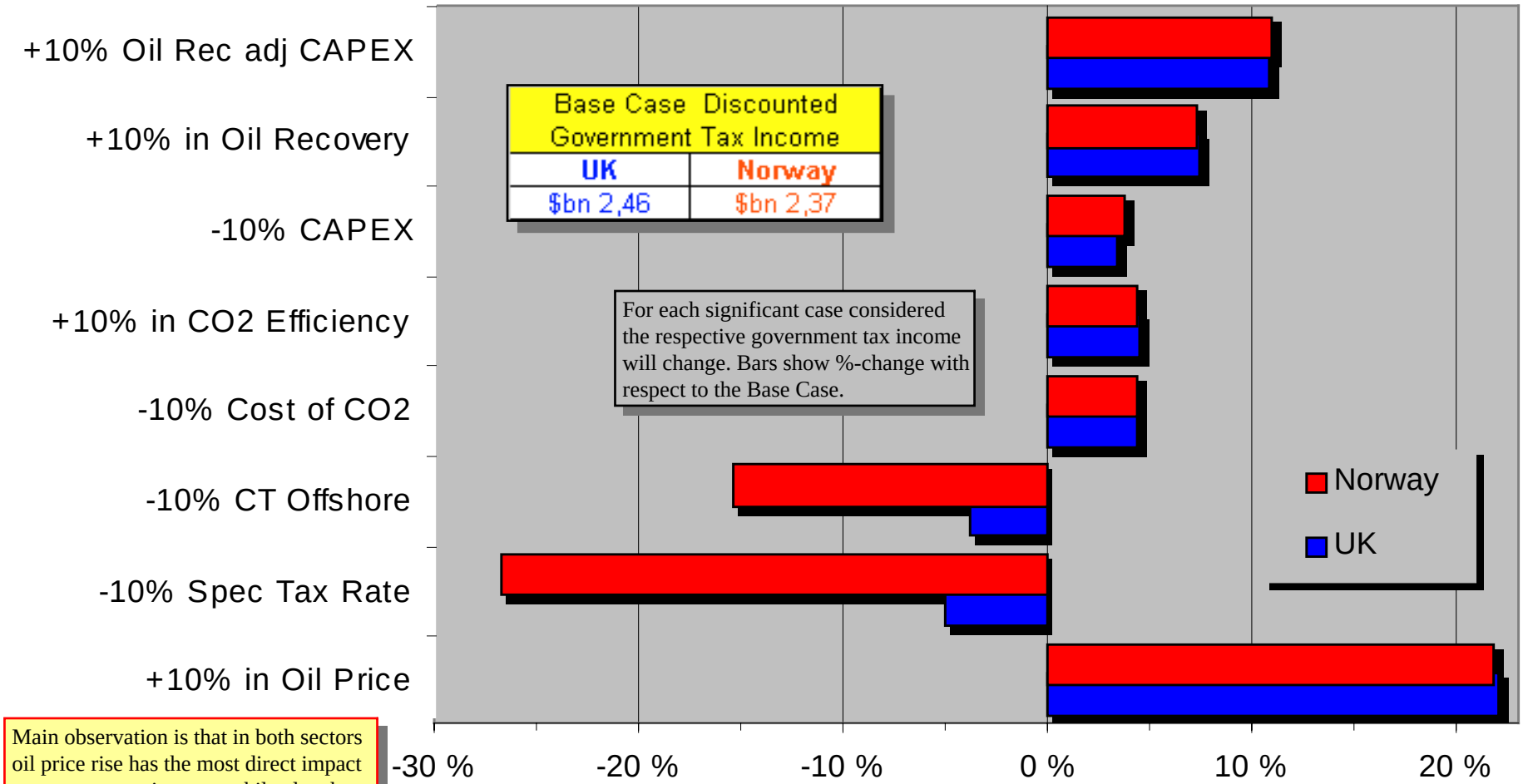


		NPV in $mm	
Case	Description	UK	Norway
0	Datum Base Case	300	249
1	+10% in Oil Price	**547**	363
2	-10% Spec Tax Rate	414	**782**
3	-10% CT Offshore	373	554
4	-10% Cost of CO2	356	276
5	+10% in CO2 Efficiency	356	276
6	-10% CAPEX	382	280
7	+10% in Oil Recovery	296	268
8	+10% Oil Rec adj CAPEX	380	299

Main observation is that in UK oil price is most significant while in Norwegian sector it is the tax regime that has the largest impact on the NPV accrued within the EOR project.

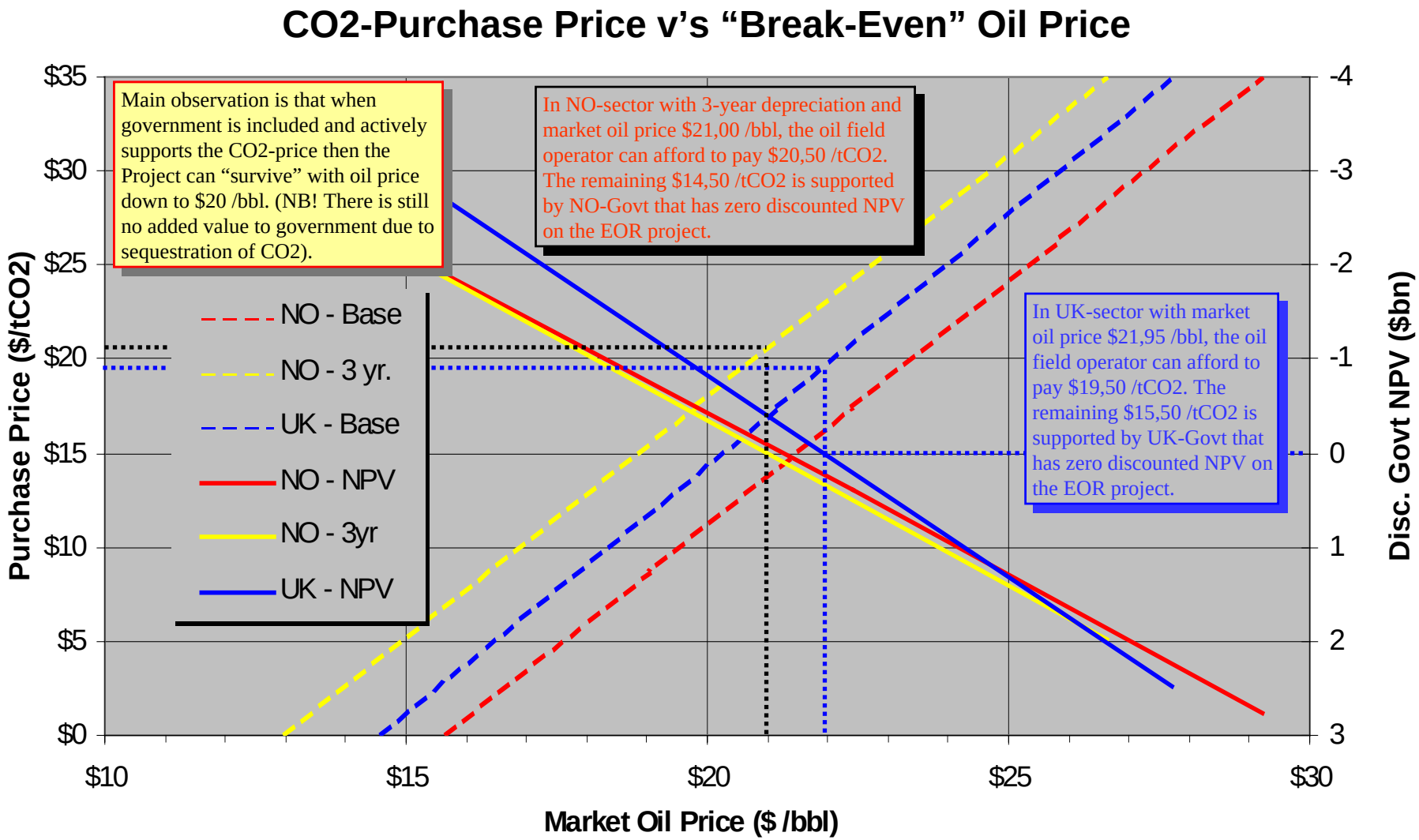
The NO / UK - EOR Project

Change in Govt. Tax Income with respect to the Base Case



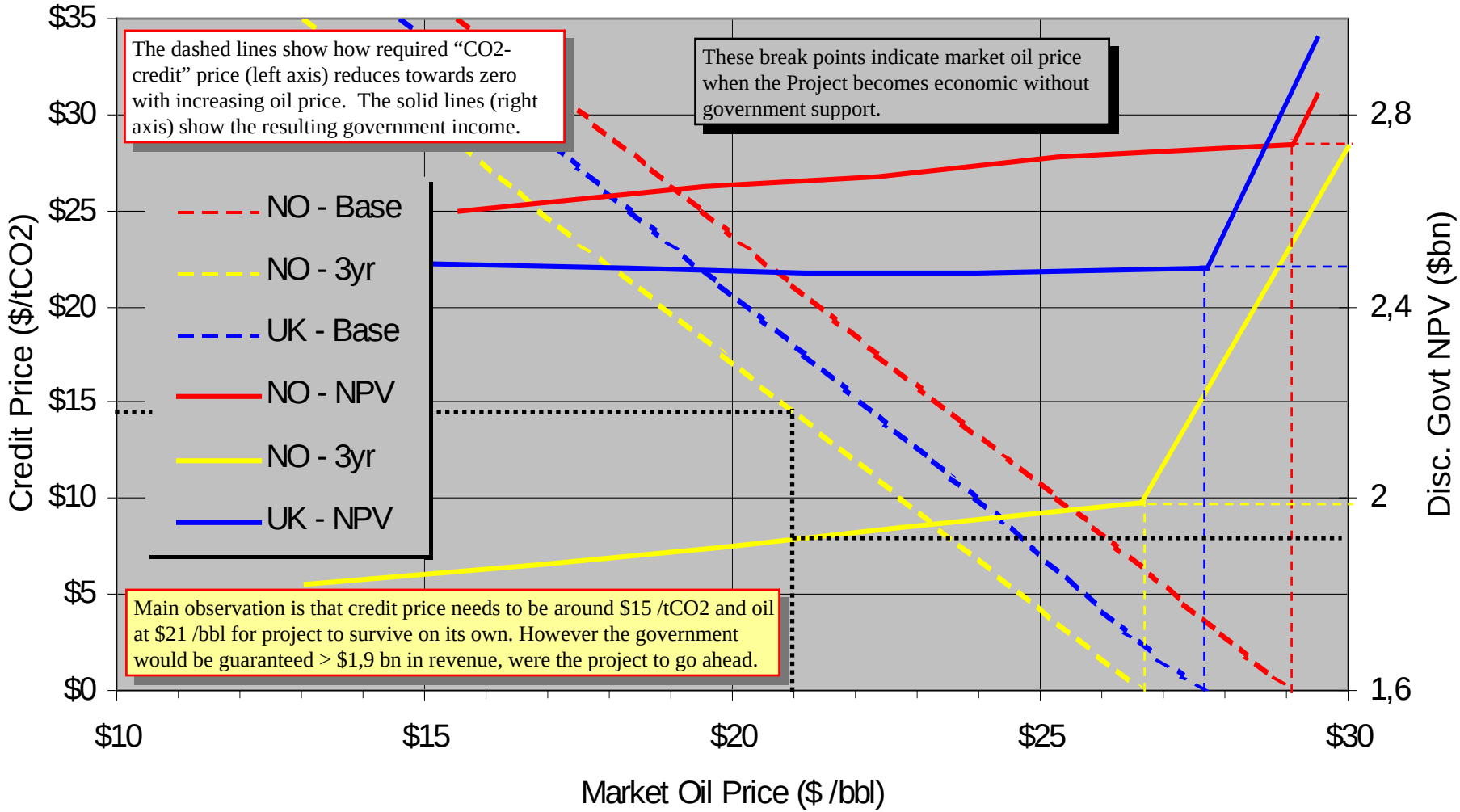
Main observation is that in both sectors oil price rise has the most direct impact on government income, while also the Norwegian government is most exposed to reduction in the offshore tax regime.

The NO / UK - EOR Project



The NO / UK - EOR Project

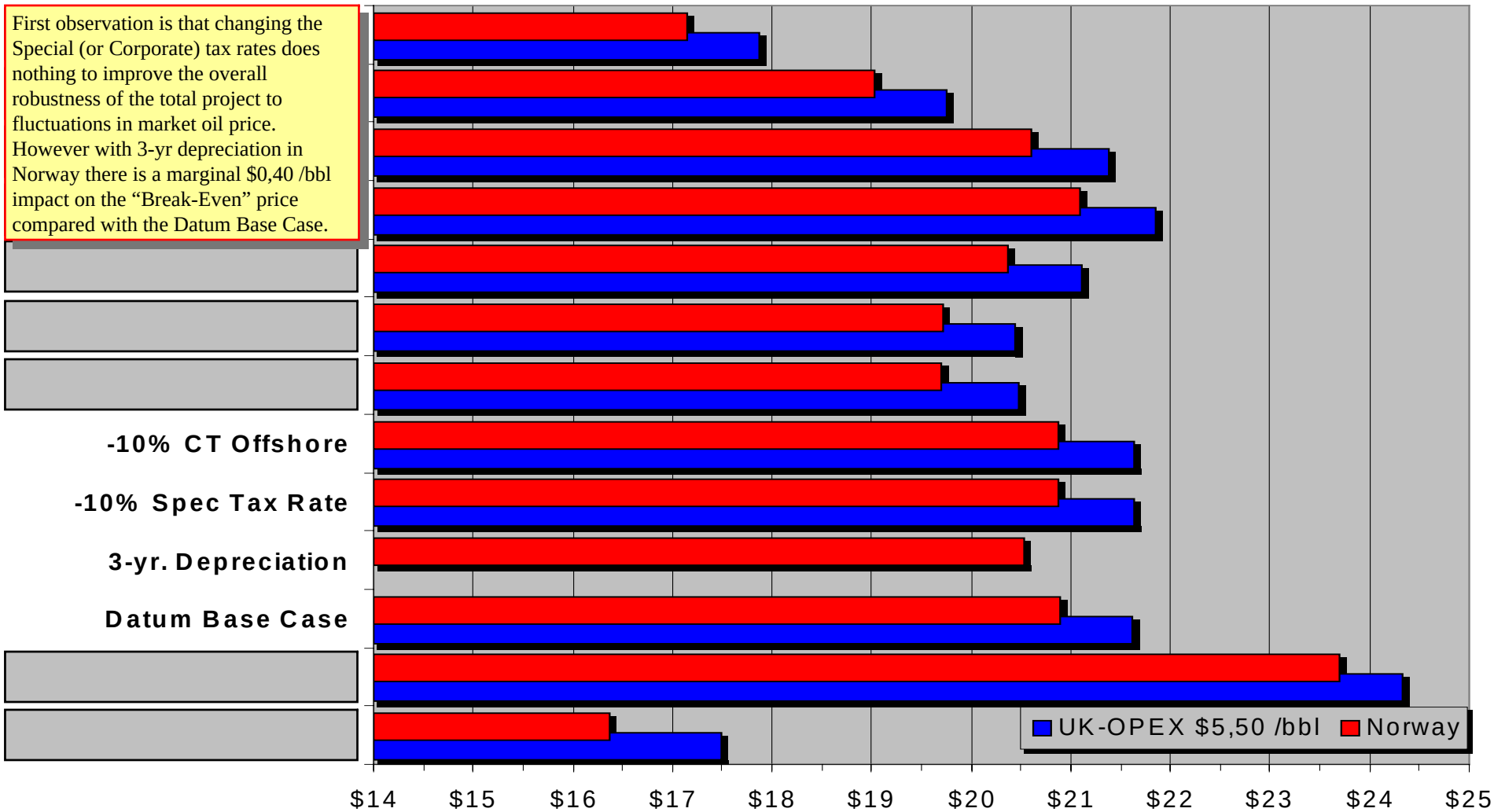
CO2-Credit Price v's "Break-Even" Oil Price



Government As Project Stakeholder

Comparison of several different scenarios.

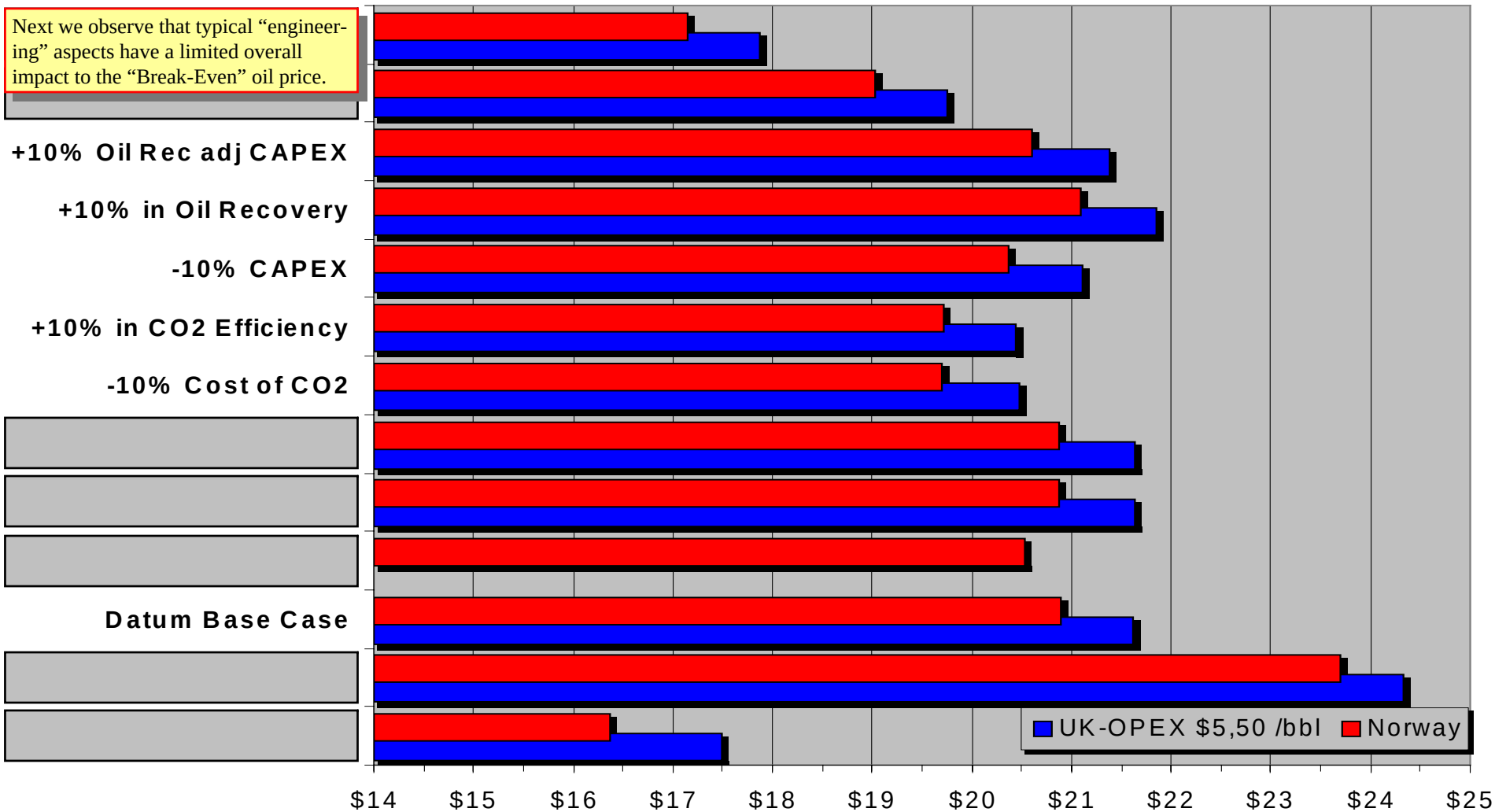
First observation is that changing the Special (or Corporate) tax rates does nothing to improve the overall robustness of the total project to fluctuations in market oil price. However with 3-yr depreciation in Norway there is a marginal $0,40 /bbl impact on the "Break-Even" price compared with the Datum Base Case.



Click <CR> to move through various alternative scenarios.

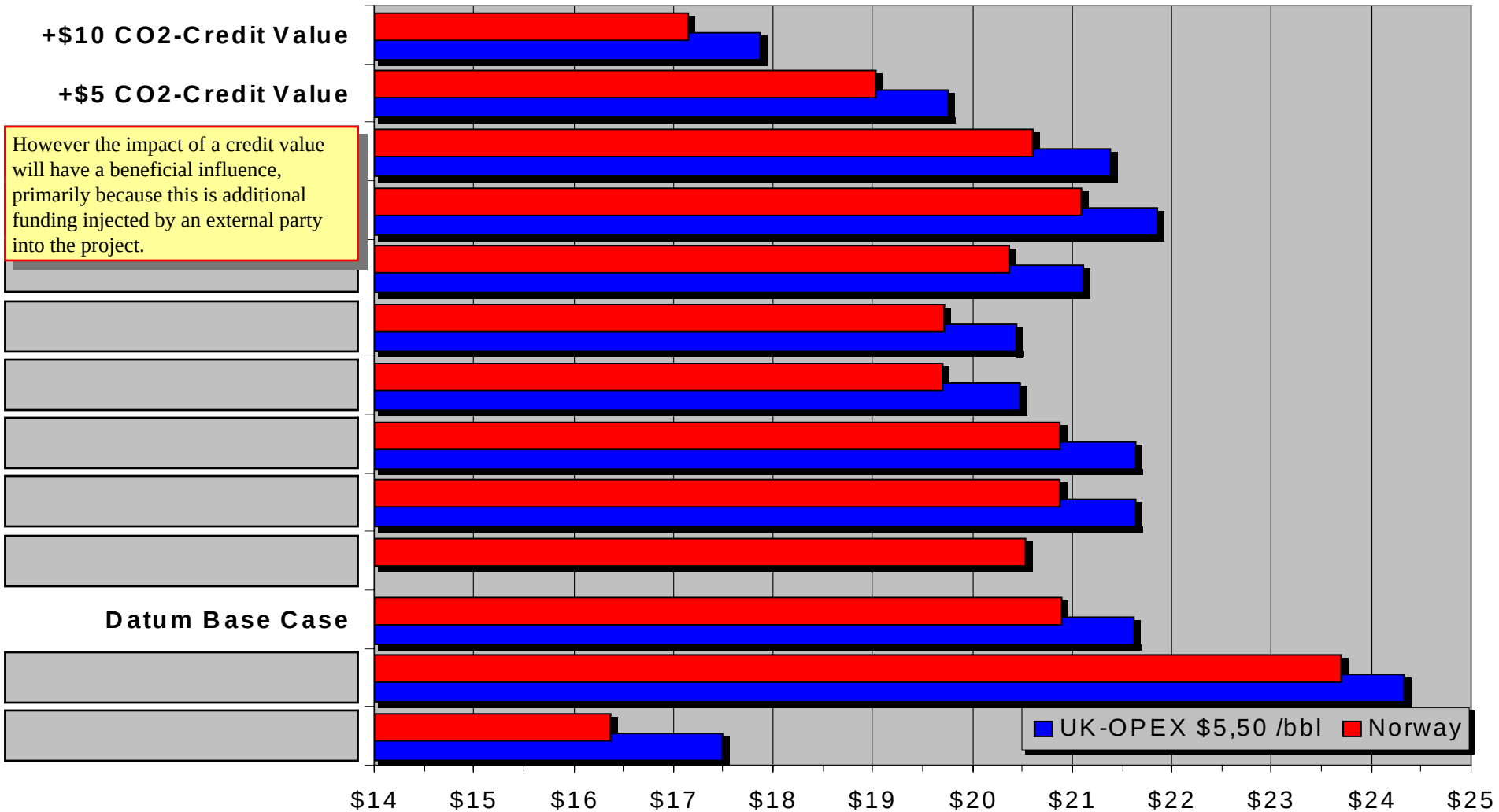
Limited Risk wrt. Engineering

Next we observe that typical “engineering” aspects have a limited overall impact to the “Break-Even” oil price.



Click <CR> to move through various alternative scenarios.

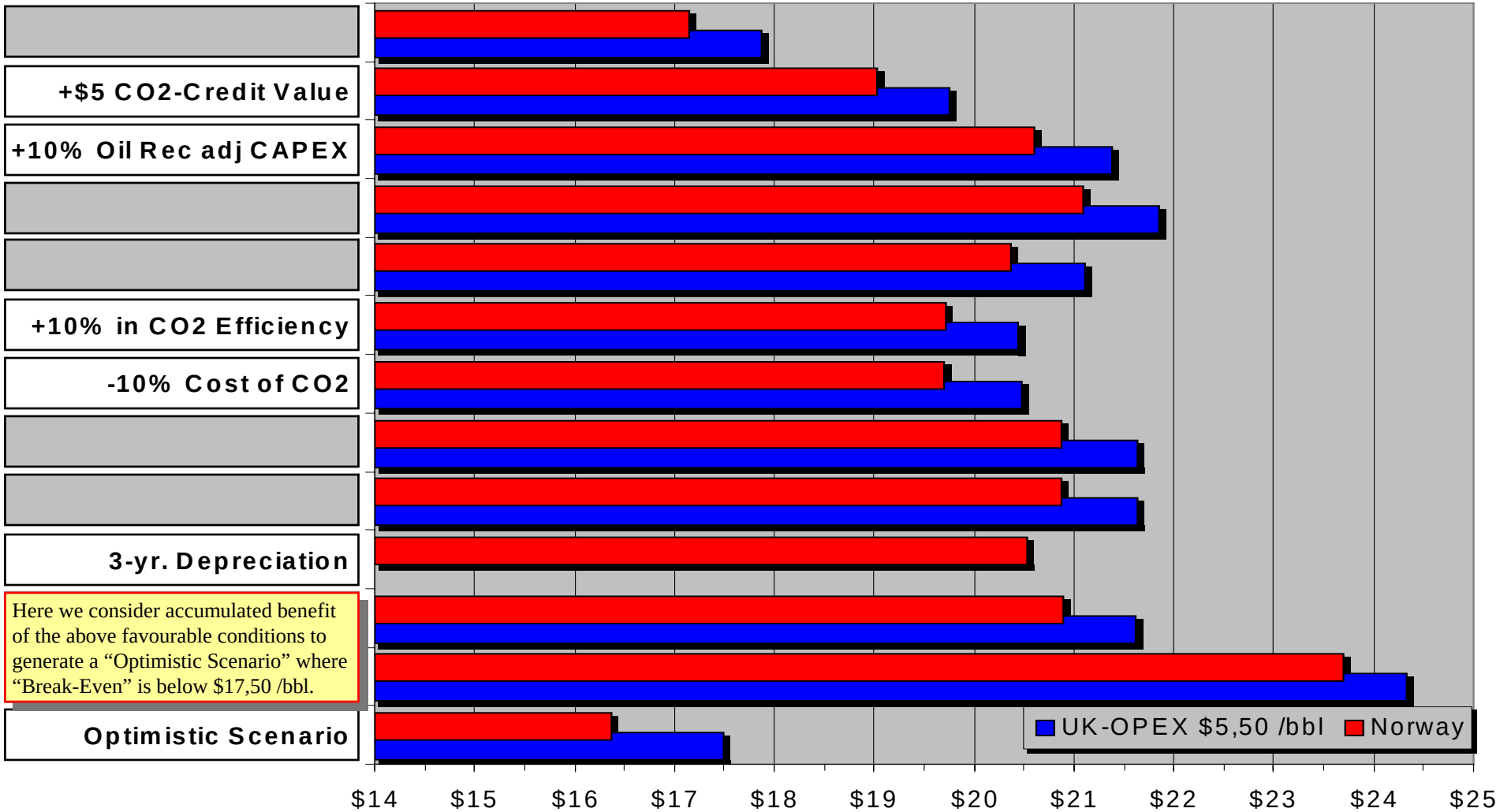
A Significant Impact of Credit Value



However the impact of a credit value will have a beneficial influence, primarily because this is additional funding injected by an external party into the project.

Click <CR> to move through various alternative scenarios.

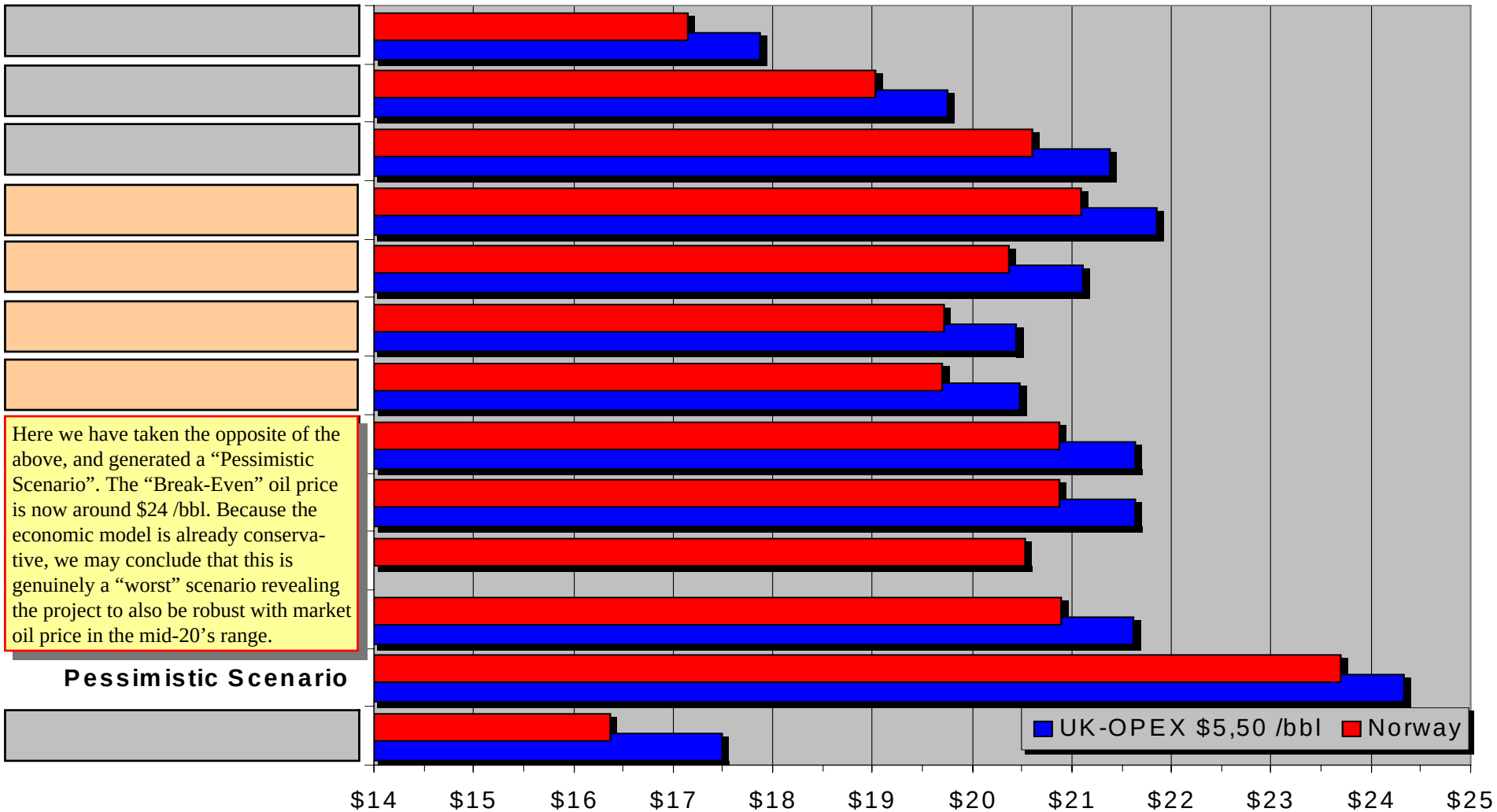
The Optimistic Scenario



Here we consider accumulated benefit of the above favourable conditions to generate a "Optimistic Scenario" where "Break-Even" is below $17,50 /bbl.

Click <CR> to move through various alternative scenarios.

A Worst Case Pessimistic Scenario

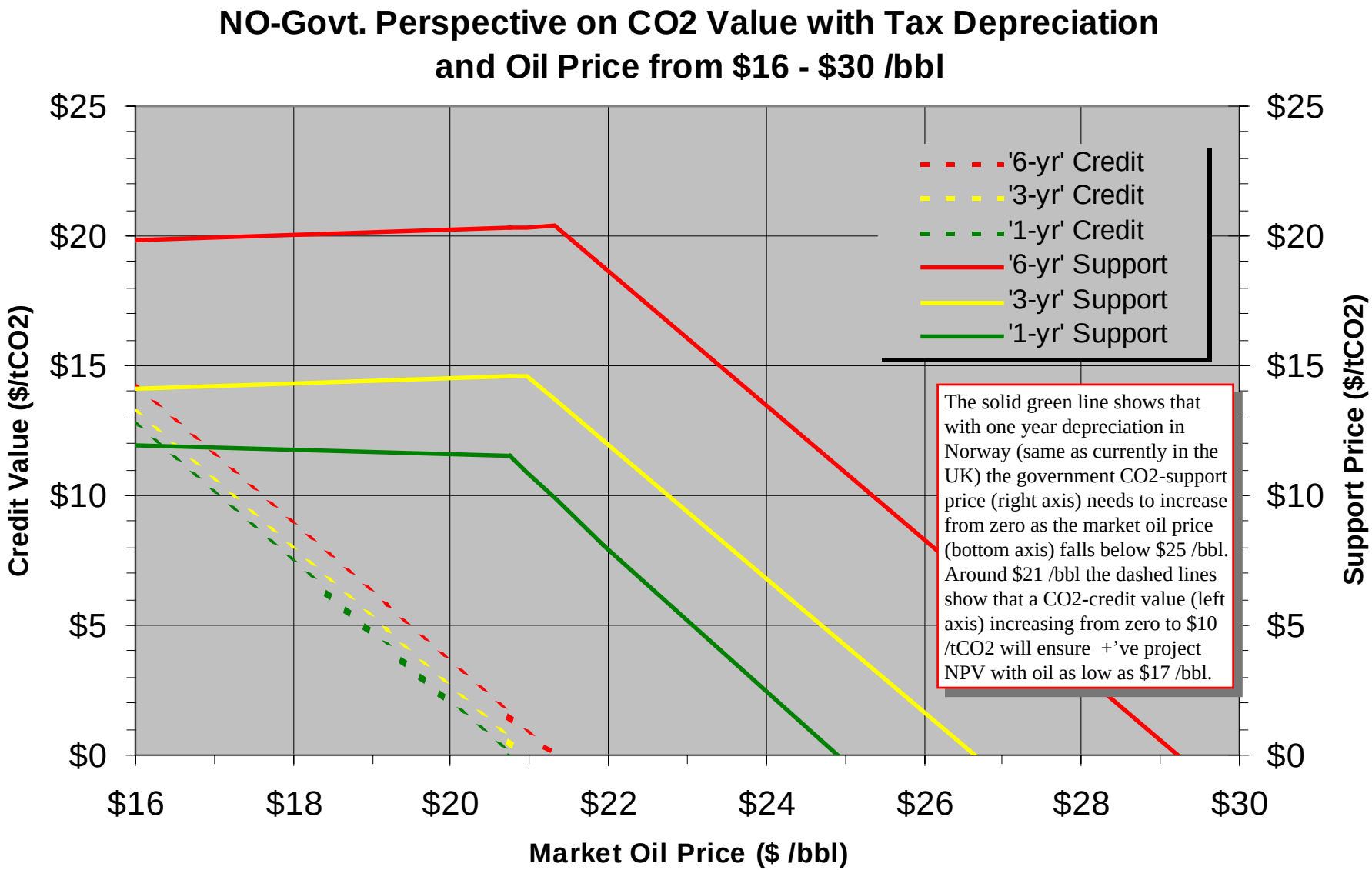


Here we have taken the opposite of the above, and generated a “Pessimistic Scenario”. The “Break-Even” oil price is now around $24 /bbl. Because the economic model is already conservative, we may conclude that this is genuinely a “worst” scenario revealing the project to also be robust with market oil price in the mid-20’s range.

Pessimistic Scenario

Click <CR> to move through various alternative scenarios.

The Govt. Exposure to Risk



The Way Forward (1) ....

- Need to work together -- Sources, E&P's and respective Governments:
  - CO2 into the North Sea is economic … if done correct!!
  - All Stakeholders should collaborate to develop the best solution
  - Governments need to co-ordinate bi-lateral agreements for valuation and handling CO2 between different countries (eg. Norway vis à vis UK, Denmark and EU)
  - Need to reduce commercial risk associated with being "early mover"
  - Need to de-couple project investment risk from shorter-term fluctuations in the market price of oil

The Way Forward (2) ....

- To enable commercial development of CO2-EOR fields will require one or more of the following:
  - Accelerated depreciation of CAPEX investment
  - Incentives through adjusting fiscal treatment of incremental oil and gas from CO2-EOR fields (eg. proposed ‘volume allowance’)
  - A supported “CO2-credit” price or “CO2-purchase” cost
  - A government “valuation” on sequestered CO2 with respect to GHG emissions and alternative climate mitigation options (eg. offset injected CO2 against current CO2-tax)
  - Mechanisms for transferring risk associated with CO2 sequestration and future leakage (if any) back to governments