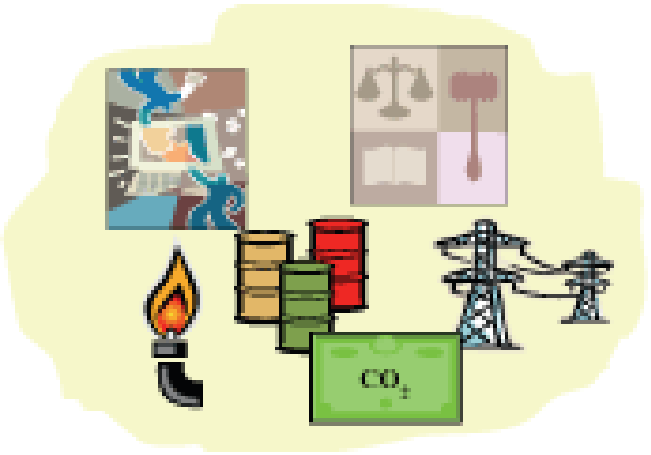
Envisaging CCS in Europe by 2040

Scenario development for ECCO European value chain for CO_2



Amy Brunsvold
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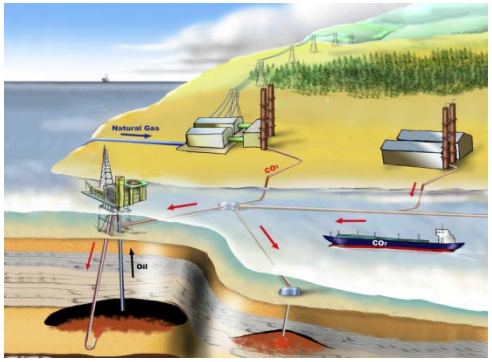
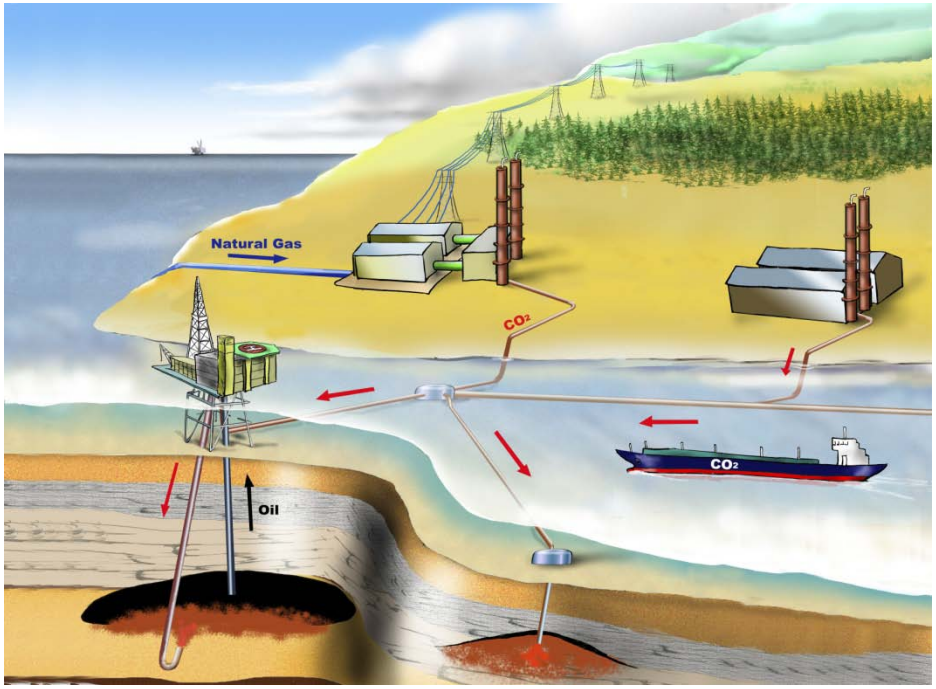


Trondheim 14.June 2011

Presentation outline

- Scenario development
  - Role of scenarios
  - Methodology
  - About the process
- Initial results

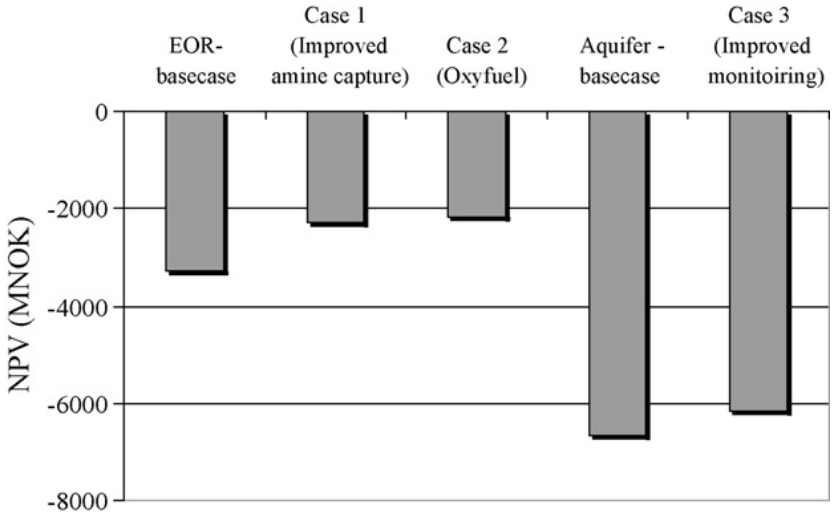


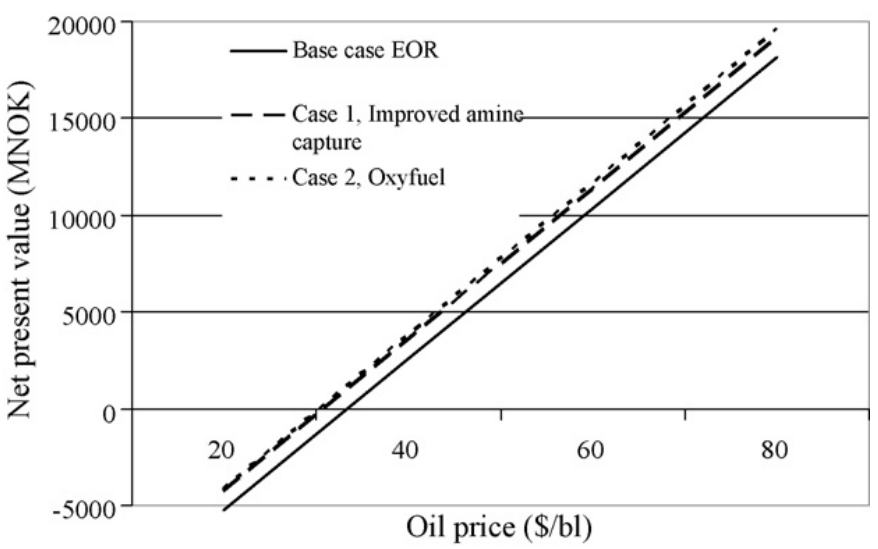
ECCO methodology
Three key features

- **Scenario analysis**
  - provide framework describing the non-quantifiable factors to define the environment of the chains
- **Case studies**
  - provide insight on the key issues related to CCS chain realization
- **Techno-economical tool**
  - provide tool for evaluation of the potential of various CCS chain options

Are Scenarios Really That Important?

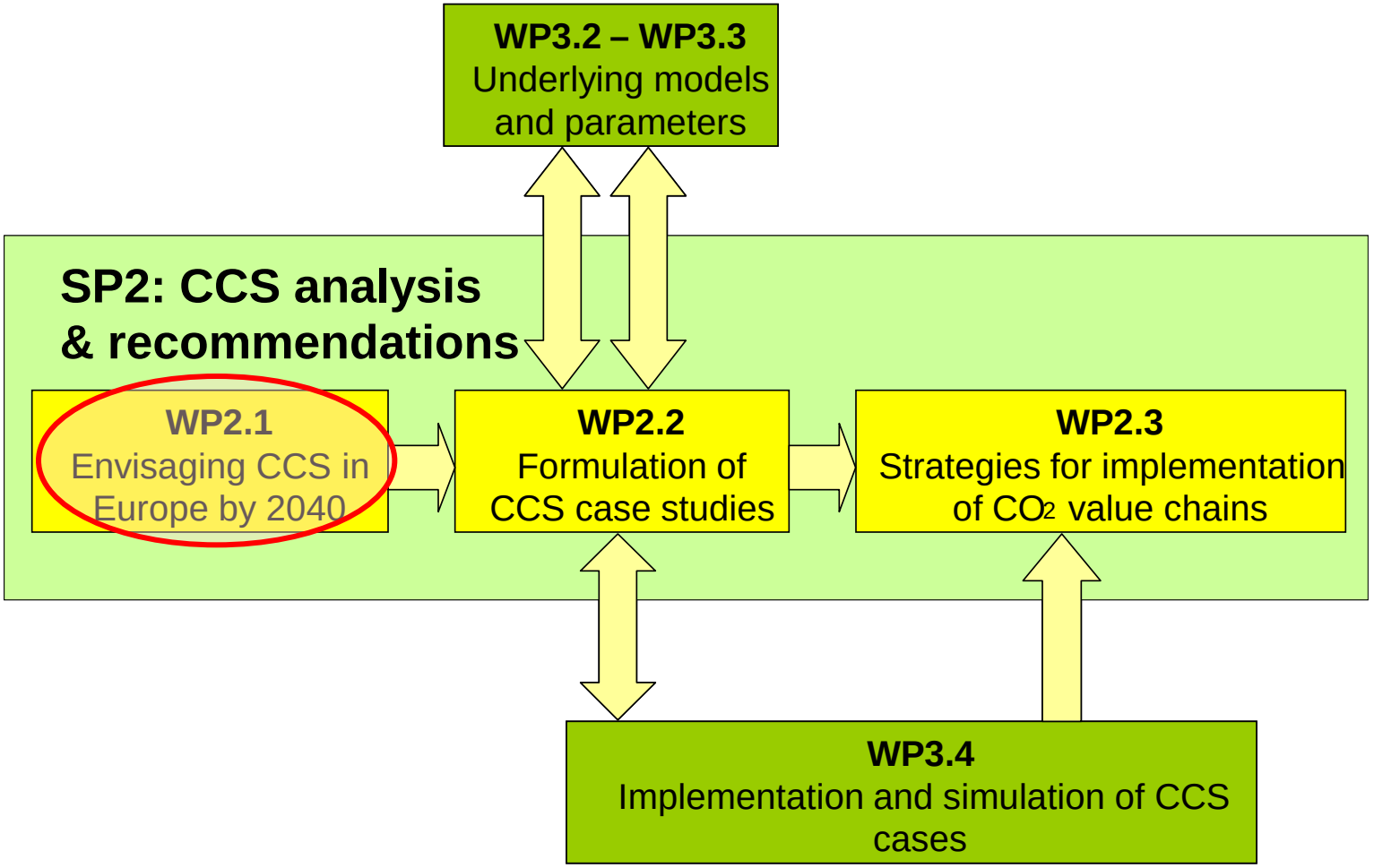
- Example: Case Study
  - EOR – basecase: 5 Mtonne CO_2/year capture by amine-based post-combustion technology
  - Case 1: Breakthrough in solvent, energy costs reduced by 45%
  - Case 2: Oxyfuel technologies, capture costs reduced by 20%, capture rate increases to 95%





”Methodology for CO_2 Chain Analysis” J.P. Jakobsen *et. al*. IJGCC2 (2008)

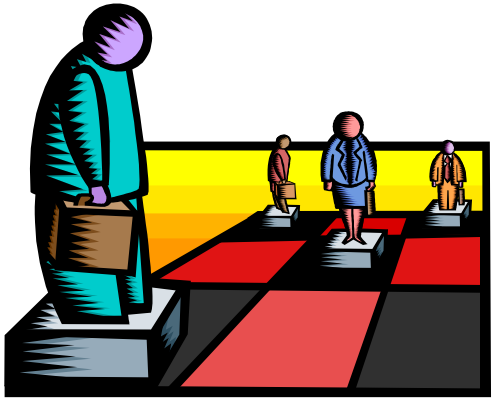
ECCO SP2: CCS analysis & recommendations Structure & Interactions with other SP's



ECCO WP2.1
Envisaging CCS in Europe by 2040

- Scenarios in ECCO should define the environment for the case studies.
- They should describe the alternative future in terms of political environment, public opinion, regulatory framework, technology and infrastructure development, and global economic situation.
- The scenarios should identify bottlenecks and help the industry and the authorities to develop strategies on how to overcome these.

Scenario development Methodology



- **Strategic planning method**
  - Different than forecasting and technology assessment
  - Handles ”soft” data and is based on intuition rather than rigorous analysis

- **Used to identify possible alternative futures**
  - combines known facts about future with plausible alternative trends in driving factors
  - recognizes that many factors may combine in complex ways to create surprising futures
  - reveals groups of facts and relationships that are important

Scenario development Process outline

1. Decide on the key question to be answered by the analysis
2. Decide actors, factors, and drivers for change (next slide)
3. Bring drivers together – framework

Workshop 1&2

ECCO European value chain for CO2
CO-FUNDED BY THE EUROPEAN UNION
SEVENTH FRAMEWORK PROGRAMME

Actors and Factors from Workshop 2

Actors	*Factors*
1. European POLITICIANS AND GOVERNMENTS 2. FINANCIAL ACTORS 3. SOCIETY AND THE PUBLIC/MEDIA 4. TECHNOLOGY DEVELOPERS/-OWNERS 5. ENERGY COMPANIES 6. INTEREST GROUPS&POLITICAL ORGANISATIONS 7. RESEARCH- AND HIGHER EDUCATION INSTITUTIONS 8. INDUSTRIAL ACTORS 9. OTHER COUNTRIES AND WORLD REGIONS	1. NATIONAL POLITICS 2. INTERNATIONAL POLITICS/GLOBALISATION 3. REGULATIONS 4. PUBLIC ACCEPTANCE 5. TECHNOLOGY DEVELOPMENT 6. LOGISTICS & INFRASTRUCTURE 7. ECONOMICS 8. CULTURE&RELIGION

Scenario development
Process outline

1. Decide on the key question to be answered by the analysis
2. Decide actors, factors, and drivers for change (next slide)
3. Bring drivers together – framework

Workshop 1&2

4. Produce initial mini-scenarios (~ 70 short, compact descriptions that focus primarily on one actor or one factor)
5. Reduce to main drivers
6. Draft the scenarios

Workshop 3

Example of Mini-Scenario Actor – Technology Developers

- ***Compliance***

  Technology has been sufficiently developed. There is a general understanding that research is important and ample funding is made available. Large infrastructure has been completed and has been put into operation. In 2040, commercial CCS is a reality in all developed countries. The concentration of CO2 in the atmosphere is now stabilized at the 2015 level.

- ***Competition Loss***

  Technology has not been sufficiently developed because of competition. Technological developments in other sectors (renewables, oil production, nuclear, etc) have drawn most of the resources. CCS possibilities were never demonstrated at full scale.

Scenario development Process outline

1. Decide on the key question to be answered by the analysis
2. Decide actors, factors, and drivers for change (next slide)
3. Bring drivers together – framework

Workshop 1&2

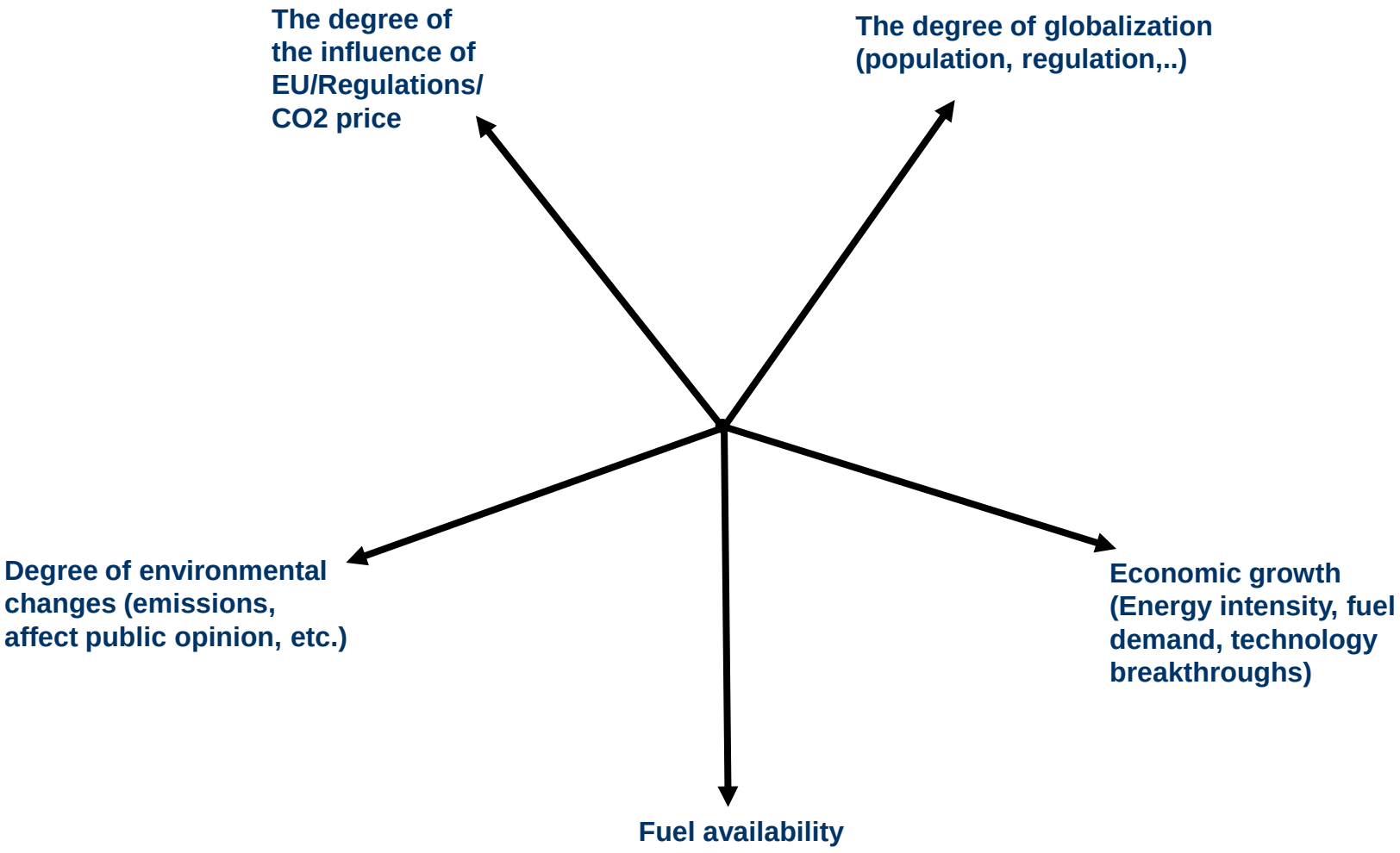
4. Produce initial mini-scenarios (short, compact descriptions that focus primarily on one actor or one factor)
5. Reduce to main (2-5) scenarios
6. Draft the scenarios

Workshop 3

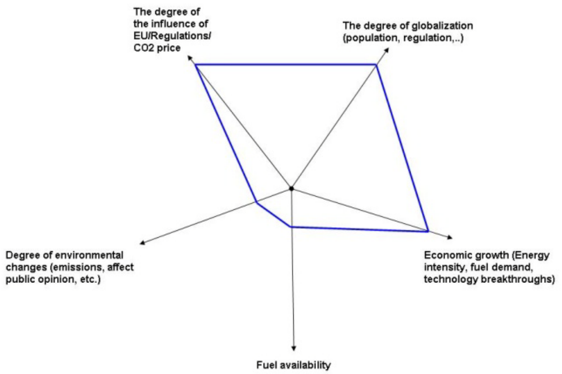
7. Identify issues arising

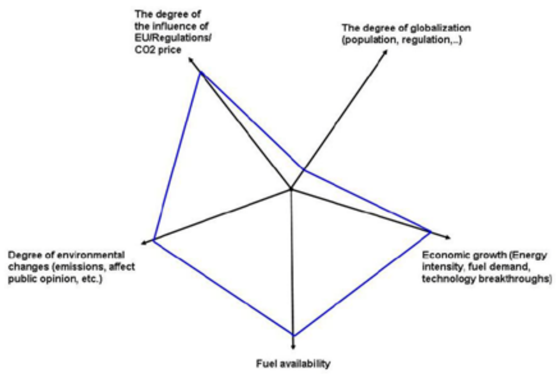
Workshop 4

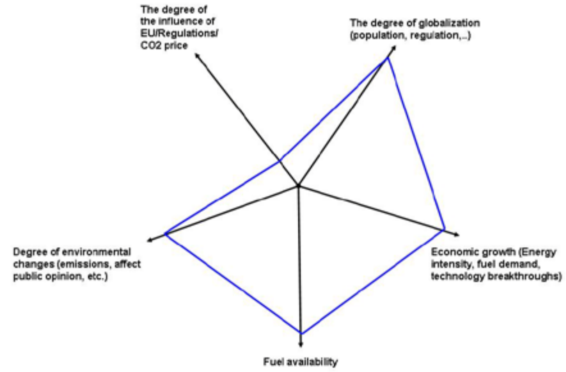
Main Driving Forces

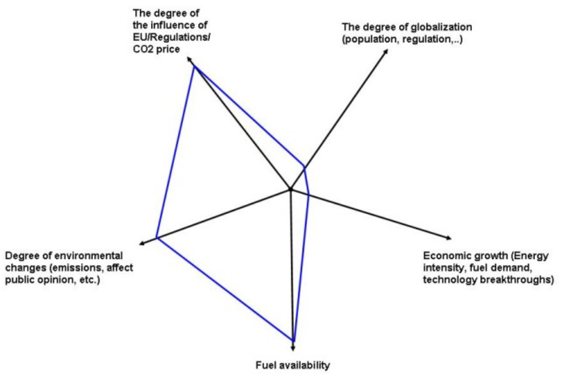


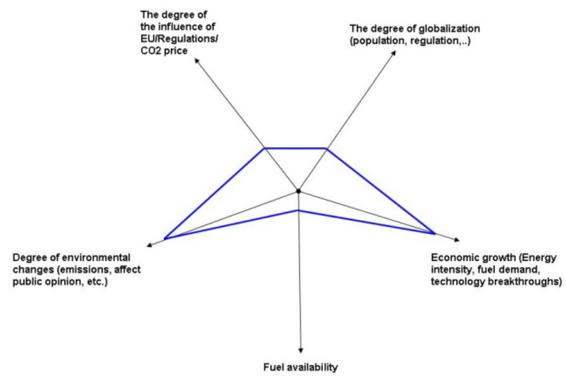
ECCO Scenarios







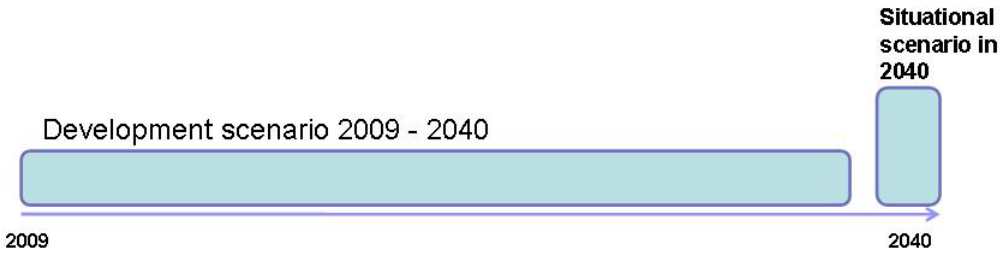




***This "spiderweb" method has been described previously by Erik Øverland, SUBITO**

Drafting a Scenario

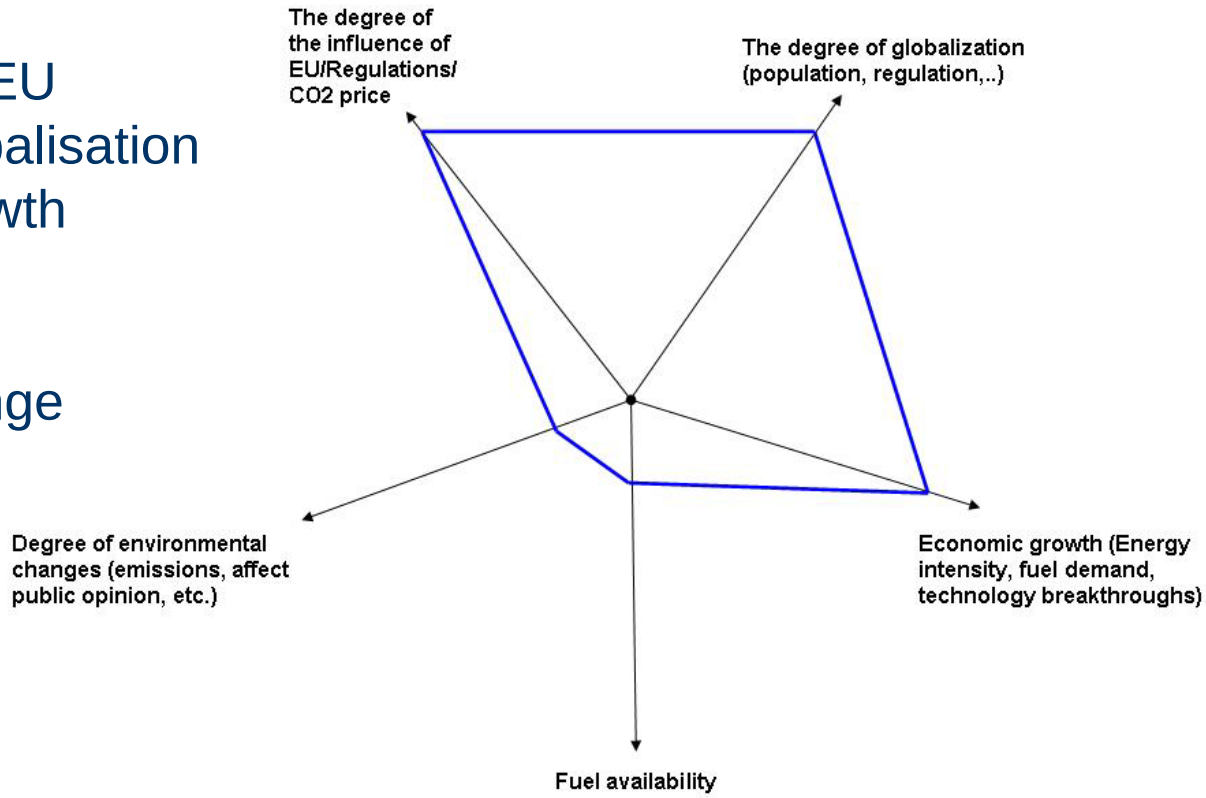
- *Situational scenarios* summarize the current state of affairs in a given year, for instance 2040.
- *Development scenarios* describe the process and evolution that led to a given situational scenario.



Example
Scenario 1: Happy Planet

Scenario features:

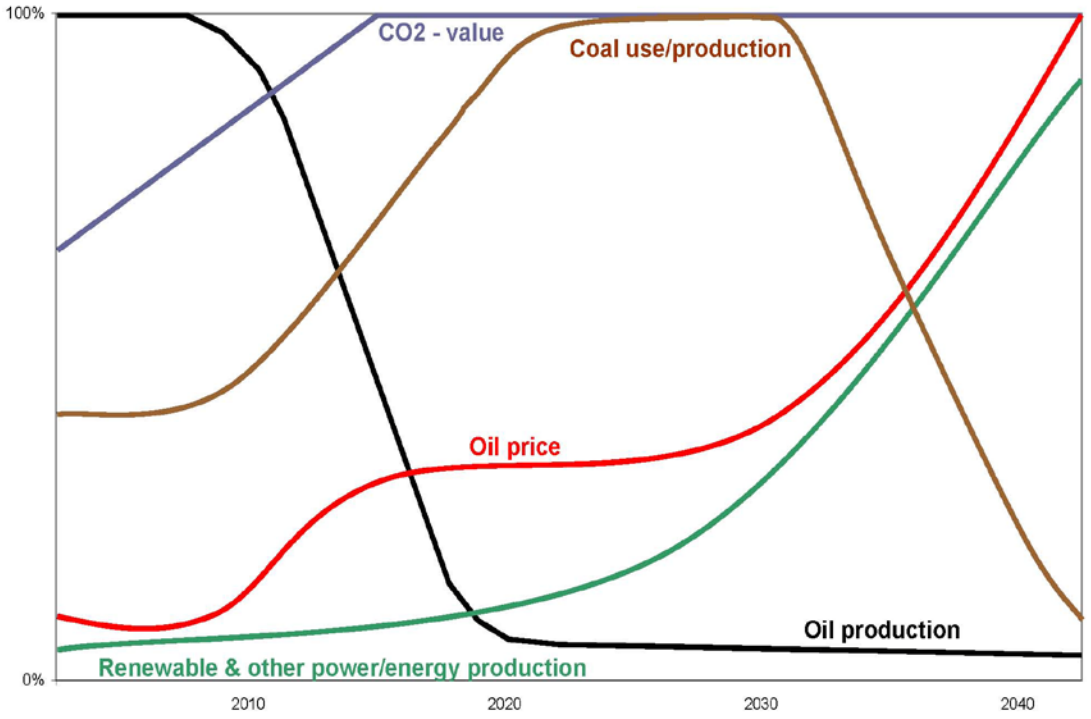
1) High impact of the EU
2) High degree of globalisation
3) High economic growth
4) Low fuel availability
5) Low degree of environmental change



Scenario 1: Happy Planet Situation in 2040

- **ENVIRONMENTAL CHANGES & PUBLIC OPINION**
  - Target emission reductions are reached.
  - There is public acceptance of all low-carbon-emitting technologies, including CCS.
- **POLITICAL & REGULATORY**
  - Europe has implemented relatively tight emission regulations that encouraged a decarbonised economy and has reduced its dependency on fossil fuels.
  - There is high degree of cooperation between the countries. There are international rules and regulations for CCS in place. Countries are sharing technologies and knowledge. China and India are developed with similar green economies.
- **GLOBAL ECONOMY**
  - Costs of capital are medium to high and there are high investments, together with investment confidence. Significant technology innovation has occurred in the energy sector, as a consequence of appropriate economic environment.
  - The fuel prices are high because the economic fossil fuels resources have been depleted.
- **CCS TECHNOLOGY & INFRASTRUCTURE**
  - In 2040, commercial CCS is a reality in all developed countries. Europe demonstrated and recognized existing CO2 infrastructures and is considered globally as a world leader. Other non-EU countries have continued though to rely largely on fossil-fuel electricity generation. However, regulations in these regions only permit they continue to use fossil fuels if CCS is implemented.
  - CCS technologies were successfully developed and shared internationally. Research institutes are well-founded and working for the common good. An international grid network was established for CO2 transport. High prices of fossil fuels triggered also the development of renewables and other alternative energy production technologies.

Scenario 1: Happy Planet



- Oil production declines rapidly until 2020, and stabilizes after that.
- Oil prices are rising 2010-2020, stabilizing around 2030, and then rising again.
- Coal production increases to fill the short-term oil gap and it peaks around 2030
- The CO_2 emission price quickly rises to meet the CCS technology costs in 2015, and then plateaus as the technology price itself maybe declining slightly.
- Initially, rising prices are politically supported in order to achieve low carbon investment.

	Scenario 1 “Happy planet”	Scenario 2 “EU stands alone”	Scenario 3 “Weak EU”	Scenario 4: “We told you so”	Scenario 5 “Competition”
Environmental changes & public opinion	Public accepts CCS as a measure for CO2 emission reduction Target emission reduction are reached	Public opinion is split however majority agrees that something has to be done Europe has met most goals for emission reduction however the worldwide level of emissions continued to increase because of lack of coordination and technology dissemination	Due to high usage of fossil fuels without CCS the emission level has risen	EU has reduced its emissions but global emissions continued to rise	Public acceptance is sufficient Target emission has been exceeded There is urgent need to mitigate the climate changes
Political & regulatory	Tight regulations set in place and accepted internationally	EU focuses on keeping economic growth but minimize emissions and uses ETS	EU’s leadership has been weakened and there are no incentives accelerating realization of large scale international CCS projects	EU still stands strong and is determined to reduce the emissions but the rest of the world is not following	Political support for CCS is lacking, there are no common regulations, ETS has failed
Global economy	Fuel prices are high, costs of capital are medium to high	Focus on economic growth Costs of capital are medium to high and there are high investment confidence and high investments	High economic growth and low energy price	The economic growth is not as high as it was around 2000 High price of energy and demand for fossil fuels leads to regional conflicts	Fossil fuels resources have been depleted, the price is high Investment confidence is good and costs of capital medium to high
Technology & infrastructure	Research was coordinated Commercial CCS became reality International network for CO_2 transport was established	Focused research and learning effect has reduced the price of CCS and made it relatively affordable	Research is driven by market forces and sponsored by industry Development of CCS technologies is limited due to lack of incentives	Energy efficiency was increased considerably Technologies for renewable energy were commercialized and cover 50% of the consumption	Research is driven by private companies and no technology transfer takes place

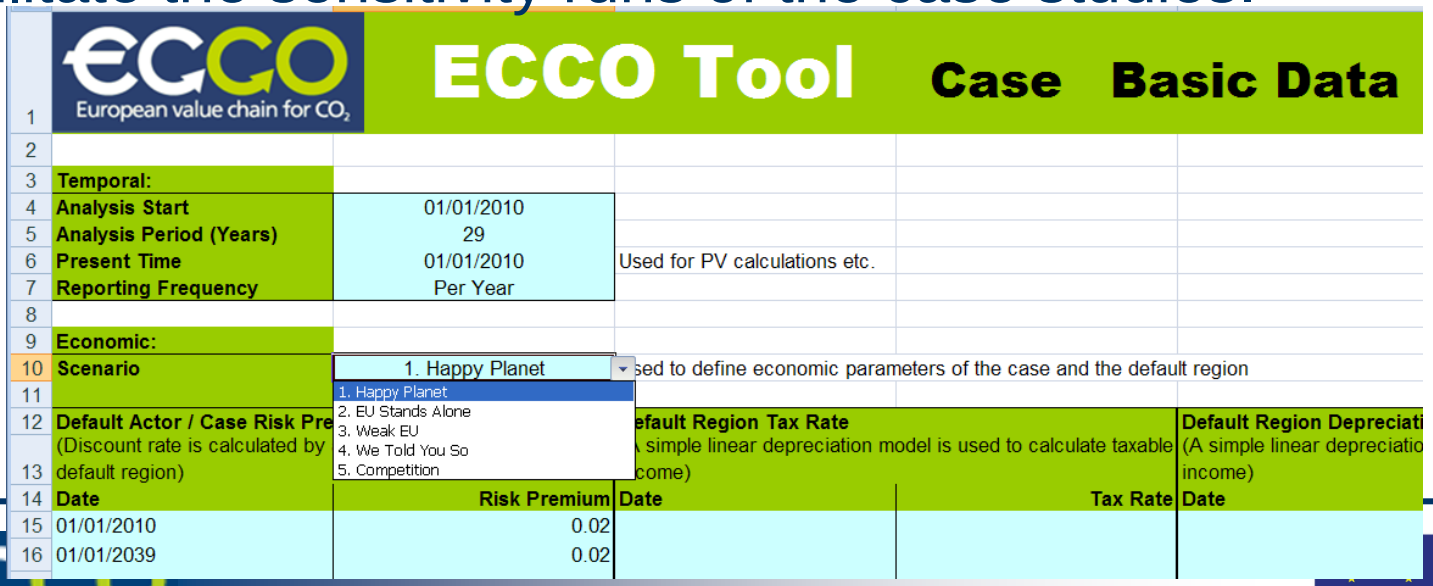
Final Scenario Workshop – Ensuring Consistency in the Scenarios

- EU “New Energy Policy” scenario
  - triggered by the inconsistencies in the “EU Stands Alone” scenario- EU would not go alone in fighting global climate change and at the same time experience high economic growth. Changed to high globalization.

  - need to include a baseline scenario that describes an energy future which is compatible with the targets of the European energy and climate change policy, endorsed by the European Council in 2009.

Translation to Time Series in the ECCO Tool

- In WP3.1, a set of quantitative time-series for the following variables: Oil price, CO_2 price, Electricity price, Coal price, E&P cost index, Real interest rate, were developed for the six scenarios.
- The time-series are embedded in the ECCO-tool so as to facilitate the sensitivity runs of the case studies.



ECCO European value chain for CO_2 — ECCO Tool — Case Basic Data

3	**Temporal:**				
4	**Analysis Start**	01/01/2010			
5	**Analysis Period (Years)**	29			
6	**Present Time**	01/01/2010	Used for PV calculations etc.		
7	**Reporting Frequency**	Per Year			
8					
9	**Economic:**				
10	**Scenario**	1. Happy Planet	sed to define economic parameters of the case and the default region		
11		1. Happy Planet 2. EU Stands Alone 3. Weak EU 4. We Told You So 5. Competition			
12	**Default Actor / Case Risk Pre**		**efault Region Tax Rate**		**Default Region Depreciati**
13	(Discount rate is calculated by default region)		A simple linear depreciation model is used to calculate taxable come)		(A simple linear depreciatio income)
14	**Date**	**Risk Premium**	**Date**	**Tax Rate**	**Date**
15	01/01/2010	0.02			
16	01/01/2039	0.02			

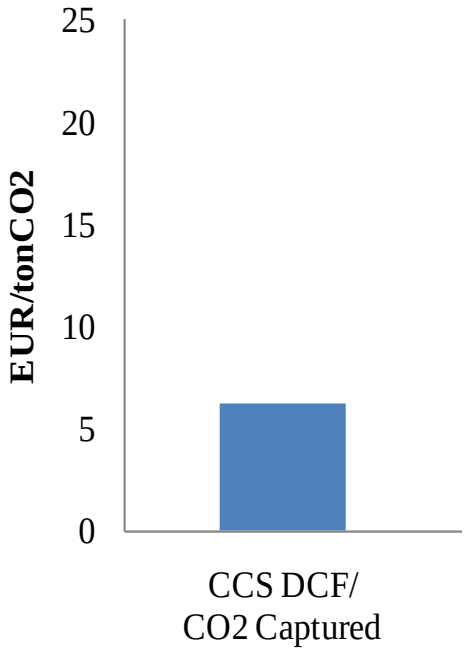
Case Sensitivity to Scenarios – Early Results

- Four of the five cases have been implemented in the ECCO tool to demonstrate their sensitivity to the global scenarios: Norway, Hungary, UK, and Baltic.

- We assume that the choice of scenario does not effect the CO_2 flows (amount, etc)

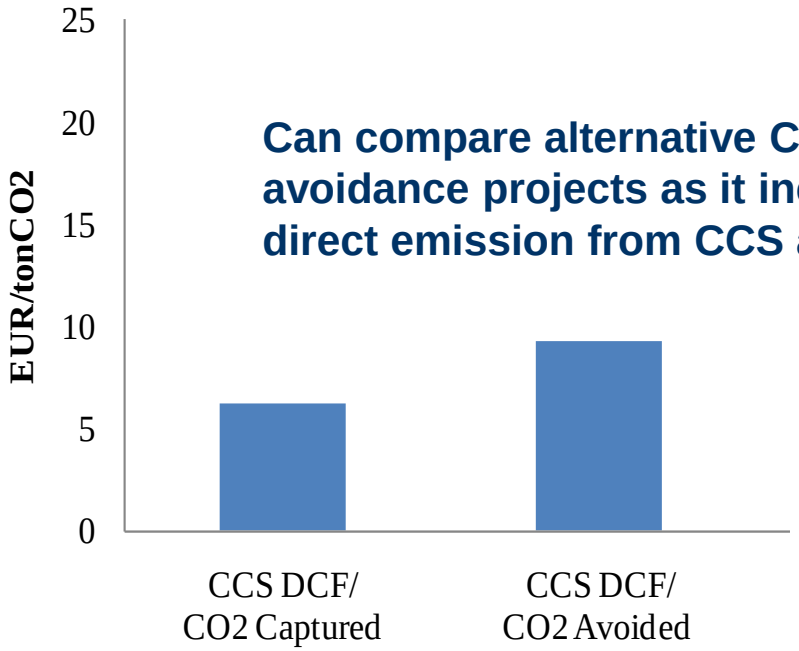
- We have also modeled every source as an add-on to ensure that costs are a result of incremental CCS directly.

Norway Case – Happy Planet Scenario



Relevant to compare cost of alternative capture technologies capturing and emitting the same amount of CO_2, but is of limited value when considering CCS as abatement option for different projects.

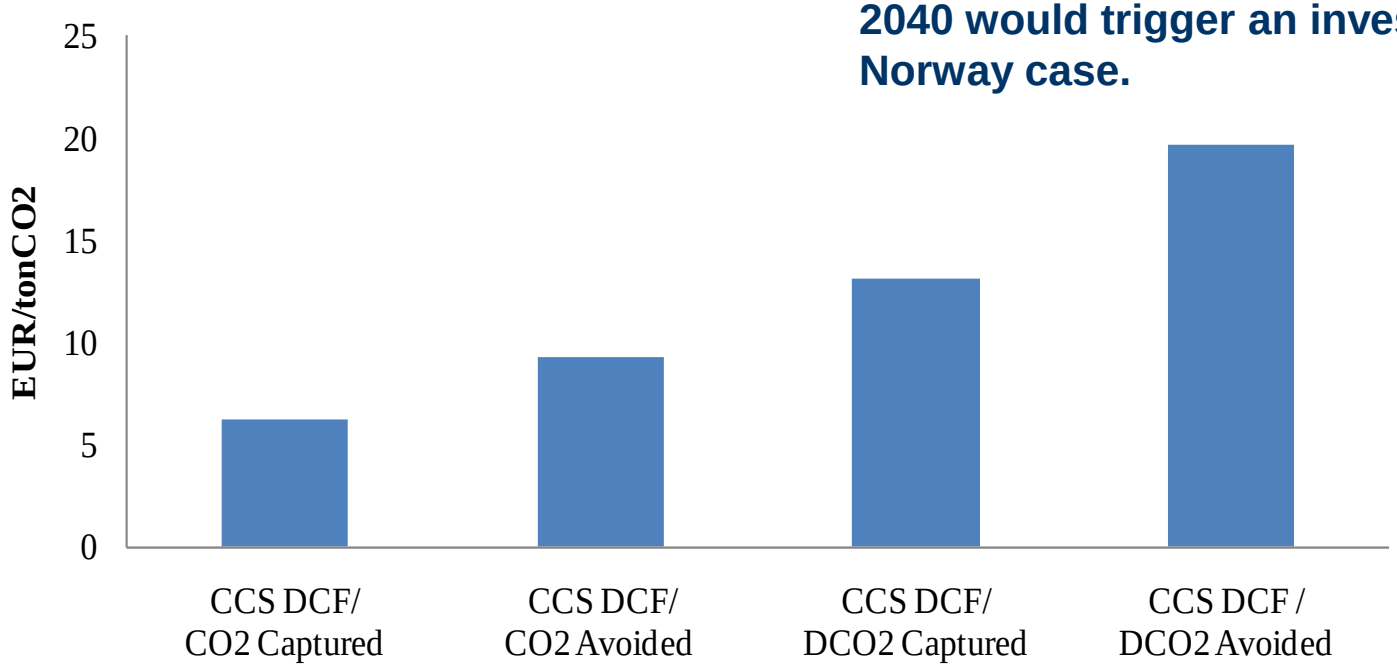
Norway Case – Happy Planet Scenario



Can compare alternative CO_2 avoidance projects as it includes direct emission from CCS activity.

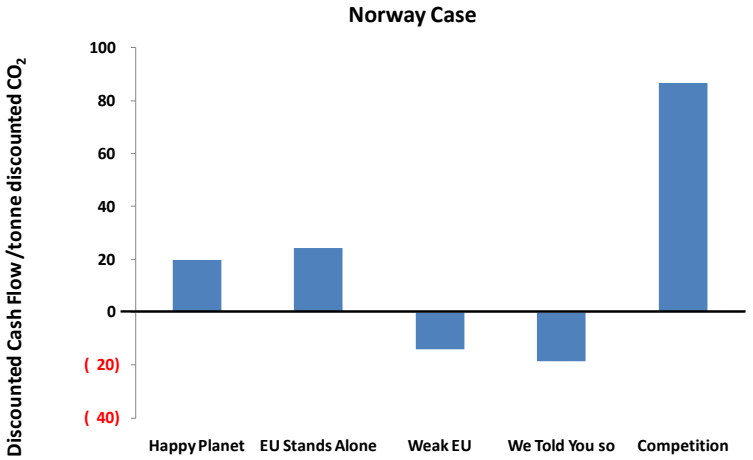
Norway Case – Happy Planet Scenario

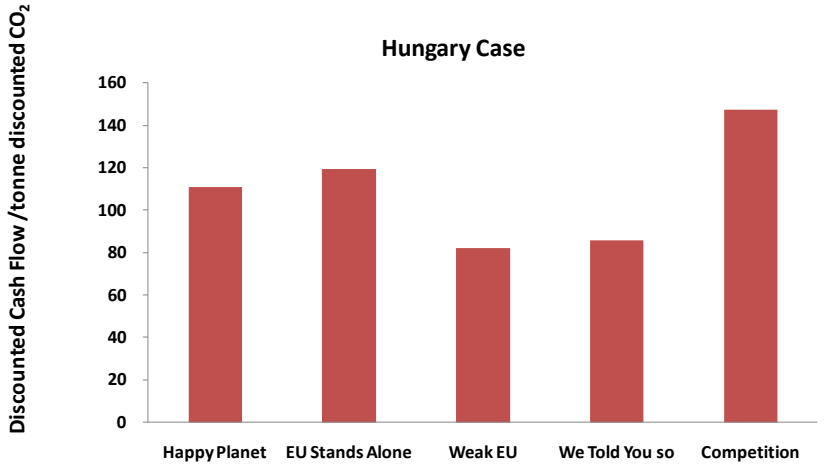
This implies that a fixed CO_2 price of ~20 EUR/tonne CO_2 in the period 2015-2040 would trigger an investment in the Norway case.

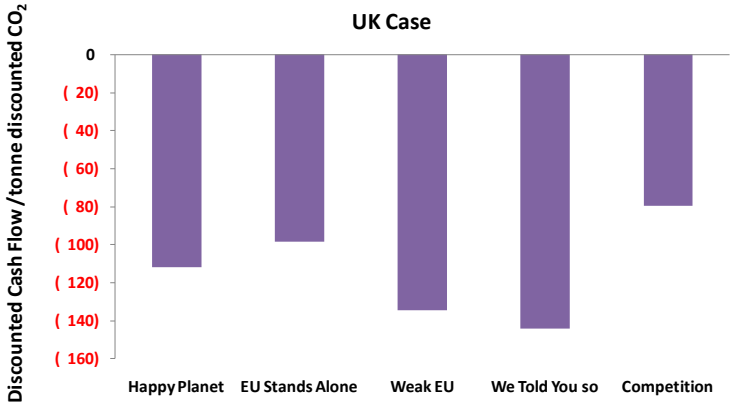


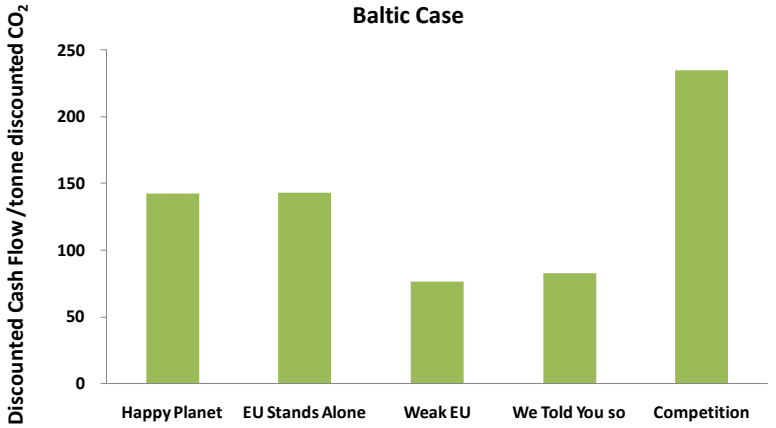
Need to discount the CO_2 to incorporate the time value of CO_2 avoided

Case Sensitivity to Scenarios – Early Results









Case Sensitivity to Scenarios – Early Results

- The cases are quite sensitive to the scenarios.
- The Competition scenario gives the highest cost per tonne CO_2 while Weak EU always gives the lowest.
  - Weak EU has lower E&P, coal, and oil prices than Competition
- Further analysis on on KPIs will be conducted

Summary

- Scenario development under ECCO and the story lines resulting from that process.
- The scenarios were developed through a series of workshops with the involvement of all project partners, including experts with background from power generation, oil and gas production and R&D relevant to many aspects within a CO_2 value chain.
- The results from the scenario study helped to set the global background for the case studies.
- So far the relative trends of the results of the scenario sensitivity on the cases are similar, but we have yet to study this in detail.

Thank you for your attention!

http://www.co2balance.com/