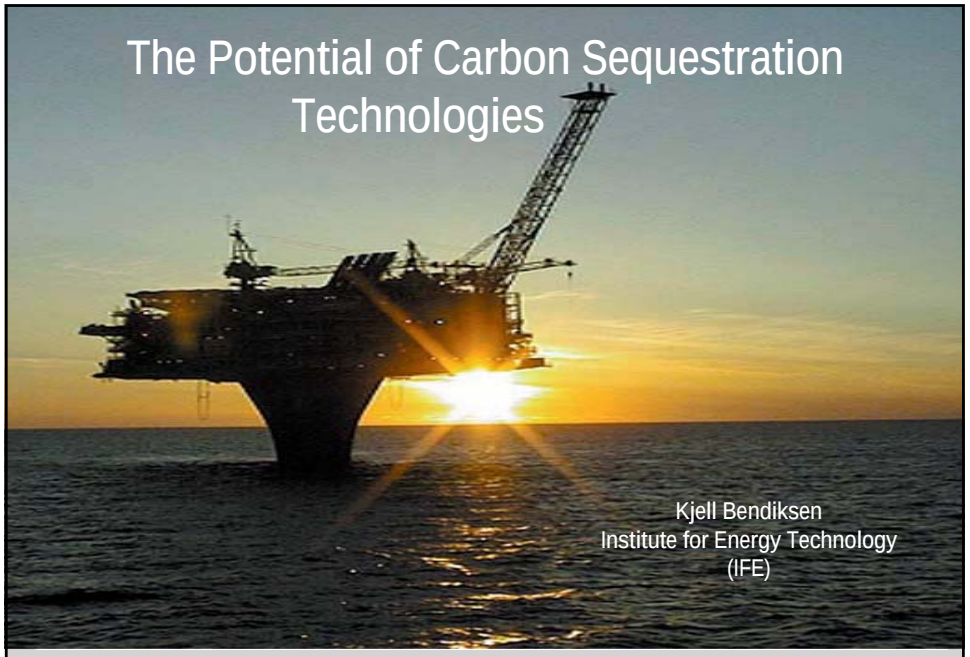
The Potential of Carbon Sequestration Technologies



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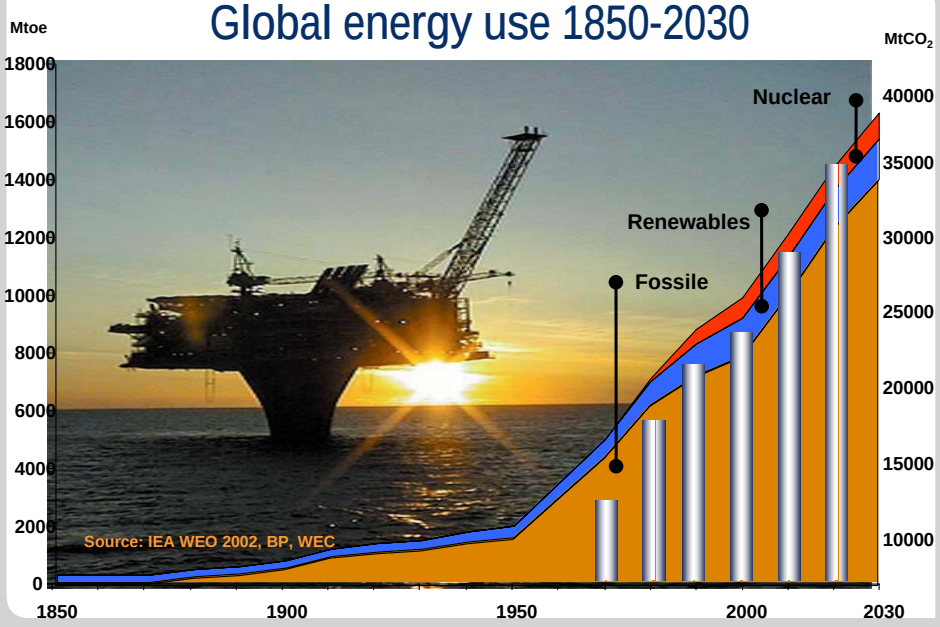
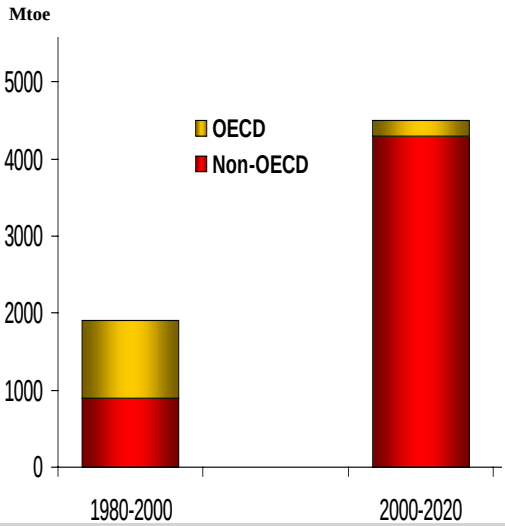
Global energy use 1850-2030



Global energy demand growth



Source: IEA WEO 2002

Global energy and climate realities

Three main challenges, not properly addressed in the Kyoto protocol:

- **The enormous short time growth in energy demand in developing countries**
- **The necessity to stabilize atmospheric CO_2-*levels*, if the IPCC's 50 years scenarios are realistic**
- **As a consequence, to drastically reduce GHG-emissions within a few decades or face climate changes**

The response: To develop and *deploy* new Low Emission (LE) technologies on a very large scale

The response: Low Emission Technologies

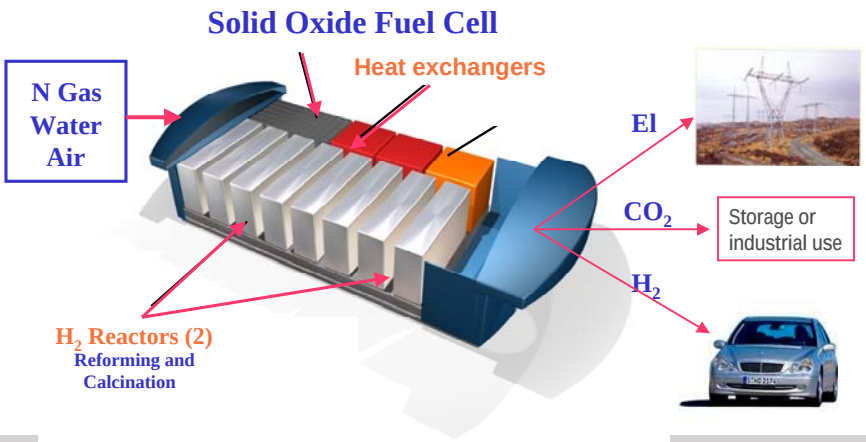
Renewables, Nuclear and CCS

Gas or coal power plants with CCS?

Norwegian CCS Technology Projects

The Kårstø 420MWe plant: CCS with EOR?

Emerging concepts
The IFE Zero Emission Gas Energy Station (ZEG)



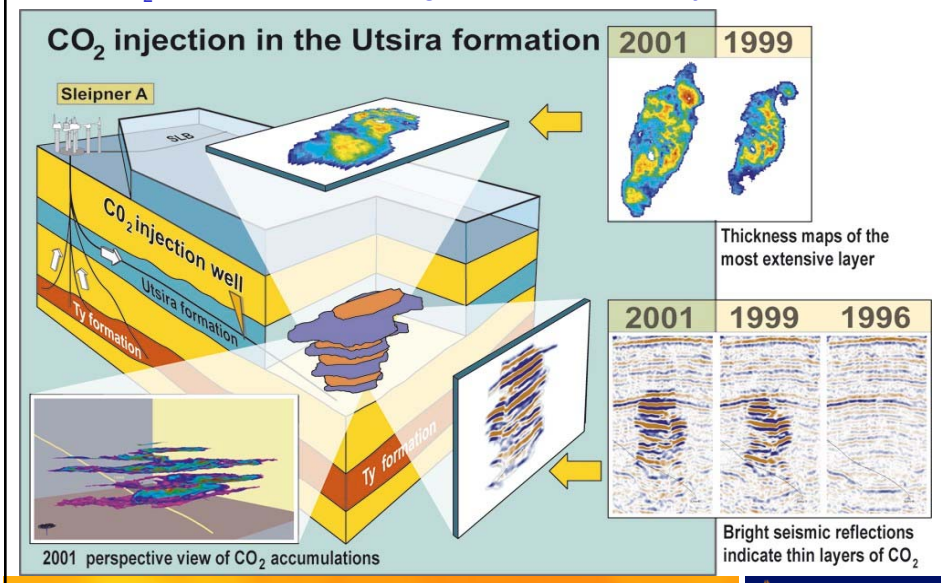
Infrastructures for CO_2 deposition (closing the loop)

CO_2 deposition, storage or mineral binding

1. **"Standard" CO_2 storage solutions**
   - **Deposition in deep geological formations, e.g the Utsira aquifer**
- **Innovative methods: CO_2 as resource, providing added value**
   - **CO_2 for Enhanced oil recovery from oil reservoirs (e.g. on the Norwegian Continental shelf)**
   - **Binding of CO_2 by production of stable carbonates from silicate minerals (e.g olivine), providing valuable by-products**
   - **Integrated industry projects (commercial products)**

"Standard" CO_2 storage/deposition methods

CO_2 accumulation and migration: Verification by 4D seismics



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Challenges of CCS Technologies

- **Reduce CCS cost gap through innovation**
  - **More important than the time horizon, and**
  - **A technology shift is required to achieve extra costs down to expected quota prices and improve energy efficiency losses (from 15 to < 10%)**
- **Develop necessary infrastructures; assert feasibility of large scale global CO_2 deposition systems**
- **Establish required legal framework and regulation regimes (OSPAR and London Conventions)**
- **Reduce risk for pioneers; need first suppliers and users**

5 **Ensure efficient introduction and co-existence with non-fossil LE solutions**

Royal Society
25.10.2005

IFE

The potential of CCS technologies

The IEA (ETA 2004) 2050 Scenario

- **Stabilization of CO_2-emissions by 2050 is possible, provided**
  - **It must cost something to emit CO_2 freely to the atmosphere: A universal global emission "penalty" of 50$/t CO_2 introduced in 2005-15**
  - **Economic incentives will lead to necessary technologic development and solutions, and to their actual deployment and use**
- **Low emission technologies may contribute significantly**
  - **21% of world el-supply in 2030 & 56% i 2050 (65% in OECD area)**
  - **Corresponds to 4-5000 coal and gas power plants**
  - **The CO_2-penalty also makes renewables competitive at an early stage**
- **But: An estimated 18 billion tons of CO_2 must be separated, transported and deposited annually!**
  - **Is this realistic? Is it even thinkable to establish and operate a global infrastructure for 15-20 billion tons of CO_2 annually?**

Conclusions

- **Energy-climate realities**
  - **Modern societies have a "bulimic" appetite for energy**
  - **There is no immediate resource crisis (IEA)**
  - **Fossil fuels cover 85%+ of global energy demand, and their share increases towards 90%**
  - **CO_2-emissions expected to increase by 60% towards 2030**
  - **It will be necessary to stabilize atmospheric CO_2-levels (IPCC)**
- **Low Emission Technologies**
  - **Objective: To develop and deploy competitive LE-technologies in time**
  - **Future alternatives are Renewables, Nuclear and CCS technologies**

Conclusions (2)

3 **CCS Technologies**

- Feasible, but still far from commercial technology
- Serious challenges
- CCS technologies may *in theory* stabilize emissions in 2050 (IEA 2004)
- Requires deploying 4-5000 CCS plants with infrastructure in 50 years

4 **Final Questions**

- Is it feasible – *possible* to establish and operate global infrastructures for 15-20 bn. tons of CO_2 annually?
- Is CCS a sustainable solution or a historical parenthesis?
- Will New renewables, nuclear power and CCS technologies be adequate to stabilize CO_2 emissions (and levels) in time
- If not, we must be prepared to cope with consequences of climate change
- There are *no* simple solutions: "Keep all options open" (WEC 2004)