Green Week

Brussels 14 June 2007

CCS – A Powerful Catalyst for change: Power, Industry, Hydrogen, Biomass

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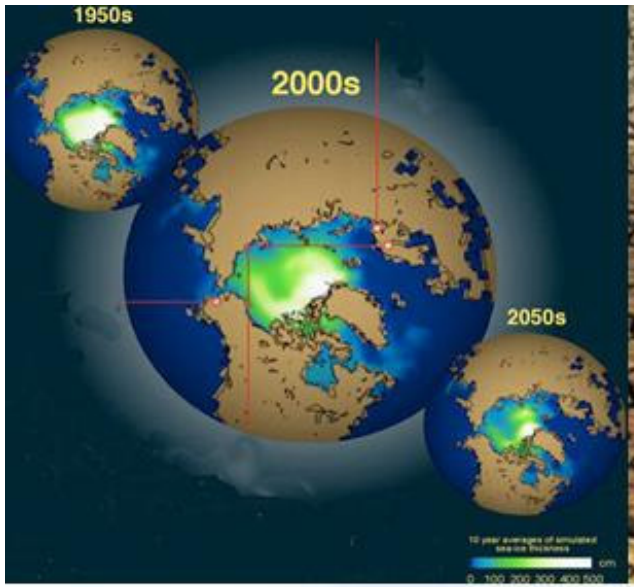
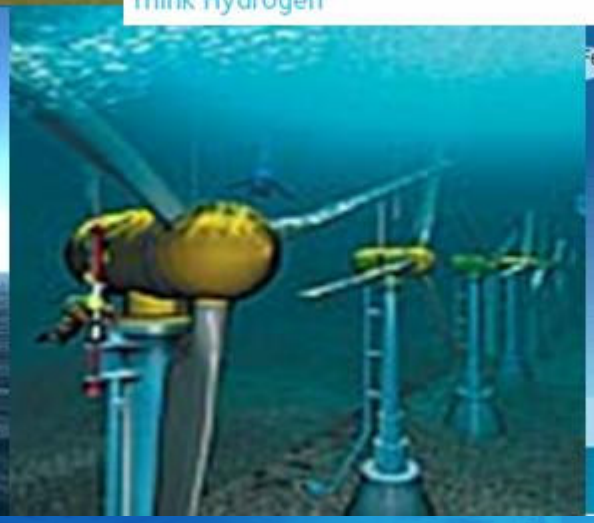
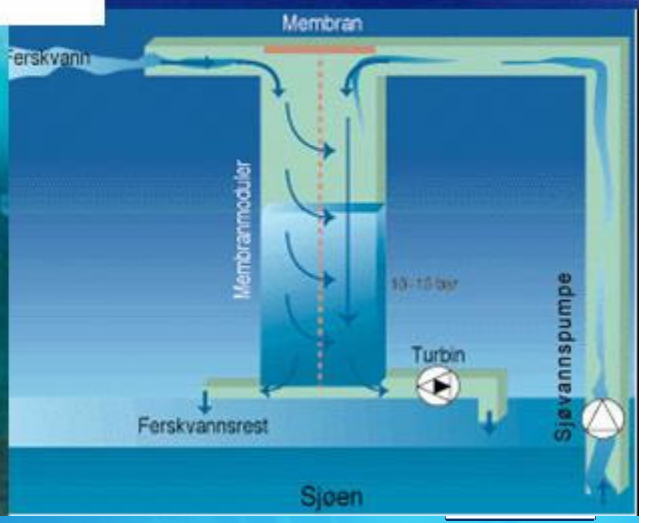
The Bellona Foundation

Climate Change is a Fact!



The Solution – Renewable Energy





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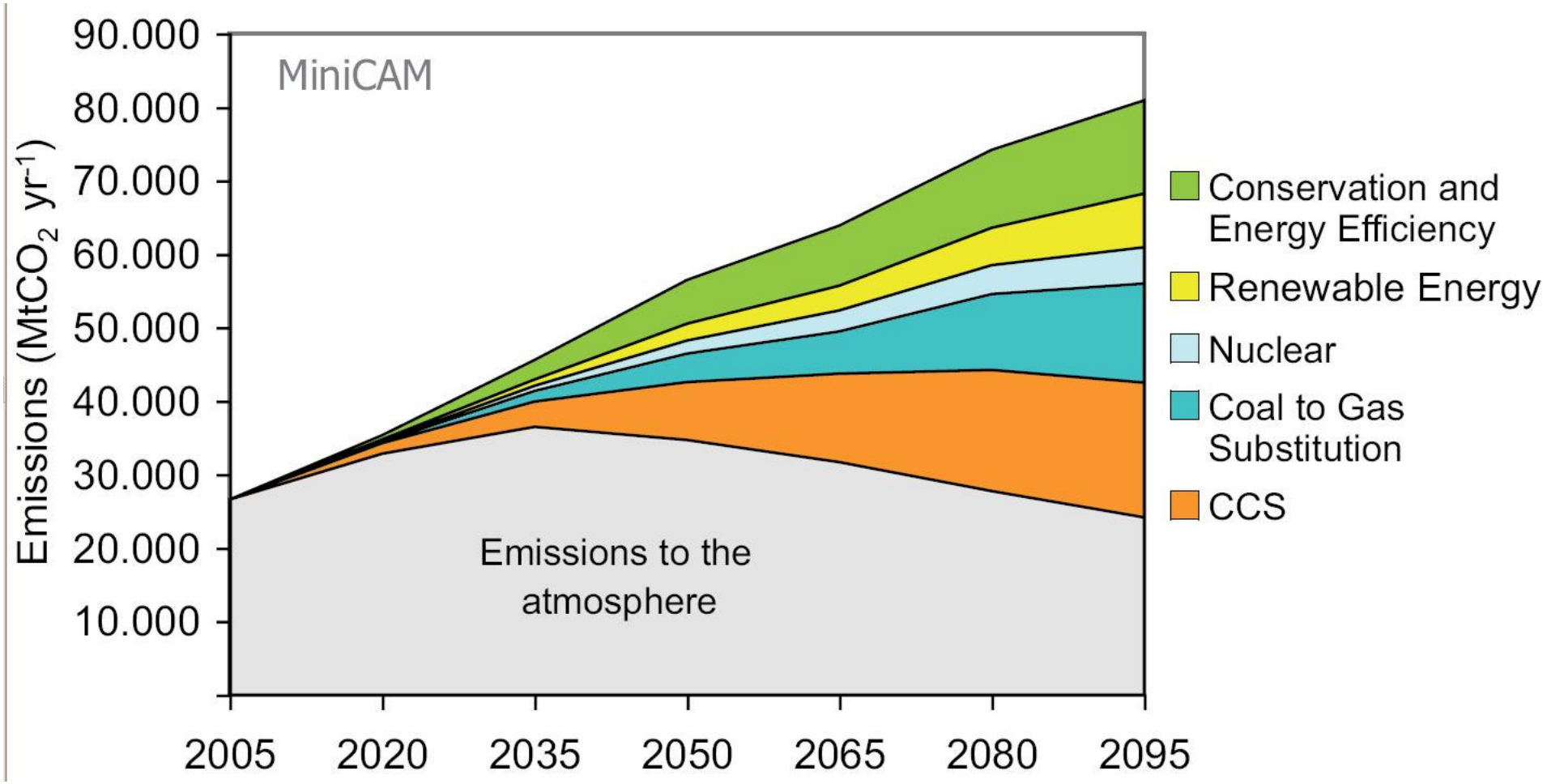
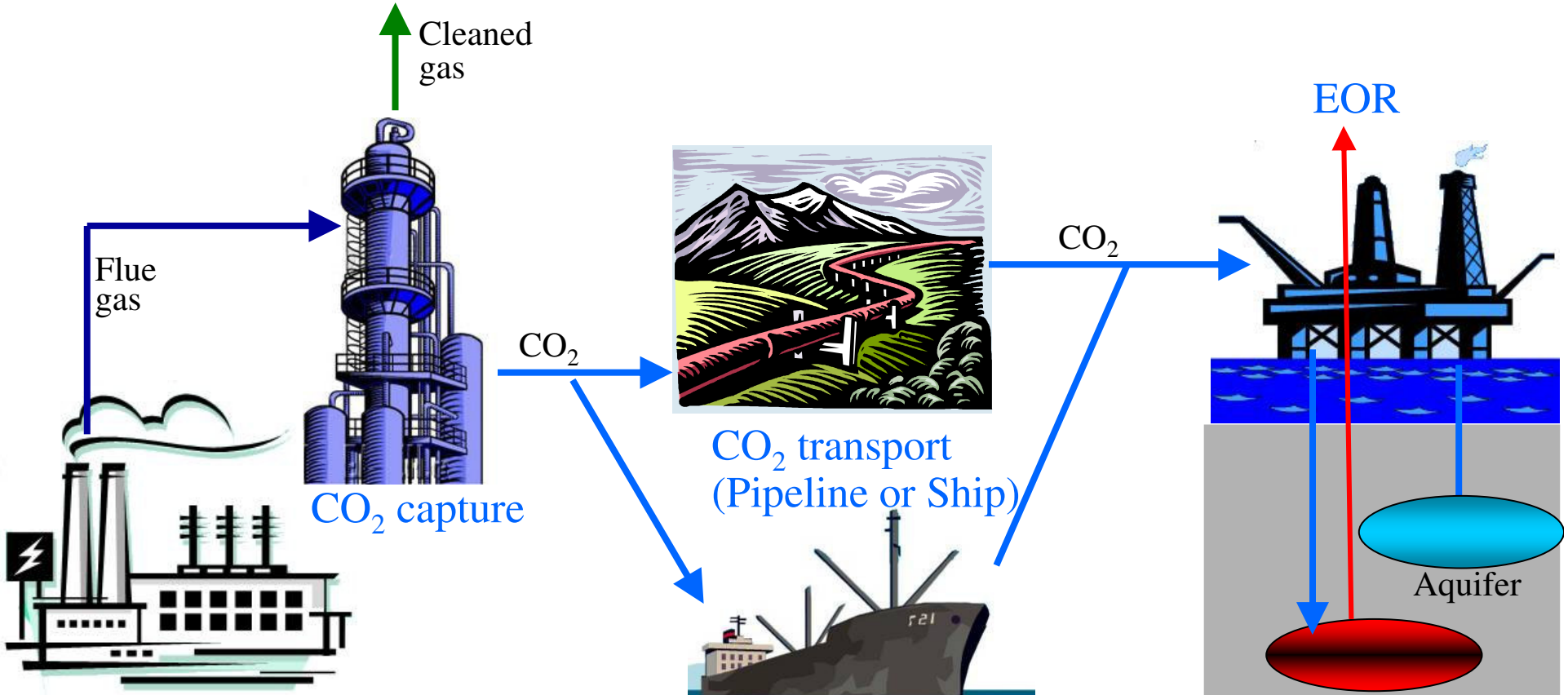
Options for CO_2 Emission Reduction



Source: IPCC Carbon Capture and Storage

CO_2 Capture and Storage



CO_2 capture

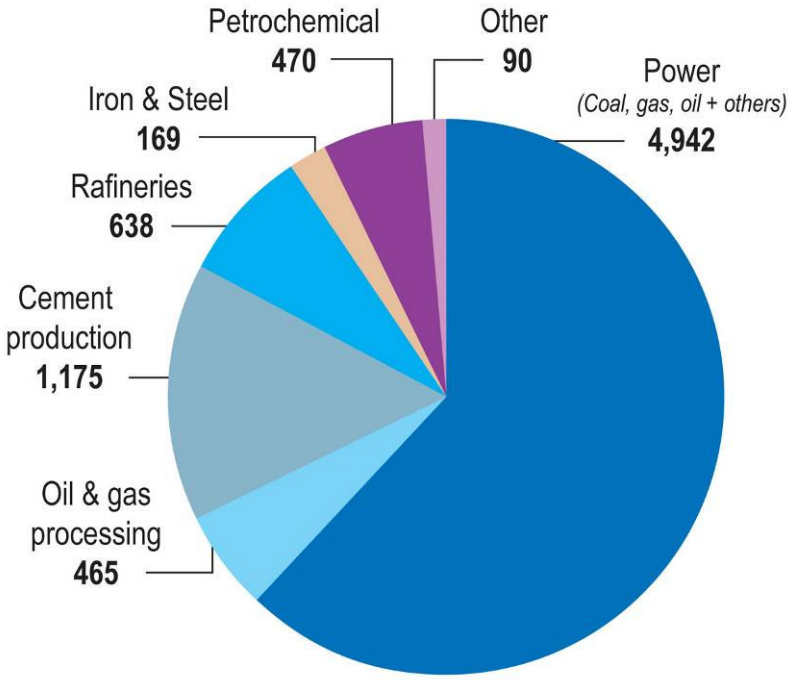
CO_2 transport (Pipeline or Ship)

CO_2 storage

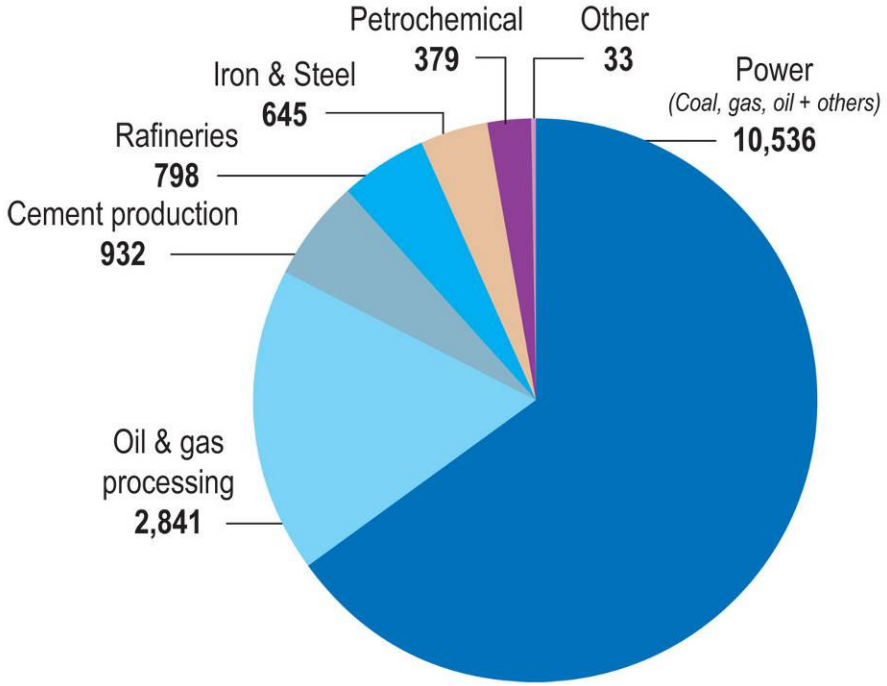
CO_2 source:

- Power plant (coal, NG, biomass)
- Industry
- H_2 production

Global Stationary Sources of CO_2 by Number and Total Emissions 2006



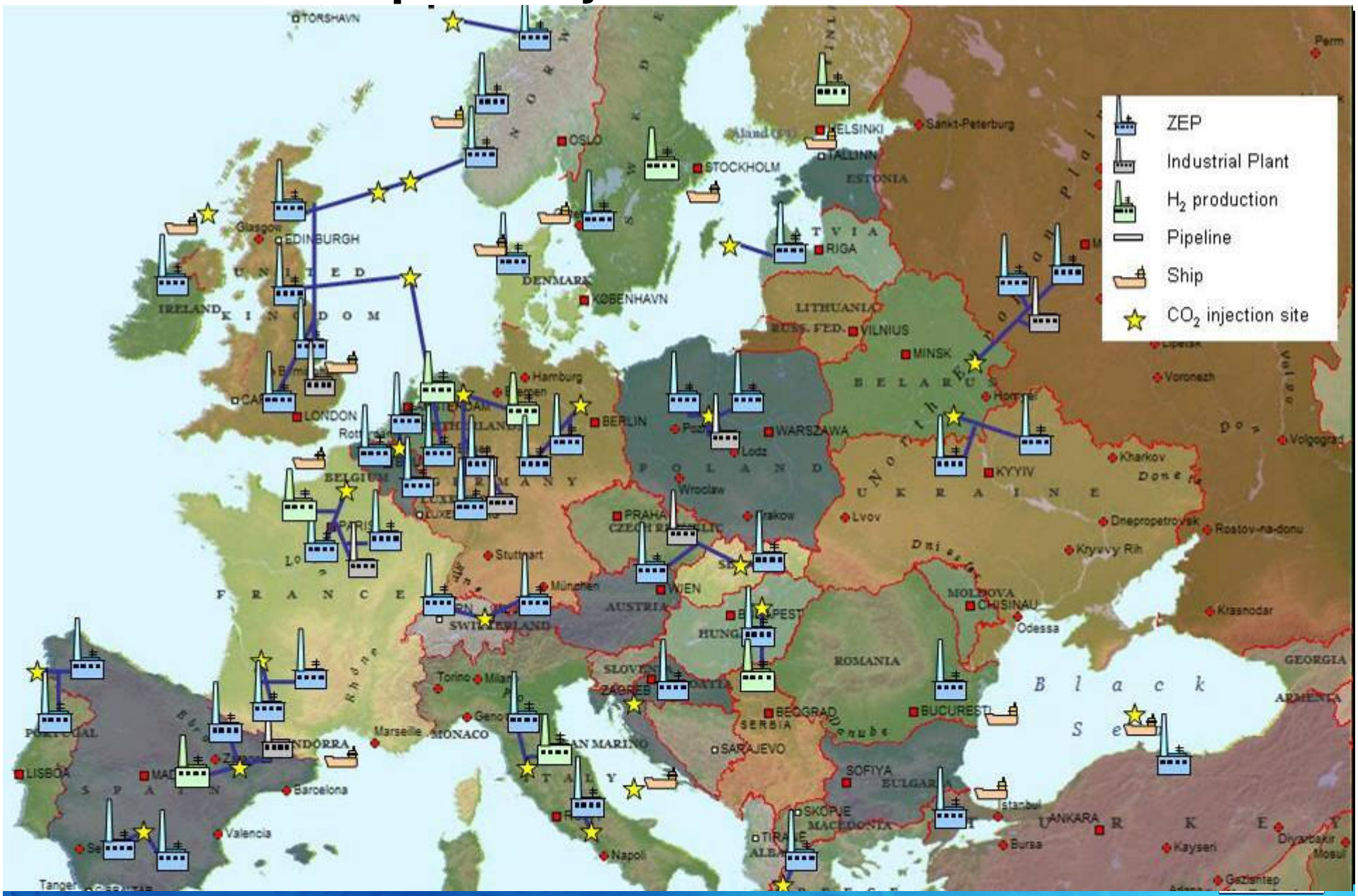
Number of Facilities



Emissions (Mt CO_2/yr)

Source: IPCC, 2005

Europe CO_2 infrastructure 2030



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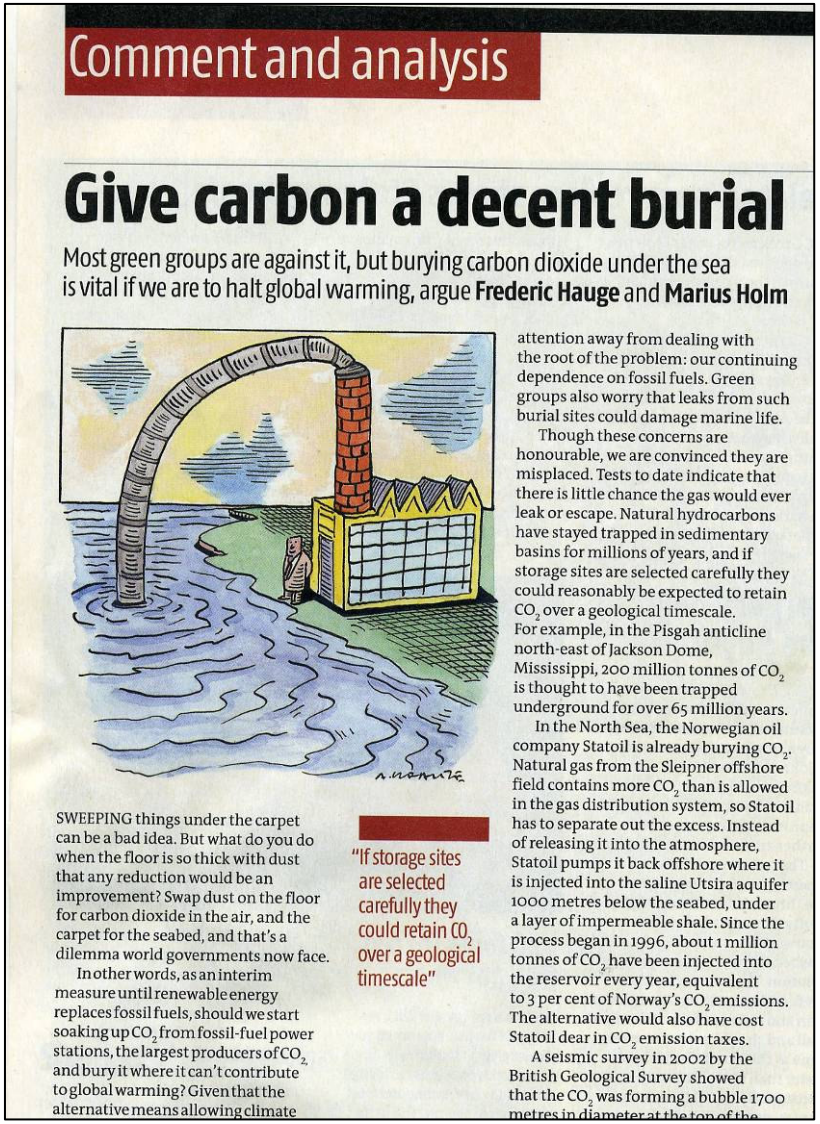
Challenges - I

- **Technological challenges**
  - Developing cheaper and more effective concepts
  - Bringing technology from small scale to large scale industrial CCS projects
  - Gain experience
  - Filling R&D gaps
- **Establish demonstration projects in parallel with R&D actions**

Small CO_2 capture plant in Malaysia

Challenges - II



Comment and analysis

Give carbon a decent burial

Most green groups are against it, but burying carbon dioxide under the sea is vital if we are to halt global warming, argue **Frederic Hauge** and **Marius Holm**

SWEEPING things under the carpet can be a bad idea. But what do you do when the floor is so thick with dust that any reduction would be an improvement? Swap dust on the floor for carbon dioxide in the air, and the carpet for the seabed, and that's a dilemma world governments now face.

In other words, as an interim measure until renewable energy replaces fossil fuels, should we start soaking up CO_2 from fossil-fuel power stations, the largest producers of CO_2, and bury it where it can't contribute to global warming? Given that the alternative means allowing climate attention away from dealing with the root of the problem: our continuing dependence on fossil fuels. Green groups also worry that leaks from such burial sites could damage marine life.

Though these concerns are honourable, we are convinced they are misplaced. Tests to date indicate that there is little chance the gas would ever leak or escape. Natural hydrocarbons have stayed trapped in sedimentary basins for millions of years, and if storage sites are selected carefully they could reasonably be expected to retain CO_2 over a geological timescale. For example, in the Pisgah anticline north-east of Jackson Dome, Mississippi, 200 million tonnes of CO_2 is thought to have been trapped underground for over 65 million years.

"If storage sites are selected carefully they could retain CO_2 over a geological timescale"

In the North Sea, the Norwegian oil company Statoil is already burying CO_2. Natural gas from the Sleipner offshore field contains more CO_2 than is allowed in the gas distribution system, so Statoil has to separate out the excess. Instead of releasing it into the atmosphere, Statoil pumps it back offshore where it is injected into the saline Utsira aquifer 1000 metres below the seabed, under a layer of impermeable shale. Since the process began in 1996, about 1 million tonnes of CO_2 have been injected into the reservoir every year, equivalent to 3 per cent of Norway's CO_2 emissions. The alternative would also have cost Statoil dear in CO_2 emission taxes.

A seismic survey in 2002 by the British Geological Survey showed that the CO_2 was forming a bubble 1700 metres in diameter at the top of the

- **Political challenges** are bigger than technical challenges
- **Regulatory framework**
  - Long-term and transparent regulatory framework are required for a wide deployment of CCS
- Establishing **Early Mover Fund**
- Clarify **State Aid Guidelines**
- **Global price** on CO_2 post Kyoto
- Individuals must force **politicians to prioritize** climate change mitigation

New Possibilities – CCS and Bio Energy

CCS combined with bio energy

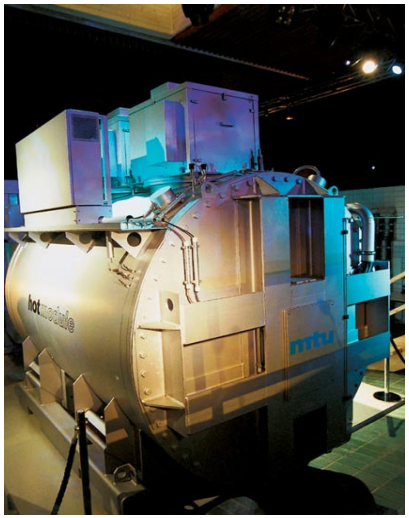
- Bio energy is CO_2 neutral
- Large potential for heat production from bio mass
- Power plants fired with biomass
- Biomass can be used for production of methane or hydrogen
- CO_2 capture and storage from biomass will give net reduction of CO_2 in the atmosphere

Source: Alholmen Bio Power Plant

CCS – New possibilities

CCS combined with:

- Fossil power production
- Biomass
- Fuel Cells
- Petrochemical plants, cement production, and iron production
- Gasification of coal
- Production of H_2
- Deep coal reservoirs that are unmineable today
- Sources with too high CO_2 content for fiscal sale

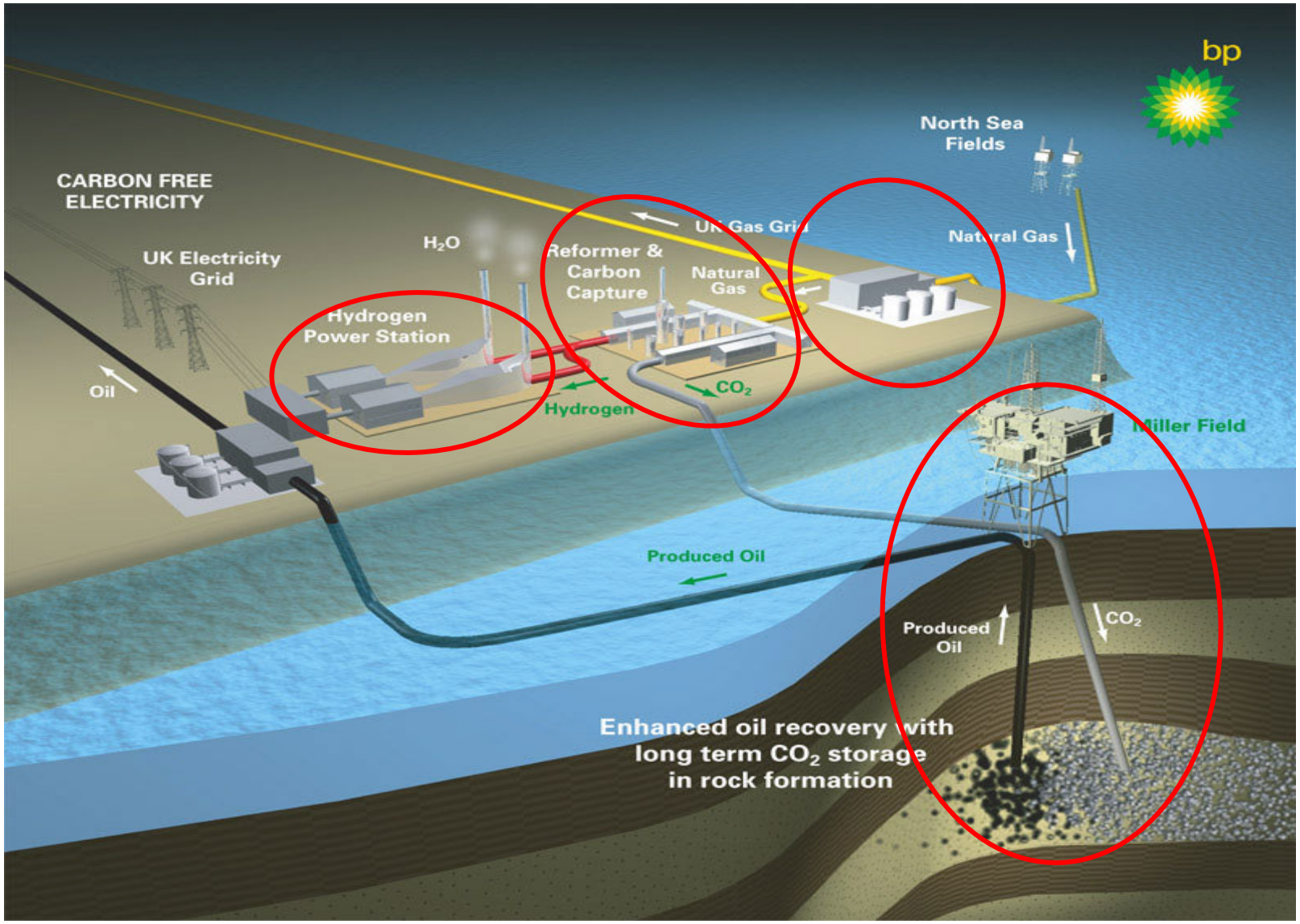


Hydrogen – No CO_2 Emissions

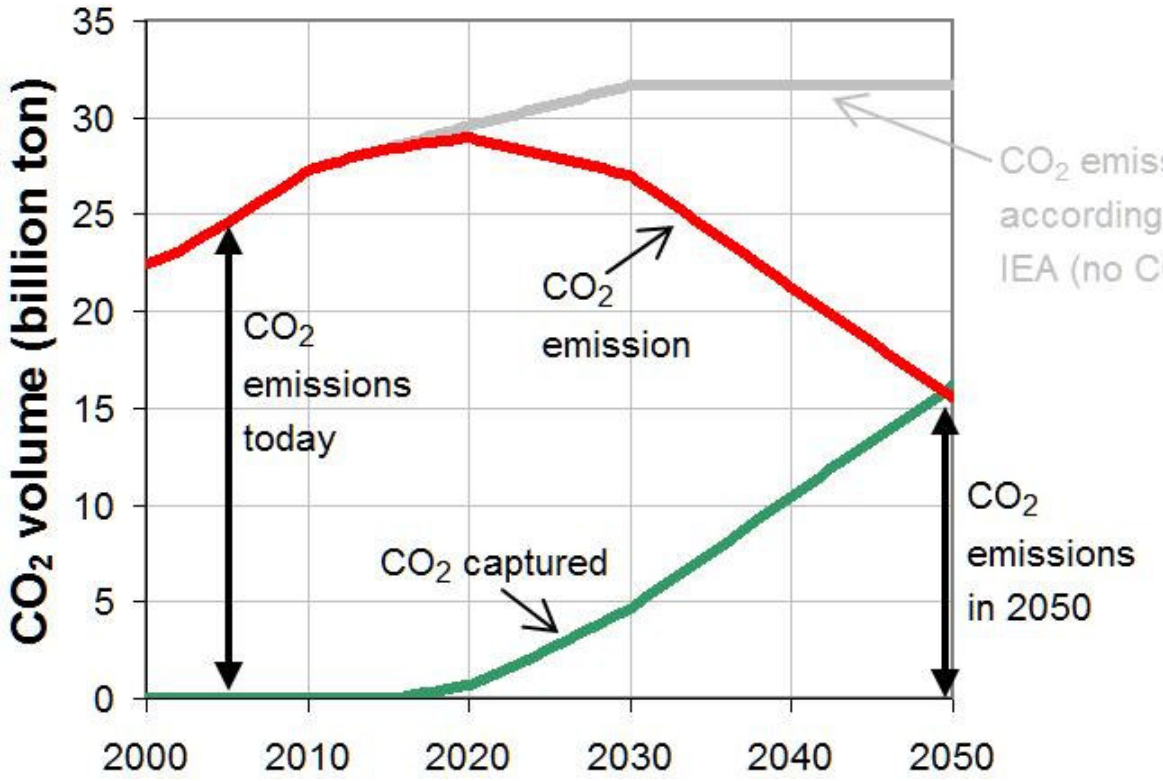
Source: www.hynor.no

Mazda RX-8 Source: www.hynor.no

CCS and Hydrogen production



Globally CO_2 Capture Potential

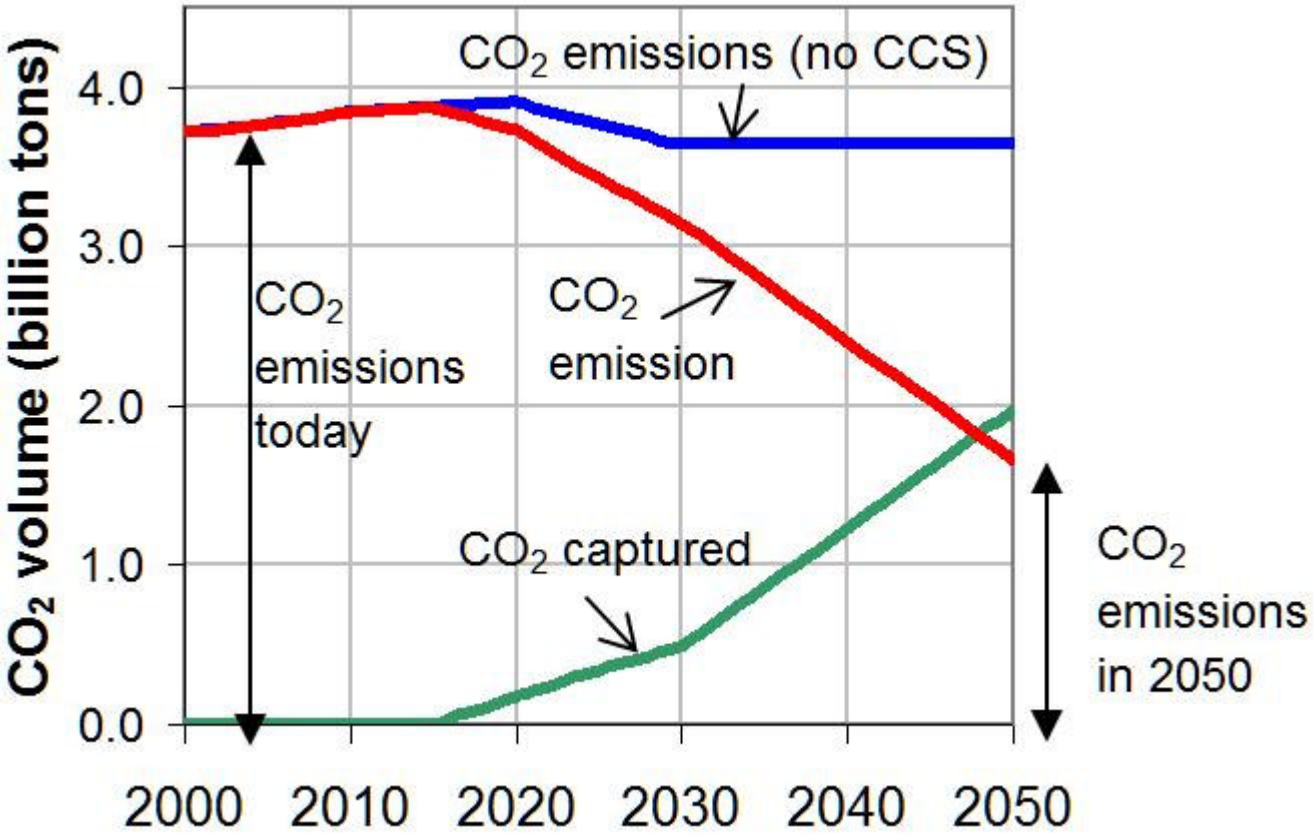


CO_2 emissions in 2050 reduced by

37 %

compared to emissions today

Potential for CO_2 Capture in the EU



CO_2 emissions in 2050 reduced by

56 %

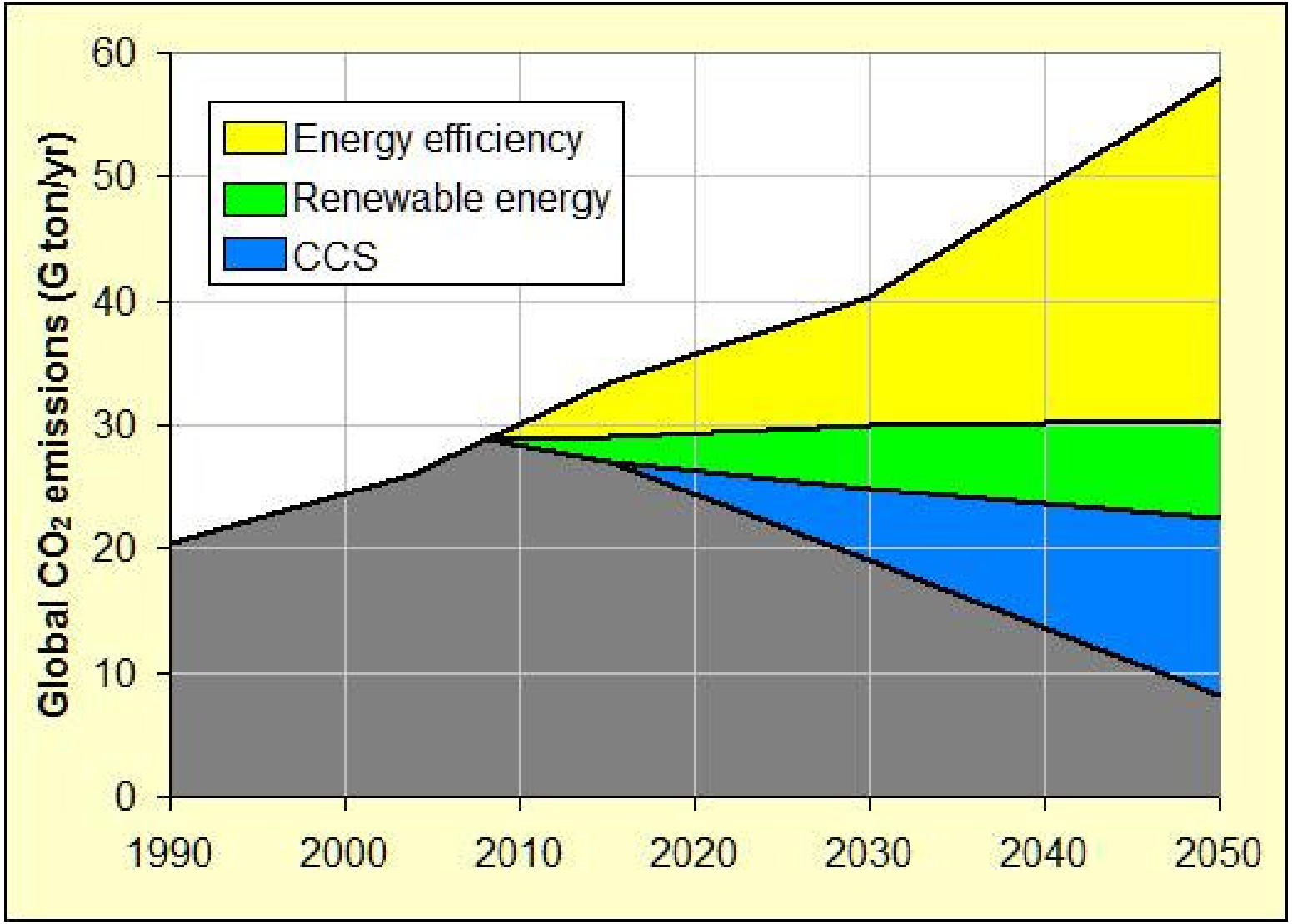
Compared to emissions today

Business opportunities

- The CO_2 capture potential equals:
  - ***150*** Coal Power Plants (750 MW) with CO_2 capture in EU by 2030
  - ***5 000*** Coal Power Plants (750 MW) with CO_2 capture globally by 2050

- Enormous business opportunities for CO_2 capture technology innovators

How to Reduce Global CO_2 Emissions

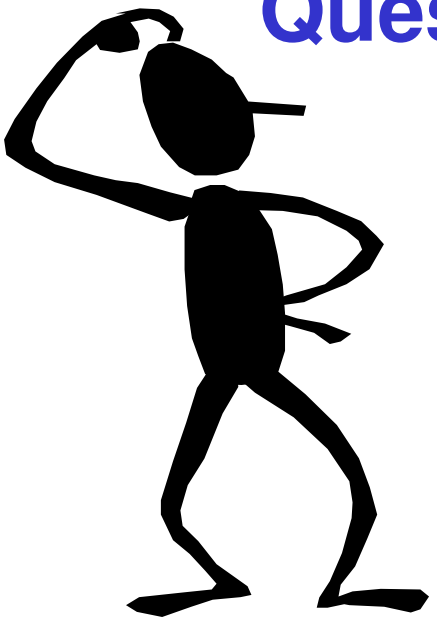


Summary

- Stabilizing the climate requires global CO_2 emissions cut by 50-80 percent by 2050
- This can only be achieved by combining:
  - *Energy efficiency*
  - *Renewable energy*
  - *CCS*
- ***There are no other alternatives with the potential for sufficient cut in CO_2 emissions***
- CCS can be combined with power plants, industry, bio mass and hydrogen production
- The Stern report: Mitigating actions are cheaper than no actions

Thank you for your attention !

Questions?



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1950s
2000s
2050s
From Pollution to Solution!
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Comment and analysis
Give carbon a decent burial
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Hydrogenbil – miljø hele veien
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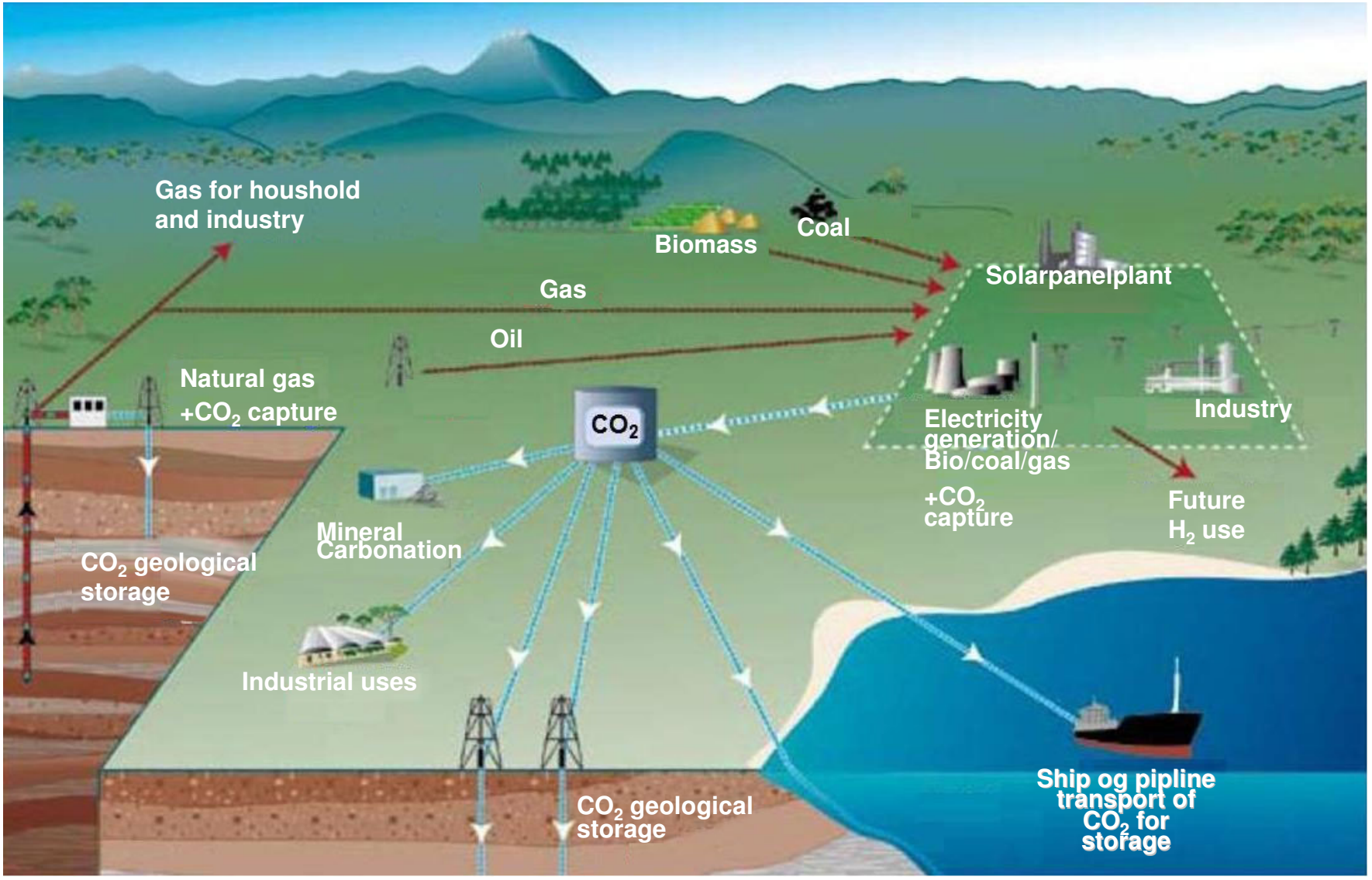
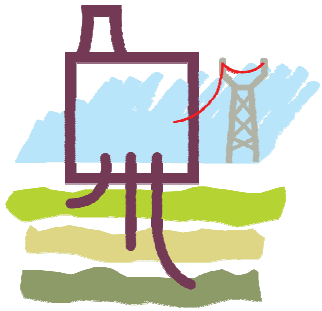
CCS Infrastructure



Kilde: CO2CRC and IPCC

Recommendations

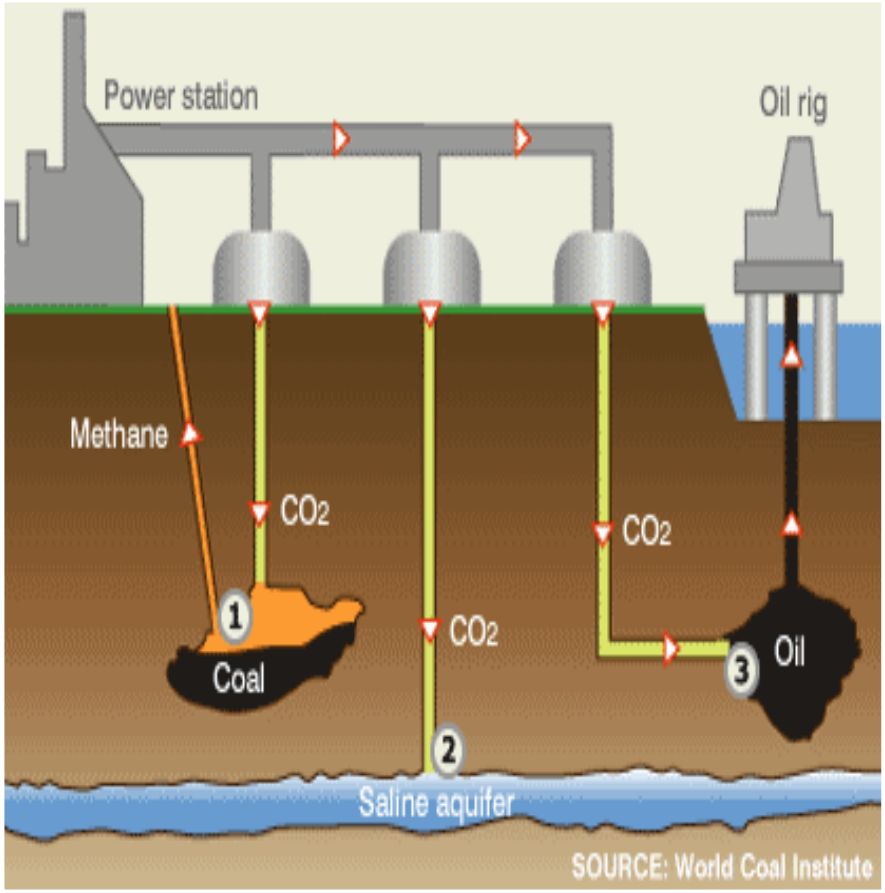

Zero Emission Fossil Fuel Power Plants

- **The Flagship Program:**
  Urgently implementing 10-12 integrated, large-scale CCS demonstration projects Europe-wide
- **R&D**
  Develop new concepts already identified for demonstration by 2010-2015 and support long-term exploratory R&D
- **Cooperation**
  Maximising cooperation at national, European and international level
- **CO_2 value chain**
  Kick-start the CO_2 value chain with urgent short- and long-term commercial incentives
- **Regulatory framework**
  Establishing a regulatory framework for the geological storage of CO_2
- **Public communication**
  Comprehensive public information campaign

Coal and CO_2 capture

- Why coal combined with CCS:
- High CO2 content in flue gas from coal power plants
- Coal gasification for H2 production
- CO2 injection in deep mines to produce metane
- Co-firing with 20 - 90 % biomass

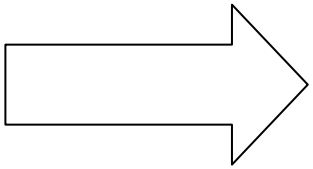
Bio/Coal power plant



Reducing the cost

- The first light bulb was not cheap, and the first mobile phone was not small

1987:
6 000 Euro
7000 g

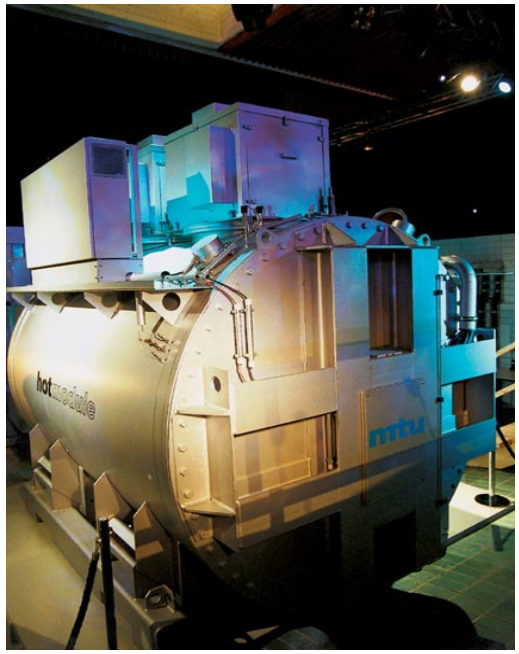


2004:
60 Euro
150 g

CCS – New possibilities

CCS combined with Fuel Cells

- High temperature fuel cells based on hydrogen or methane is the most effective power production (75 % efficiency).
- Low temperature fuel cells for onshore transport. More than twice the efficiency of traditional engines
- Fuel cells based on biomass, stranded gas and gas from coal



CO_2 capture and H_2 production

H_2 can be produced from steam reforming of low pressure gas:

- Stranded gas
- Gasification of coal
- Injection of CO_2 to produce *low pressure gas* from deep coal mines
- Biogas

CO_2 from H_2 production can be captured and stored

CCS and Power Production