Strategies for Securing Energy Supply while Promoting Environmental Policy Goals

International Council for Capital Formation

Brussels 18th October 2005

Lars Strömberg

Vattenfall AB

Stockholm/Berlin

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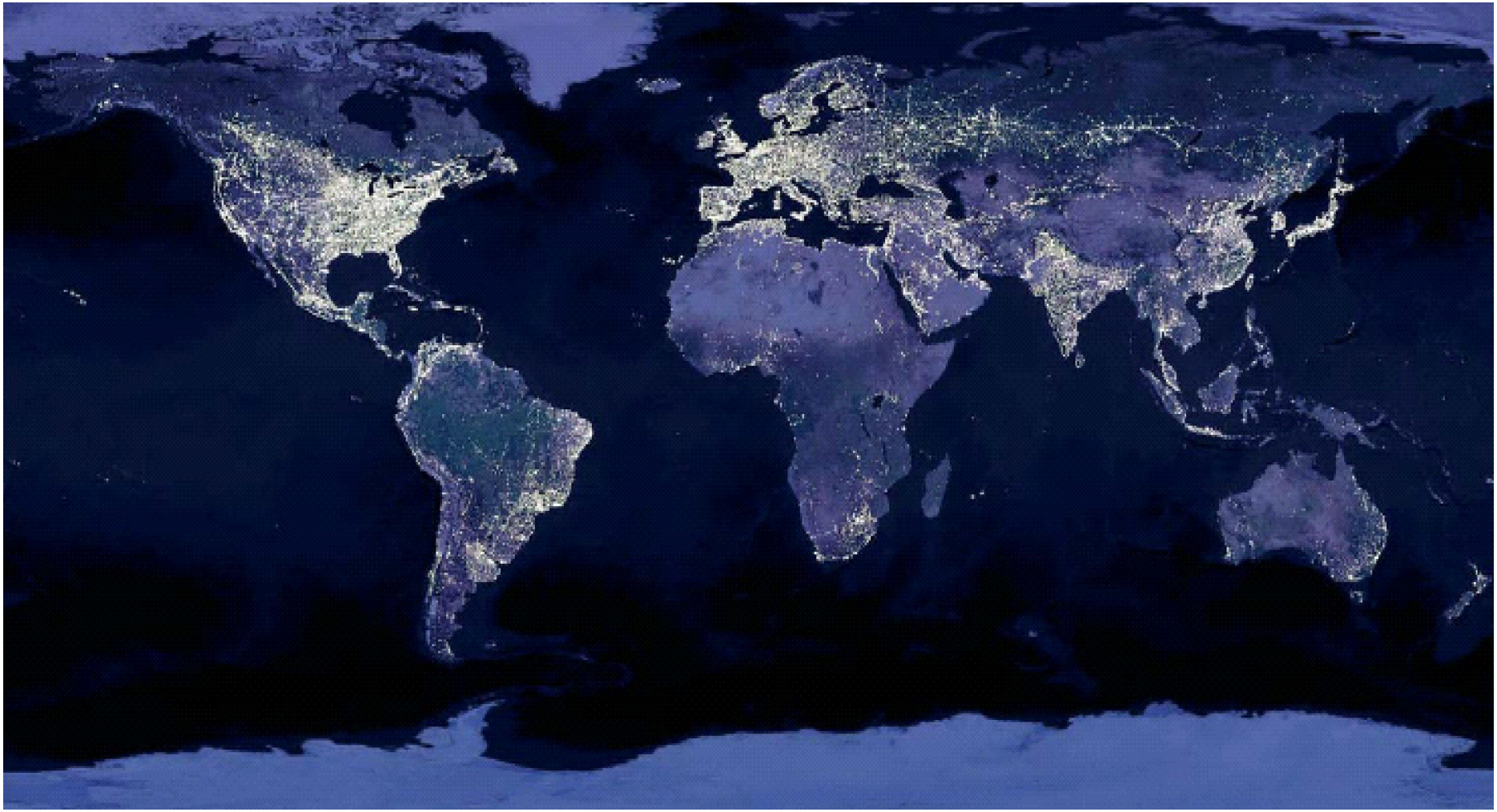
The Climate Change

- The Climate Change problem is for real
- EU ministers have agreed on, that we have to reduce the emissions to maintain a reasonable CO2 concentration in atmosphere
  - 15 – 30 % until 2030
  - 60 – 80 % until 2050
- A radical solution is necessary. We cannot wait

Who’s got the problem ?



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The Problem

- Fossil fuels are needed
  - Analysis show that fossil fuels will remain as major energy source in 2030 (85 %)
- The top priority is to introduce renewable energy sources in the energy system
  - All analysis show that renewable energy sources will play a large role, but not large enough and soon enough
- In several countries nuclear power is decommissioned
- No renewable energy source not known today can play a significant role in 25 years from now, i.e. 2030

Emissions from fossil fuels must be reduced

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Schwarze Pumpe power plant

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One solution is the CCS

- Carbon Capture and Storage, CCS can offer one solution with the largest potential so far.
- CCS can give an almost zero emission technology
- CCS is less expensive than most renewable energies today
- CCS is not the ultimate solution, it is a bridging technology to the sustainable solutions which have to be found

Capture and storage of CO_2

Capture and storage

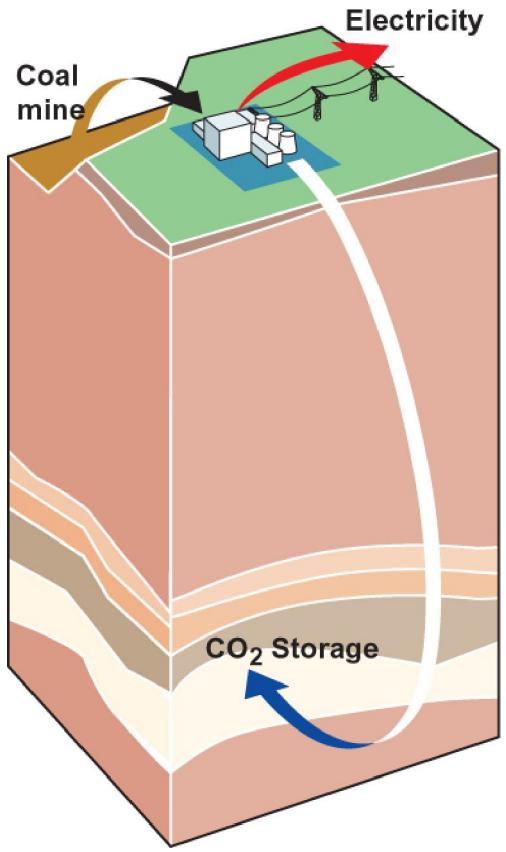
- The bridging technology to the future

The CO_2 free Power Plant principle

The principle of capture and storage of the CO_2 under ground

The CO_2 can be captured either from the flue gases, or is the carbon captured from the fuel before the combustion process.

The CO2 is cleaned and compressed. Then it is pumped as a liquid down into a porous rock formation for permanent storage.



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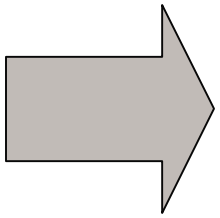
Long lasting and acceptable solution with coal ?

- CO_2 emissions to the atmosphere from coal and other fossil fuels can be eliminated by CO_2 separation and underground deposition at lower cost than most of the renewable alternatives.
- If so - coal can be considered a long lasting energy solution, since resources are so large and widespread.
- This would also satisfy the strive for security of supply



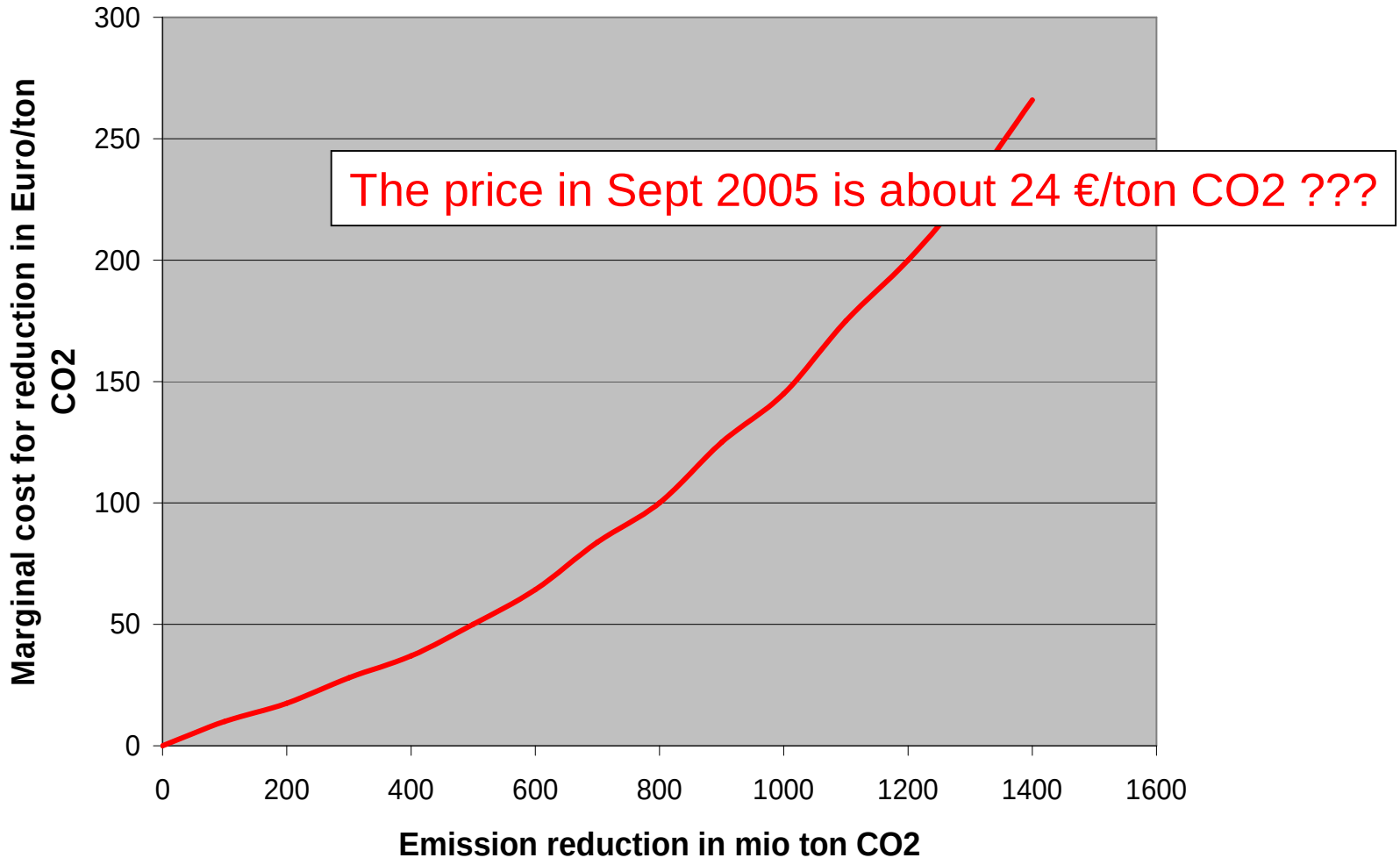
- CO_2 separation and storage will not be effective until about 2020
- Demonstration plants will be built during this time

Emission Trading

Emission Trading sets the commercial framework for new technology in Europe

Marginal cost vs. Reduction of CO2 emissions in EUR/ton CO2

Source: ECOFYS Economic evaluation of sectorial reduction objectives for climate change



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CO_2 free power plant

Storage and transport

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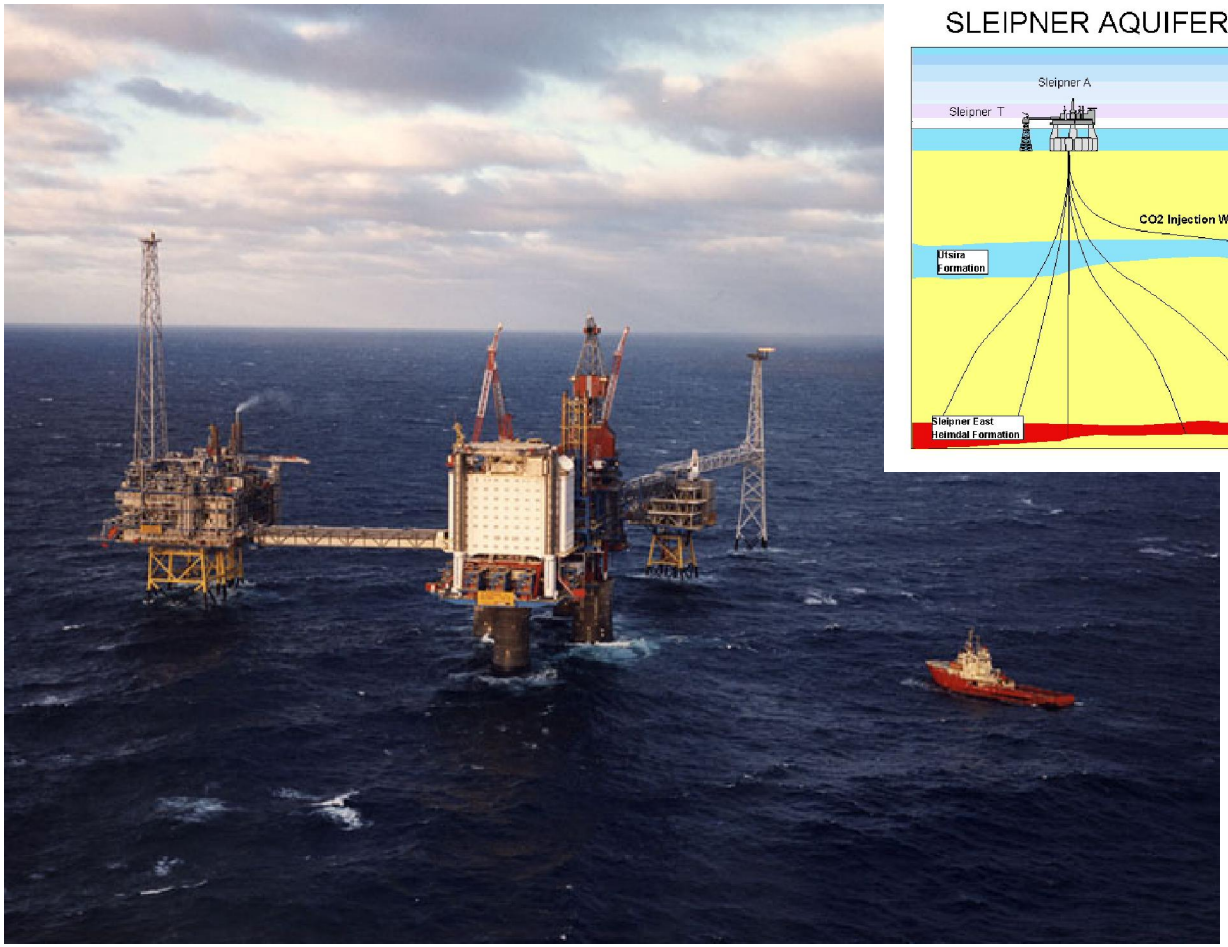
Storage of CO_2 in a Saline Aquifer under the North Sea



CO_2-injection into the saline aquifer Utsira. (Source:STATOIL)

The Sleipner field. Oil and gas production facilities. (Source: STATOIL)

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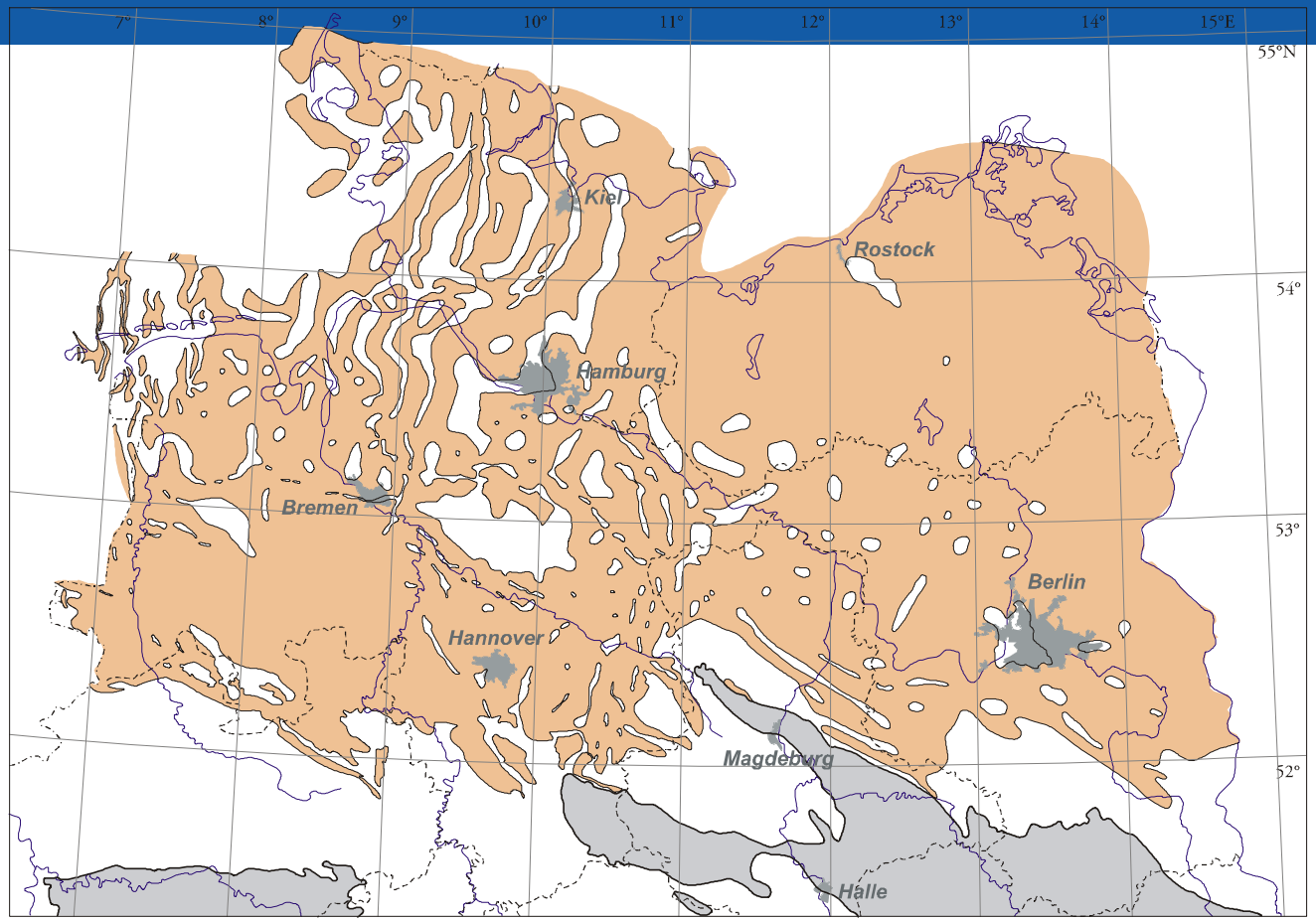
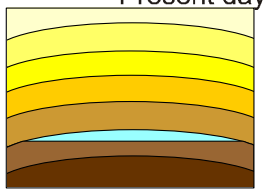
Storage Capacity, saline aquifers



Distribution of Rhetian Basement below Cenozoic cover

Present day distribution of the Rhetian - aquifers (a. DIENER et al. 1984, FRISCH & KOCKEL 1998)



There exists more storage capacity within Eorope (and in the world) than the remaining fossil fuels

Source:

Franz May,

Peter Gerling,

Paul Krull

Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover

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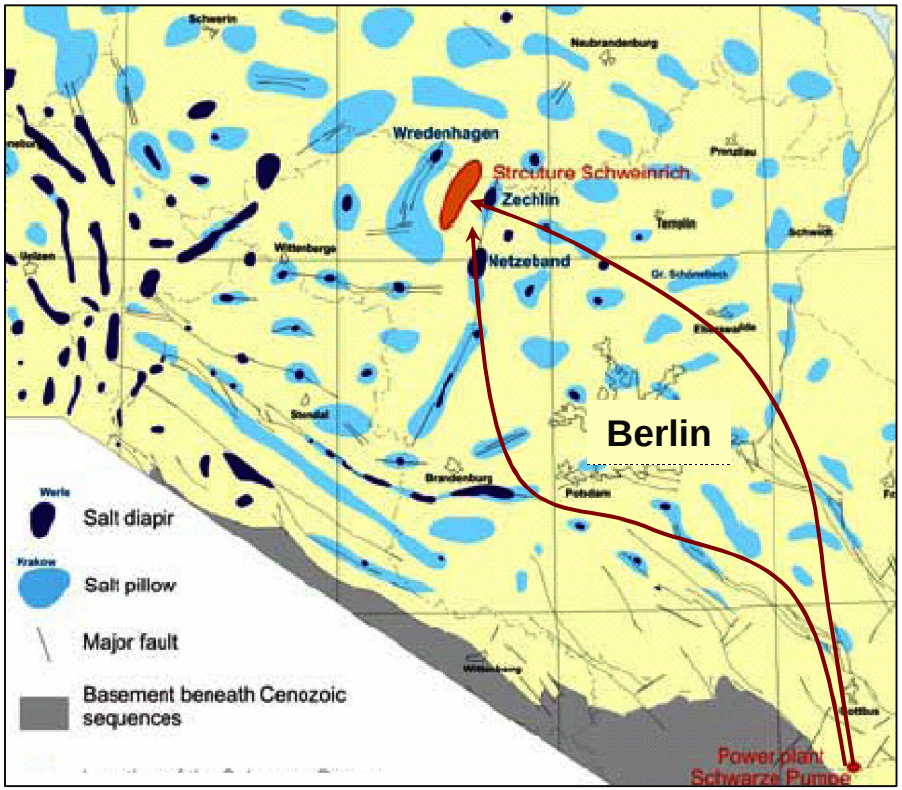
CO_2 Transport and storage Schweinrich structure



- Two pipeline transport routes are possible
- Both routes can be designed to follow existing pipeline corridors >90%
- Structure can contain 1,4 billion ton of CO2, equivalent to about emissions from 6000 MW their whole lifetime

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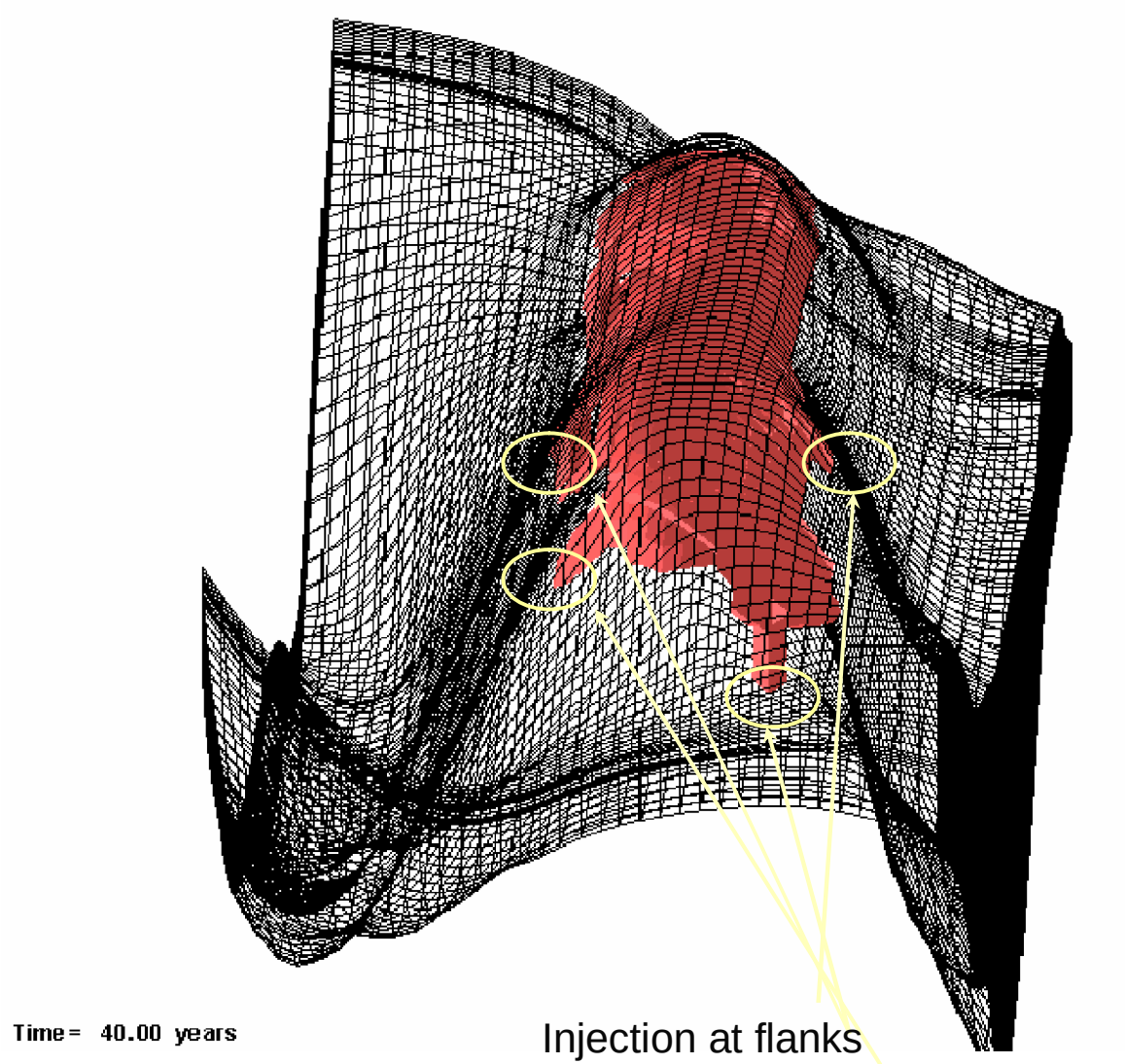
Reservoir simulation – 40 year model



Injection at flanks

- Due to buoyancy, the CO_2 strive against the top of the formation
- The CO_2 spreads in the whole reservoir
- Conclusion: It is possible to inject 400 Mt CO_2

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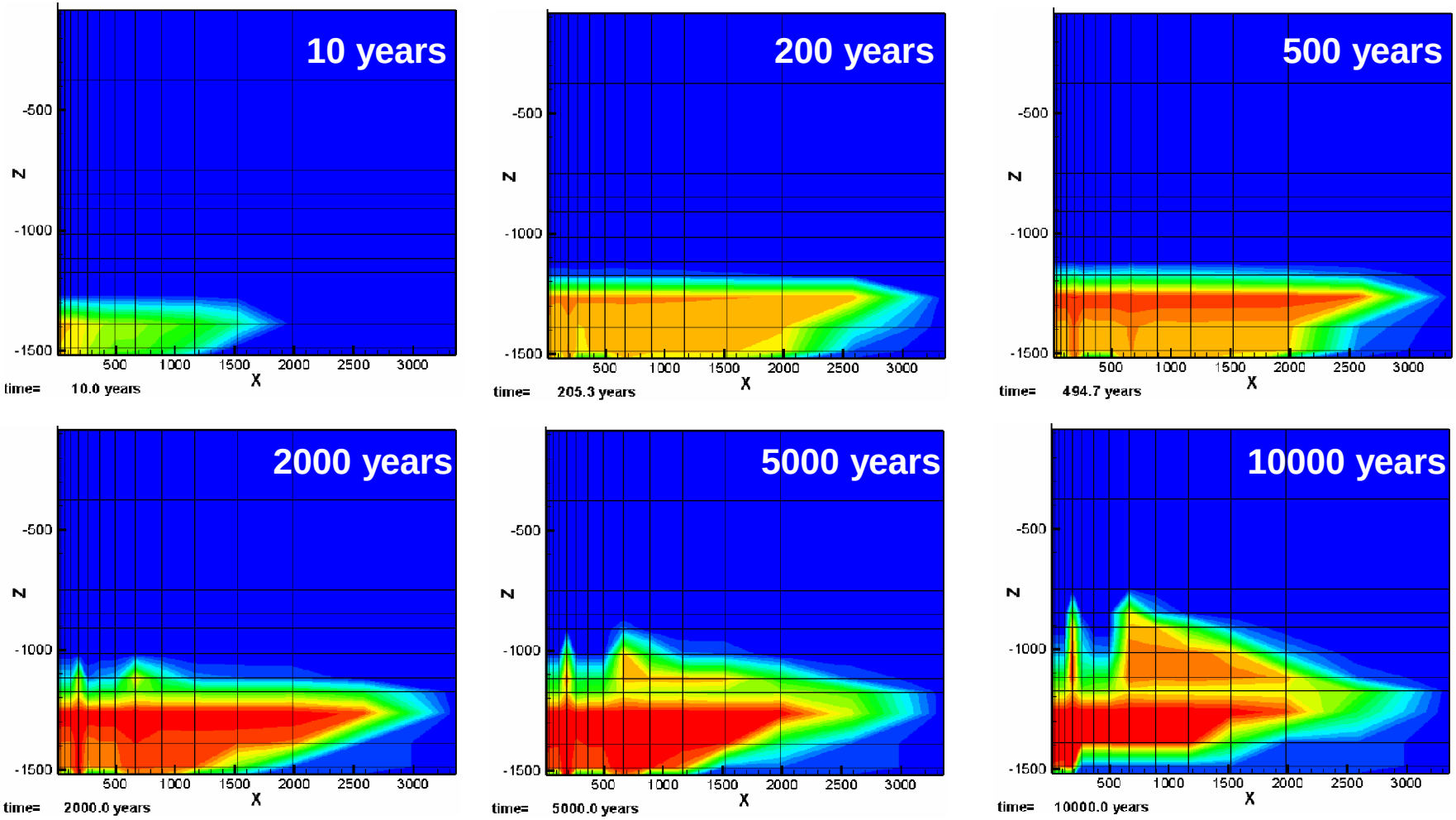
Geological structure modelling. Schweinrich



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CO_2 storage cost

Storage at Schweinrich of 10 Mton CO_2 per year over 40 years:

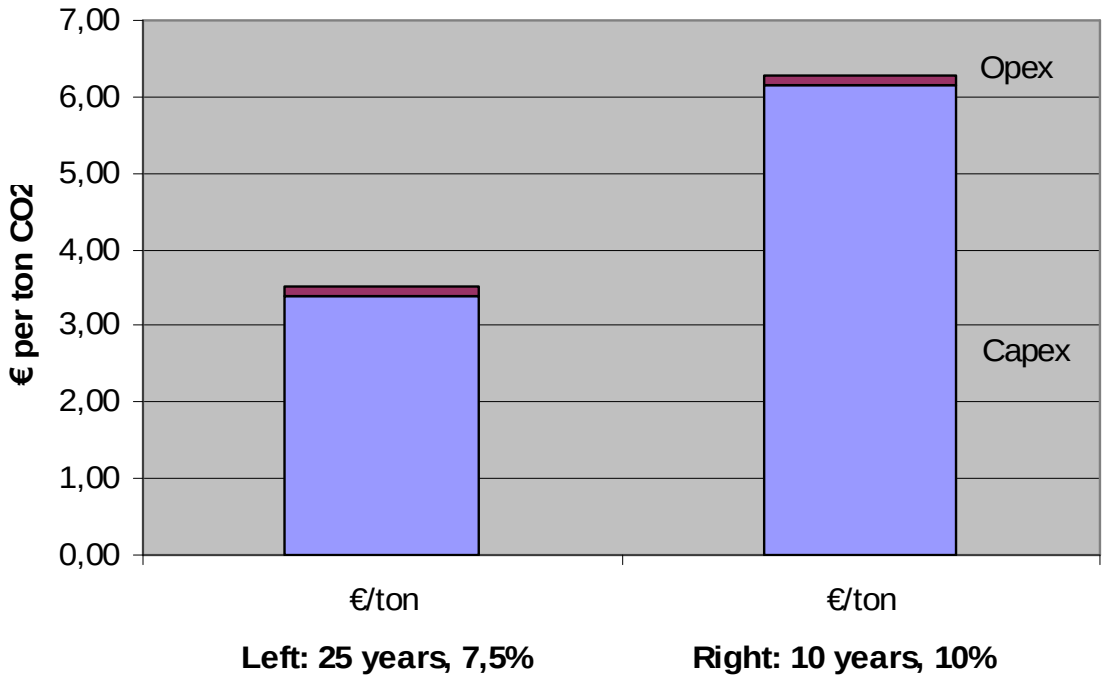
Parameter	Units	Base case	High cost case
Discount rate	%	12	18
Number of wells	-	6	12
Drilling cost	€/m	1000	2000
Platform cost	M€	20	50
- Feasibility phase		0.3	1
- Investigation phase		5.7	9
- Injection equipment		14	40
O&M	M€	3	10
Post operational cost	M€	0.3	1
Resulting cost	€/ton CO_2	0.7	3

Fictive cost calculations using tool developed in EU-funded GESTCO project:

CO_2 transport cost:

Transport to Schweinrich from Schwarze Pumpe power plant:

- Distance 320 km
- 10 Mton CO_2 per year over 40 years:



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CO_2 free power plant

Capture

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CO_2 Free Power Plant: Technology Choice

The ultimate technology choice is not clear yet. Several technologies will probably be applied to different commercial situations.

- Post combustion capture.
  - At present the most expensive option but commercially available in large size.
  - Can be applied to existing plants.
  - Needs no demo. Optimization of existing options needed.
- Pre combustion capture.
  - The most complicated technology. IGCC demos have not been successful
  - Produces hydrogen as integrated intermediate fuel for the power process, from coal or gas.
  - Development need for the gas turbine run on hydrogen – Lab tests + pilot + demo
- CO_2/O_2 (oxy-fuel) capture
  - The most preferred option at present
  - Technology straight forward and builds on the modern supercritical coal fired boilers
  - Tests in technical scale positive. Needs pilot plant and demo plant
- Chemical Looping technology is the most interesting long term option.
  - Lab experiments very encouraging.

CO_2 free power plant

Pilot Plant

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Construction area

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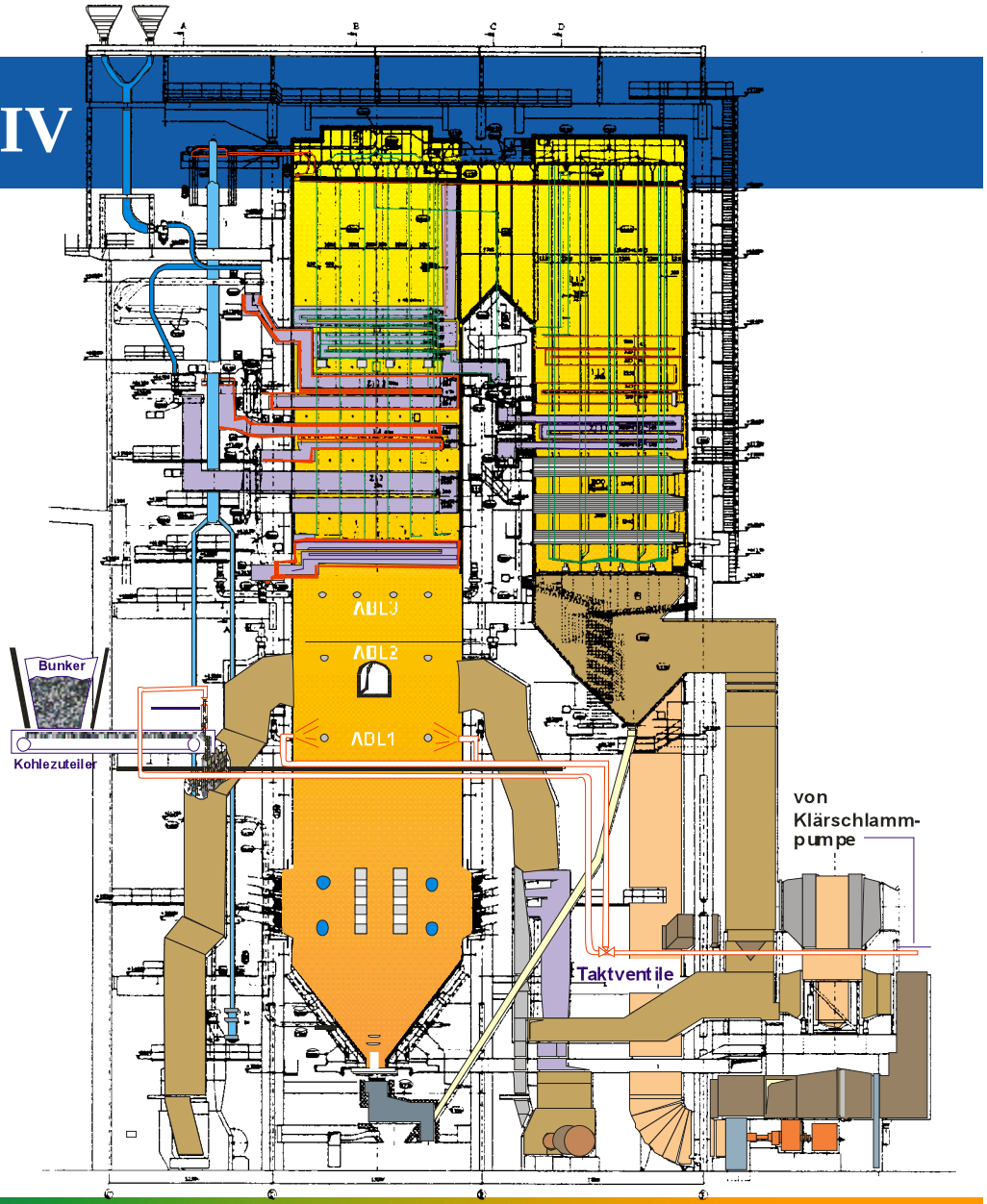
Boxberg IV

Why Oxy-fuel technology ?

We work with all three (four) technologies, but:

- Oxyfuel technology is the technology giving lowest costs at present
- It is suitable for coal and have relatively little development work left
- We can build on our good experience with present PF technology



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Analysis of some technology options

Options for reduction of CO_2

- Specific data for the plants

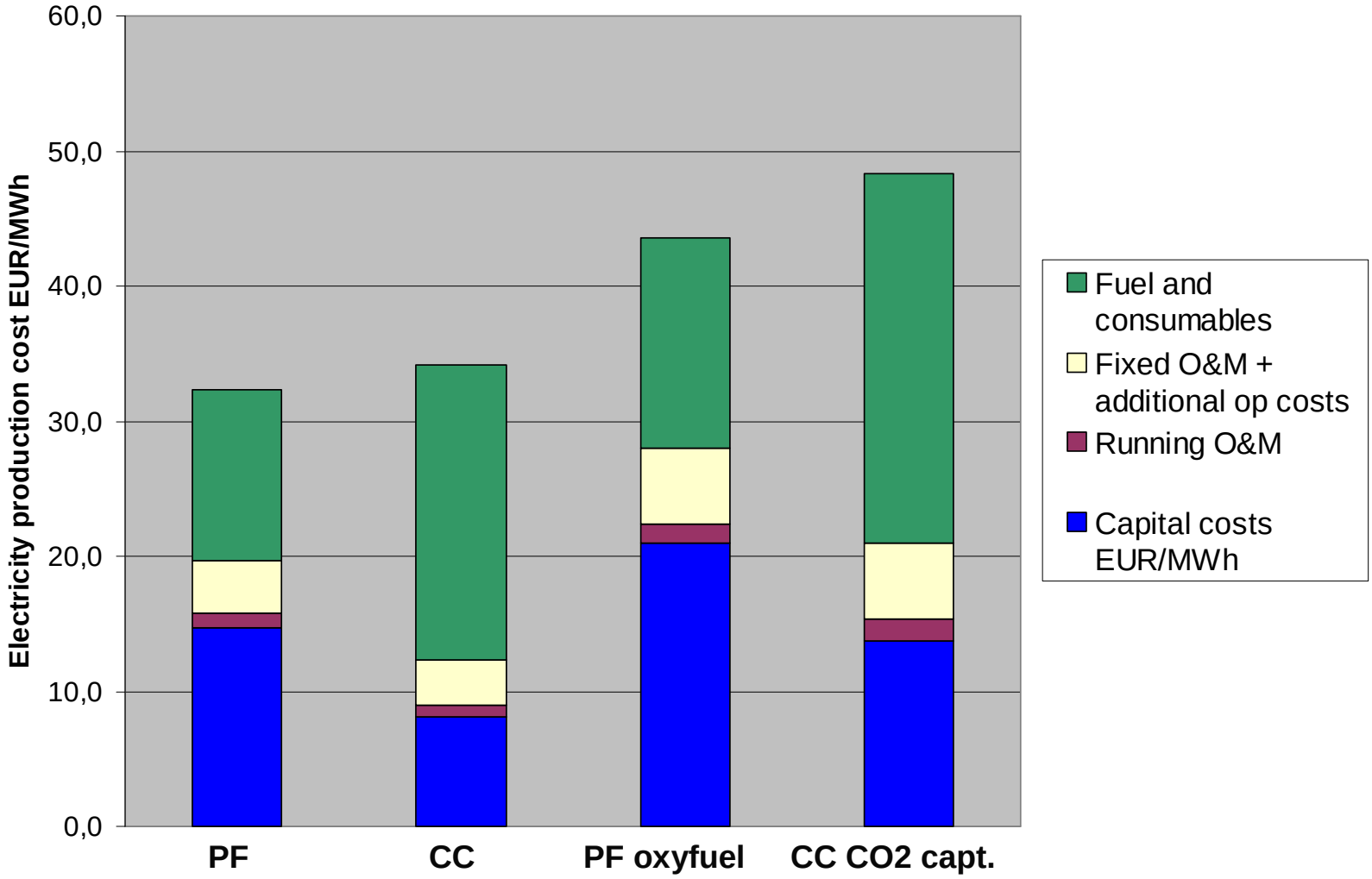
	PF	CC	PF oxyfuel	CC with capture
Specific Investment costs €/kWe	1000	550	1425	938
Additional investment mio €			140	100
Power output MW	900	500	720	405
Energy penalty MW			180	95
Efficiency %	45	60	36,5	49

Options for reduction of CO_2

- Common data used for the four plants:

Coal Price	50 $/ton ~ 5,7 €/MWh
Gas price	13 €/MWh
Depreciation time	25 years
Interest rate	10%

Electricity generation costs



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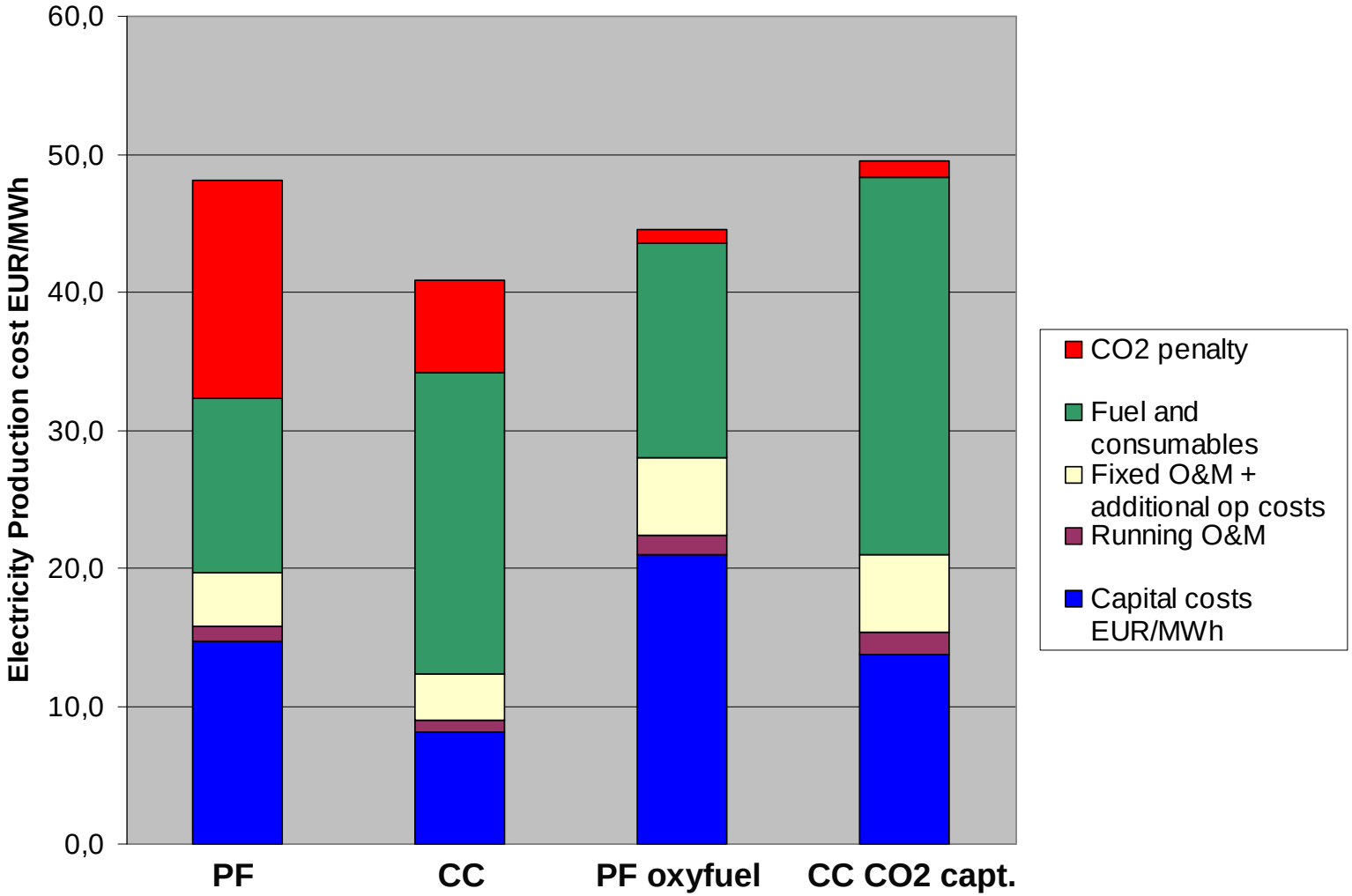
Generation costs incl. CO_2 costs (20 €/ton)



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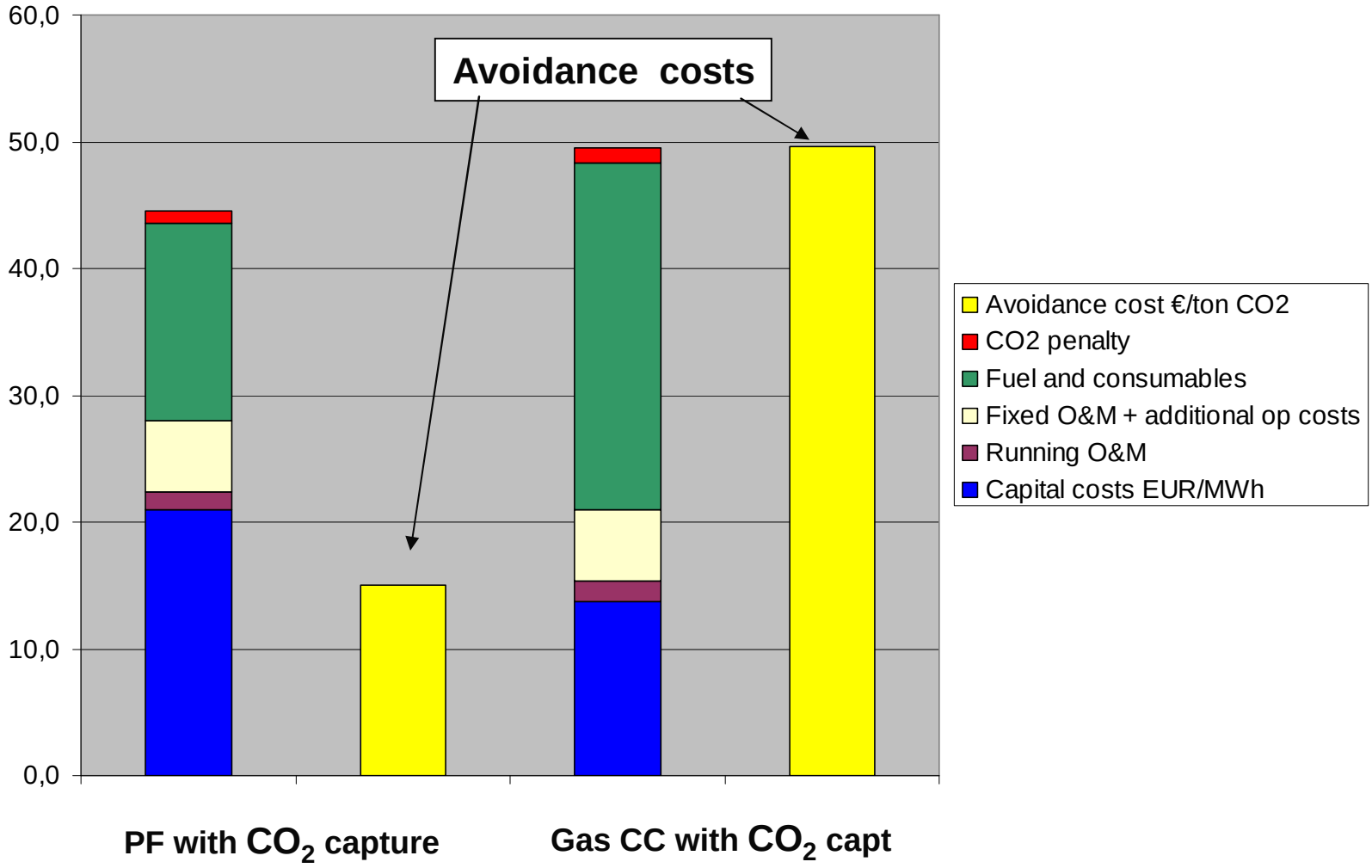
Avoidance costs of CO_2



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Taking responsibilty

- Lord Oxburgh, former chairman of Shell Transport and Trading:

  "CCS is absolutely essential if the world is serious about limiting greenhouse gas emissions“

- The new report from the Intergovernmental Panel on Climate Change (IPCC) concludes:

  “CCS could achieve more than half of the emissions reductions necessary to mitigate climate change up to 2100”

Vattenfall agrees with this. We also believe CCS is needed to fulfill our climate goals