”Views on Carbon Capture and Storage and the Social, Legal and Financing framework”

The 2nd Ministerial meeting of the CSLF

Melbourne, September 13-15, 2004

Lars Strömberg

Vattenfall AB

Group Function Strategy

Stockholm/Berlin

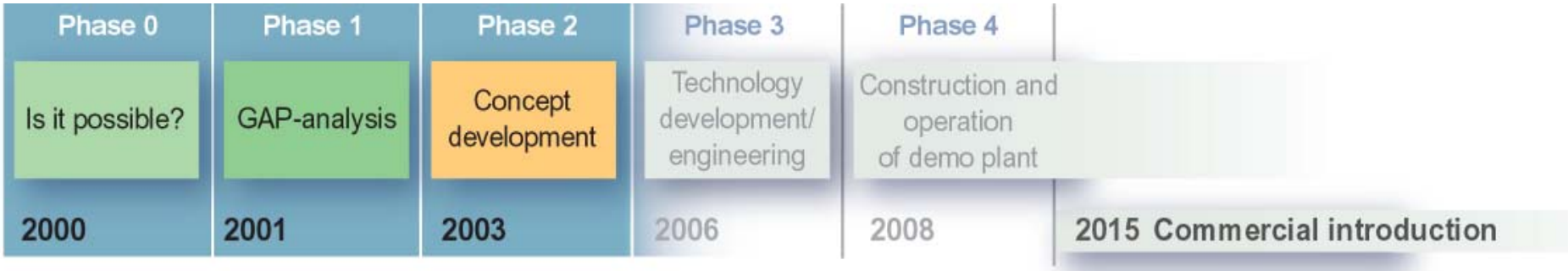
The Vattenfall Group

- Vattenfall is one of the major Energy companies in Europe
- Vattenfall sells about 180 TWh electricity
  - The main part is produced by hydropower, nuclear power, coal and natural gas.
  - A smaller part is produced by biofuels and wind power
  - About 17 TWh is produced in combined heat and power plants
- Vattenfall also sell about 37 TWh heat
  - The main part is produced by biofuels, coal and gas in cogeneration plants
- Vattenfall emits almost 80 million tons of CO_2 per annum

CO_2 free power plant

Take responsibility and do something

CO_2 free power plant: 15 years of R&D



- Development target 20 €/ton stored CO_2
- Initial feasibility studies in 2001
- GAP analyses in 2002
- Concept development in 2003-2006
- A 250 MW electric demo-plant by latest 2010
- Commercial concept after 2015

CO_2 free power plant

Question: Why not renewables ?

Answer: Both – and, but renewables is not enough

Fossil fuels – an essential part of our society

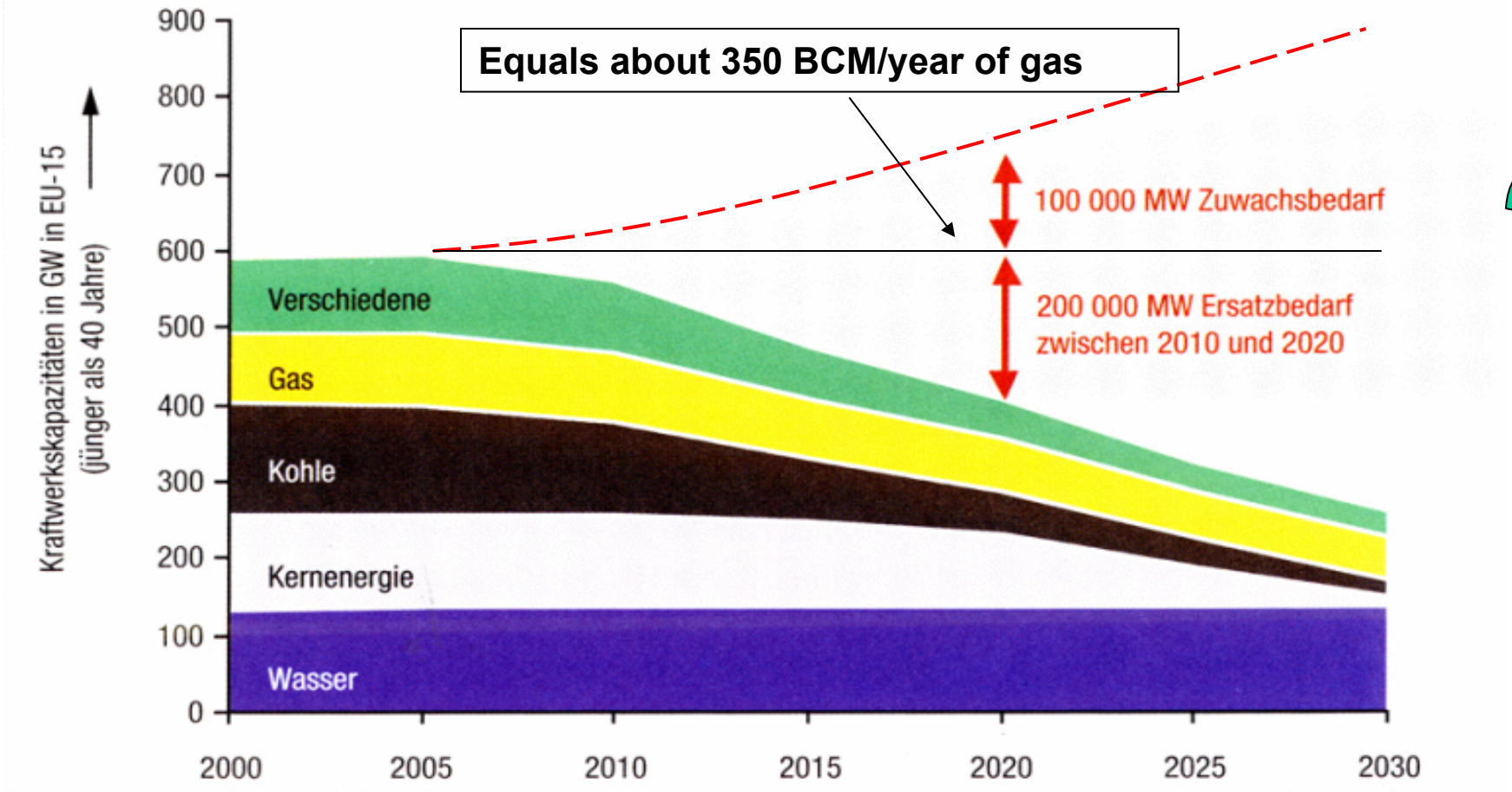
Today, fossil fuels are completely dominant in world wide energy supply. World Energy Outlook 2002:

"*Global primary energy demand is projected to increase by 1.7% per year from 2000 to 2030. Fossil fuels will remain the primary sources of energy, meeting more than 90% of the increase in demand*"

According to the Green Paper on Energy Supply, 80% of the energy consumption in EU-30 derives from fossil fuels:

EU 30	Today	2030
Fossil fuels	80%	85%
Nuclear	15%	6%
Renewables	6%	8%

Need for new capacity in Europe (EU 15)

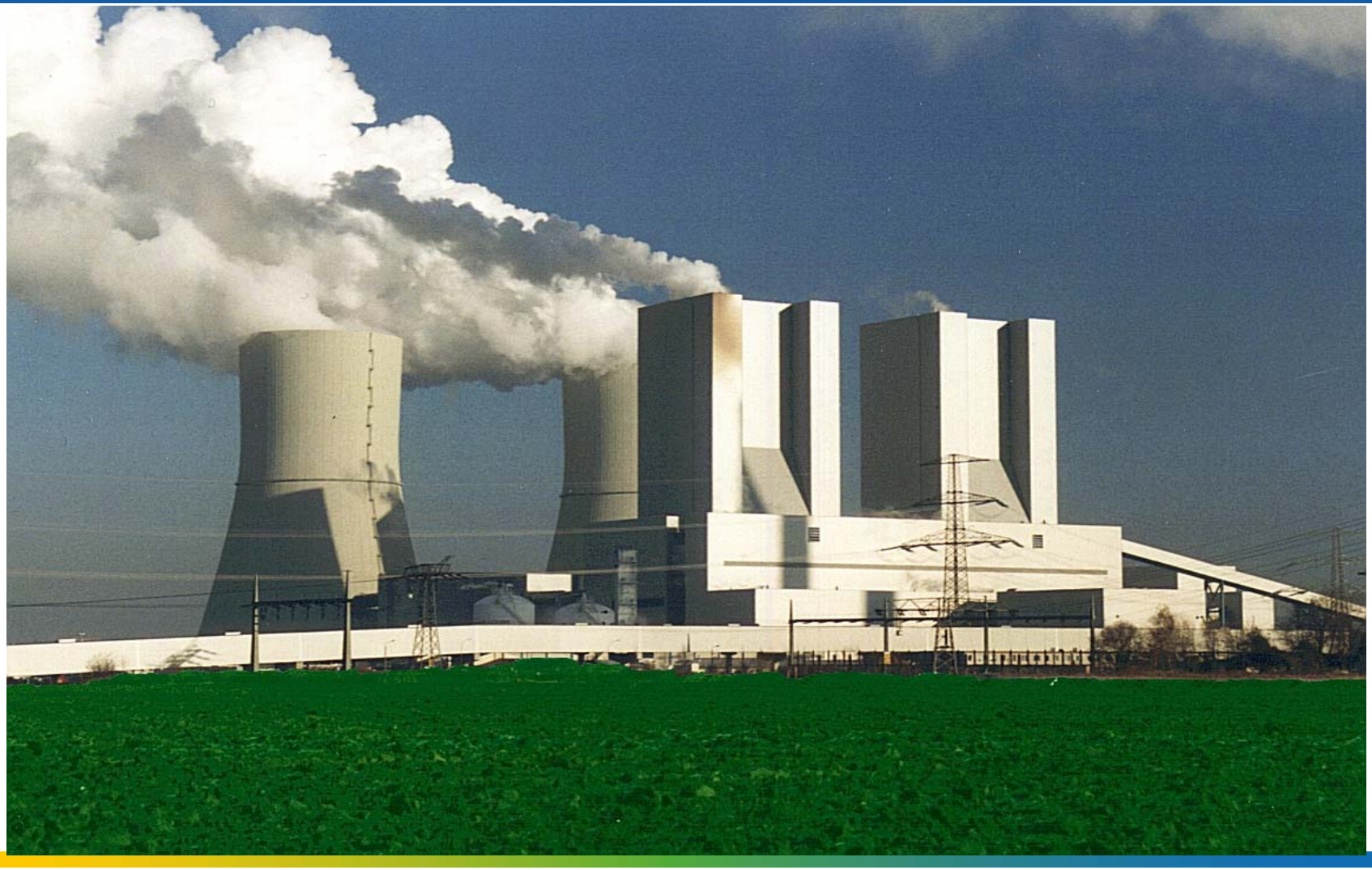


Source: VGB PowerTech Annual Report 2002 / 2003 + EU and Eurelectric

CO_2 free power plant

The big challenge for Coal is the CO2 issue

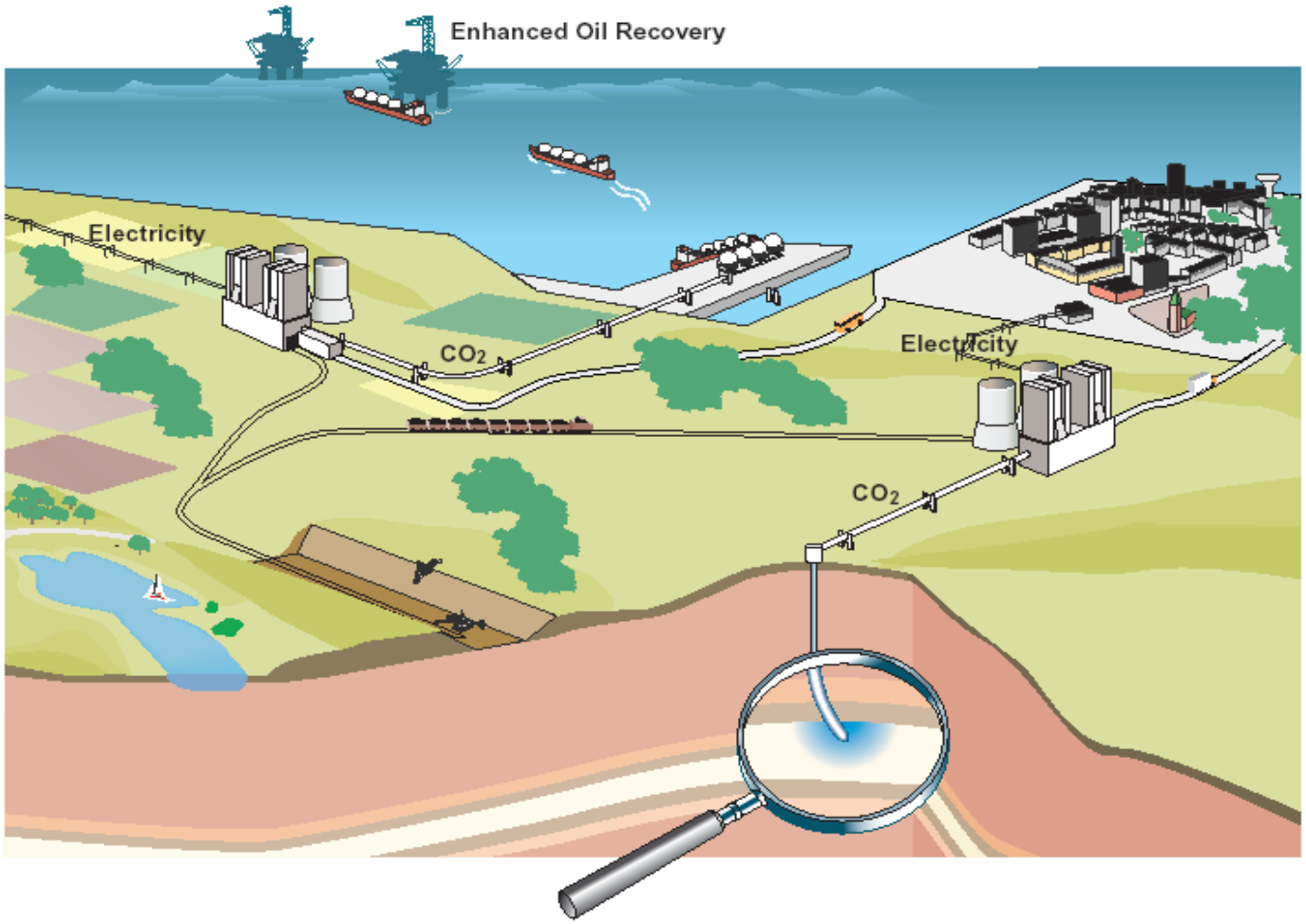
Power Plant Lippendorf



CO_2 free power plant

Gap Analysis – what do we have to do ?

CO_2 Capture and storage



Focus of the work to reduce CO_2

Focus is different for each part of the chain

- Capture
  - Develop and evaluate the concepts
  - Cost, cost plus cost reduction
  - Verification and validation
- Transport
  - Apply known concepts to this scale
  - How to develop and infrastructure
- Storage
  - Verification of technology
  - Potential, actual availability
  - Risk, Security and Environmental consequences
  - Building confidence and acceptance

CO_2 free power plant

Building confidence

Storage of CO_2 in a Saline Aquifer under the North Sea

CO_2-injection int
the saline aquife
Utsira.
(Source:STATOI

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

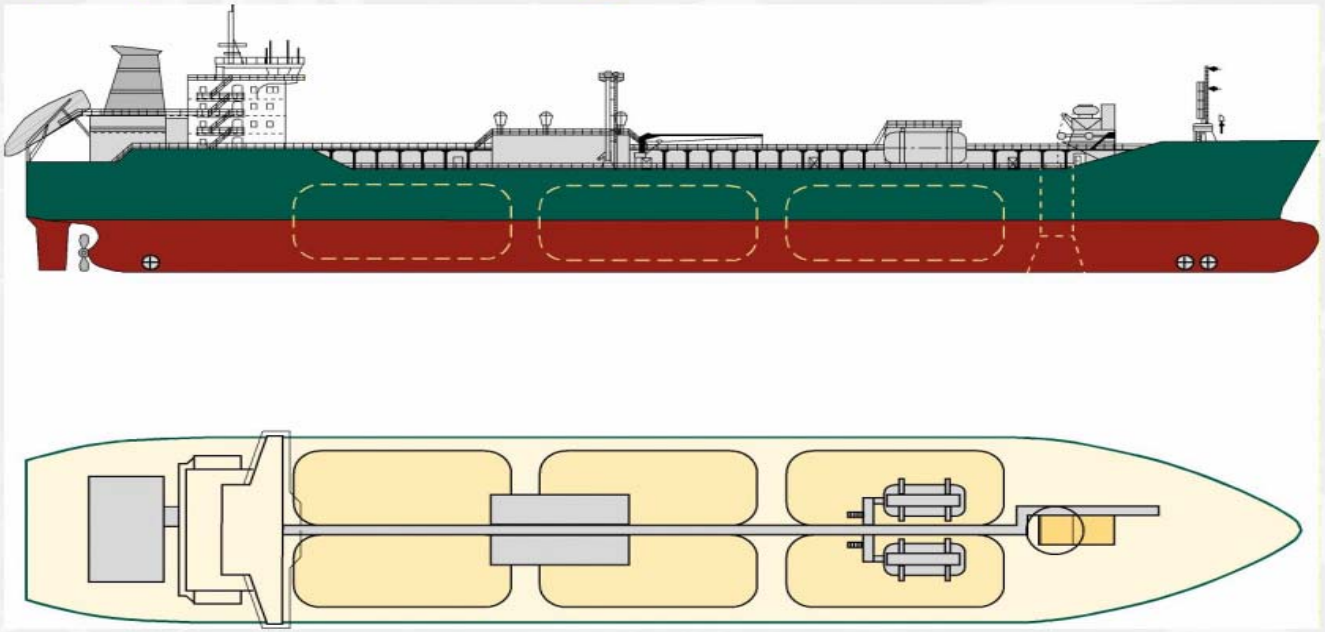
Transportation with water carriers

Transportation of CO_2 in Semi-Cooled Ships.

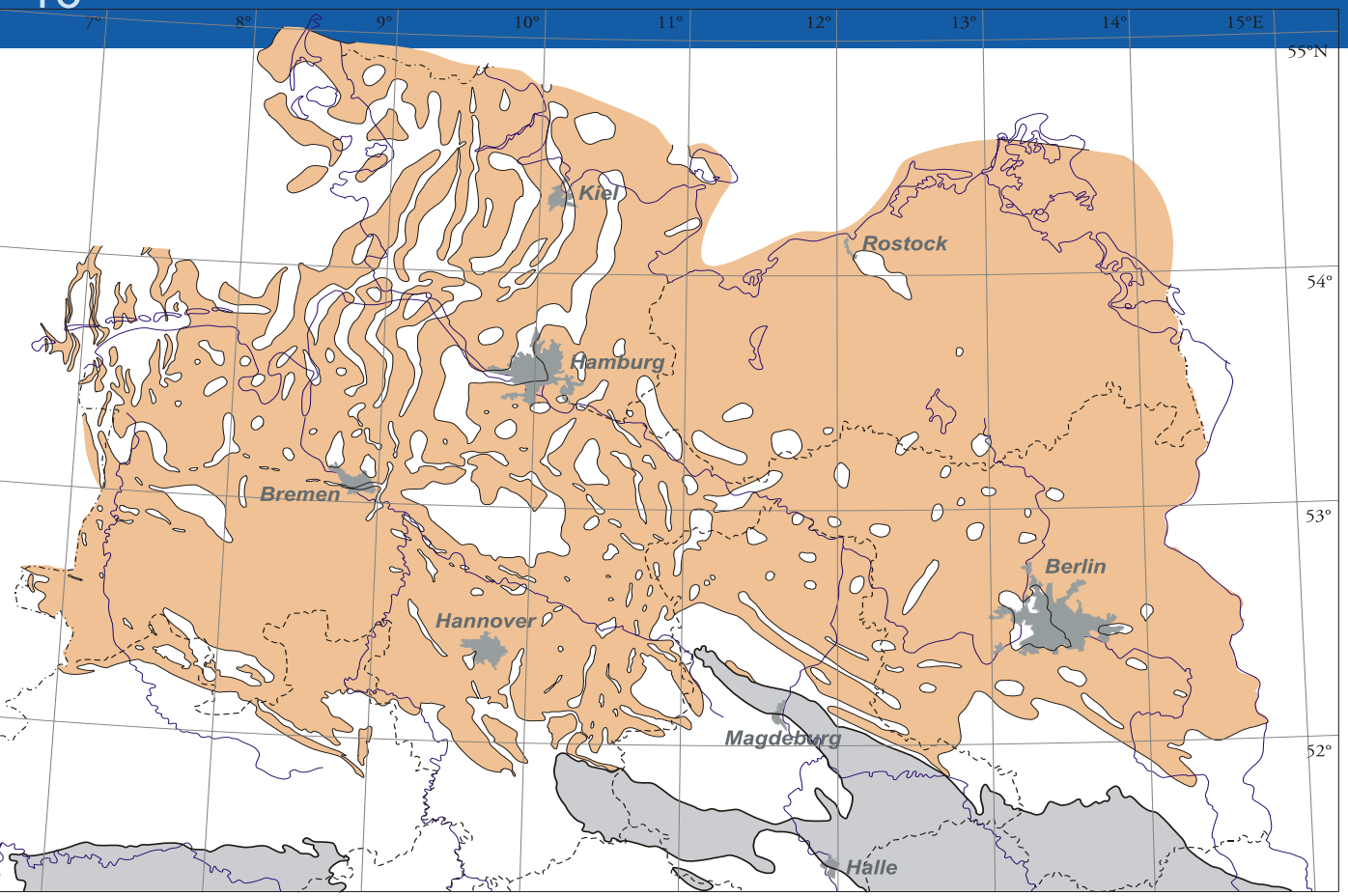
STATOIL

Illustrated ship has a carrying capacity of 20 000 m3

Project participants: Navion, SINTEF, Vigor and Statoil



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)

Specific problems:

- structurally complex
- thickness variation
- porosity variation
- residual saturation

Source:

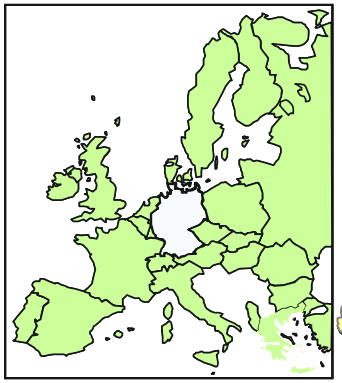
Franz May,

Peter Gerling,

Paul Krull

Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover

CO_2SINK



underground gas storage facility to be shut down

North German Basin

CO_2 Storage In a Natural aquifer in Ketzin

Aerial view of the Ketzin underground storage site

Emission Trading

Emission Trading sets the commercial framework for new technology

The EU scheme for GHG emission trading

"The Directive establishes a scheme for greenhouse gas emission allowance trading within the European Community to promote reductions of greenhouse gas emissions in an economically efficient manner".

Adopted by European Parliament 2 July 2003

Sept 2003: Adopted by European Council

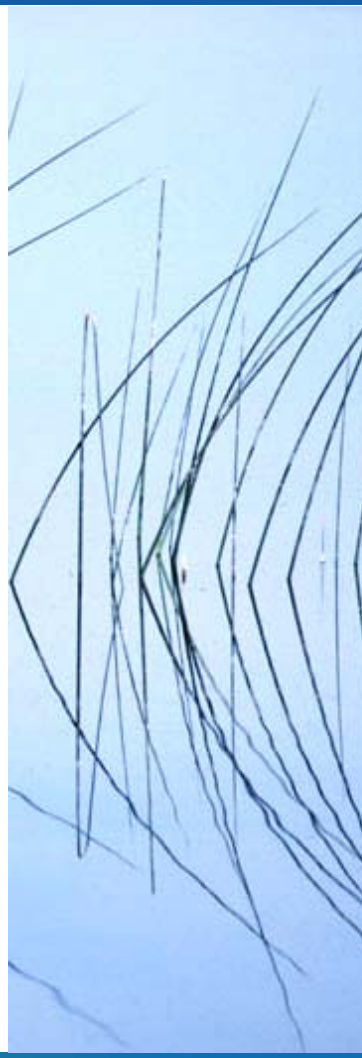
March 2004: National Allocation Plans

Sept 2004: Allocations fixed

January 2005: Effective

First period: 2005-2007

Second period: 2008-2012



The EU emission trading system

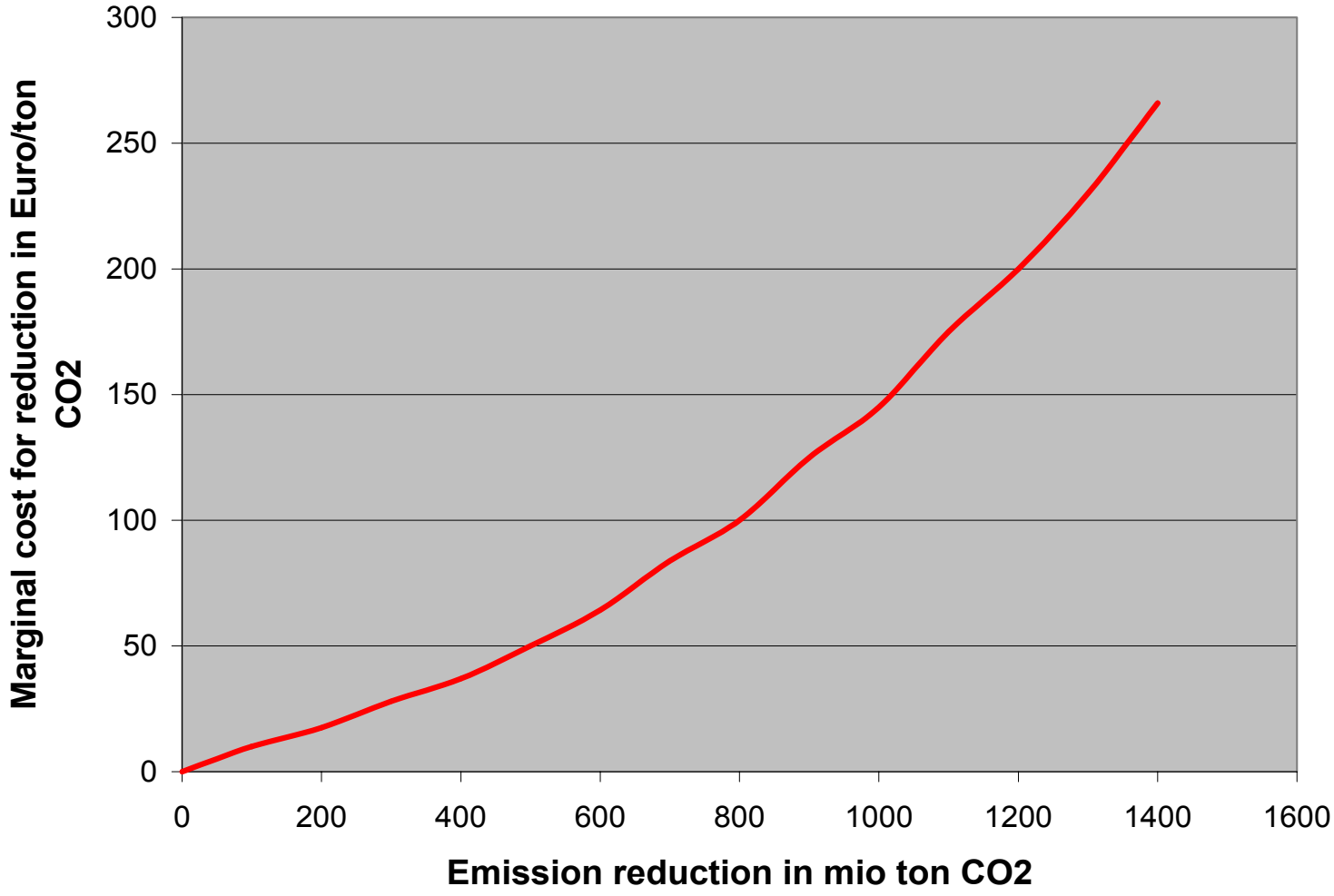
The long term price of the allowances will be set by reduction requirements and the costs of physical reduction

As emission allowances become scarce they will have an increasing value

The cost for allowances will be added as a direct marginal production cost and therefore increase the spot price of electricity

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

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



Analyses show that…

by 2010 …..

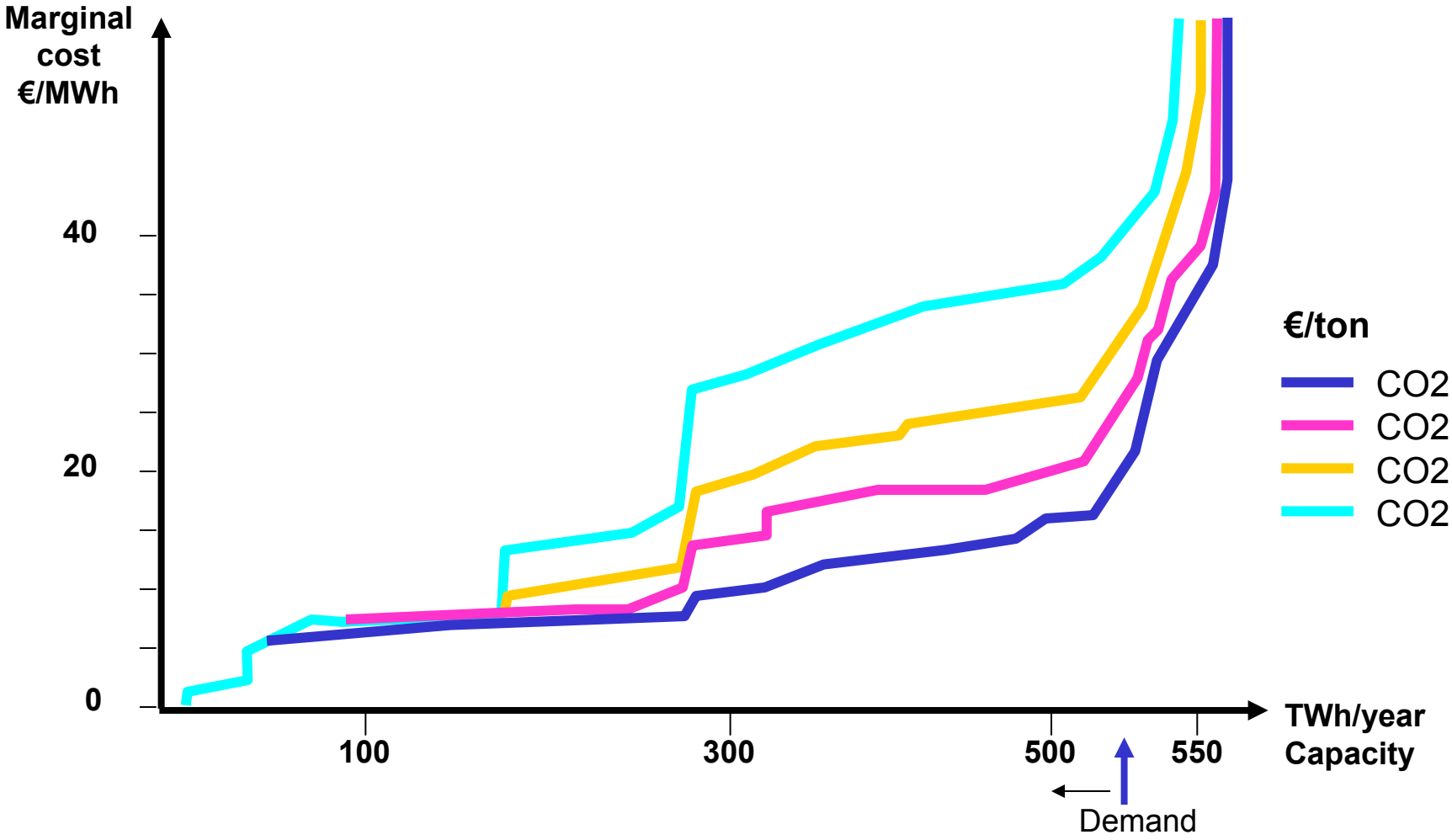
- Costs for emission allowances might be around 10 EUR/ton of CO2

but in 2015….

- If the trading system prevails
- When new technology for fossil fuels with near zero emissions, can play a significant role
- The cost for emission allowances will increase to 20 EUR/ton of CO_2 or higher depending on reduction demand.

This is the target to be met by new ”zero emission” technology

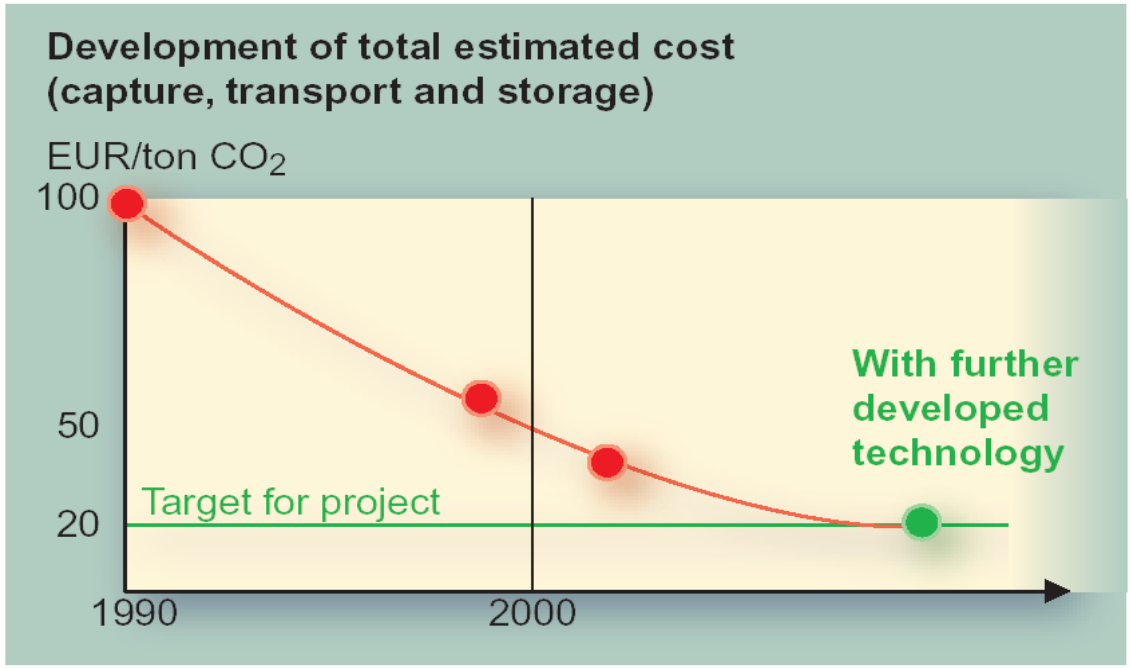
Supply and Demand in Germany

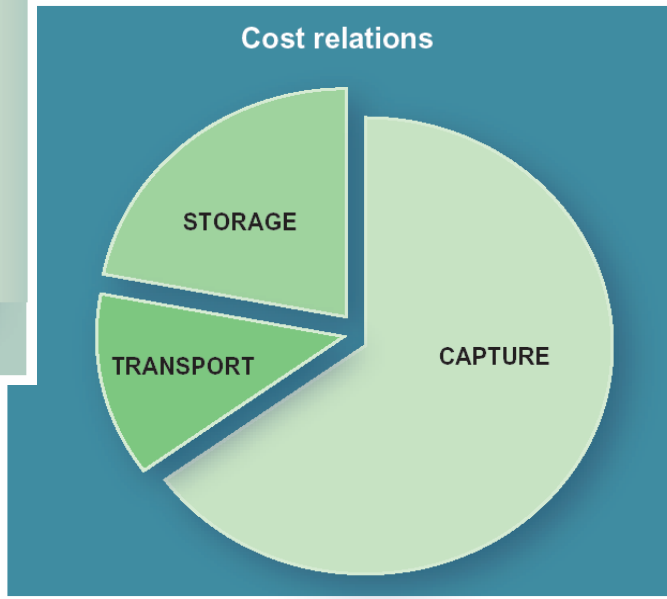


CO_2 free power plant

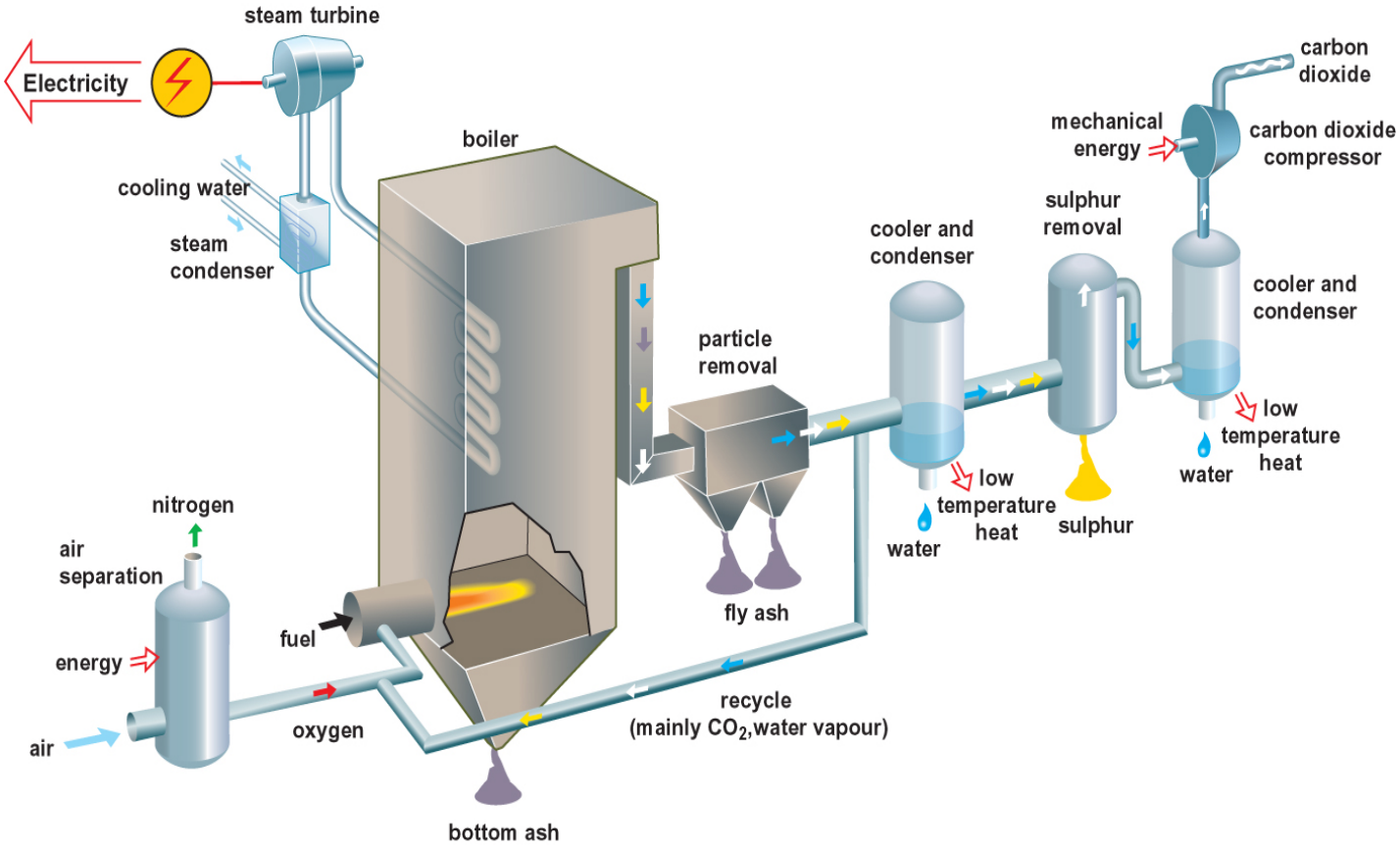
Different ways to capture the CO2 – minimize costs

CO_2 capture and storage – cost estimates





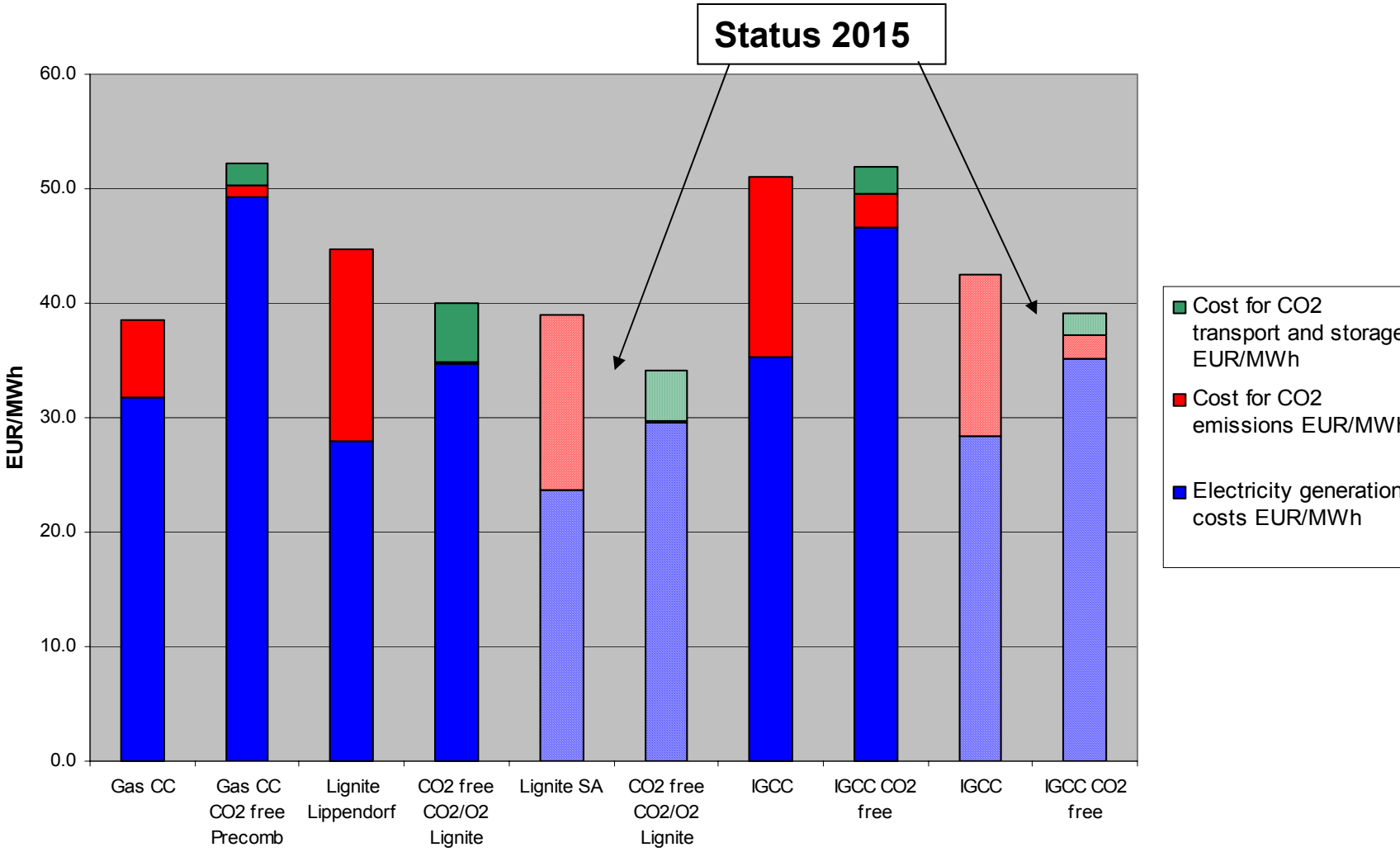
O_2/CO_2 combustion is the preferred option at present



CO_2 Capture
Evaluation of options

	Gas CC	Gas CC CO2 free Precomb	Lignite Lippendorf	CO2 free CO2/O2 Lignite	Lignite SA	CO2 free CO2/O2 Lignite	IGCC	IGCC CO2 free	IGCC	IGCC CO2 free
Reference	Sintef	Sintef	VAB	VAB	VAB	VAB	IEA	IEA	IEA	IEA
Fuel	Gas	Gas	Lignite	Lignite	Lignite	Lignite	Coal	Coal	Coal	Coal
Power output MW	400	392	865	700	500	500	776	676	750	700
Specific Investment cost EUR/kW	625	1430	1272	1570	1005	1366	1371	1860	900	1250
Efficiency %	60	49	42,7	34,3	47	39,8	43,1	34,5	48	43,2
Fuel cost EUR/MWh fuel	12,5	12,5	4	4	4	4	5,8	5,8	5,8	5,8
O&M cost EUR/MWh	2,7	5,8	4,0	5,0	3,4	3,9	6,7	9,5	6,0	7,8
CO2 emitted kg/MWh	335	53	836	7	760	4	786	142	706	102

CO_2 Capture
Evaluation of options



Capture and storage of CO_2

Financing the development is the big challenge, if public acceptance is achieved

Financing of the development of the CO_2 Free Power Plant

The technology must meet the commercial conditions in the Emission Trading system in the long term:

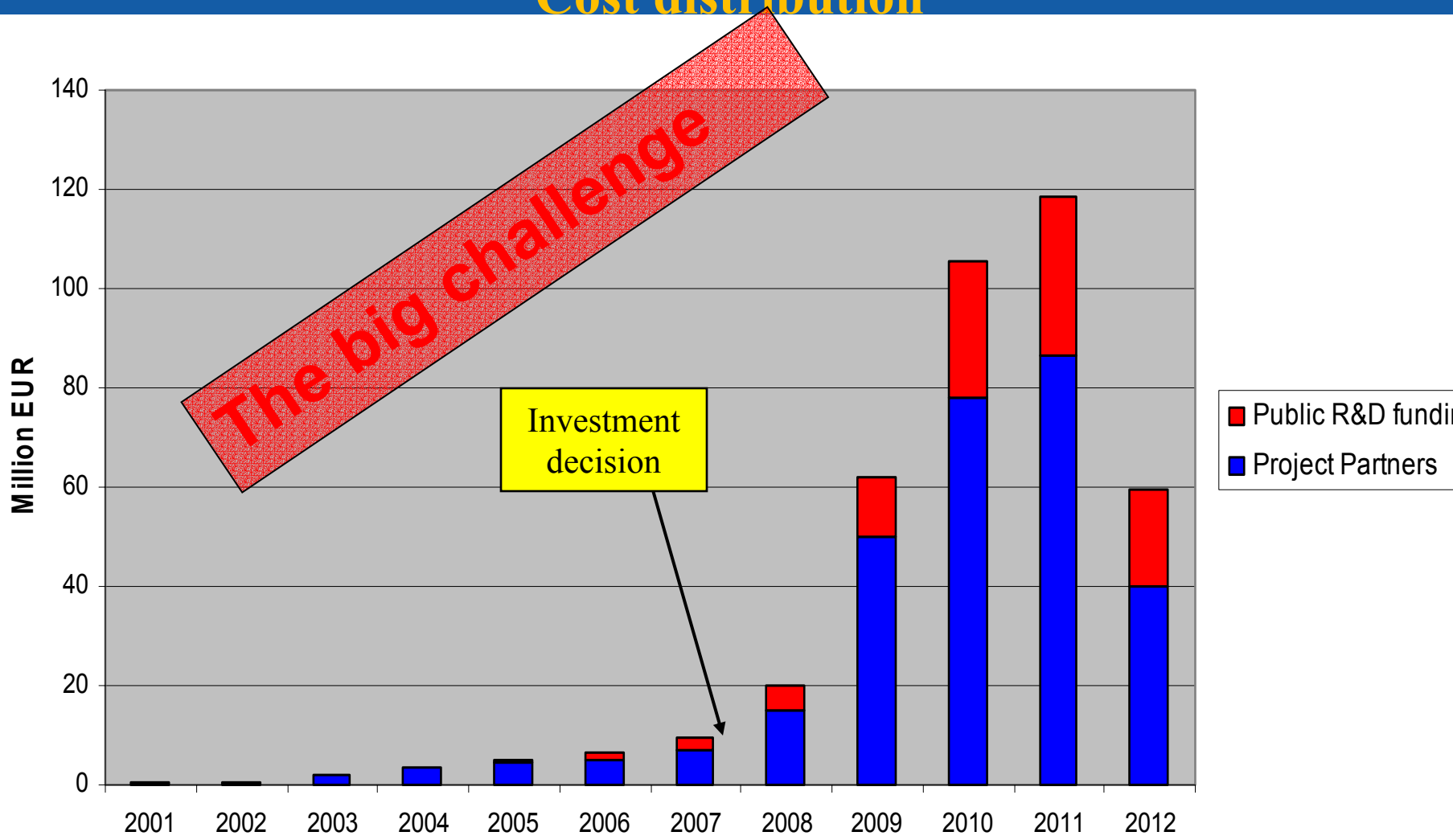
- Capture must probably be cheaper than 15 EUR/ton of CO_2, equivalent to about 10 – 12 EUR/MWh
- The CO_2 storage and transport system must be developed to a large infrastructure to become a cost level of 5-7 EUR/ton

The problem will be to finance the route to this developed status

- Technology development must be financed by applying new technology to competitive plants and finance the extra cost.
- The build up of a storage and transport infrastructure must start with the obvious entrees, as EOR, existing gasstorages, depleted oilfields, etc. Thereafter new establishments can be made.

Financing must be a mix of public and commercial funding, driven by market mechanisms.

CO_2 free Power Plant Demo
Cost distribution



CO_2 free power plant

Conclusions

Conclusions

- Fossil fuels are needed many decades yet. There is no other option available large enough
- CO_2 capture and storage can enable energy generation at a lower cost than most renewable alternatives.
- The CO2 emission trading scheme sets the commercial framework for new technology in Europe
- If CO_2 capture and storage is developed to a viable option with avoidance costs down to 20 €/ton of CO_2, the technology can be commercially introduced after 2015.

Public acceptance will be the most difficult "soft" challenge

Financing of the necessary demonstration systems and plants will be the most difficult "hard" challenge.

Schwarze Pumpe power plant