ZEP
Technology Platform
Zero Emission Fossil Fuel Power Plants

Zero Emission Fossil Fuel Power Plants ZEP European Technology Platform, Perspective of an Energy Supply Company

Heinz Bergmann
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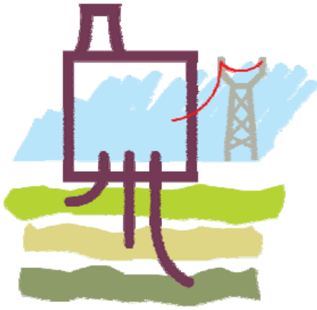
Geneva, 29 November 2006
UNECE Committee on Sustainable Energy: Coal Session



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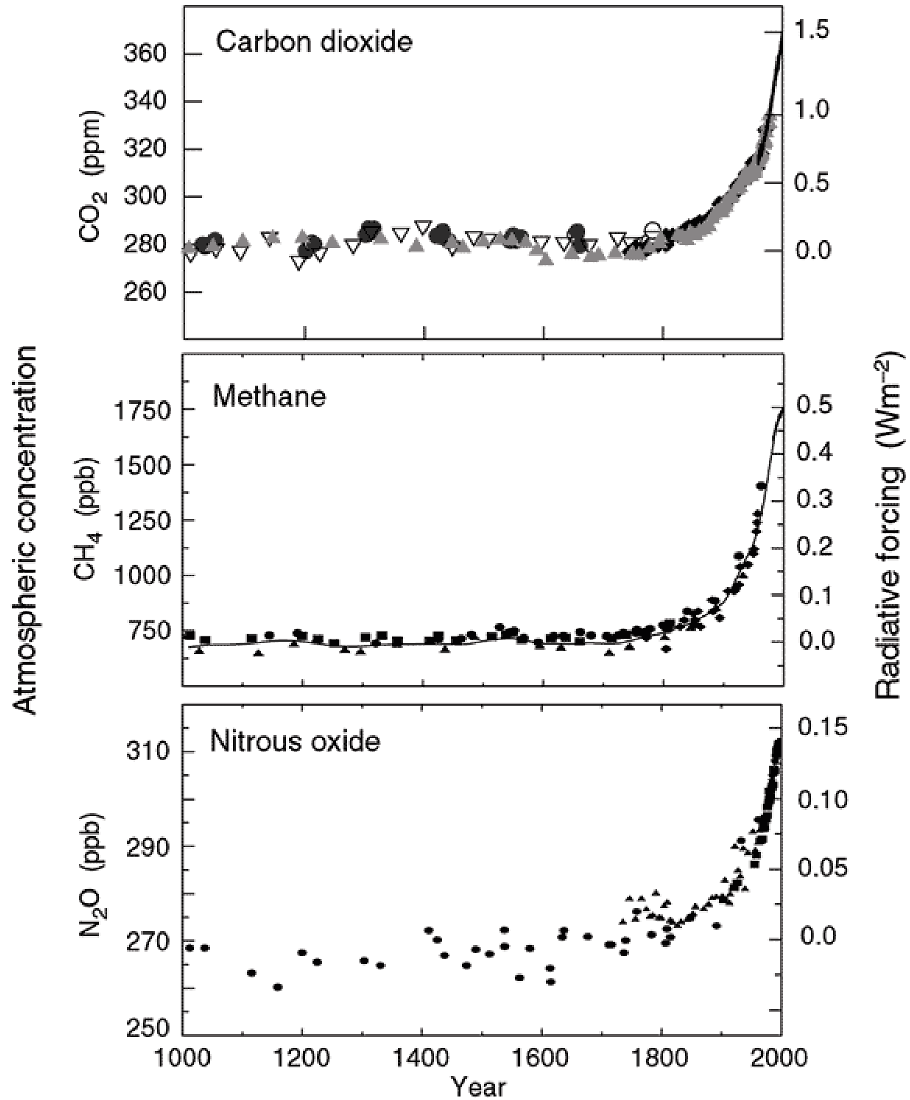
Challenge of Climate Change

(Source: Herve le Treut/LMD, CNRS, Sept. 2006)

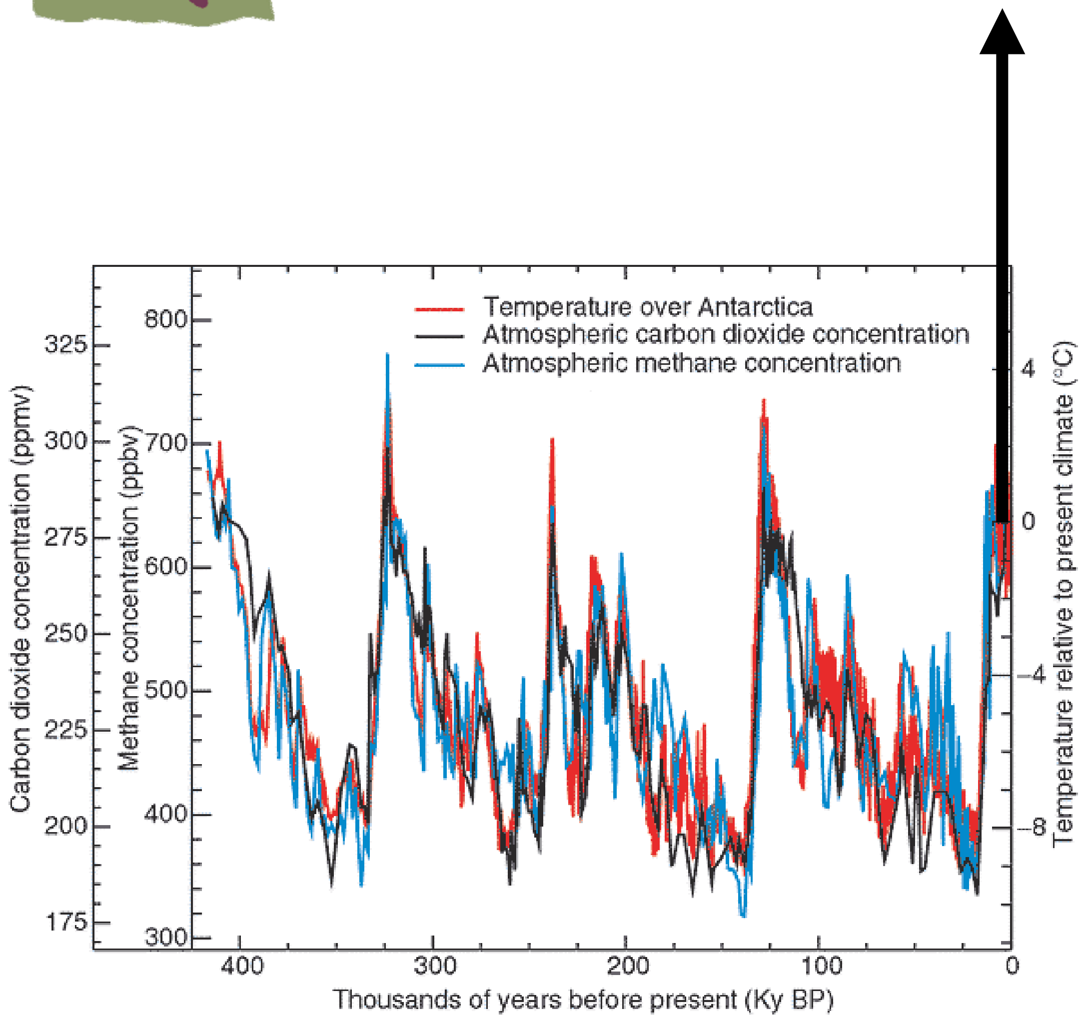
The composition of the atmosphere has changed more significantly in the past century than in the previous two thousand years.

Anthropogenic changes in the composition of the atmosphere modify the equilibrium of a complex system.



Challenge of Climate Change

(Source: Herve le Treut/LMD, CNRS, Sept. 2006)



Considered on a geological time scale, current changes are happening at a very fast pace.

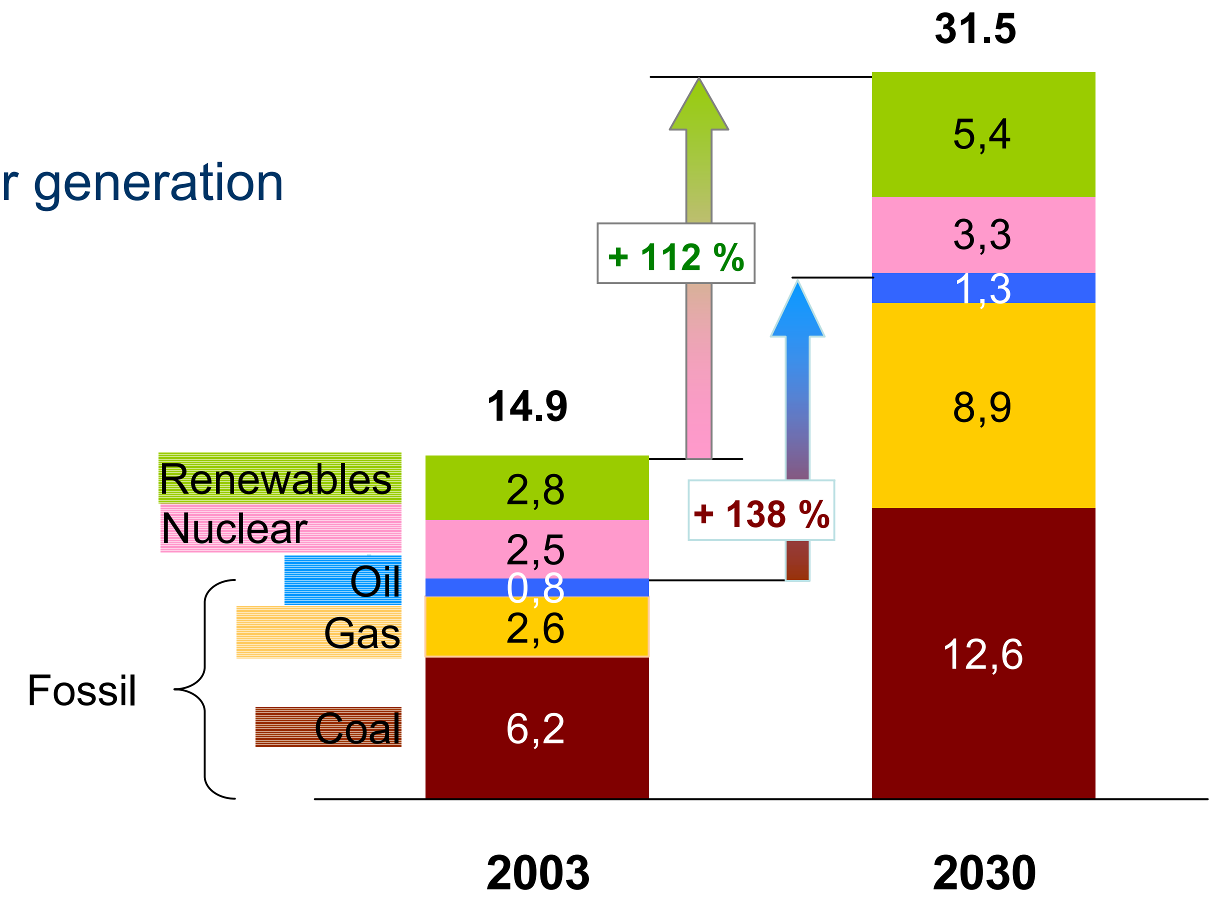
A Global solution with long term commitments is needed.

ZEP takes an active role to accelerate governments and global institutions towards practical solutions.

Future Role of Fossil Fuels in the Global Energy Mix

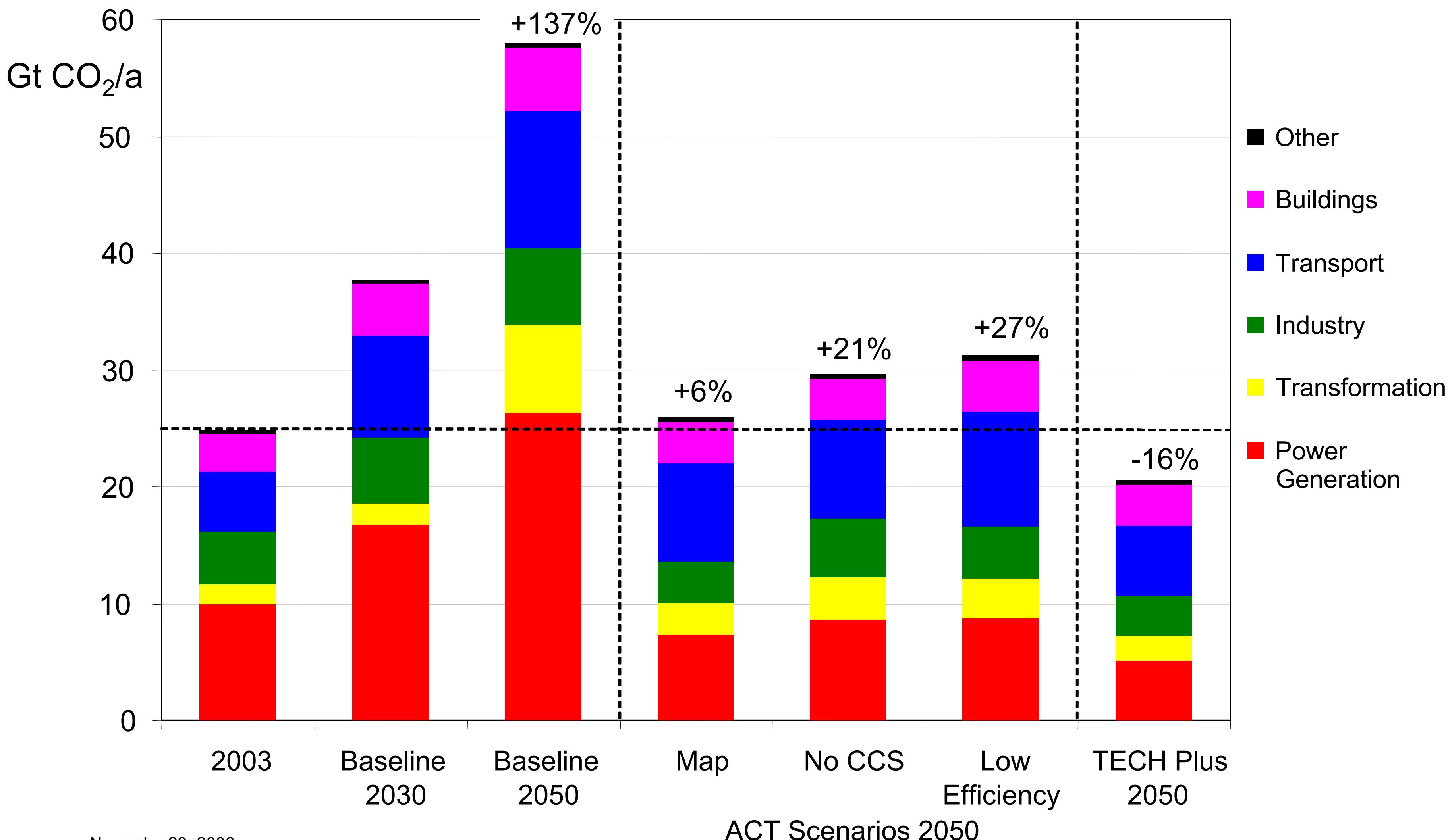
(Source: DOE/EIA, International Energy Outlook 2006, Washington 2006)

Global net power generation
in billion MWh

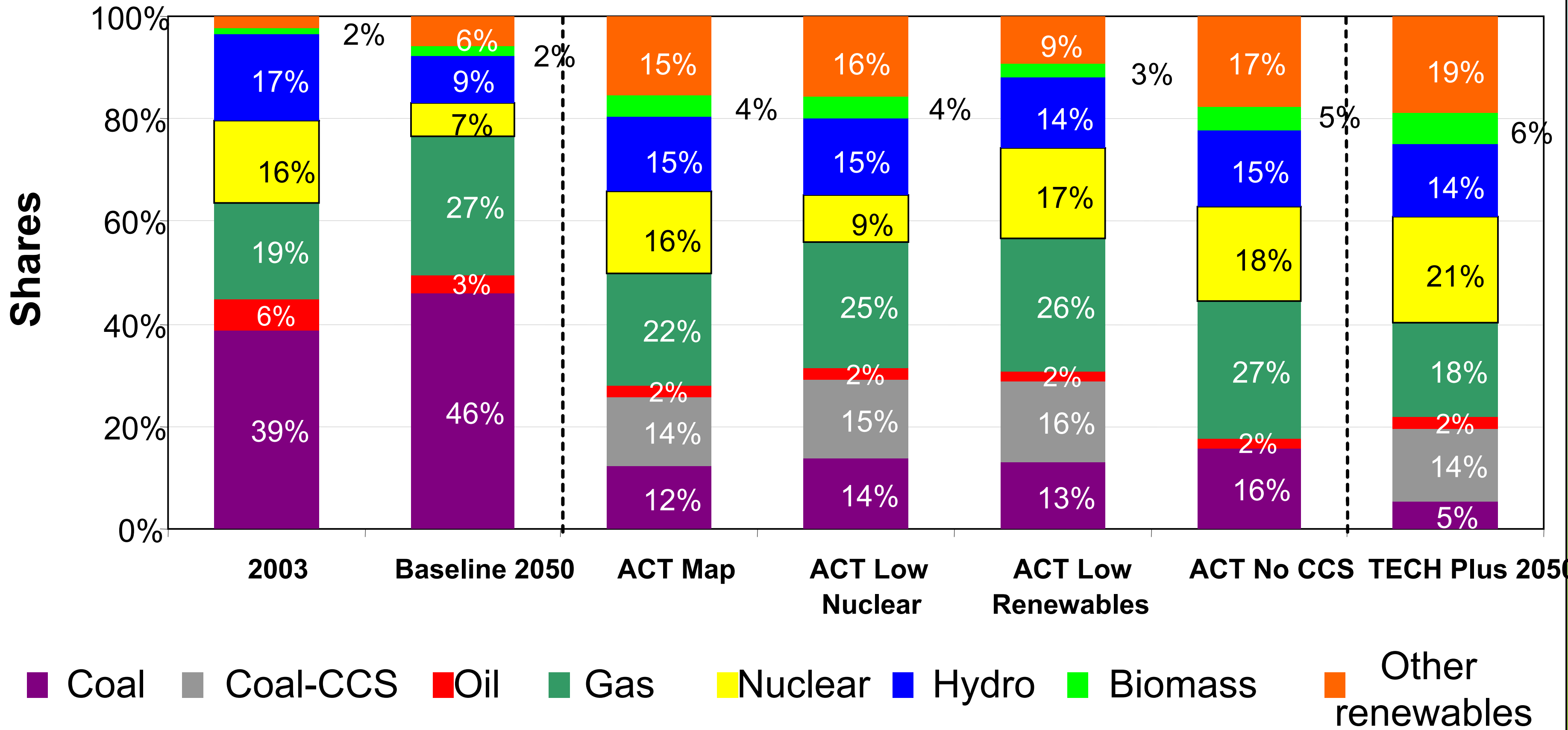


► Coal will remain vital to energy supply in the future.

Global CO_2 Emissions
- IEA Scenarios 2003-2050 (Source: IEA, June 2006)



Global Electricity Generation by Fuel
- IEA Scenarios 2003-2050
(Source: IEA, June 2006)



Important role for CCS and strong growth in the shares for renewables and nuclear.

A Three Phase Argumentation

- Reducing emissions and increasing efficiency in ecologically and economically optimised steps
  - Modernisation of existing plants: SO_2, NO_x, dust, retrofit
  - Construction of new state-of-the-art power plants
- Development of high-efficiency power stations with the aim to minimise consumption of resources and reduce specific emissions, particularly those of CO_2
- New Technologies for CO_2 capture and storage

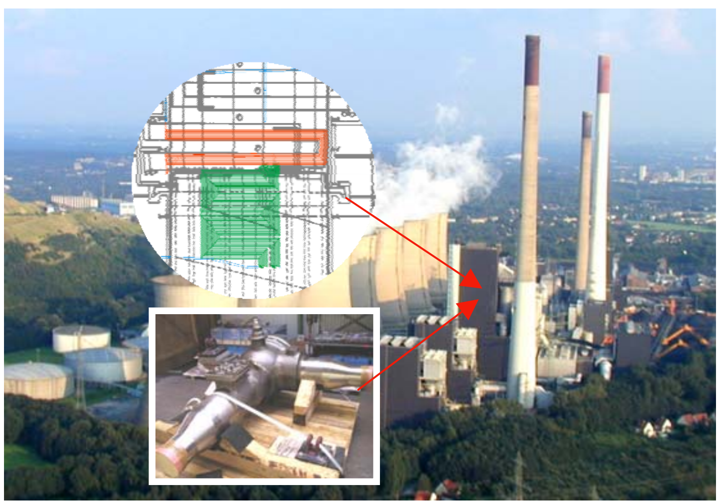
Current Efforts to Increase Power Plant Efficiency

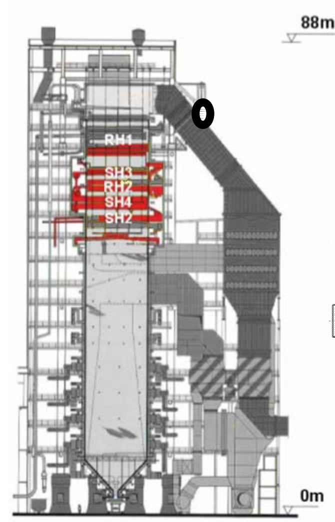
	percentage points
• COMTES 700: material and component test for 700 °C technology (joint project of VGB, generators, equipment suppliers and EU)	+ 4 % (compared to 600/620 °C, 275 bar live steam)
• Fluidised-bed drying process for lignite (RWE Power)	+ 4 % (43 → 47 % - net)
• CCGT-Project Irsching to increase net efficiency up to 60 % (Siemens, E.ON)	+ 1,5-2 % (58 → 60 % - net)
• Efficiency improvements by replacement of existing steam turbines by new turbines with 3D-designed blades (retrofitting)	Depending on individual case
• Further increasing of net efficiency of PC-boilers by development of materials for live steam parameters of 750 °C and more (COORETEC, BMWi)	+ 5 % (→ 55% - net)

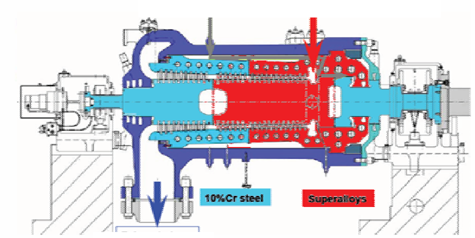
Objectives: Efficiencies of more than 50 % for steam power plants and above 60 % for gas turbine plants

EC-Projects on the Way to 50% Coal Fired Power Plant (Source: E.ON)

COMTES700	NRWPP700
• EC-funded project managed by VGB to test nickel-based components (joint project of generators and equipment suppliers) • Pilot plant in Scholven with 40 MW_{th} • Operation 2005 - 2009	• Pre-Engineering study from 09/2006-07/2008 for a 700°C demonstration plant with >400 MW • EC-funded project managed by VGB • Basic and detail design for boiler, turbine and connecting pipework







Efficiency enhancement as a fundamental way to CO_2 reduction

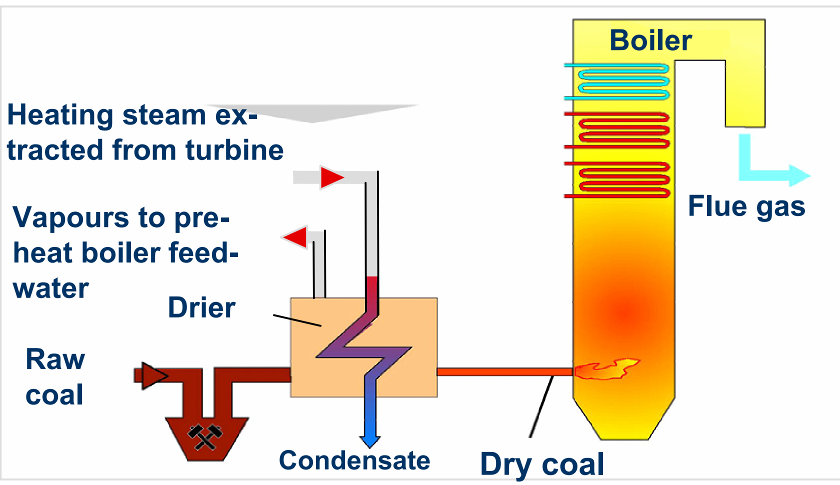
(Source: RWE)

Development goal: dry lignite-fired PP

Offsets lignite's drawbacks compared to hard coal; application from 2014

η: + 4 % points ➔ η > 47%

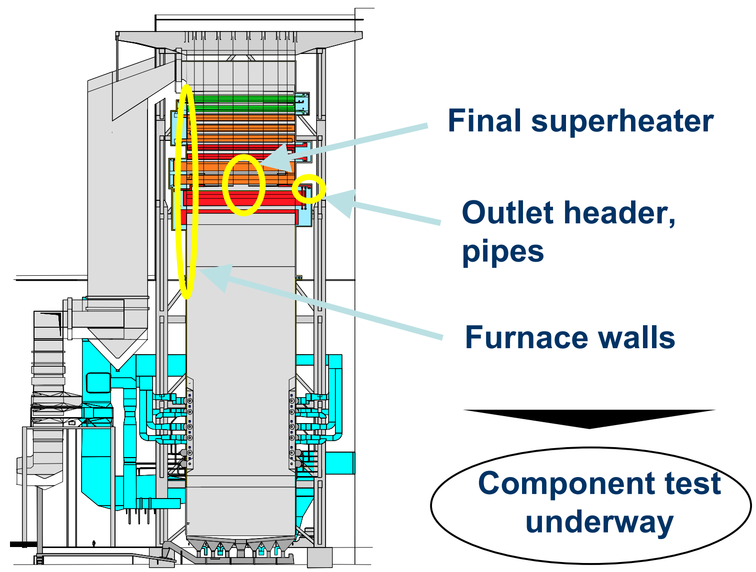
WTA technology permits drying heat recovery through recondensation of the evaporated water.



Development goal: 700°C PP for L/HC

Novel materials permit steam parameters of 350 bar/700 °C; application from 2018

η: + 4 % points ➔ η > 50%

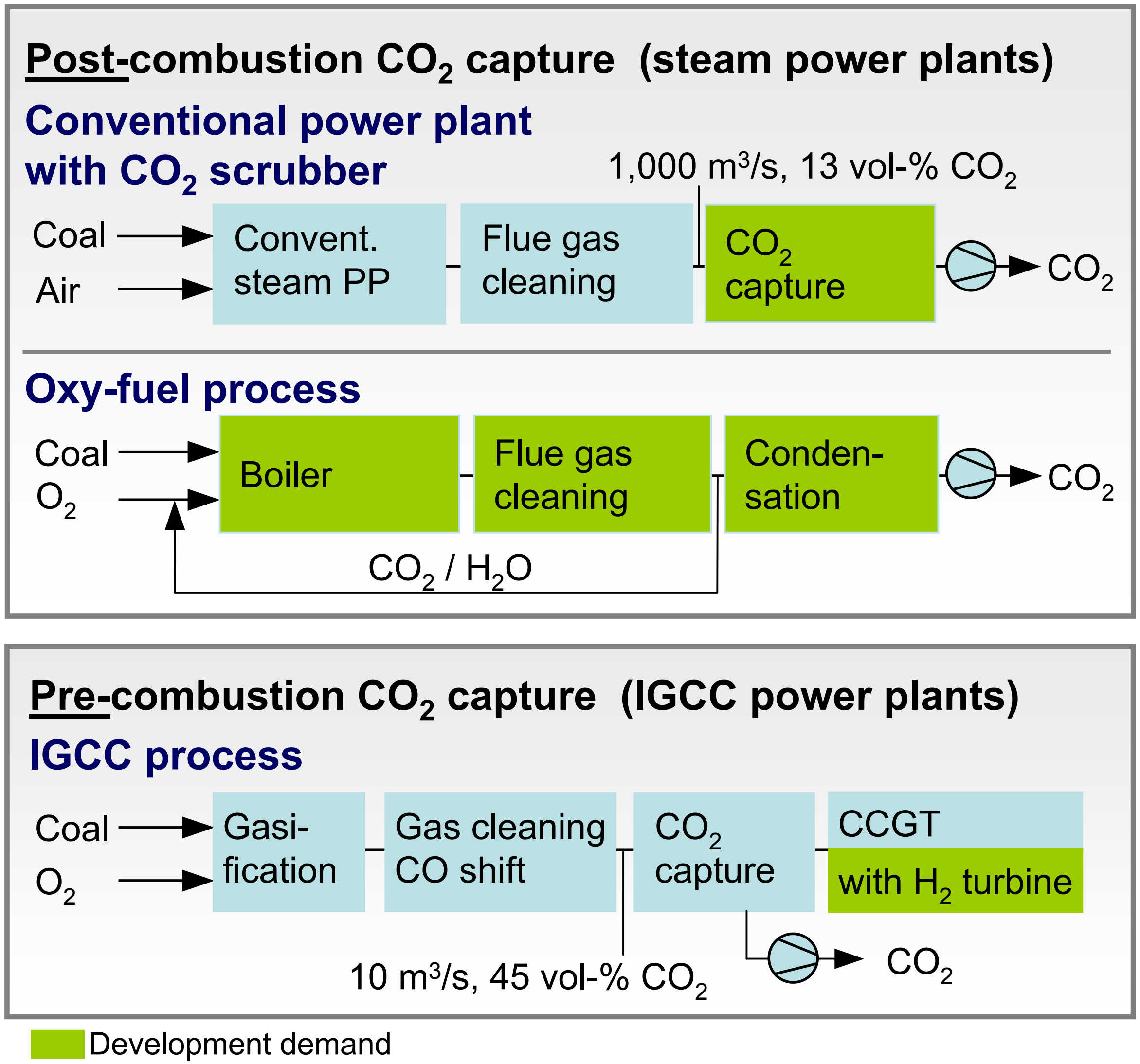


Together, both measures bring up the efficiency of lignite-fired power plants to > 50 %

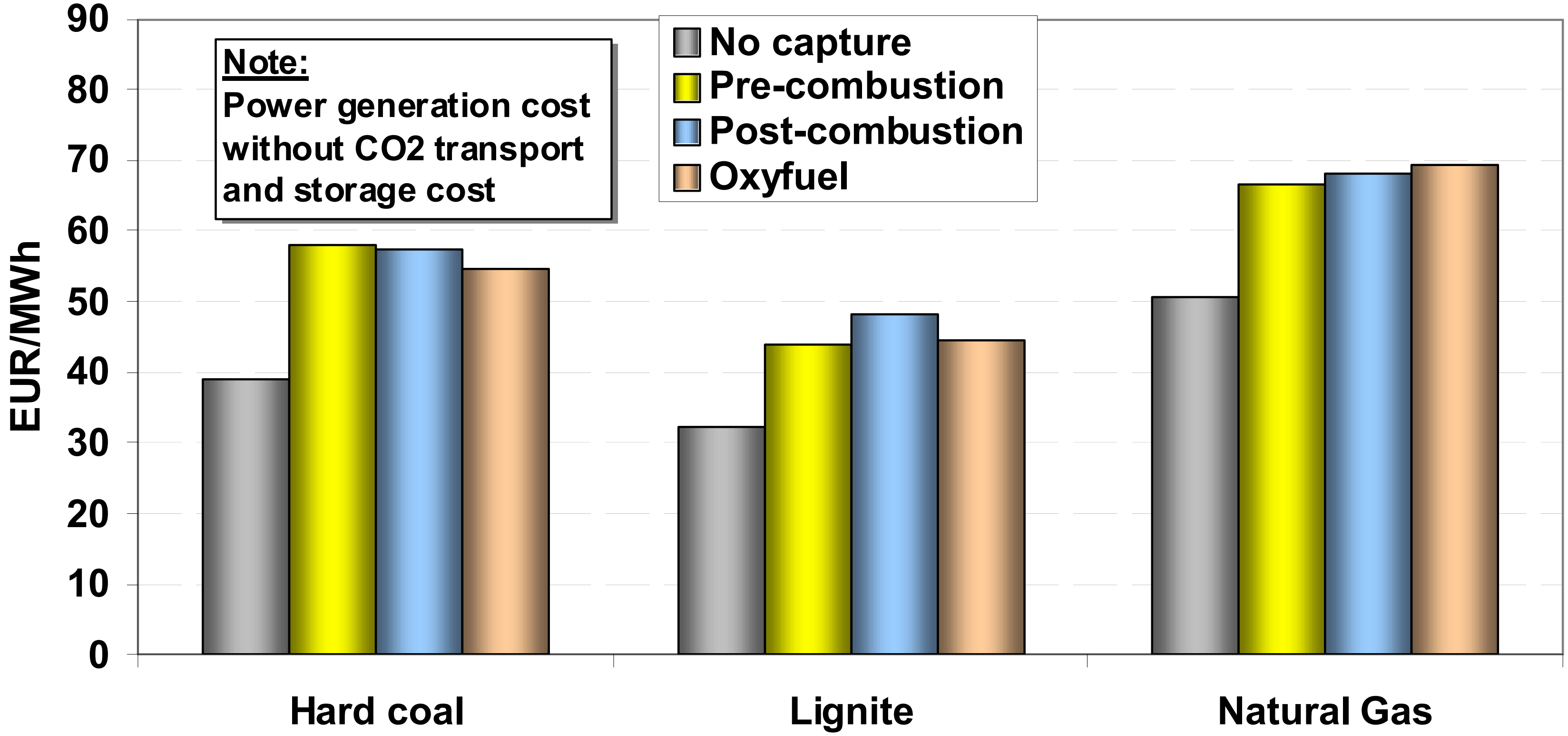
Main Technology Options for CO_2 Capture from Power Plants

Three technologies seem capable to fulfil the primary target to 2020

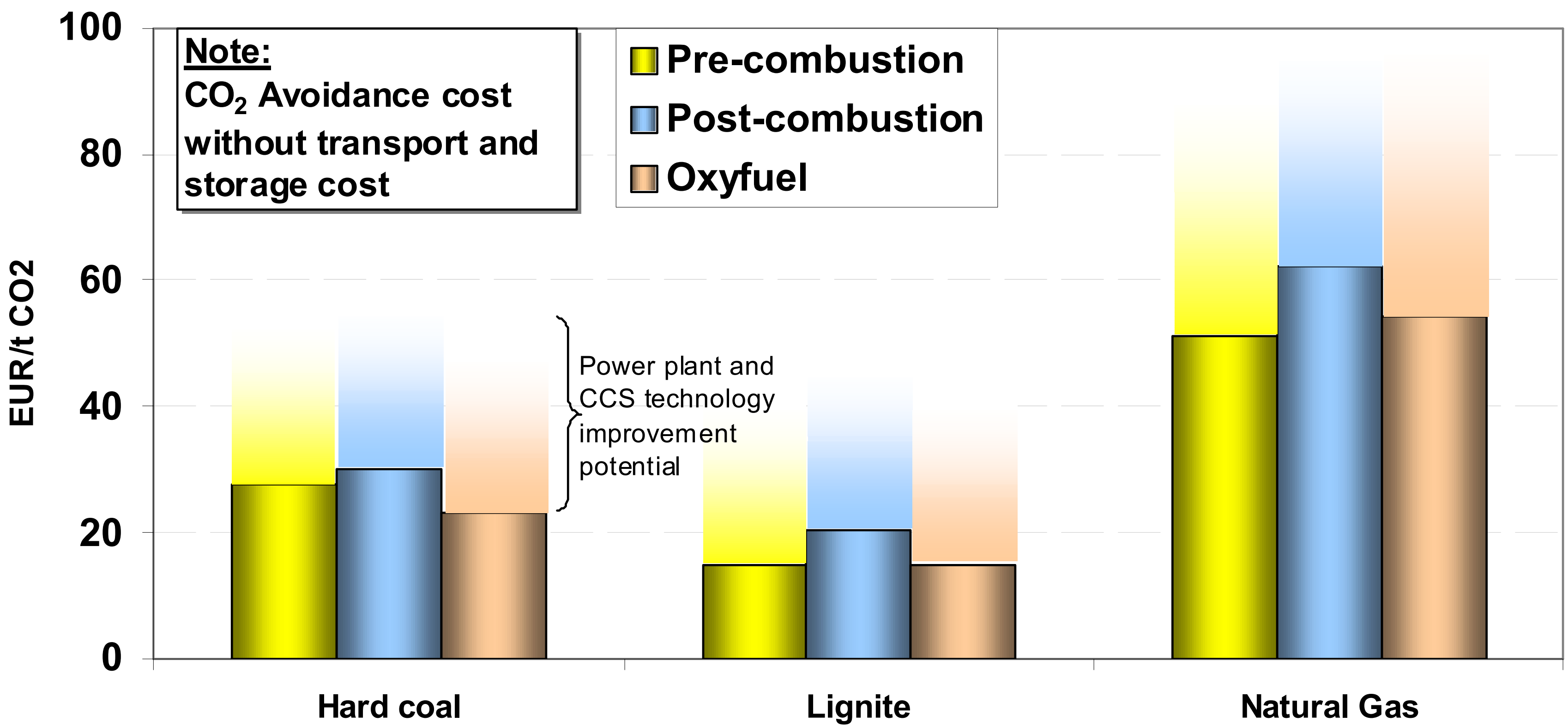
- All largely contain known technology and components
- All need optimization, scale up and process integration
- Power process efficiency increase is always a supporting activity



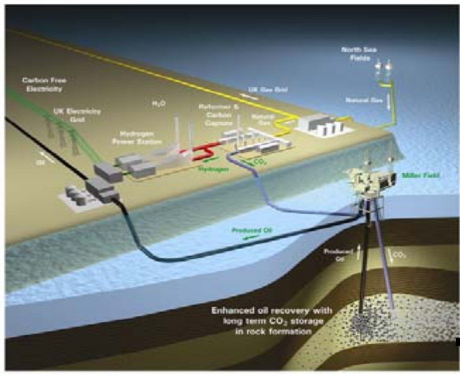
Power Generation Cost for Large Scale Power Plants in 2020 (Source: ZEP – WG1)

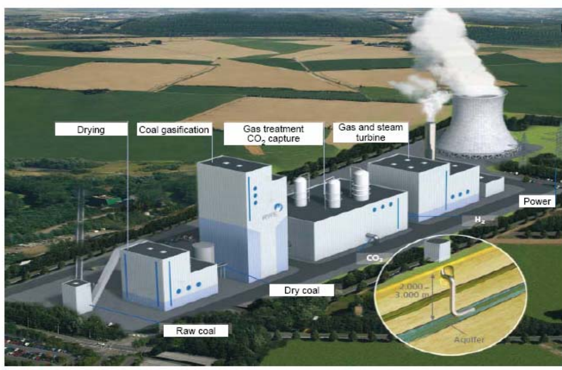


Avoidance Cost for Large Scale Power Plants in 2020 (Source: ETP ZEP – WG1)



Pilot and Demo Projects





Post-Combustion

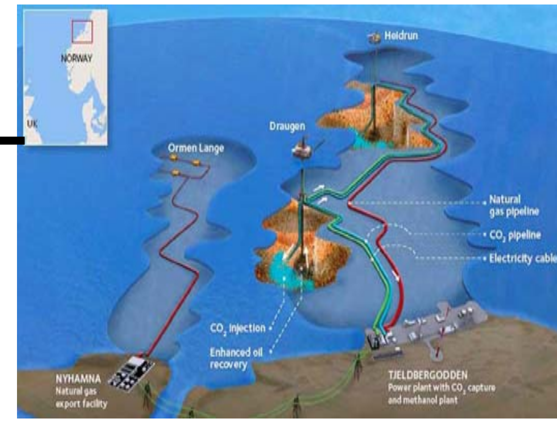
- Shell/Statoil, NO, 860 MW, NG-CC, EOR (Draugen, Heidrun), 2010
- RWE, coal, retrofit, Tilbury/UK, 2016

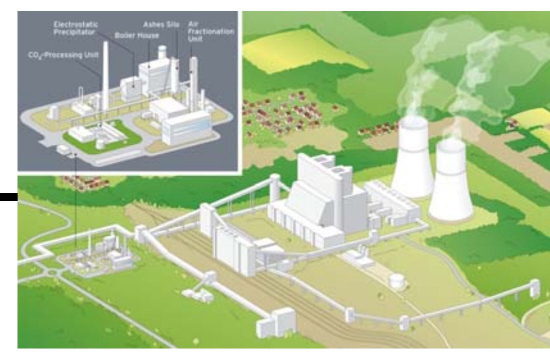
Pre-Combustion

- BP/S&SE/GE, UK, 350 MW, NG-CC, EOR (Miller), 2010
- RWE, D, 450 MW, coal, IGCC, 2014
- E.ON/UK, Killingholme, 450 MW, 2011
- GE, PL, 900 MW, coal, IGCC, 2011

Oxy-fuel

- Vattenfall, Schwarze Pumpe/D, 30 MW_{th}, coal, 2008
- Total, Lacq/F, 30 MW, liquid fuel, retrofit, 2008





Share of Fossil Fuels in German Power Plant Capacity 31.12.2005

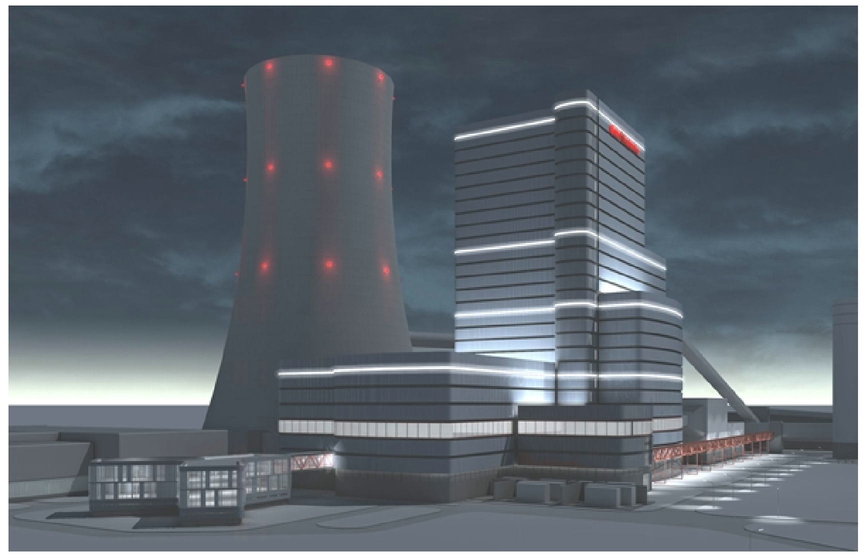
GW	RWE	E.ON	Vattenfall
Hard coal	9,6	7,5	0,5
Lignite	10,1	1,3	7,4
Gas	3,7	3,8	1,0
Oil	-	1,1	-
Fossil Fuel	**23,4**	**13,7**	**8,9**
Nuclear	5,5	8,5	1,5
Other	2,9	3,4	2,9
Total	31,8	25,6	13,3

Quantum leap in power plant technology (Source: E.ON, 31.10.2006)

innovate.on
efficient ecological energy

… 50plus by using new materials

Location	**Germany**
Efficiency	50 %
Capacity	> 400 MW_{el}
Investment	> 600 Mio. €
Start of operation	2014



2008	2010	2014
Preliminary planning **Search for location**	**Material development** **Request for proposal**	**Construction** **Start of operation**

IGCC with CCS Project at Killingholme
(Source: E.ON)

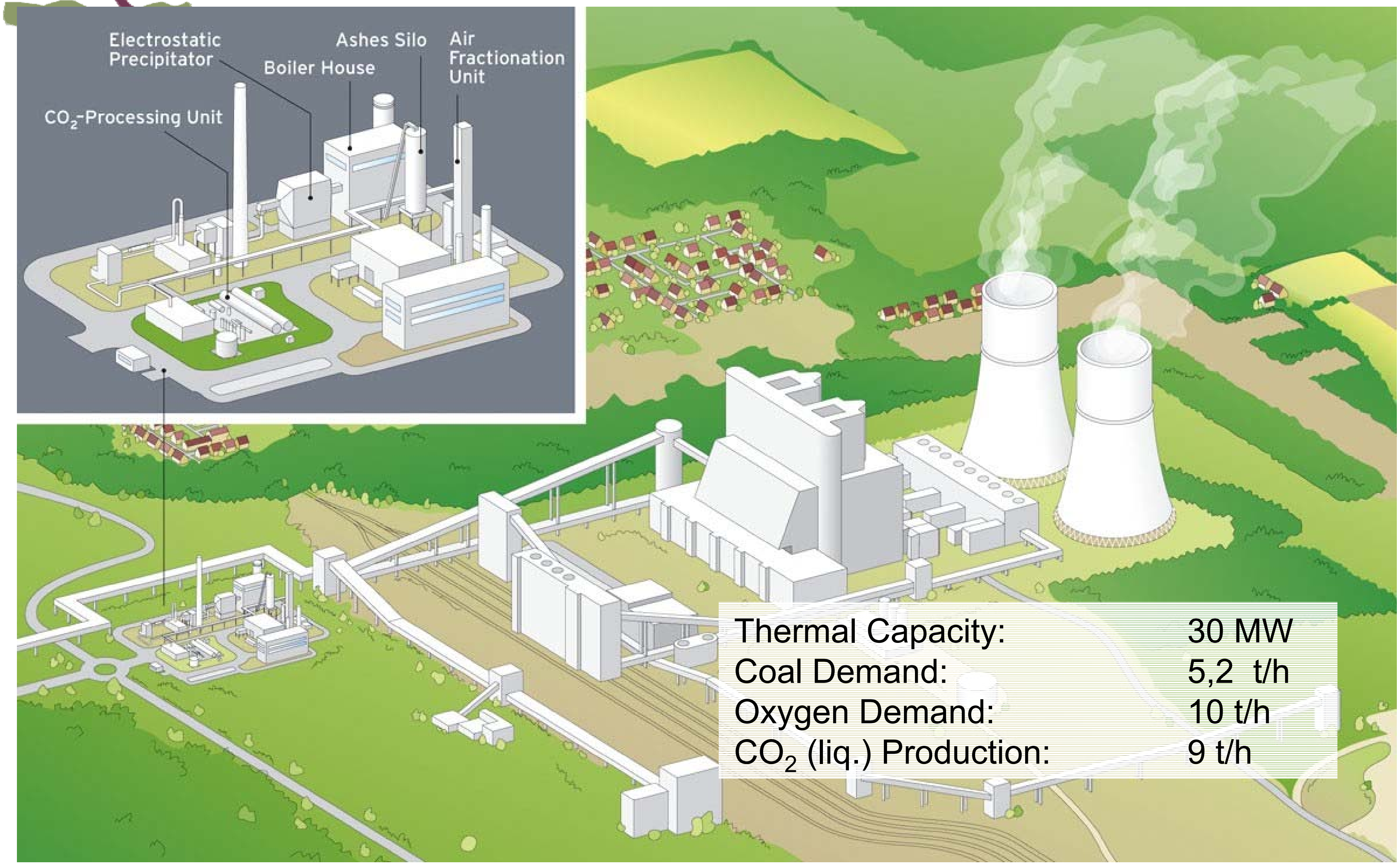
Picture shows existing 900MW CCGT in the foreground with a possible IGCC layout behind

Overview

- Single coal-based IGCC module with CCS, nominally 450MW, net output ~350 MW, CO2-storage in gas field of southern north sea
- Built on or close to the existing Killingholme site in Lincolnshire
- Feasibility Study completed at end Sept, now moving into project development.
  - Consent applications in 2007
  - Detailed engineering and tendering 2008
  - Investment decision end 2008
  - Commissioning 2011/12

The Vattenfall Project of a CO_2-free Oxyfuel Pilot Plant

(Source: Vattenfall)



Thermal Capacity:	30 MW
Coal Demand:	5,2 t/h
Oxygen Demand:	10 t/h
CO_2 (liq.) Production:	9 t/h

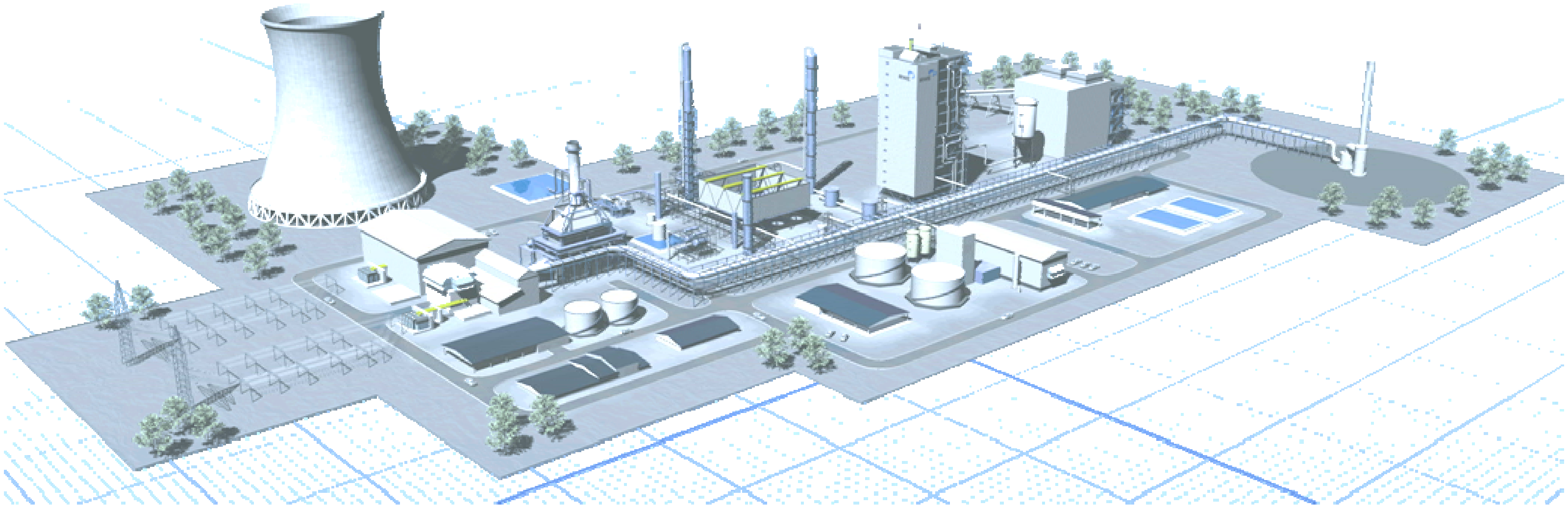
Advantages of oxyfuel technology
(Source: Vattenfall)

- Power plant process with high efficiency potential
- High CO_2-separation potential
- Comparable to conventional steam power plant process
- Investment and operation cost good assessable based on conventional power plant technology

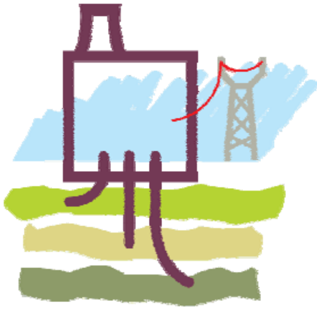
Development of the oxyfuel power plant (Source: Vattenfall)

Incineration tests	Test facility	Pilot plant	Demo plant	Commercial plant
0,05 MW_{th}	0,5 MW_{th}	30 MW_{th}	300- 600 MW	1.000 MW
Basics of incineration behaviour 2004 / 2005	Basics of flue gas recirculation • 2005 / 2006	Test of complete technology chain • 2008	Realisation of CO2 storage / proof of economics • 2015	Competitive power plant • 2020
• TU Dresden ADECOS (Joint project)	• BTU Cottbus CEBRA (Joint Project)	• KW Schw. Pumpe Vattenfall	…	…

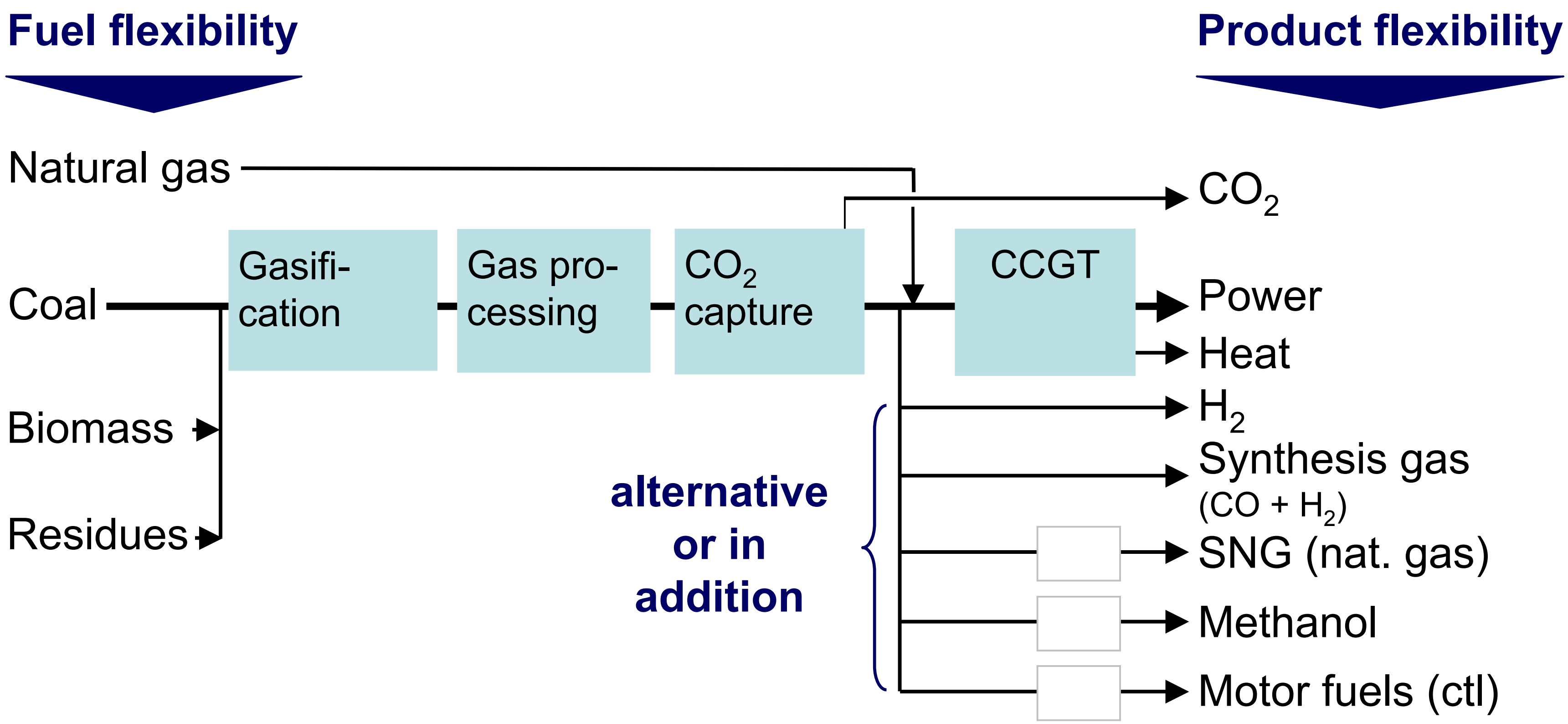
The RWE Project of a Zero-CO_2 450 MW Power Plant with CO_2 Storage (IGCC-CCS)
(Source: RWE)



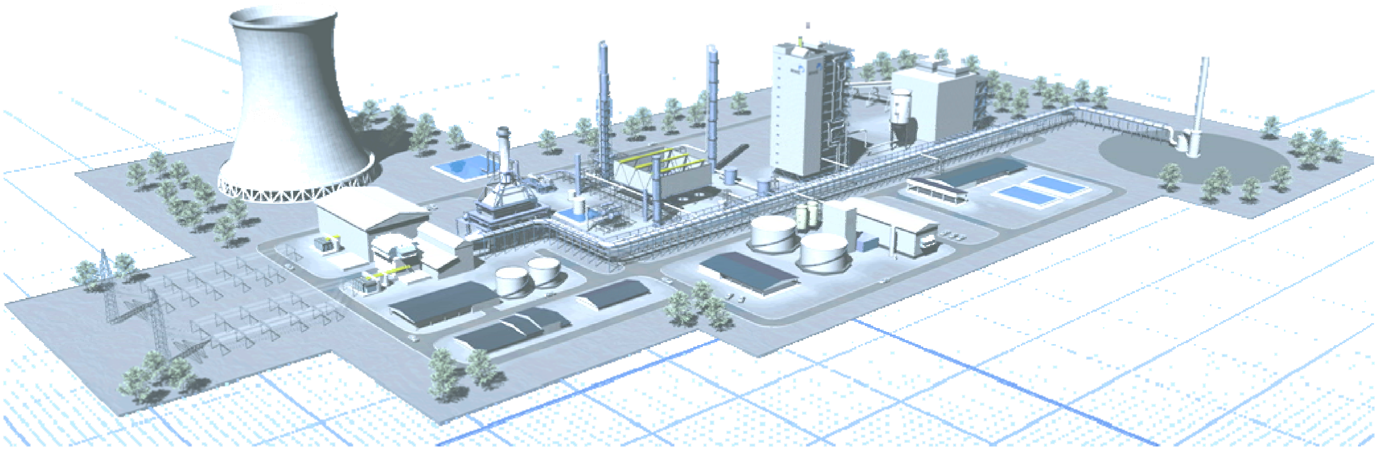
- Basic technology: IGCC
- El. capacity: 450 MW_{gross}/360 MW_{net}
- Net efficiency: 40%
- CO_2 storage: 2.3 mill. t/a in depleted gas reservoir or saline aquifer
- Commissioning: 2014
- RWE budget: approx. € 1 billion



IGCC Offers Excellent Product Flexibility



Advantages of IGCC technology
(Source: RWE)



- Fuel and product flexibility
- Only technology that can already be implemented on a large scale today
- Components tested in large scale, own RWE know-how
- Power plant process with highest efficiency potential, efficient operation also without CO2 capture

Main Activities of German Utilities towards CO_2 Reduction

E.ON:

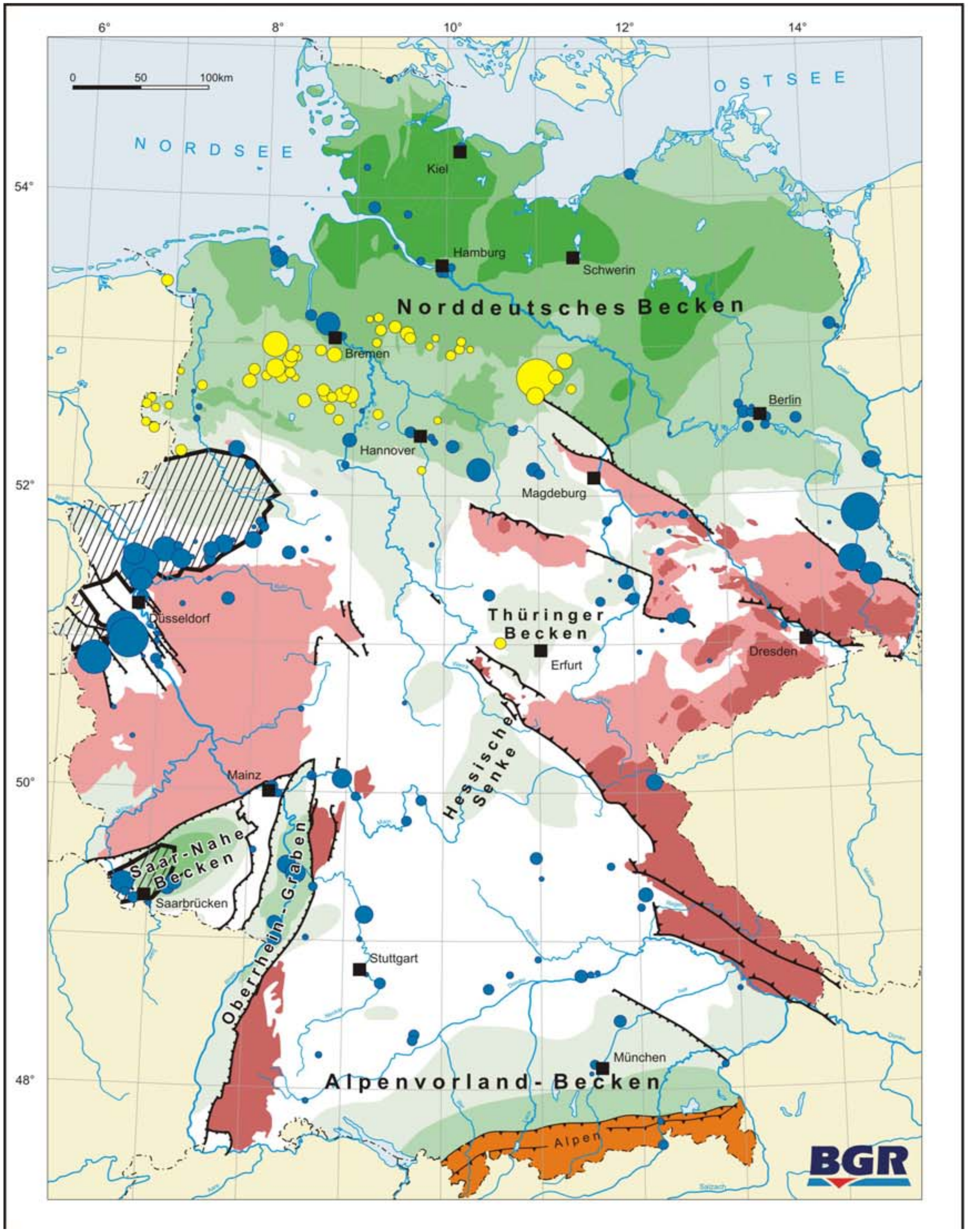
- 700 °C demo plant > 400 MW 2014
- IGCC with CCS at Killingholme/UK
- Participation in FutureGen Alliance in USA for 275 MW-coal-fired IGCC with CCS

Vattenfall:

- Development of oxyfuel technology, pilot plant 2008, demo plant 2015

RWE:

- Zero-CO2 450 MW-coal-fired IGCC 2014
- CO2-scrubbing for lignite and hard coal for advanced conventional power plant technology and as a retrofit option
- Feasibility study for clean coal 1000 MW hard coal fired power plant at Tilbury/UK



Bedeutende CO_2 - Quellen

Kraftwerke, Hütten- und Zementwerke, Raffinerien u. a.

0,2 → 20 Mt/a

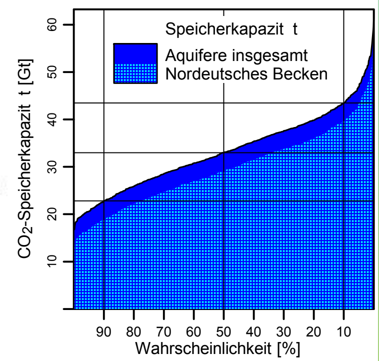
Regionen mit Speichermöglichkeiten

zunehmende Mächtigkeit der Beckenfüllung: 1km, 3km, 5km, 7km, 9km

tiefliegende und Salzwasser führende Speichergesteine (Aquifere)

Steinkohle - Flöze

Erdgas - Felder



Regionen ohne bedeutende Speichermöglichkeiten

metamorphe Gesteine

magmatische und hoch-metamorphe Gesteine

Speichergesteine nicht oder in zu geringen Tiefen vorhanden

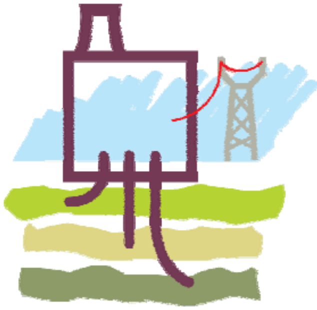
Speicherpotenzial

Expected Support of EC/Politics (1)

- Clear commitment to coal as important part of the future energy mix
- Clear commitment to CCS as instrument for CO_2 mitigation to stop climate change
- Support of efficiency increase to minimise consumption of resources and as pre-requisite of ZEP
- Create legal framework for geological storage of CO_2:
  amendment of EU waste and water framework directive and
  amendment of national mining law

Expected Support of EC/Politics (2)

- Support and active cooperation in public relations to get the acceptance for ZEP
- Sufficient financial support of the ZEP recommendations within SRA and SDD to allow for the necessary R&D and to set out for 10 - 12 demo projects
- No preference for renewable energies within the European FP7
- Close collaboration in ETP-ZEP and in continuation of German COORETEC initiative



Towards Zero CO_2 Power Generation

CO_2 capture

- post-combustion at conventional plants
- pre-combustion at gasification plants
- oxy-fuel combustion

CO_2 storage

- deep saline aquifers
- depleted oil and gas fields
- unmineable coal seams
- mineralisation

Some technologies are well-proven, others need significant R&D.
All require demonstration with monitoring & verification of storage sites.
An information campaign for public acceptance is needed.

Research in both areas is necessary with the same effort.
There will be no acceptance for a zero emission power station without CO_2 storage possibilities.

Summary

- Coal will remain its worldwide importance for electricity generation.
- Coal has to be used even more efficient and environmental friendly.
- Precondition is the large scale test of efficiency increasing technologies like integrated coal drying and raised steam parameters as well as CO2 capture and storage.
- The necessary time-frame is about 10 to 15 years. Joint development projects make it easier to be successful.
- The joint generators activities and the cooperation within the ZEP technology platform confirm these considerations
- CO2 capture and storage is a promising option to secure the future of power generation based on fossil fuels. It doesn't reduce, however, the necessity of CO2 avoidance through further efficiency increases
- The technical feasibility of ZEP technologies is beyond dispute.
- The economic efficiency will depend on the polital frame-conditions.

Thank you for your attention