Spotkanie Grupy Ekspertów
ds. techniczno-ekonomicznych aspektów ograniczenia emisji zanieczyszczeń
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Can combustion of coal in large power plants be regarded as environmental friendly source of energy?

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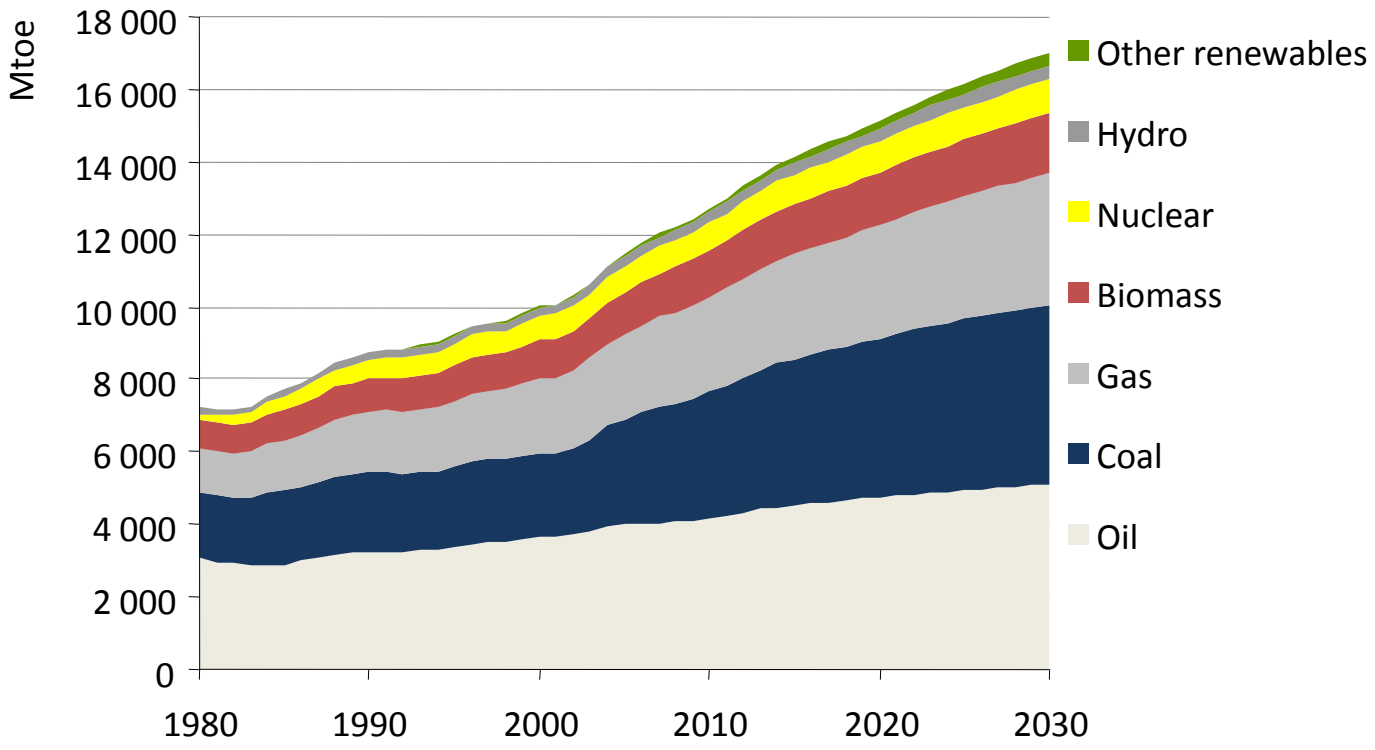
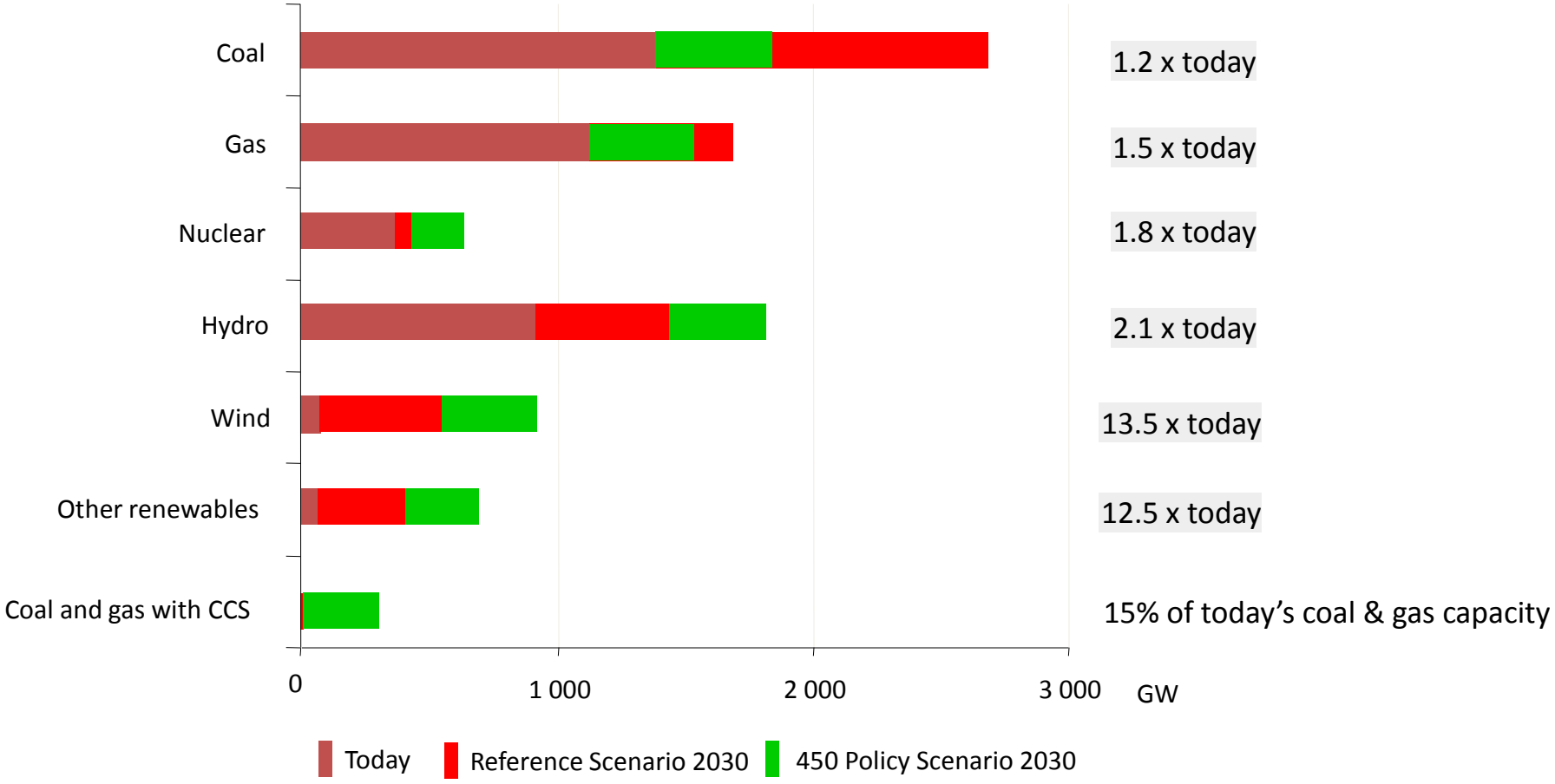
World primary energy demand in the Reference Scenario: this is unsustainable!

IEA WEO 2008



World energy demand expands by 45% between now and 2030 – an average rate of increase of 1.6% per year – with coal accounting for more than a third of the overall rise

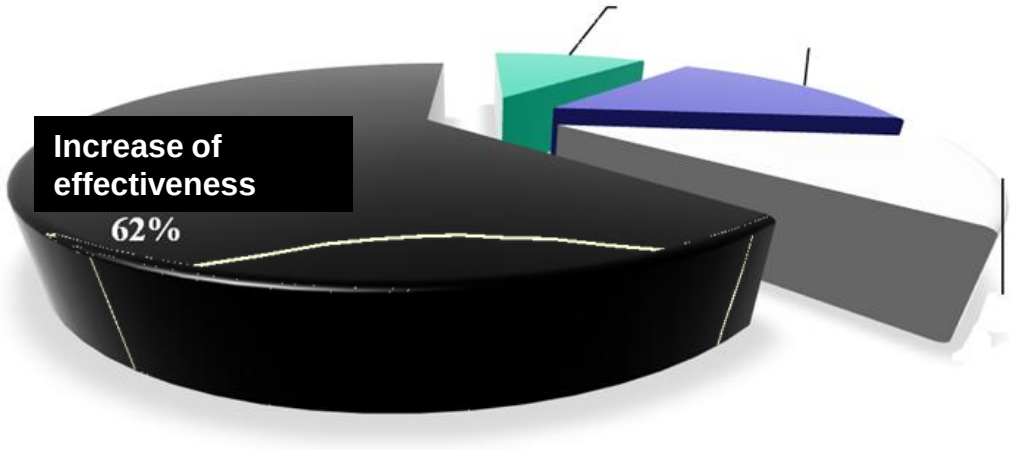
Total power generation capacity today and in 2030 by scenario



In the 450 Policy Scenario, the power sector undergoes a dramatic change – with CCS, renewables and nuclear each playing a crucial role

Coal is there !

Reduction of CO_2 emission in 2030 according to the 550 ppm scenario



Reduction = 7,6 Gton CO_2/year

IEA Energy Outlook 2008

What tonnage are we talking about?

In relation to NOx, SOx, ash streams the scale of CO_2 is disproportionately higher

600 MW power block generates about:

- **8 000 tons/years of NOx**
- **30 000 tons/year of SO_2**
- **150 000 tons/year of ash**
- **4 500 000 ton/year of CO_2 !!**

The transport and storage are another problematic elements

CO_2 and the EU

- **Currently the world CO_2 emission is about 28 bilion tons/year of which EU accounts for about 4 billion tons/year (about 15%)**
- **The need for global action, otherwise the CO_2 will increase by 2030 to 50 billion tons**
- **Possibility of CO_2 reduction by 20% or even 30%, in 2050 – 85-95%!!**
- **No rules in many countries outside EU**
- **Acute EU policy in the subject of CO_2 can lead to deterioration of competitivness and relocation of production outside EU, where standards are less restrictive**

Restrictions in coal options

- **The increase in CO_2 emission must be stopped**
  - All emitters, not only those from coal
  - Dates and levels of stabilization are unknown

- **Sustained efforts are a critical aspect**
  - Environmental pollution and climate changes
  - Safety during mining, transport and storing
  - Availability of area for CCS
  - Costs

Without CCS fossil fuels have no future

This is the only solution for energy production, cement industry, metallurgy, etc.

This applies to all fuels, not only coal.

Thinking for today and tomorrow

- **Costs will increase until solution is found**

  - the cost of solution is unknown
- **Successful technological solutions will be the cheapest**
- **The perception of society will be dependent on actual events**

  - what happens to the climate will affect actual actions and society perception
- **Perhaps global warming will be slower than expected**
- **Warming is much faster in the Arctic**
- **There may appear extreme weather events**

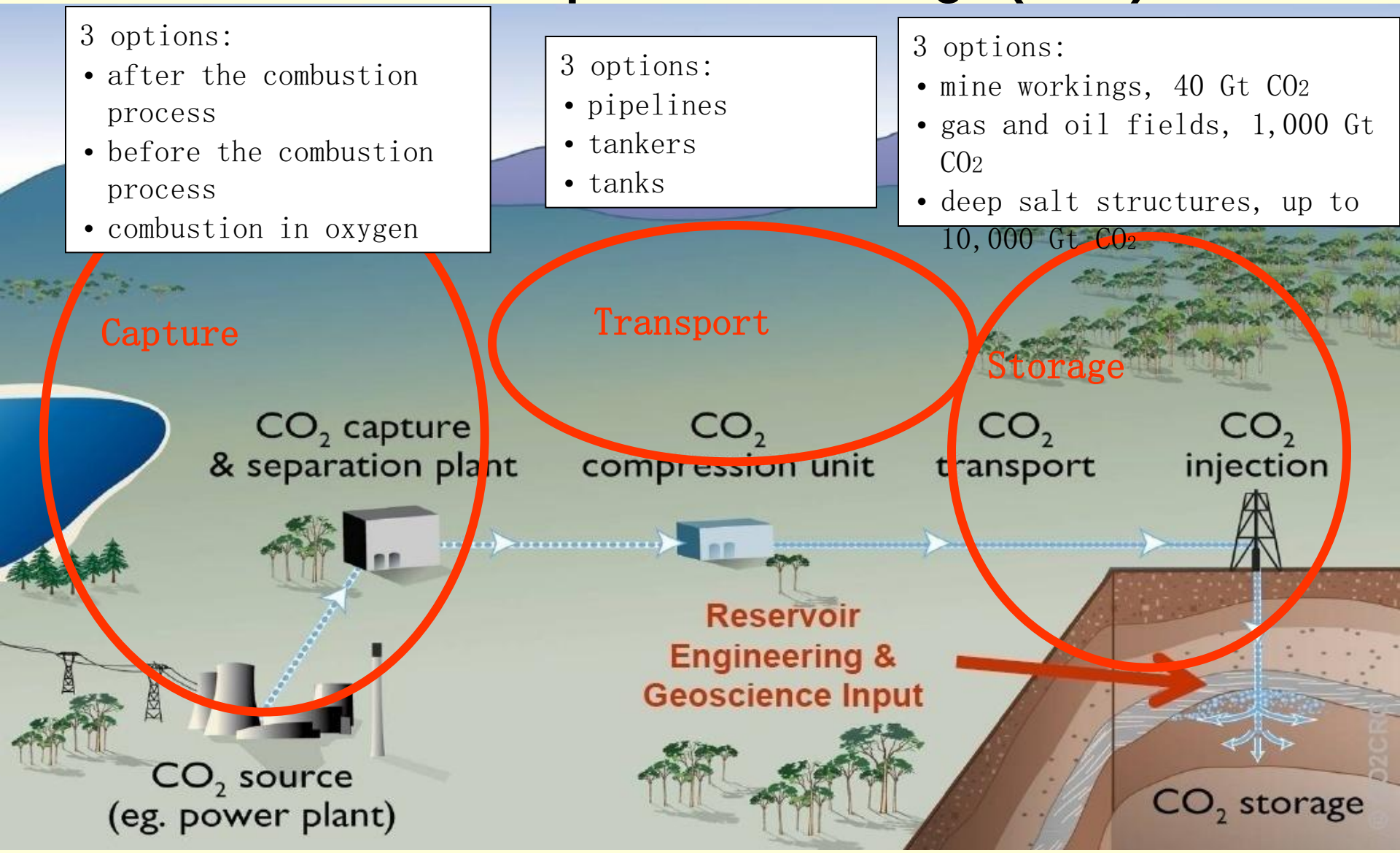
Technological options

- There is a lack of comercially available key technologies
- An urgent need to demonstrate CCS
- The best solution – building new units with CCS, rather than upgrading existing units
- Steps: a gradual closing of classic power plants and construction of poli-generation systems + coal units with CCS

- Blue scenario (emissions in 2050 – a half of those from 2005) requires $13-$16 trillion for R&D and Demo
- The role of gas and nuclear energy, as well as RES, will increase
- We can't choose one technology, all promising ones should be considered
- Lack of funds for R&D – a need for breakthrough technologies
- *IEA „A global revolution is needed in ways that energy is supplied and used"*

Source: EPA, Clearwater, 2010

Carbon capture and storage (CCS)



Schedule of activities

- **Option 1**: It's already too late

- **We passed on the first red light**
- **We can't stop before the next**
- **The need to minimize the damage in order not to cause a collision**

- **Option 2**: the solution is hundreds of years of effort

- **A delay of 20-50 years in the development of infrastructure (pipelines etc.)**
- **50 years in the development of existing infrastructure (storages)**
- **50 years of effort to decrease CO_2 emission**

Systematic approach to zero-emission

Construction of new, highly efficient coal IGCC systems with supercritical parameters

CO_2 emission lower by 15%

Demonstration instalation of IGCC as well as for capture and storage of CO_2

CO_2 emission lower by as much as 90%

Reconstruction of the existing systems based on coal

Construction of power plants with capture and storage of CO_2

CO_2 emission lower by as much as 90%

Target: Zero - emission

0 ⟶ **20 years**

What can „capture-ready” means when it comes to an installation?

	Element	Low rate of „CSS ready”	+ additionally for a medium rate of CSS ready	+ additionally for a high rate of CSS ready
CO_2 capture installation	Location of the object	Location of the object must include future aspect of transport and underground storage of CO2 („potential feasibility”).		
	Choice of capture technology	An identification of at least one capture technology for potential application must be done.		
	Project of capture installation	Technical feasibility study	FEED (front-end engineering and design study)	EPC (Engineering, Procurement and Construction)
	Cost rating of capture installation	Economical feasibility study	FEED cost study	Implementation of cost study of EPC
	Installation	Securing a place for the required equipment and future building area. No investment or investment at a minimum.	Preliminary investments on a medium scale.	Very advanced investments in installation
	Social acceptance	Inform the public about possible expansion of installation in the direction of CCS by a website or other activities (unspecified at this stage)	Identify areas of cooperation with local community at the stage of CCS project	Social acceptance for building project of CCS installation
	Analysis of environmental aspects of capture installation	A preliminary environmental assessement	An environmental impact report	Obtain all necessary environmental permits
	Building permit	Feasibility study for obtaining all necessary permits	Preparation of necessary documents	Obtain all necessary permits (economic, environmental) for implementation of capture installation
	Business associations, involvement of partners	A list of companies (partners) necessary for implementation of building phase and exploitation of capture installation in order to prove technical feasibility of the project	Signing intentional letters with potential main partners (technology providers, research institutions)	Signing conditional contracts with all the companies involved in construction and later exploitation of capture installation.
	Ongoing involvement of installation operator	No	Annual update of actual state	Start mechanisms for implementation of CCS technology after certain date or after creation of certain circumstances (eg. reaching of a certain level of commercialization of technology).

What can „capture-ready” means when it comes to transport pipelines?

	Element	Low rate of „CSS ready”	+ additionally for a medium rate of CSS ready	+ additionally for a high rate of CSS ready
CO_2 pipeline	Chioce of a channel for a CO_2 pipeline	Identification of a single pipeline route or several variants of the route	Obtaining options for the right for route	Obtaining rights for a route
	Social acceptance	Inform the public about possible expansion of installation in the direction of CCS by a website or other activities (unspecified at this stage)	Identify areas of cooperation with local community at the stage of a project	Finding social acceptance at a plannig stage
	Project of a pipeline	Technical feasibility study that include possible collision of a pipeline route with other potential lines of CO2 supply to other landfills	FEED (front-end engineering and design study)	EPC (Engineering, Procurement and Construction)
	Cost rating of capture installation	Economical feasibility study	FEED cost study	Implementation of cost study of EPC
	Analysis of environmental aspects of a pipeline	A preliminary environmental assassement	An environmental impact rapport	Obtain all necessary environmental permits
	Building permit	Feasibility study for obtaining all necessary permits	Preparation of necessary documents (applications)	Obtain all necessary permits (economic, environmental) for implementation of a pipeline
	Business associations, involvement of partners	A list of companies (partners) necessary for implementation of building phase and exploatation of pipeline in order to prove technical feasibility of the project	Signing intentional letters (disobliging) with potential main partners (technology providers, research institutions)	Signing conditional contracts with all the companies involved in construction of a pipeline or joining a consortium in order to develop a coordinated network of pipelines
	Ongoing involvement of installation operator	No	Annual update of actual state	Start mechanisms for implementation of CCS technology after certain date or after creation of certain circumstances (eg. reaching of a certain level of commercialisation of technology).

What can „capture-ready” means when it comes to storage areas?

	Item	Low rate of „CSS ready”	+ additionally for a medium rate of CSS ready	+ additionally for a high rate of CSS ready
Storage location	Choice of location for the landfill	Identification of one (or variants) location of the landfill with sufficient capacity for a specified number of years of exploitation	Options for obtaining one or more landfills	Obtaining a right for one landfill
	Landfill capacity verification	Preliminary analysis of capacity and the potential volume of the landfill, taking into account the modeling of the long-term landfill behaviour. Assessment of the location of such in terms of eg. access (difficulty), soil conditions (drilling difficulties), etc.	Preliminary drilling, geochemical analysis, verificatin of developed landfill behaviour models.	Seismic calculations in 3D conditions, the implementation of the CO2 injection tests, a final verification of previously prepared simulation models
	Social acceptance	Inform the public about possible expansion of installation in the direction of CCS by a website or other activities (unspecified at this stage)	Identify areas of cooperation with local community at the stage of a project	Finding social acceptance at a planing stage
	Project of a landfill	Technical feasibility study that include possible collision of a pipeline route with other potential lines of CO2 supply to other landfills	FEED (front-end engineering and design study)	EPC (Engineering, Procurement and Construction)
	Cost rating of a landfill together with the infrastructure	Economical feasibility study	FEED cost study	Implementation of cost study of EPC
	Analysis of environmental aspects of a storage location	A preliminary environmental assessment	An environmental impact report	Obtain all necessary environmental permits
	Building permit for a landfill together with the infrastructure	Feasibility study for obtaining all necessary permits	Preparation of necessary documents (applications)	Obtain all necessary permits (economic, environmental) for implementation of a landfill
	Business associations, involvement of partners	A list of companies (partners) necessary for implementation of building phase and exploatation of pipeline in order to prove technical feasibility of the project	Signing intentional letters (disobliging) with potential main partners (technology providers, research institutions)	Signing conditional contracts with all the companies involved in construction of a landfiill or joining a consortium in order to develop a coordinated network of landfills
	Ongoing involvement of installation operator	No	Annual update of actual state	Start mechanisms for implementation of CCS technology after certain date or after creation of certain circumstances (eg. reaching of a certain level of commercialisation of technology).

Emission reduction options

Main approaches:

- **Pre-combustion measures: improved efficiency of energy production, coal washing, substitution of fuels,**
- **Post-combustion measures: CCS**
- **Co-control of climate gases and air pollutants (GHGs, PM, SO_2, NOx)**
- **Pollutant specific emission control technologies**

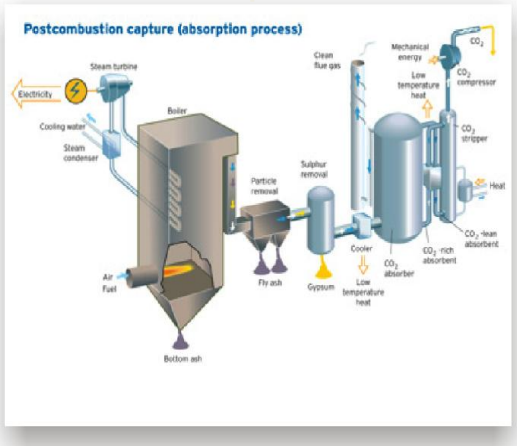
Selection of appropriate measures depend on:

- **Current technology (different measures may be most cost efficient in different regions)**
- **Rules, regulations etc.**
- **Economic and social factors**

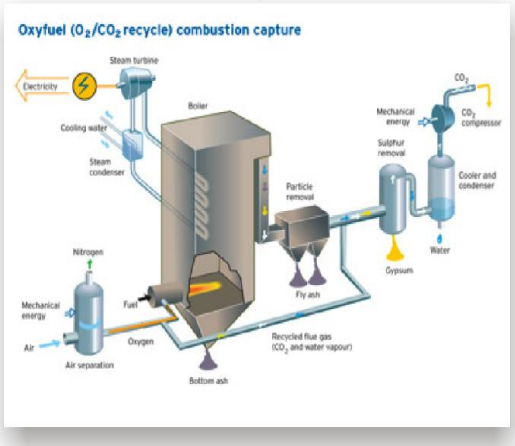
FUTURE COAL-FIRED PLANT

ZERO-EMISSION PLANTS WITH CO_2 SEPARATION

CO_2 separation after combustion process



Combustion in oxygen atmosphere



CO_2 separation before combustion process

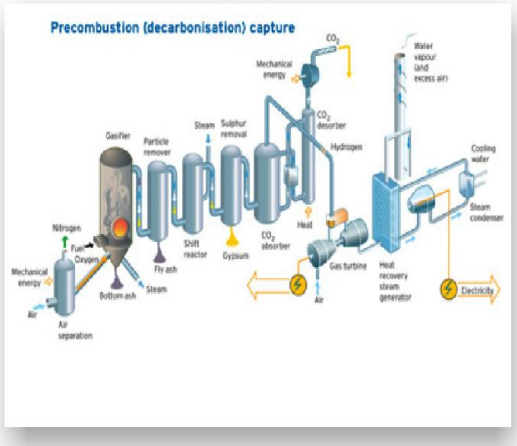
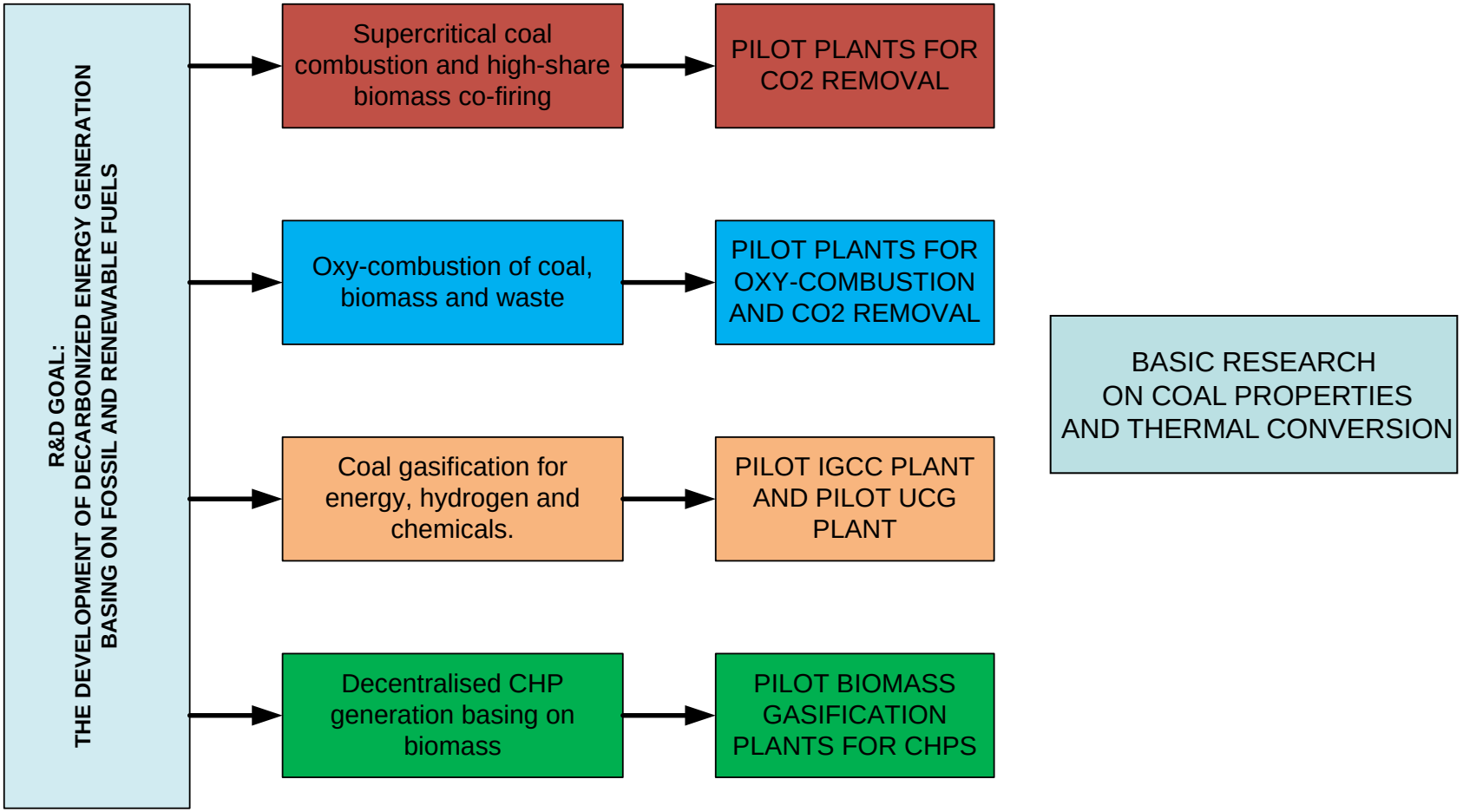
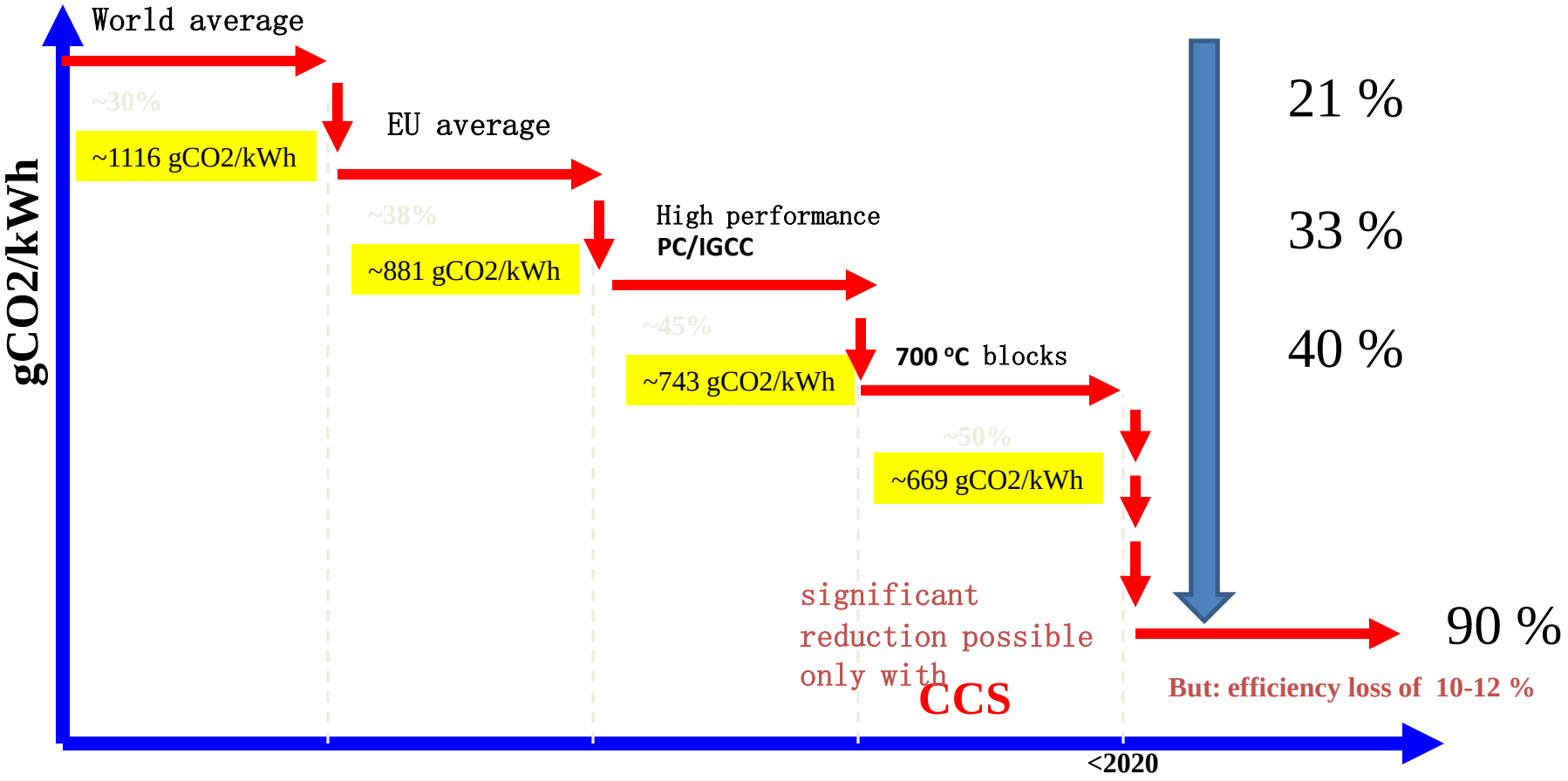


Image source: Vattenfall

Technology options



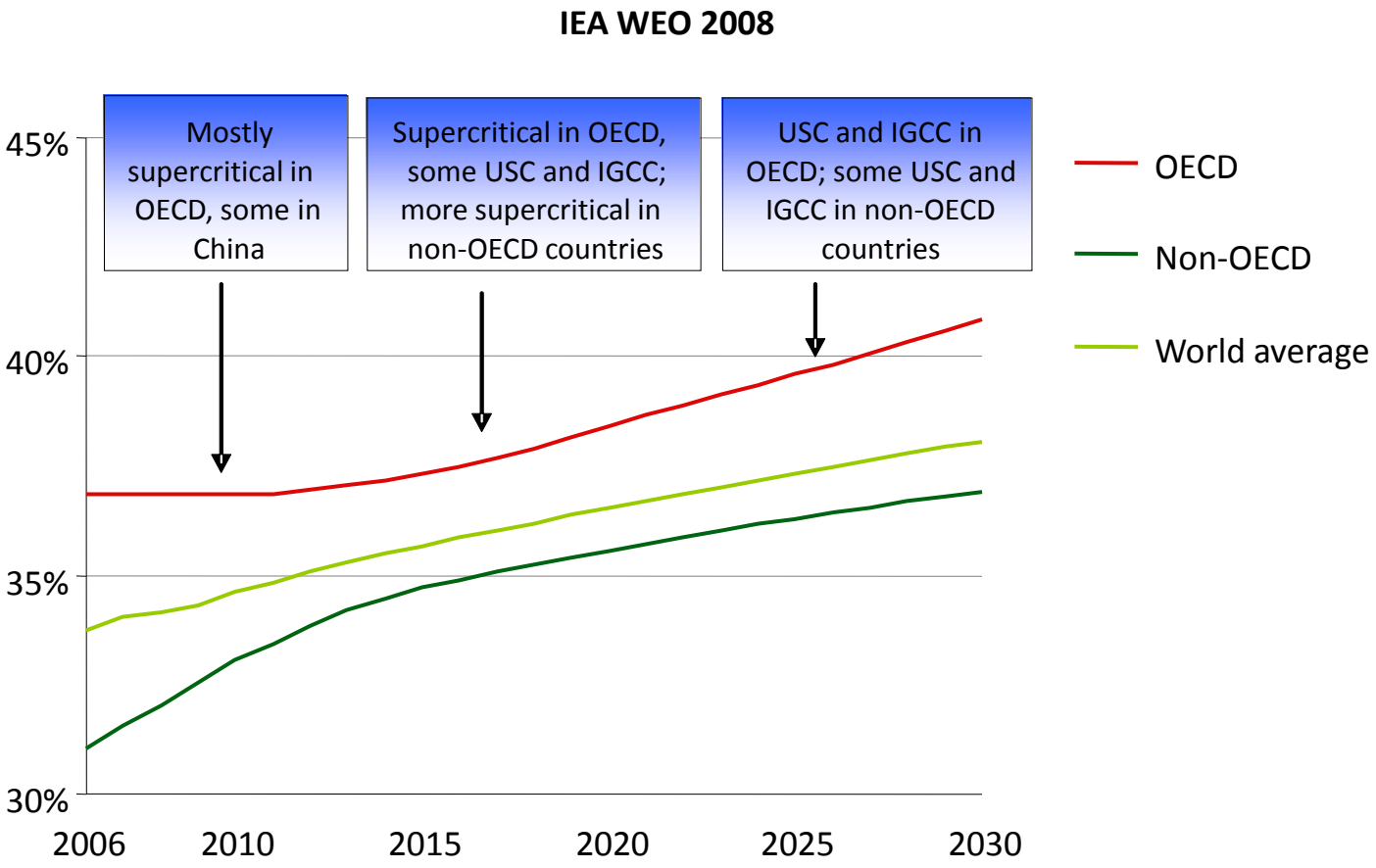
CO_2 emission reduction as a result of technological changes



Increase of efficiency results in significant effects, but only CCS leads to real CO_2 emission reduction.

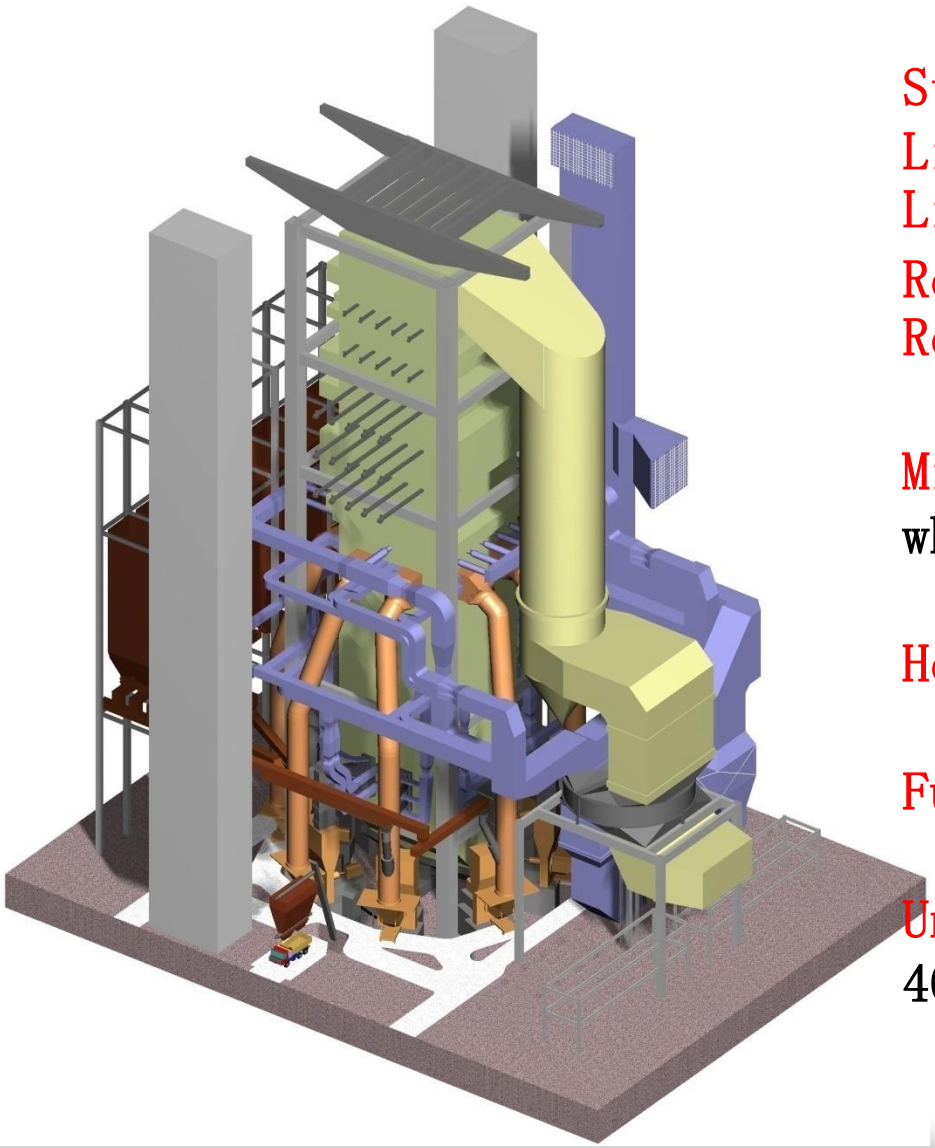
adapted from VGB 2007; efficiency – HHV,net

The Reference Scenario: Efficiency improvements in coal-fired generation



The average efficiency of coal-fired generation rises from 34% in 2006 to 38% in 2030, as supercritical technology initially & then ultra-supercritical become widespread

Patnow: Boiler View & Technical Data



Steam Capacity : 1374 t/h
Live steam pressure : 266 bar
Live steam temp. : 544 °C
Reheat steam press.: 52 bar
Reheat steam temp : 568 °C

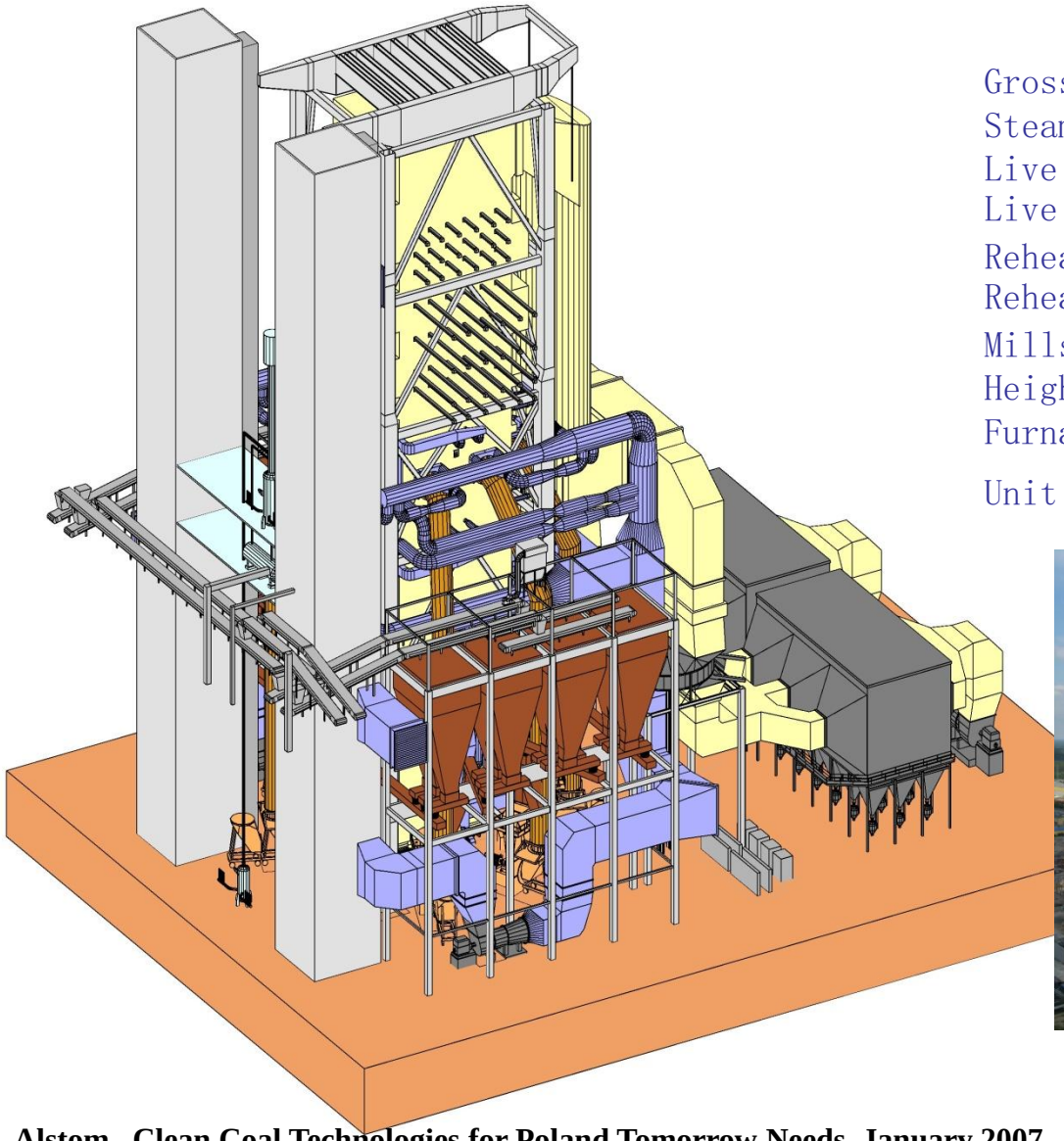
Mills: 8 beater
wheel type

Height of boilerhouse : 114 m

Furnace aspect length : 17 m

Unit net efficiency :
40,8 %

Belchatow: boiler & technical data



Gross capacity : 858 MWe
Steam capacity : 2484 t/h
Live pressure : 266 bar
Live steam temp. : 568 °C
Reheat steam press.: 55 bar
Reheat steam temp : 587 °C
Mills : 8 beater wheel type
Height of boilerhouse : 143 m
Furnace aspect length : 23 m
Unit net efficiency : 41,7 %

Alstom, Clean Coal Technologies for Poland Tomorrow Needs, January 2007

Lagisza Supercritical CFBC – new design

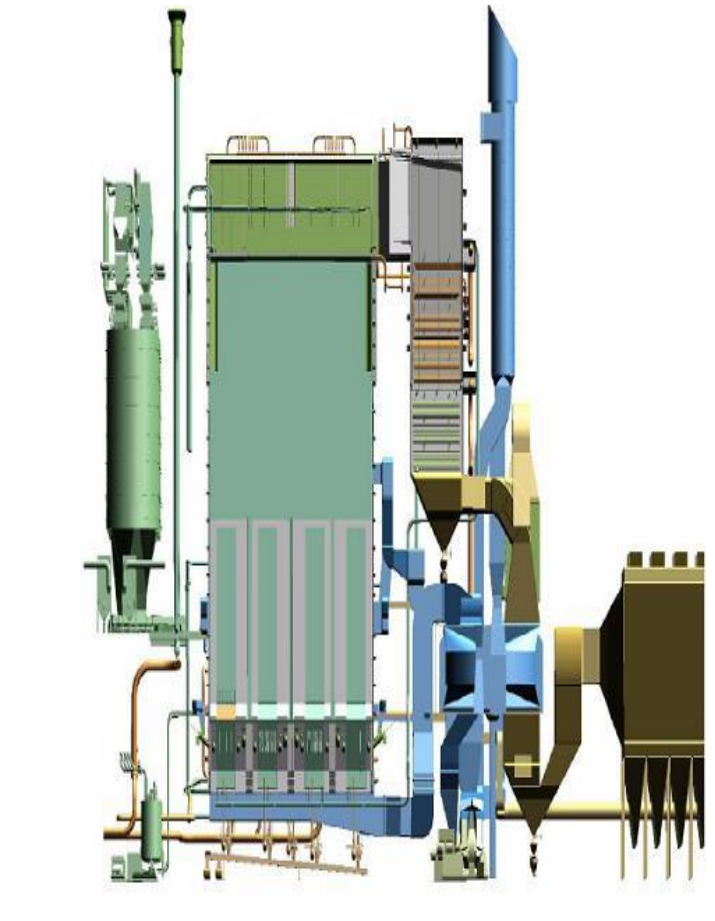
The world's first CFBC unit with supercritical steam conditions

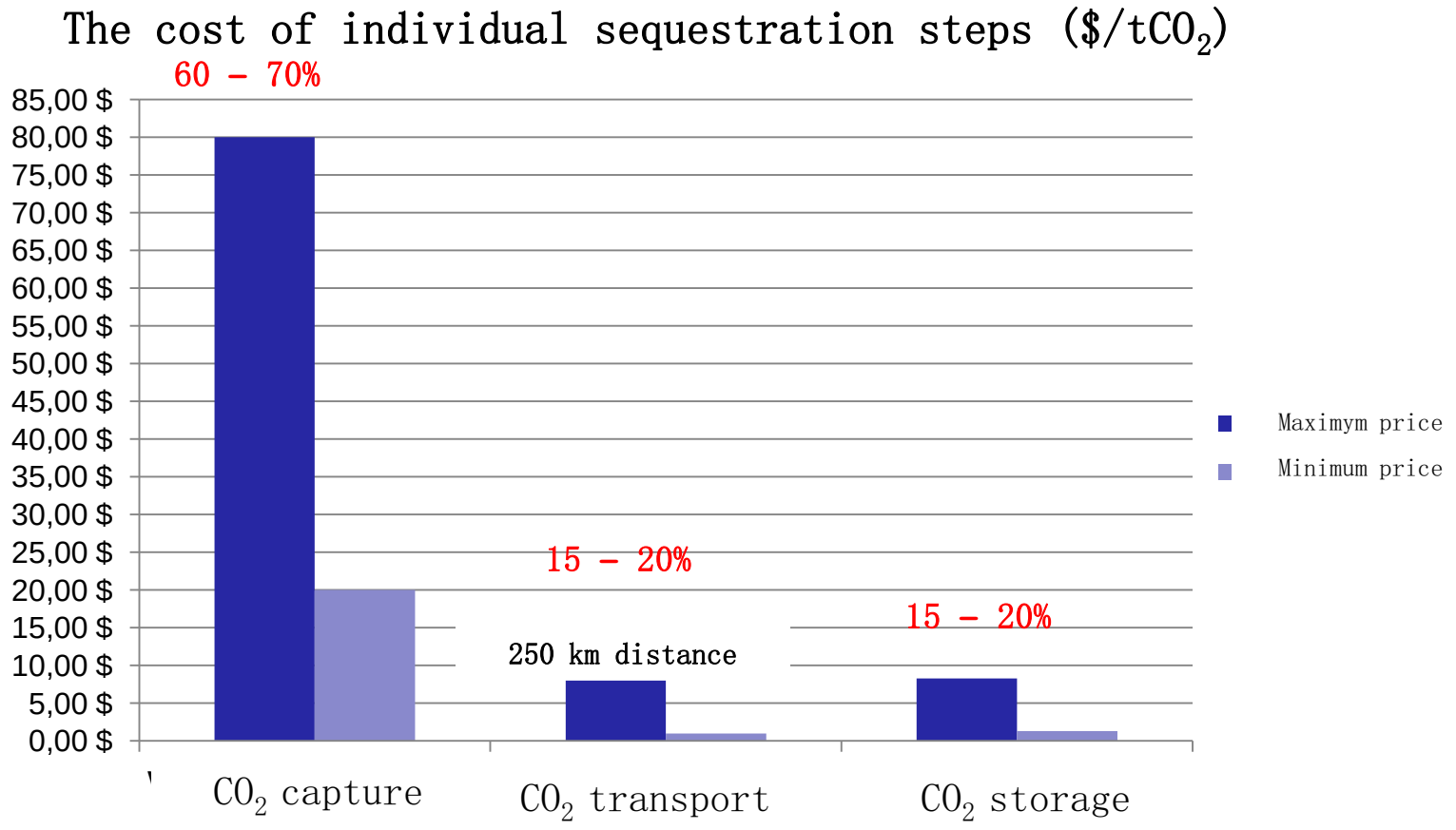
Largest CFBC; 460 MWe

Start-up in 2009

Emissions of SOx, NOx and particulates lower than required by latest EU LCPD limits.

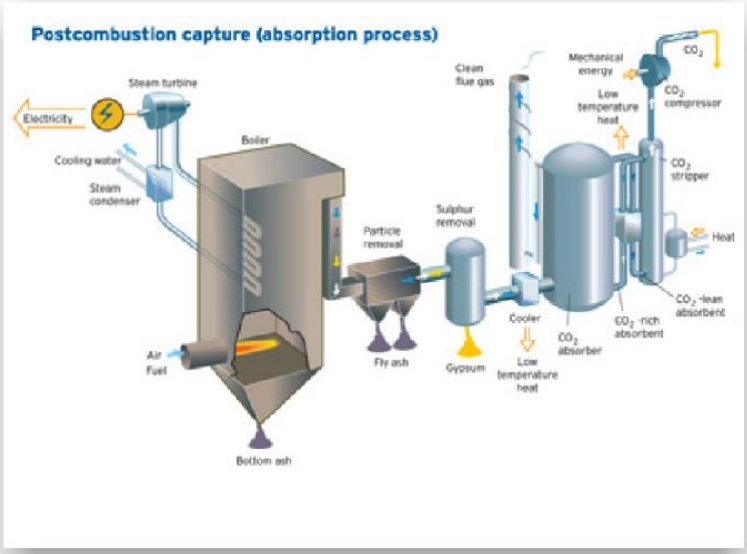
Located to NE of Katowice, Poland



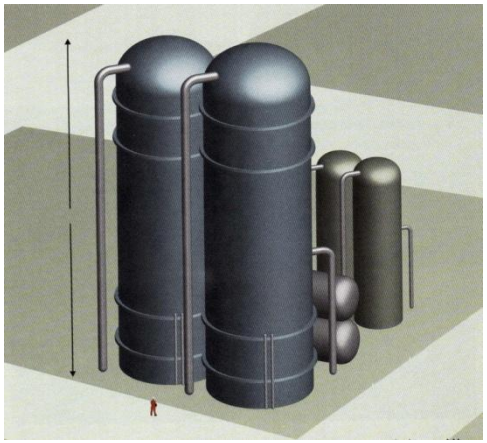


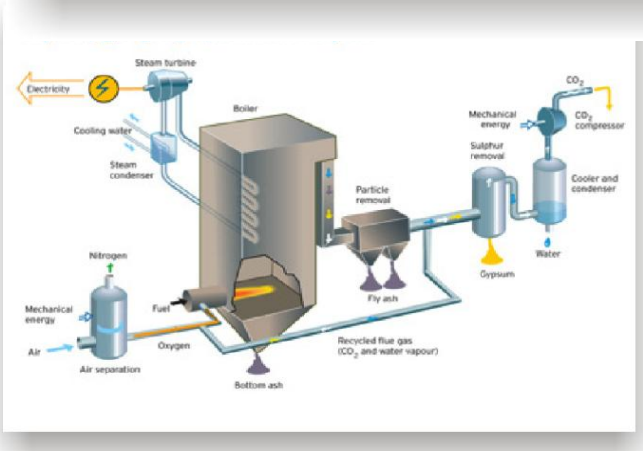
Very high energy consumption for CO_2 capturing

SEPARATION OF CO_2 – ABSORPTION vs OXY-COMBUSTION

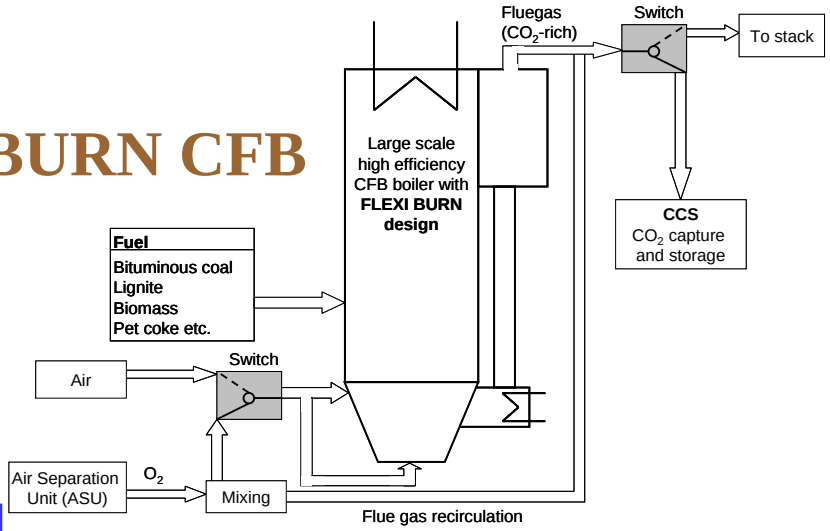


The case of PGE Elektrownia Bełchatów



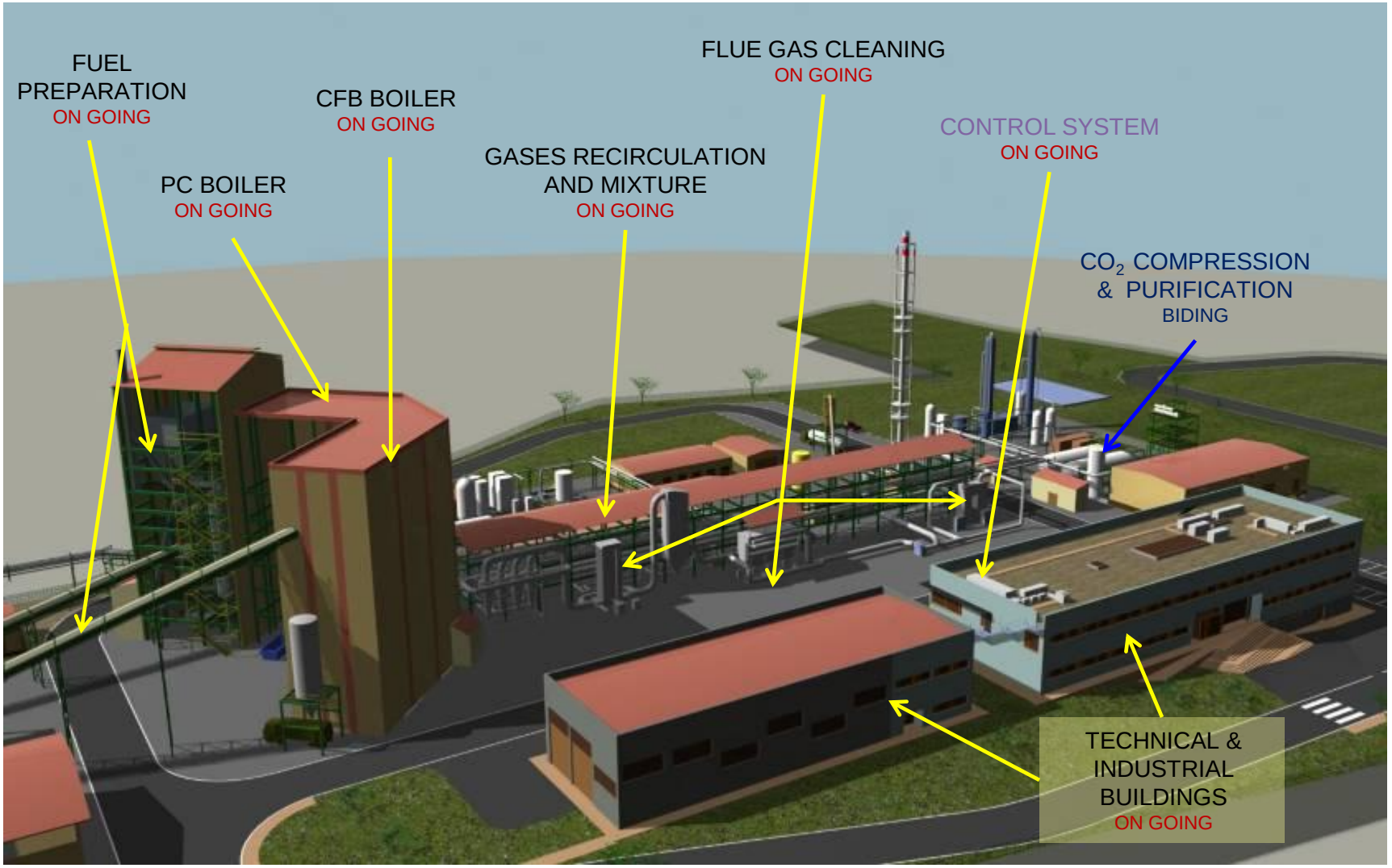


FLEXIBURN CFB

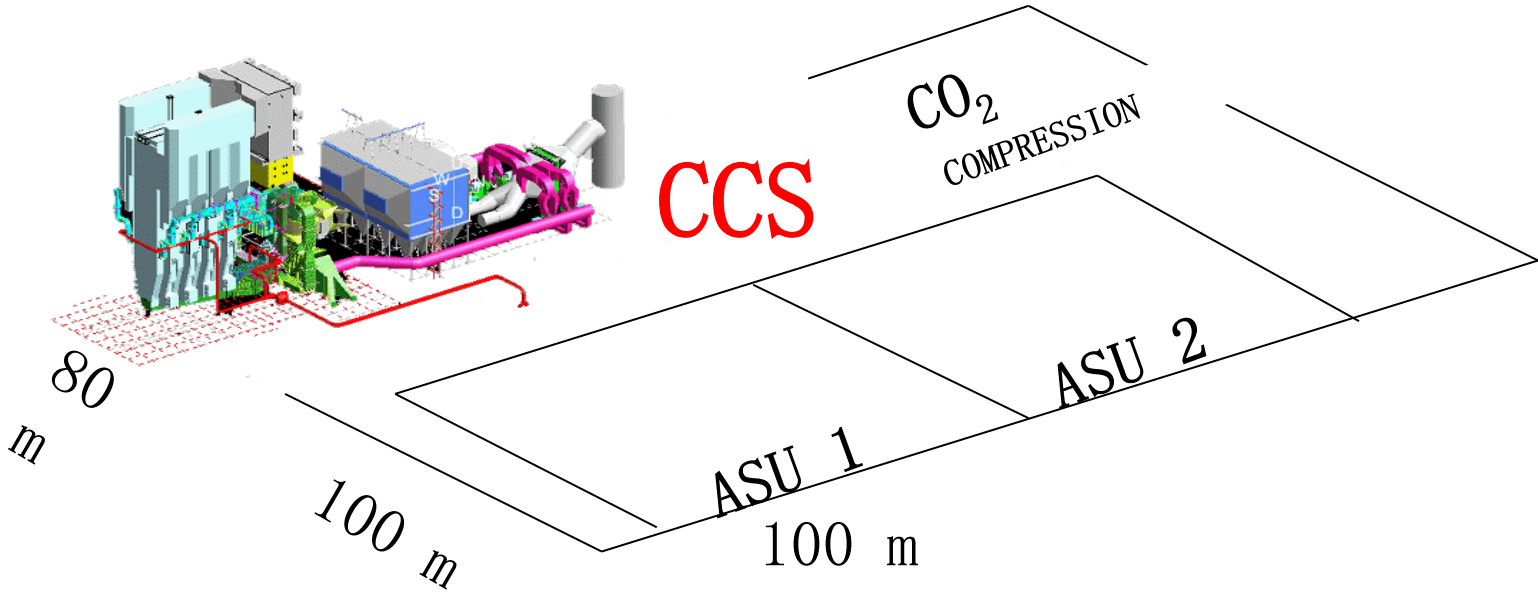


Oxy-combustion Vattenfall and our proposal

CIUDEN´S TDP 3D VIEW



All objects of a specific combustion energy power, for which the construction license or permit to operate will be granted after the entry into force of CCS Directive, are required to have on-site a suitable area for a CCS installation if the suitable storages are available and the CO2 transport and a modernization for Co2 capture are technically and economically feasible (Section 46 of the Preamble)



Additional area for development of ASU and CO_2 capture installations

Technical specification of post-combustion CCS

- Post-combustion technology based on „advanced amine” process
- 1.8 million tones of CO2 captured and injected into geological formation per annum (260 MWe, 90% capture rate)
- Transport compressed CO2 at supercritical phase using pipeline to storage site within 60-140 km
- Storage at deep saline aquifers

Implementation of the CCS – the main obstacles

New technologies in the pilot phase

- risk of implementation
- cost

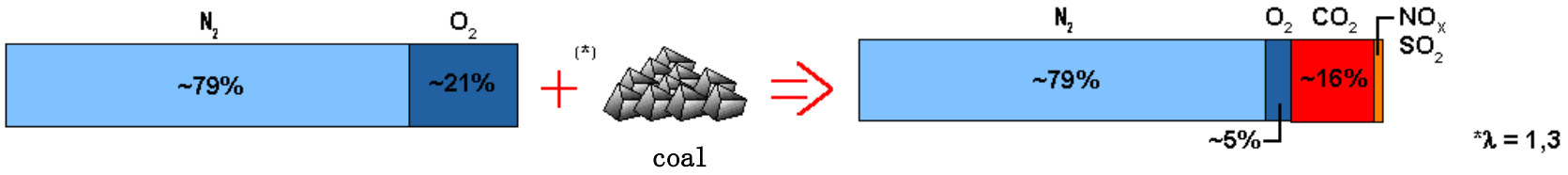
Permissions for CO_2 storage

- not in my backyard
- a strong opposition of local authorities
- storage on land is very expensive

Political uncertainty

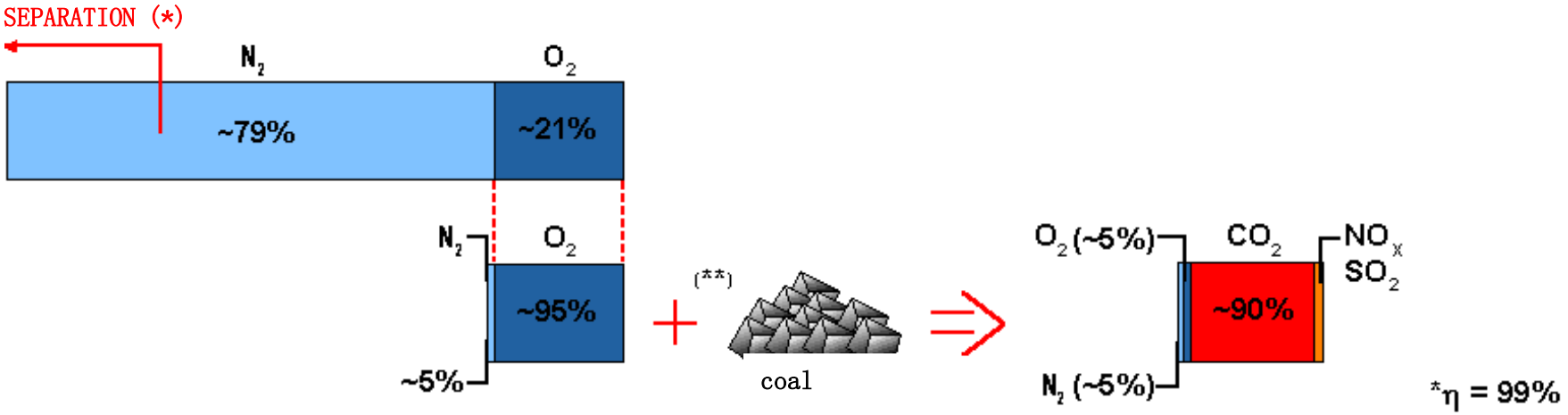
- introduction of European Trading System
- support on national and EU level

THE (CONVENTIONAL) COMBUSTION OF COAL IN THE AIR



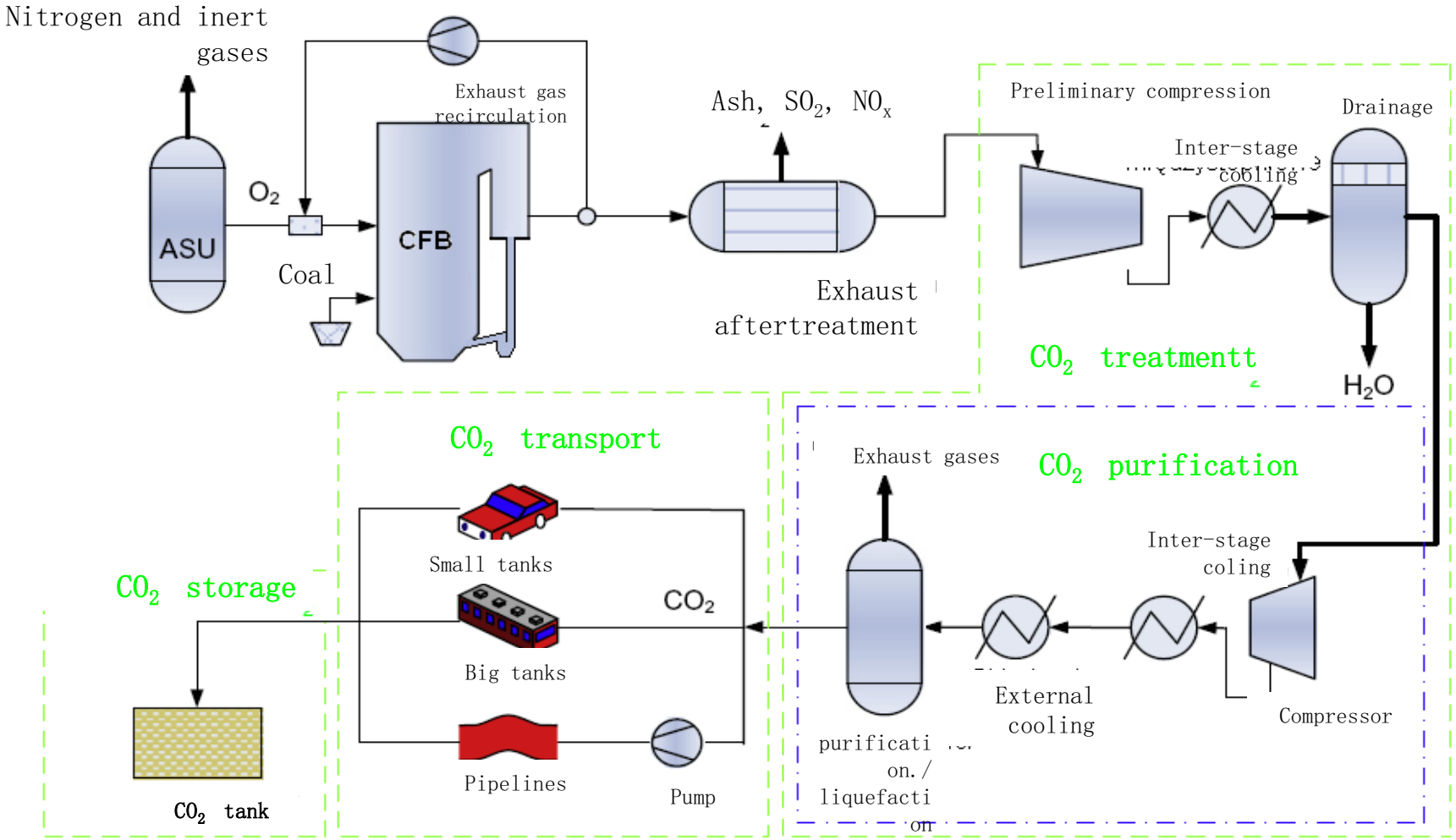
vs

THE COMBUSTION OF COAL IN THE AIR



- addition of O_2 to the nozzles that lead air to the combustion chamber (*oxygen enrichement*),
- injection of O_2 to the flame (O_2 *lancing*),
- providing air and pure oxygen separately tinto the combustion chamber (*air-oxygen combustion*),
- substitution of air by pure oxygen (*oxygen combustion*).

Combustion in oxygen – CCS without CO_2 capture



Oxy-combustion in PC and CFB boilers

CFB, PC

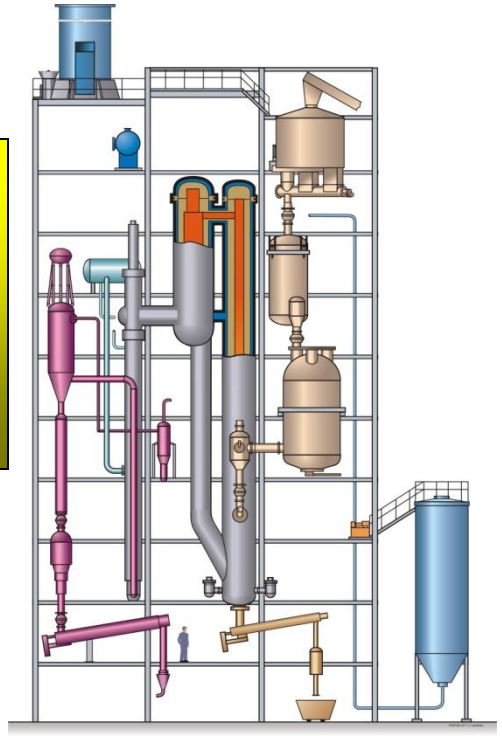
STEAM CYCLE

INTEGRATION

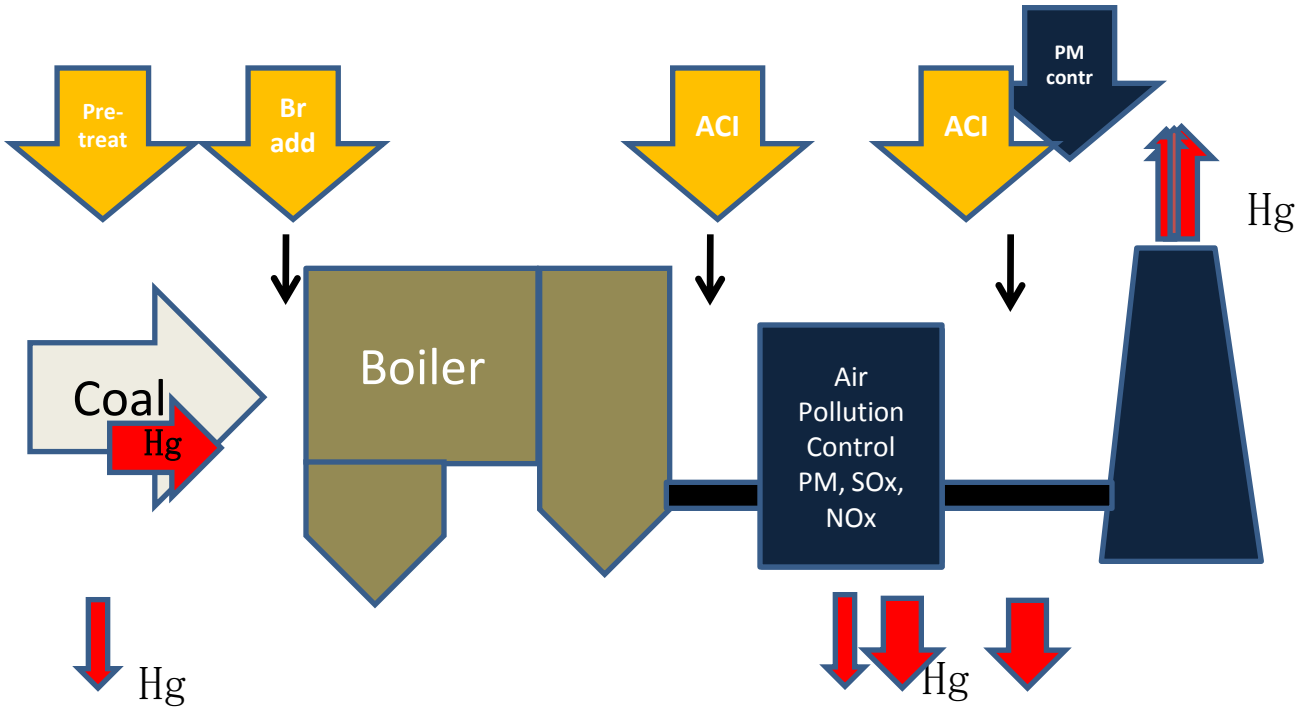
ASU

CO_2 sequestration possible conceptions:

- chemical absorption
- physical absorption
- membrane techniques
- cryogenic separation



Example of emission control in a coal-fired power plant



Can coal combustion be environment friendly?
YES, it can, BUT:

- New, highly efficient combustion technologies are needed to produce electricity and heat (new blocks with supercritical vapor conditions, co-generation, hybrid systems, etc).
- Carbon dioxide emissions should be reduced through the implementation of pre-combustion, post-combustion methods, or combustion in oxygen.
- CCS technologies should be implemented mainly in new power stations (storage of carbon monoxide should be resolved).
- Co-control technologies should be employed to reduce emissions of various contaminants, such as mercury (e.g. various adsorbers).
- Cost of the above technologies should not lead to deterioration of competitivness and relocation of energy production outside EU, where standards are less restrictive.

Emission reductions are achievable

Thank you for your attention