Evolution and Prospects of Fossil Fuel Electricity Generation

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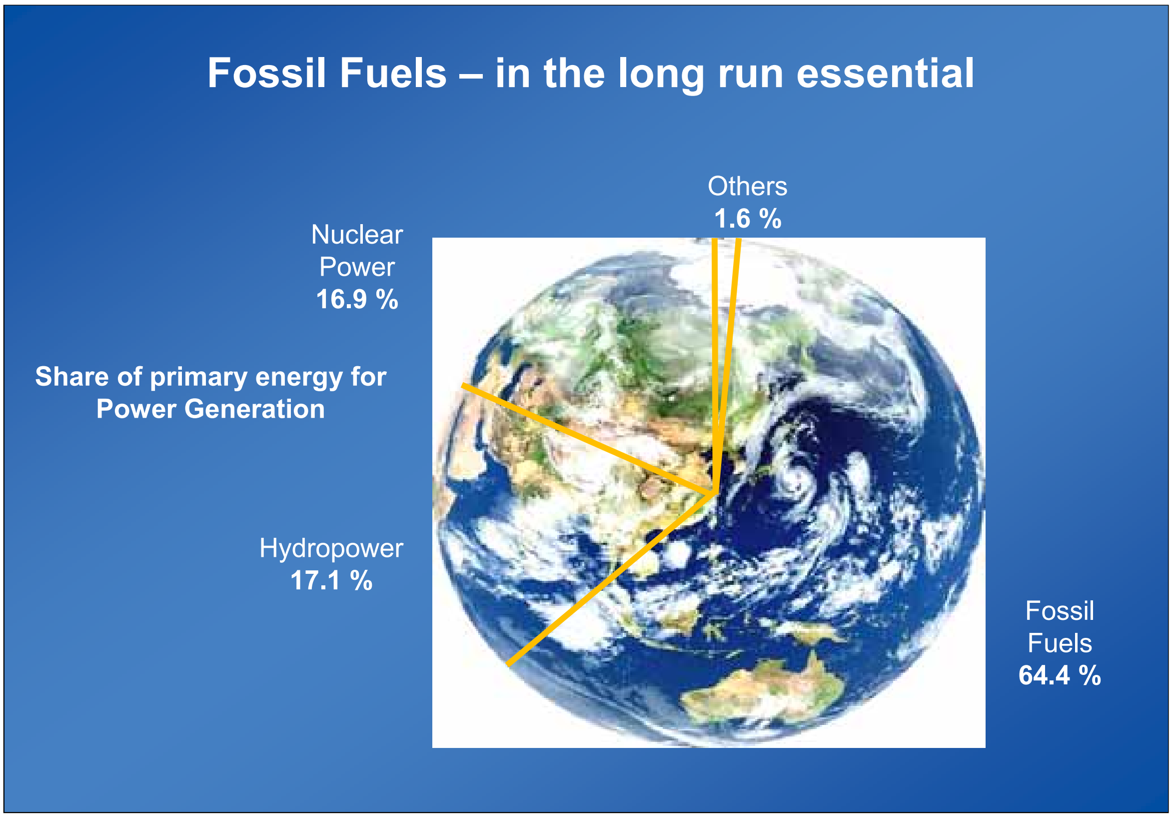
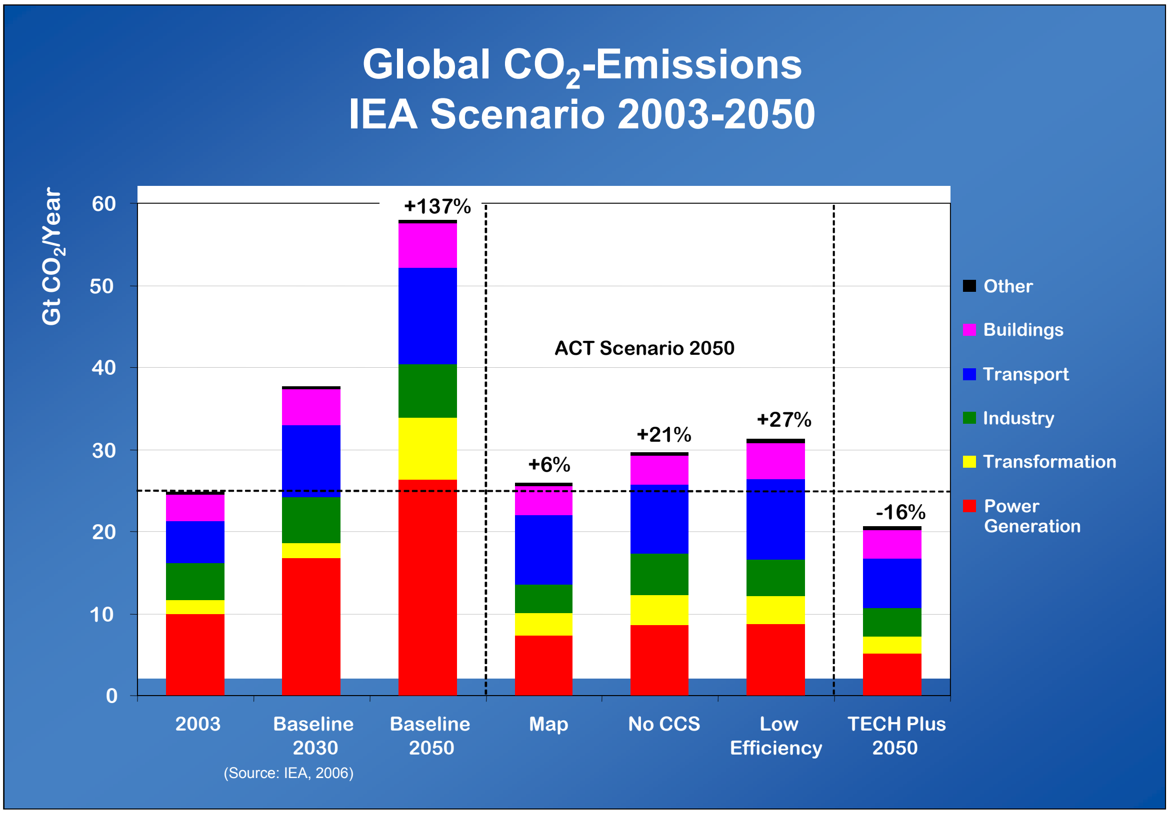
Good morning, Lady and Gentlemen!
I would like to focus on the evolution and prospects of fossil fuel electricity generation, and in particular I would like to explain to you a little bit the vision of the European energy industry in the next 30 to 50 years. This will be my main task during this morning.
The outline of my presentation is given here:

- Global Demand on Electricity
- Global CO_2 – Emissions until 2050
- Options for CO_2 Reductions
- Combustion Technologies with CCS
- New Power Plant Projects in Europe

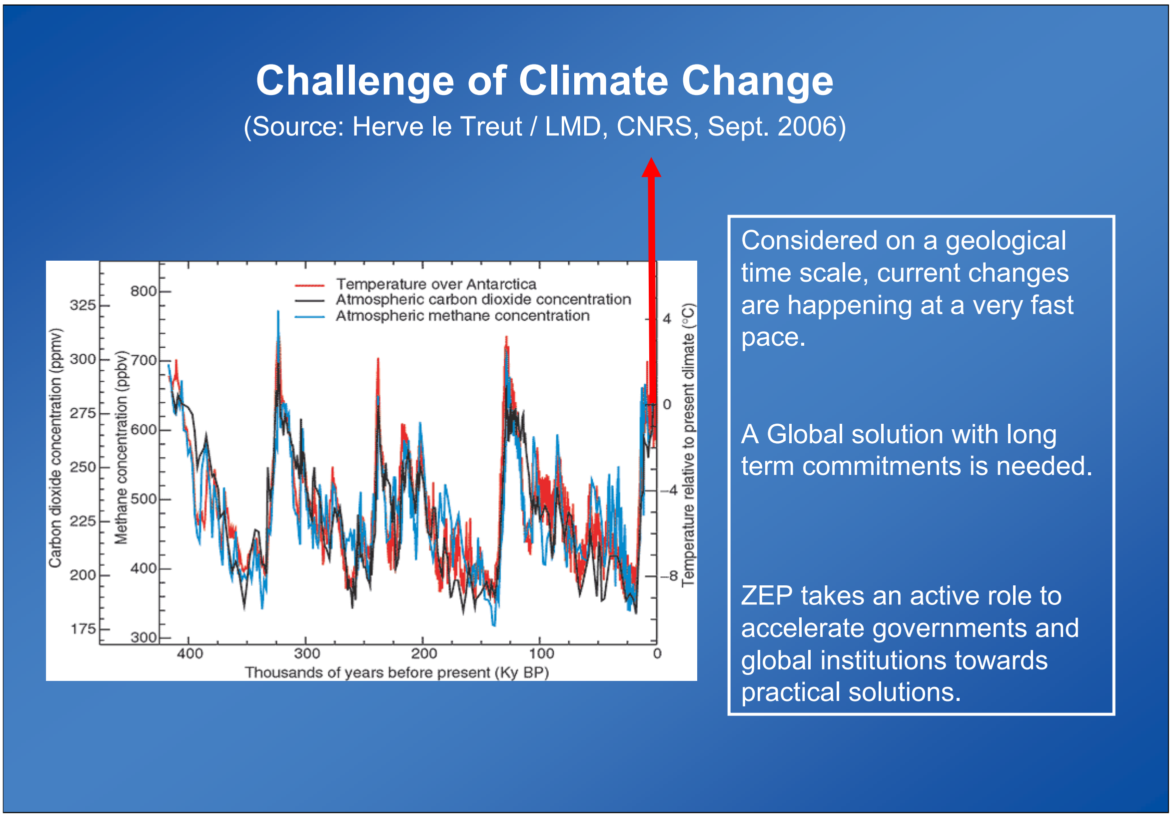


This slide shows you the situation we are faced with.
Today 64.4% of world electricity production comes from fossil fuels, i.e. energy produced on the basis of oil, gas and coal.
When discussing the future of the energy system in Germany with for example some NGO's, I hear quite often the vision of fuel switch from coal to gas to reduce CO_2-emissions.
From the perspective of the calculation sheet this is o.k., but first of all this is a very local perspective when looking on that picture…
…and secondly this is not very far sighted. After a couple of decades the problem will come back, and even bigger.
As the gas reserves are much more limited than the coal reserves – you all know the scenarios – it could work up to a certain point, but than after we burned the gas for electricity production only coal is left, of course apart from nuclear.
So, what I am arguing for is that we have to agree that coal will be part of the future solution, especially when looking from a global perspective and how the coal reserves are distributed over the world.



This figure shows some predictions of the IEA. If the fuel mix (both for end-use and electricity generation) had not changed since 1973 and if there had been no energy savings, emissions would have grown at about the same rate before and after 1990.

The impact of switching to lower carbon fuels was limited in both periods so it becomes clear that the main reason that emissions grew more rapidly after 1990 is the slowing rate of energy savings.



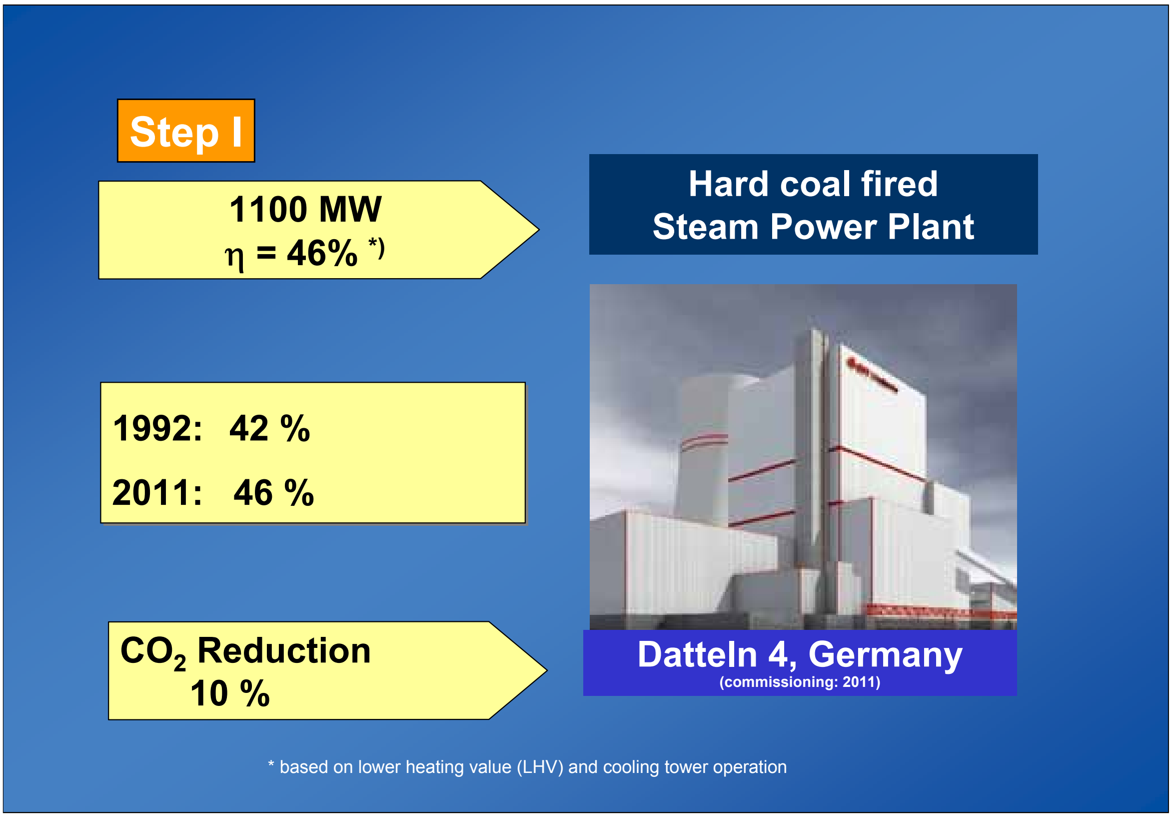
Here you can look at the actual situation. On the lower axis you see the thousands of years before present. You can see the dramatic increase of CO_2-emissions up to now. We have now an average figure of 380 ppm CO_2-concentration in the atmosphere. This is about 30% higher than some thousand years ago.

So we think we have to implement a step by step approach for the power plants to have a substantial reduction of CO_2-emissions. We decided to have 3 steps, starting in

Step I with the construction of new efficient coal fired power plants (State of the Art Technology), coming then in

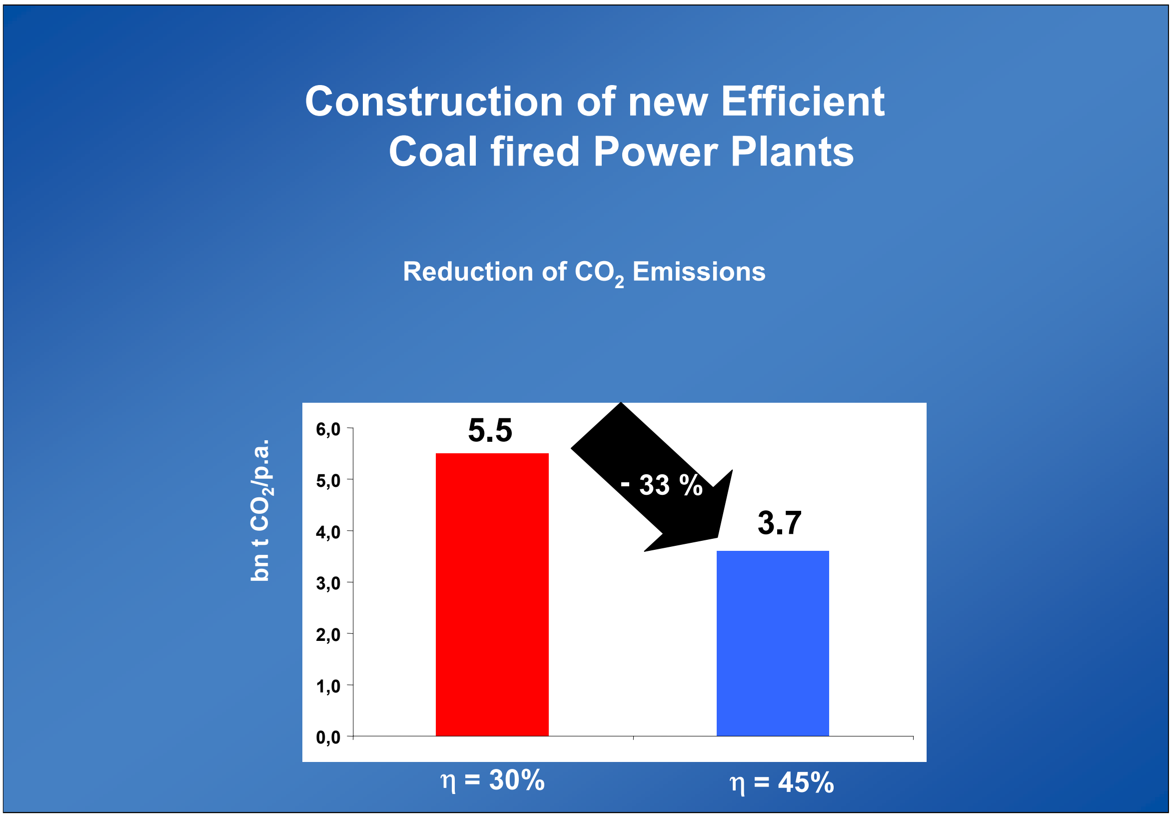
Step II to the introduction of 700°C-Technology. Finally, i.e. after 20 years, in

Step III we might introduce on a commercial basis the carbon capture and storage (CCS) technology.



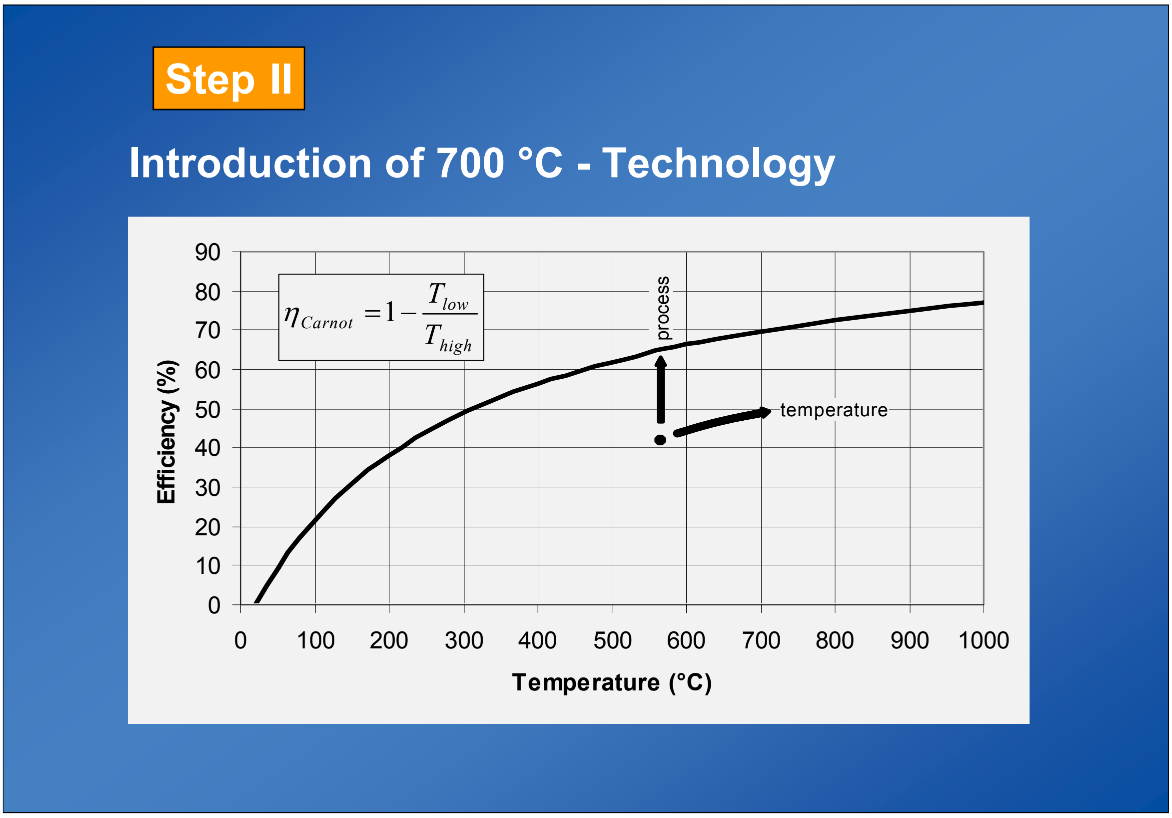
Here you can see the Step I approach. In this step you install highly efficient power plants, i.e. you increase the efficiency from 42% to 46%, as a typical example of a plant in Germany. For all the colleagues not involved in power plant engineering, it means, if you could put in 100% thermal power from coal you would get out 42% or 46% electricity.

This would bring you a CO_2-reduction of 10%.



If we would transfer this situation to the world, and you have to consider that in the world the average efficiency of the power plants is only 30%, you could substantially reduce the CO_2-emissions by increasing the efficiency of old existing plants.

Look at the left side: There you see that we have a 5.5 billion tons of CO_2 is coming out of hard coal fired power plants. There is a 33% chance of reduction by building new highly efficient power plants.



In Step II we increase the temperature of the life steam in the power plant up to 700 °C and that we introduce nickel based alloy materials able to run a power plant up to 700 °C life steam.

Large Scale Test Facility COMTES700

Test of components at 700 °C steam temperature under realistic conditions

Test of critical components
out of new materials
at high temperatures
under realistic conditions

Project partners: 9 utilities, 4 manufacturers
Project coordinator: VGB PowerTech
Project budget: > 23 M€, herein about 6 M€ EU

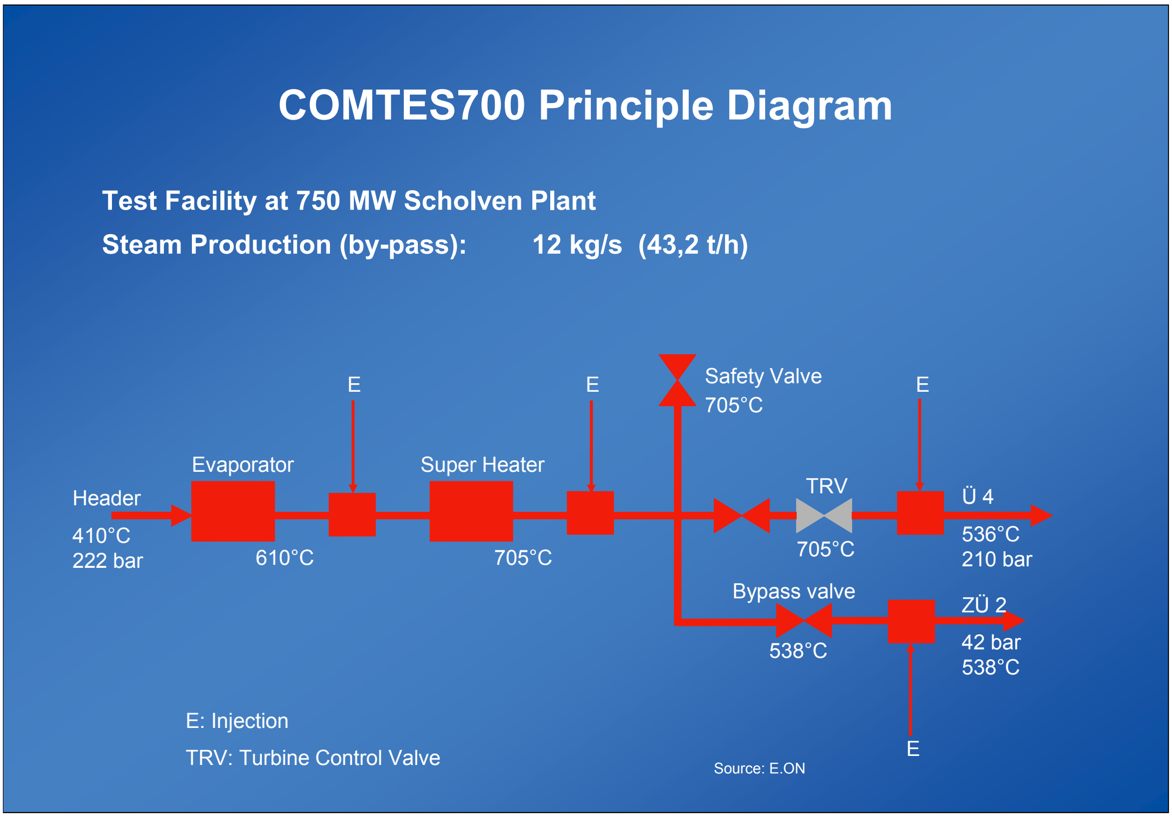
Project start: 7/2004
Begin operation: 7/2005
Operation time: >20,000 h

COMPONENTS TO BE TESTED:
- Membrane wall (44 tubes)
- Super heater (32 tubes)
- Header
- Pipes
- Bypass valve
- Safety valve
- Turbine valve
- Fittings

parallel: Tests in the power plants Esbjerg and Weisweiler

Source: E.ON

We have already started here together with component manufacturers and 9 European utilities a project called COMTES700. In this project we test a lot of critical components to implement the 700° technology under realistic conditions, i.e. these test facilities are integrated in a 700 MW block. We produced here high temperature life steam in order to test critical components of a power plant such as membrane walls, super heaters, etc. The project started in 7/2004, we have now reached about 8,000 successful operating hours. So we are quite optimistic to reach our aim here.



Here you can see some details of such a plant. In a bypass we produce within an evaporator temperatures up to 610 °C, in a super heater 705 °C, and after that it is cooled down again in the facility for further processing.

COMTES700 / 700 °C Test Facility

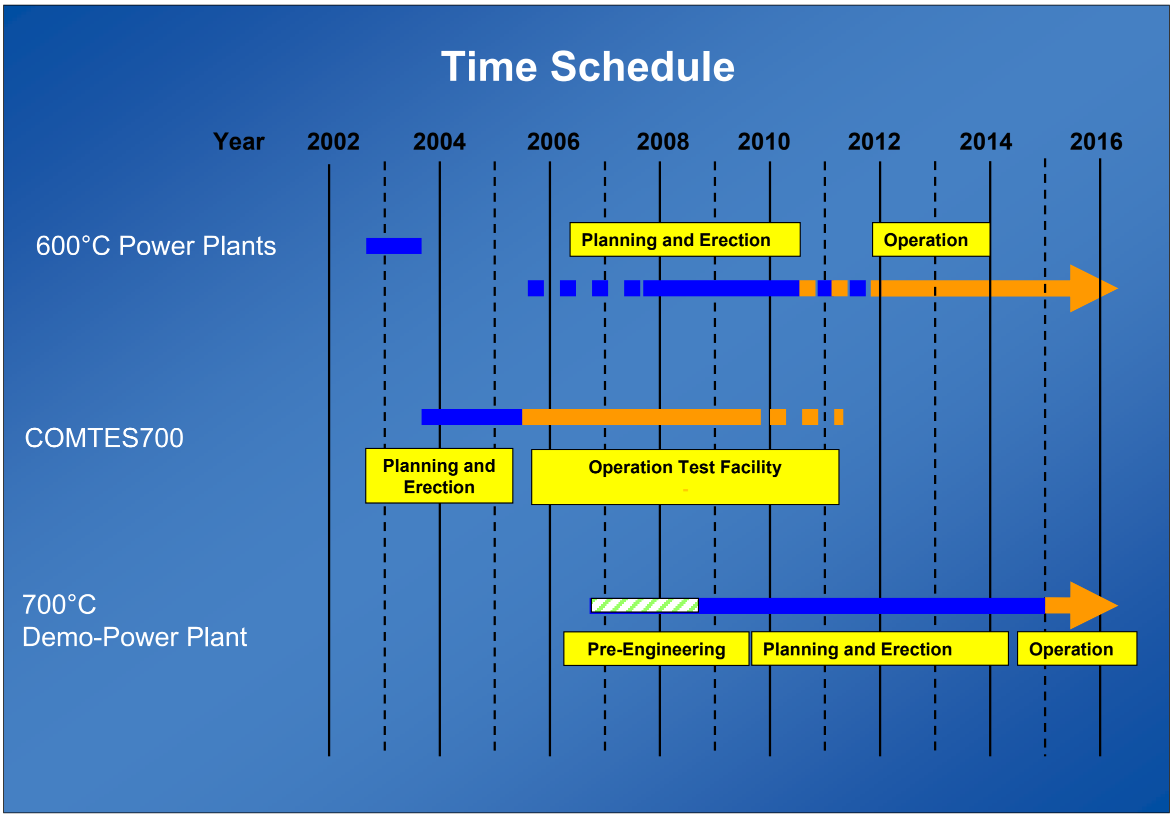
Source: E.ON

How does such part look like? If you look in the center of this figure, it is quite incredible and interesting, you have a pressure of 220 bar in the test facility and you see the red portion in the center, that is actually the tube. It has a temperature of 700 °C and a pressure of 220 bar in the test facility. In the next step we will increase the pressure up to 350 bar. One major factor is of course that we have available nickel based alloy which will secure such a process. We are in the stage to develop this material and we are quite confident to implement such processes..

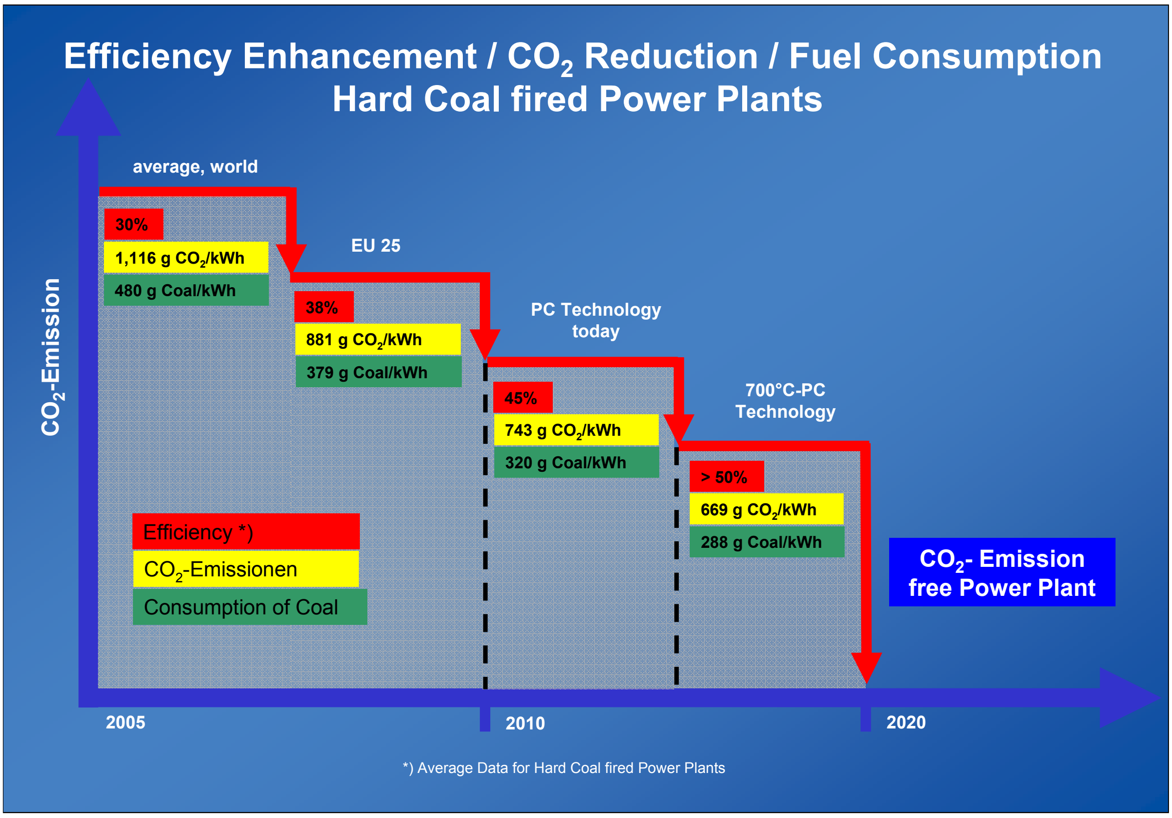
NRWPP700 – Pre-Engineering

- Start-up: September 2006
- Running Time: 22 month
- Project Volume: 4.5 m€
- Project Partner: EdF, Electrabel, EnBW, E.ON, EVN, DONG, RWE, STEAG, Vattenfall, NRW
- Project Co-ord.: VGB PowerTech e.V.
- Major WP: - Design of a 400 MW PC Demo.-Plant
- Transfer to 1000 MW Plant (Hard Coal)
- Transfer to 1000 MW (Brown Coal)
- Net Efficiency: above 50%

We just started in September of this year a first basic engineering step for the building of a 400 MW PC demonstration plant. We have a lot of project partners. All of these companies come together to make the engineering for the demonstration plant of 400 MW with a 700 °C life steam temperature. This project has a volume of about 4.5 million €. The net efficiency of the plant should be in the range of 50%.



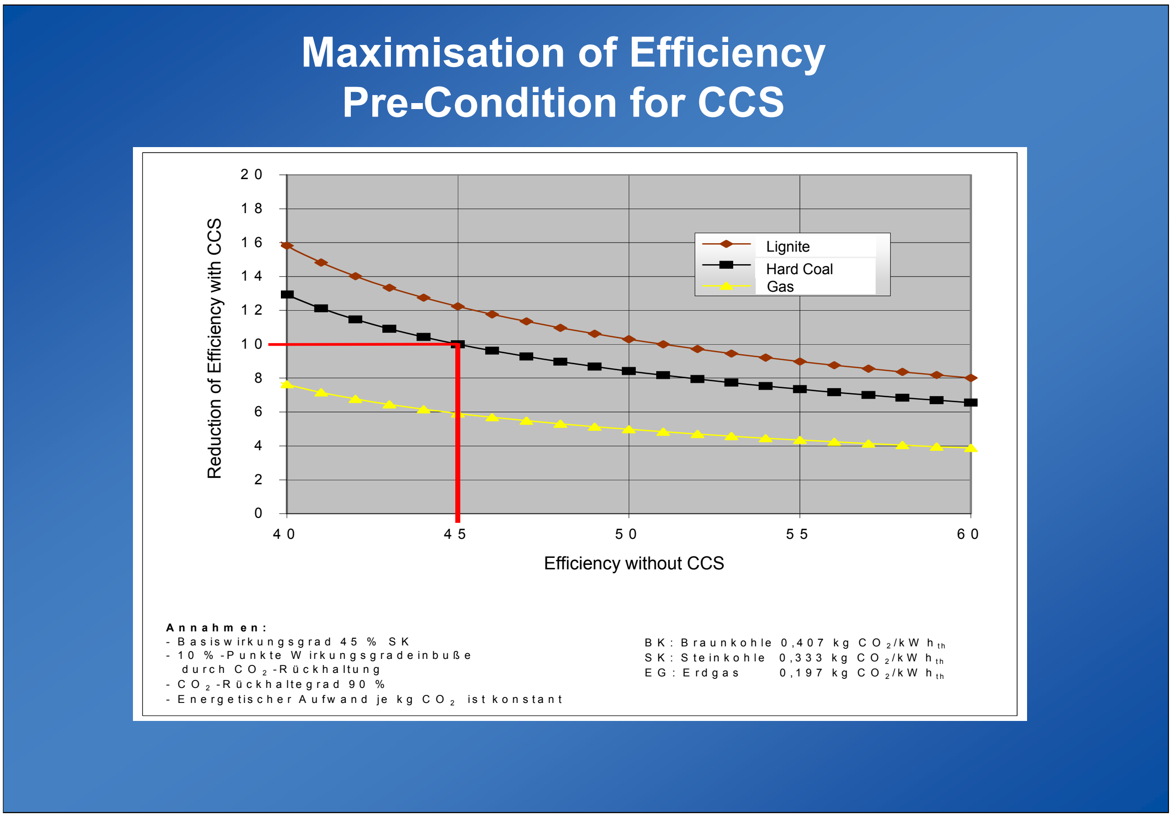
Here you can see the time schedule of such a plant. We have already introduced the 600 °C power plant technology. Then I explained here the COMTES700 test facility which starts operation in 2005 and now we are in the stage of the pre-engineering of the 700 °C demo-power plant. We think this plant could go into operation in 2014.



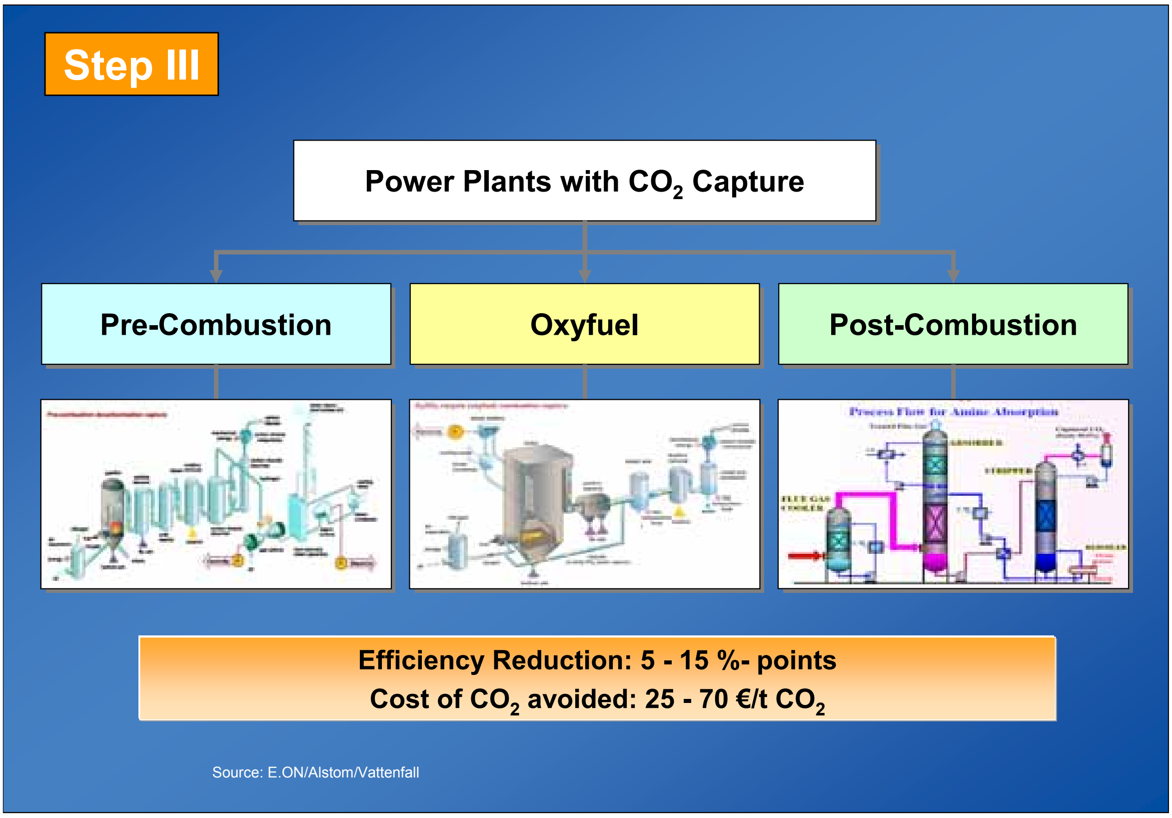
Here you see the major advantages of the steps I have explained so far. The red colour indicates the efficiency, starting with 30% for the average value in the world, which means, that you will emit 1,116 g of CO_2 for the production of one kWh, and you need to put in about 480 g of coal for the production of one kWh.

Then you have the values for the EU25. Finally you see the values of the 700 °C technology with 280 g of coal for one kWh. The emission is dramatically reduced to 669 g CO_2 for the production of one kWh.

But if you look at the CO_2-emission free power plant, that might be the next step, it will mean to decrease the efficiency again. We have to use a lot of auxiliary power to implement the CCS technology.



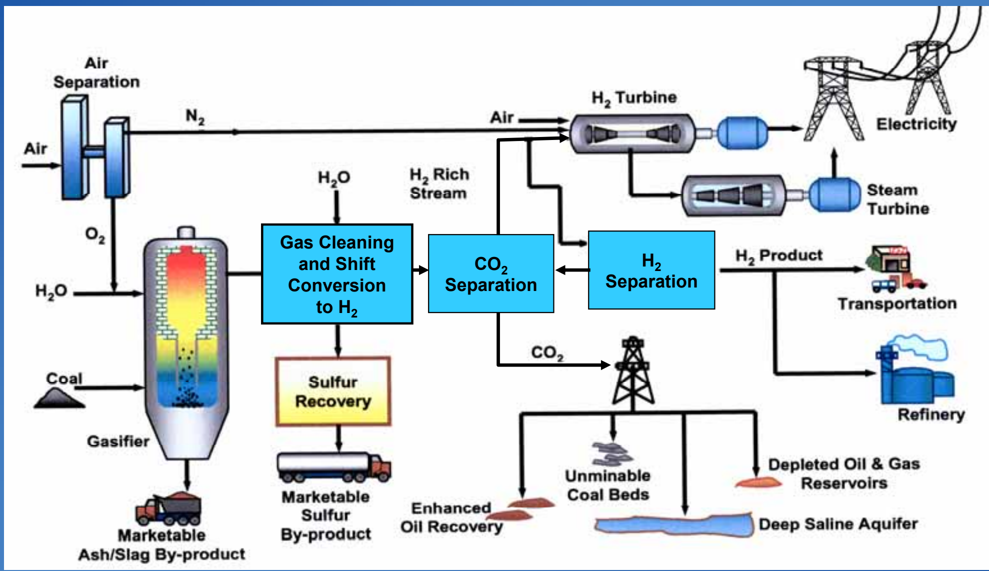
The maximisation of efficiency is a precondition for the introduction of the CCS (carbon capture and storage) technology. Having just an efficiency of 45% you will loose about 10% in efficiency by the introduction of CCS. But if you increase the efficiency, for example, to 55%, if you look at the center for the hard coal, you will loose only 7% to 8%.



Now let us talk about Step III and power plants with CO_2 capture technology. There are 3 major options. We call them: pre-combustion, oxyfuel and post-combustion technology. This describes where we get out the CO_2 from the process, before the combustion or we run the process with oxygen or we remove the CO_2 after the combustion.

In the bottom line, you see, we can expect efficiency reduction in the order of 5% to 15%.

Pre - Combustion Capture
FutureGen - Project



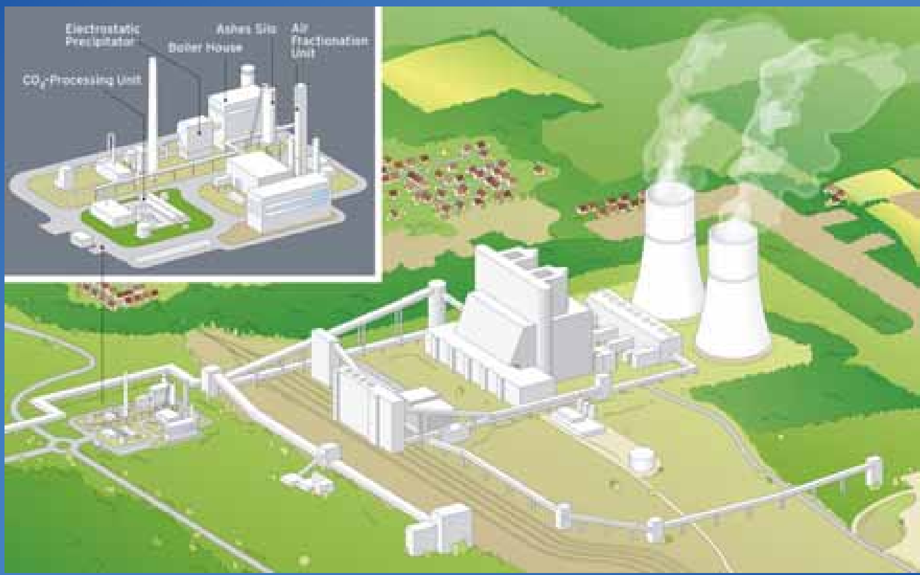
Source: FutureGen Project

Some project were started to implement the pre-combustion process. A major project here in the USA is the so-called FutureGen project. The American government has decided to invest about $1 billion in a 275 MW gasification plant where you produce gas and then you have the possibility to introduce a gas cleaning and shift conversion process, where you produce a large amount of hydrogen and you are able to separate the CO_2 from the process. Then you can use the hydrogen for automobiles or another way would be of course, you would burn it in a gas turbine to produce electricity.

I think it is planned for such a plant to go into operation in 2012.

Oxyfuel-Process

Vattenfall, Schwarze Pumpe/Germany, 30 MWth, Coal, 2008



Source: Vattenfall

Now we come the oxyfuel process. Vattenfall intends to build a 30 MW thermal power plant at Schwarze Pumpe, Germany, which shall go into operation in 2008.

In the oxyfuel process you increase the CO_2 concentration by burning the coal with pure oxygen. Imagine this would be just a simple diagram of a 700 MW plant and the outcome on the flue gas side would be 15% of CO_2, 6% of H_2O and 76% of N_2. If you implement an air separation unit, so you will remove all the N_2 and just run the burning process with pure oxygen, and that will increase the CO_2 part in the flue gas up to 66%. The next step would then be to introduce a so-called flue gas dryer, that will cool down the flue gas below the condensing temperature of the water, and to condense out the water to get a flue gas concentration of the CO_2 of 89%.

The next step for such a power plant would be to install a so-called flue gas recycle system, because burning coal with pure oxygen will increase the temperature dramatically higher than the ash melting point. Finally, the CO_2 will need to be condensed for further processing and pumping it into the storage.

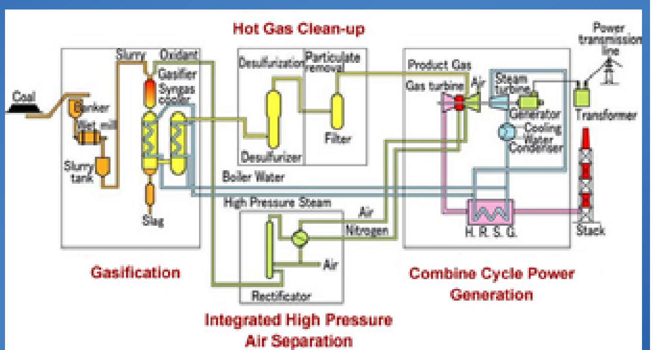
Post - Combustion Capture

Shell / Statoil, NO, 860 MW, NG-CC, EOR (Draugen, Heidrun), 2010

Source: Statoil

Here is an example for the post-combustion process. Shell together with Statoil are operating an 860 MW carbon capture (CC) plant. They will store about 1 million tons of CO_2 a year in the so-called Draugen- Heidrun field. The plant shall be in operation in 2010.

Pros and Cons: IGCC with CCS



Benefits:

- highly efficient combined cycle technology applied for coal combustion
- production of chemical by-products possible

But:

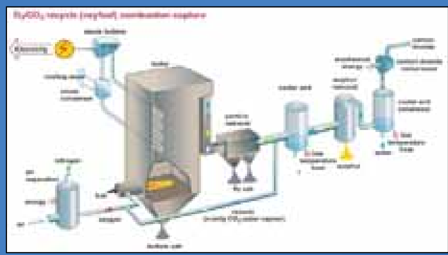
- complex technology
- availability and price not yet competitive
- higher fuel consumption than conventional power plant technology

Source: E.ON

Pros and Cons: Oxyfuel Technology

Benefits:

- Process based on a proven technologies
- High CO_2 concentration allows efficient separation



Source: E.ON

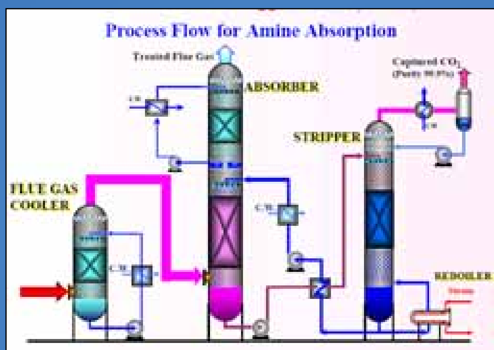
But:

- more complex than conventional technology
- additional costs for oxygen production
- higher fuel consumption than conventional power plant technology

Pros and Cons: Post-Combustion Capture

Benefits:

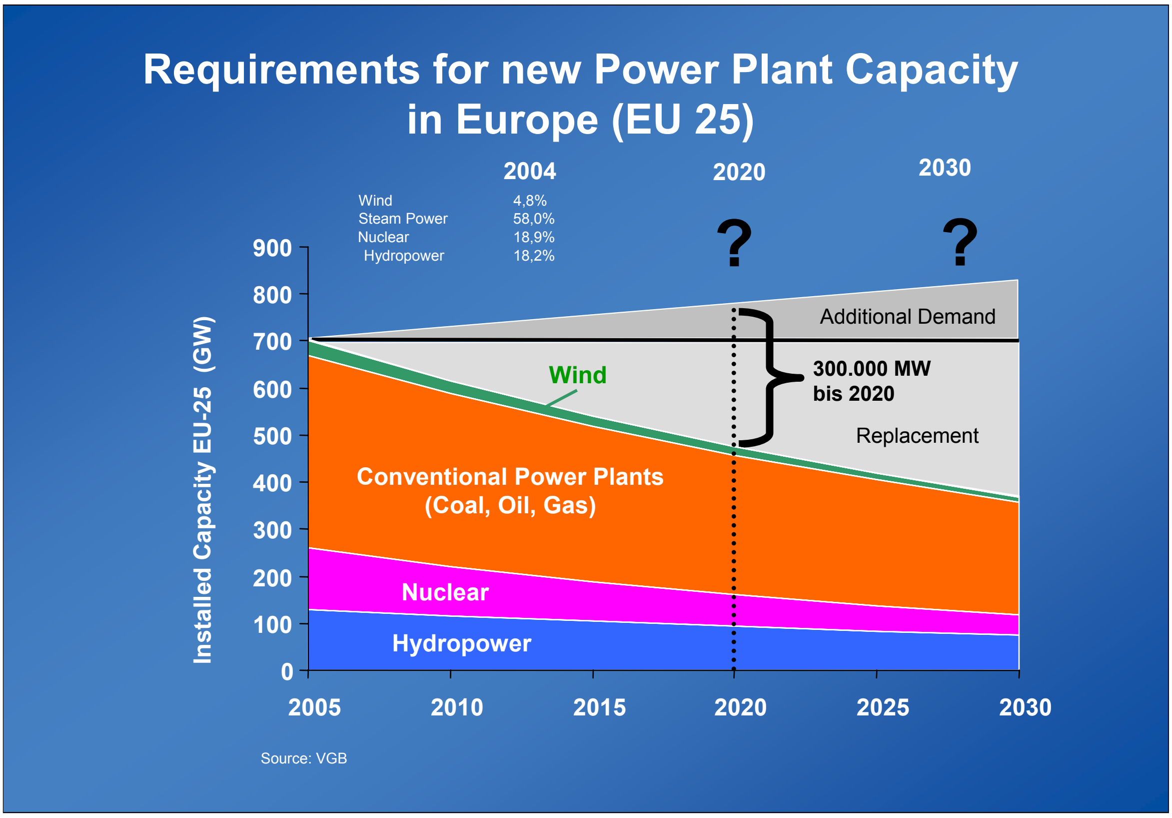
- Power plant process based on a proven technologies
- Amine absorption process known from other chemical processes



Source: E.ON

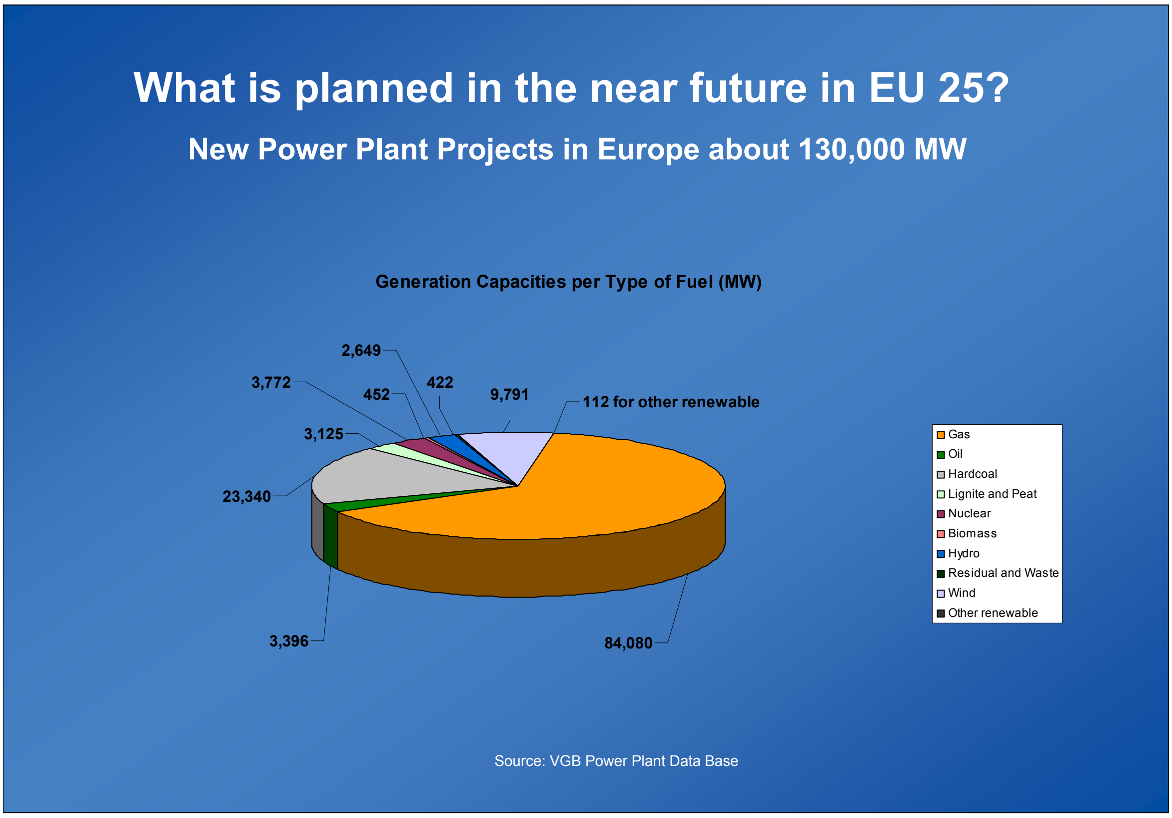
But:

- more complex than conventional technology
- high auxiliary consumption for regeneration process
- higher fuel consumption than conventional power plant technology



What will be the situation in Europe through the next 20 to 30 years?

We expect a high requirement for new power plants, up to 2020 this will be in the range of 300,000 MW. There might be a big market for the cable industry.



VGB collected numbers on power plant projects planned so far in EU25 countries. Plant projects with about 130,000 MW are in the pipe. There a lot of projects going on. It is astonishing that about 85,000 MW are planned with gas. We have heard this morning about the volatility of the gas prices. Nevertheless a lot of utilities plan to build power plants with gas. The second largest share with about 23,000 MW goes to hard coal power plants. 2 plants will be built with nuclear power, that is one in Finland and the other one in France.

What does it mean for the Cable Industry?

Cable Demand for the 1,100 MW Plant

Medium Voltage	41 miles
Low Voltage Control	346 miles
Fire Signaling	55 miles
Control & Communication	324 miles
Heating, Ventilation, Air Cond.	172 miles
Broadband LAN	11 miles
Others (black-box systems)	38 miles

Source: VGB Power Plant Data Base

I took a specification for a 1,100 MW plant. This plant is just under construction in Germany. The required cable volumes are listed on this slide.

Thank you very much for your attention.