Carbon Capture and Storage – Part of the solution to the climate change problem?

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I. INTRODUCTION

Focusing the state-of-the-art of renewable energy science and technology, you are forced to advance the established energy sources. Today, it's not possible to substitute coal-burning power plants, nuclear power plants or gas-fired power plants for solar power stations or wind power stations.

The task is also to explore environmentally compatible technologies for reduce the carbon dioxide emission and uncouple it of the economic growth. The energy demand grows because of the emerging markets like China or India and their coal deposits. The Kyoto Protocol or the objectives of the European Union are confronted the countries with the problem of global warming resulting from the greenhouse gases.

II. CARBON CAPTURE AND STORAGE

For example, the Carbon Capture and Storage (CCS) technology allows an environmentally compatible consumption of fossil fuels. Before, during or after the power plants process the carbon dioxide should be absorbed followed by underground storage at the point sources. According to experts and scientists the CCS technology will be fully developed around 2020 and will be a part of the future energy mix.
The CCS is a process consisting of three elements: capture, transportation and storage of carbon dioxide.
There are several ways for capturing: the pre-combustion, the oxyfuel, the post-combustion.
During the *pre-combustion* a fuel (e.g. coal) will be extricated before the combustion at power plant. At a high temperature, the fuel is separated into synthesis gas of carbon monoxide and hydrogen. In the next step, the carbon monoxide converts with a help of steam into carbon dioxide, which can be sectioned out of this gas mixture and be compacted into liquidity. This procedure is also known as Integrated Gasification Combined Cycle.

→ Air
Separation of air
→ Coal / O_2
Gasification
Gas purification
Deposition of CO_2 →
Power generation

At the *oxyfuel*, the proportion of oxygen in air is boosted to reduce the fumes. Instead of nitrogen and sulfur compounds, only hydrogen and carbon dioxide are the residues of the combustion in oxygen followed by the cooling down and condensation of water. The advantage of the oxyfuel is the clean carbon dioxide after the burning in clear oxygen (see below "Schwarze Pumpe").

→ Air
Separation of air
→ Coal / O_2
Boiler
Fume Cleaning
Deposition of CO_2 →

Another possibility is the *post-combustion* with the expansion of the conventional flue gas cleaning. After the denitrification and desulfurization, the flue gas flows through a fluid of amine which reacts with the carbon dioxide. After heating, the carbon dioxide is available in a clear state that can be compacted.

→ Air / Coal
Conventional Steam Power Plant
Fume Cleaning
Deposition of CO_2
→ CO_2

In the majority of cases, the carbon dioxide cannot be storaged close to the power plant. It is necessary to transport the liquid carbon dioxide in pipelines or by motor trucks or ships. The storage locations which can be in run are utilized natural gas or oil fields (Enhanced Oil Recovery), deep coal steams (Enhanced Coal Bed Methane) or saline aquifers.

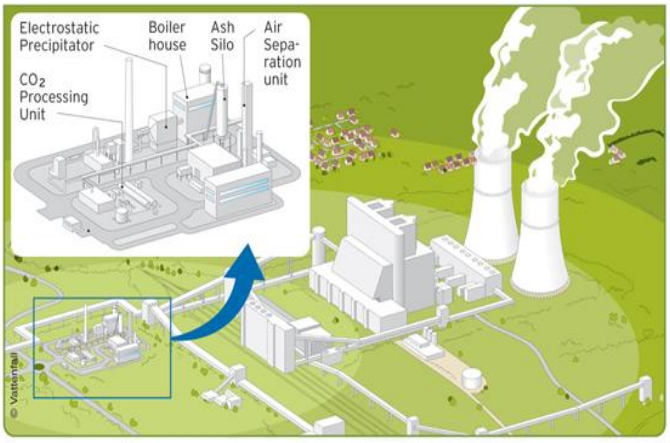
III. SCHWARZE PUMPE/GERMANY

In 2005 Vattenfall decided on building a 30 MW oxyfuel pilot plant, with an investment of 50 Mil. €, which is the first visual sign of Vattenfall's project on CCS. This installation is located near the existing lignite fired 1600 MW power plant in Schwarze Pumpe, Germany.

On May 29th 2006 was the groundbreaking ceremony of the Vattenfall pilot plant, which has been in operation from the middle of 2008. The initial testing programme will run for three years. Thereafter, the pilot plant will be available for other tests. The plant is planned to be in operation for at least 10 years. The pilot plant is an important milestone to reach the goal of commercial concepts for carbon capture and storage at coal fired power plants by 2015 until 2020. It will be the first pilot plant in the world to use the oxyfuel capture method. The construction of the 30 MW thermal pilot plant at "Schwarze

Pumpe" is an important thing for the Vattenfall project. It is the necessary link between initial engineering and successful operation of the future 250—350 MW electricity demonstration plant. Vattenfall's goal is to develop a concept at a total cost of approximately €20/tone of avoided CO_2. But it is to mention, that not only the plant in Schwarze Pumpe is inaugurated to CSS.

Figure 1. Carbon Capture Unit



Further, nearby the plant in Jänschwalde, which uses no CO_2 reducing system, Vattenfall currently investigates the possibilities of implementing both oxyfuel and post-combustion technology at these plants.
The complete implementing could be realized in the year 2015.

IV. WORLDWIDE DEVELOPMENTS AND PROJECTS

The mentioned desire to use fossil fuels without polluting the atmosphere implicates other projects in research and development on CCS technology. The center of that can be sight in Europe and the United States. Furthermore, developing and emerging markets even show the readiness for cooperation. For example, the public Algerian energy association and a joint venture of international associations prove the separation of CO_2 in the Sahara Desert. In addition, India and China cooperate with the Great Britain or rather with the United States. First of all, these cooperations conduce to find storage locations. The important role of China in CCS technology because of the determining importance of climate protection depends of the rapid economic growth, the growth of the energy demand or the coal deposits.
Beside German companies, Great Britain and the United States regard the CCS technology as a central topic of their energy policy. For example, the US-"Clean Coal Power Initiative" receives a two billion Dollar budget annually till 2011.
In Germany, the public research spending for the projects "Geotechnologien" or "Cooretec" aggregate around 1.5 Billion Euro for the whole energy und climate section from 2008 till 2011.

The priorities and research objectives of the CCS projects reached a big variety. Engineers and academics are engaged in sub-process or whole the process chain of deposition of CO_2 and in questions of transport and storage.
The Australian Otway Basin Pilot Project wants to press big quantities in empty natural gas fields as soon as to study the other CCS technologies.
The US-CO_2 Capture Project focuses the competitive deposition of CO_2 and the safety aspect of the three methods.
The European CO_2 ReMoVe (research, monitoring, verification) explores the criteria of the storage and technologies of feeding storage locations.
The international Carbon Sequestration Leadership Forum consists of 21 countries and supports the exchange of information and multilateral collaboration.

V. CONCLUSION

The Carbon Capture and Storage technology seems to be a trendsetting way in future energy mix, next to the renewable energy. It is an advancement of conventional power plants, which ensure the power supply. It is necessary to broaden the existing international cooperation to reach the goal as soon as possible.
But we are also forced to ask, if the carbon capture in natural gas or oil fields, deep coal steams or saline aquifers is the right solution. At the moment, we don't see possible risks in the far-away future. In order to guarantee the success of the project, it is necessary that all countries which use coal plants introduce the CSS technology. If this takes part of the energy production, the benefits for the environment will be increased.

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