# COMPARISON OF CARBON CAPTURE AND STORAGE WITH RENEWABLE ENERGY TECHNOLOGIES IN THE YEAR 2020 BY WAY OF A LIFE CYCLE AND A COST ASSESSMENT

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## ABSTRACT

- To use coal and natural gas in a more environmentally-friendly way, the option of "carbon capture and storage" (CCS) is discussed,
- a first system-analytic view in the form of a life cycle and a cost assessment and a comparison with renewable energies was done regarding future conditions in the power market (2020),
- the results show that a realistic $CO_2$ emissions' capture rate of 88 % at the power plant results in a reduction of greenhouse gases by only 65 %,
- renewables will be competitive with electricity from CCS power plants from the beginning of CCS technology in 2020.

## INTRODUCTION

- Coal is the most abundant fossil fuel. Therefore the question arises how coal can be used in a more environmentally-friendly way to meet the international greenhouse gas reduction goals,
- the option of "carbon capture and storage" (CCS) is discussed, that means the capture of the $CO_2$ at the power plant, its liquefaction, transport, and storage in the underground,
- CCS requires a high energy consumption; levelised electricity costs are expected to increase by 50 %.

## METHODS

- Ecology: LCA according to ISO 14.040ff., modelled via a material flow network,using the "UBA-method of impact categories" (German Env. Authority)
- Economy: Experience curves and learning rates,
- CCS technologies: post-combustion, pre-combustion, and oxyfuel with data from the industry,
- "Future situation": Higher efficiency and sensitivity analyses for hard coal methan emissions, $CO_2$-capture rate, operation materials, leackage rates.


Figure: Photo Disc

### Fossil fired power plants in 2020

- Location: Ruhrgebiet (western part of Germany),
- transportation of the $CO_2$ via a pipeline from the Ruhrgebiet to Northern Germany (empty natural gas fields) over 300 km,
- $CO_2$-capture rate at the power plant of 88 % (oxyfuel: 99.5 %),
- no leakage rate of the storage,
- using higher efficiencies considered to be possible for 2020.


Figure: Photo Disc

| Power Plant | Fuel | Capture method | Decrease of Efficiency |
|---|---|---|---|
| Pulverized Coal | Hard coal | Chemical scrubber (MEA) | 49% > 40% |
| Pulverized Coal | Hard coal | Oxyfuel | 49% > 38% |
| Pulverized Coal | Lignite | Chemical scrubber (MEA) | 46% > 34% |
| Integrated Gasification combined cycle (IGCC) | Hard coal | Physical absorption (Rectisol) | 50% > 42% |
| Natural gas combined cycle (NGCC) | Natural Gas | Chemical scrubber (MEA) | 60% > 51% |


Figure: Schüwer

### Renewable power plants in 2020

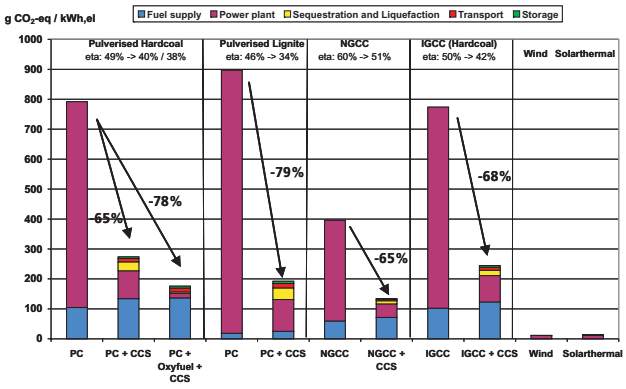
- Location: wind offshore power plants in the North Sea and solar thermal power plants in North Africa,
- electricity transport via high voltage direct current lines (HVDC) to the Ruhrgebiet.

## RESULTS AND DISCUSSION

### (1) Greenhouse gas emissions

- capture, transport, and storage of $CO_2$ require 23 % - 40 % more energy,
- $CO_2$ and methane are emitted also in the preprocesses (mining industry, transport),
- the greenhouse gas emissions in total are reduced by only 65 % to 79 %,
- renewable electricity causes only 2 % of the fossil fired power plant's greenhouse gas emissions,
- the cleanest power plant *without* CCS (natural gas combined cycle) causes only 45 % more emissions (400 g $CO_2$-equ./kWh) than the worst power plant *with* CCS (pulverized hard coal with 274 g $CO_2$-equ./kWh).

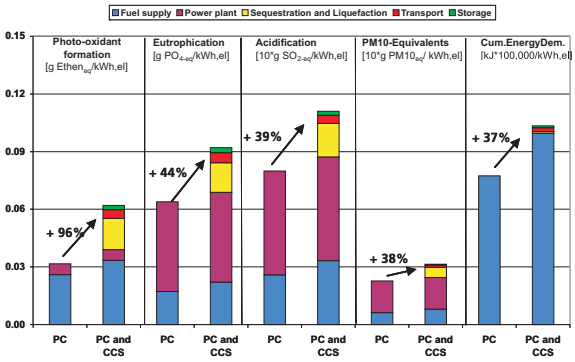
Therefore it does not seem justified to talk about "$CO_2$-free" fossil power plants to reduce the greenhouse effect in a sustainable manner.




*Greenhouse gas emissions ($CO_2$ and methane) for fossil fired power plants compared with renewable energies*

### (2) Further impact categories

- The impact indicators increase by 37 % to 96 % in the case of a pulverised coal power plant,
- the increase of about 40 percentage points is caused by the higher energy resource consumption (+34 %) as well as through the additonal energy used for transport and storage,
- the photo-oxidant formation increases much above average (+ 96%) due to the production of the solvent monoethanolamine (MEA) used for scrubbing.

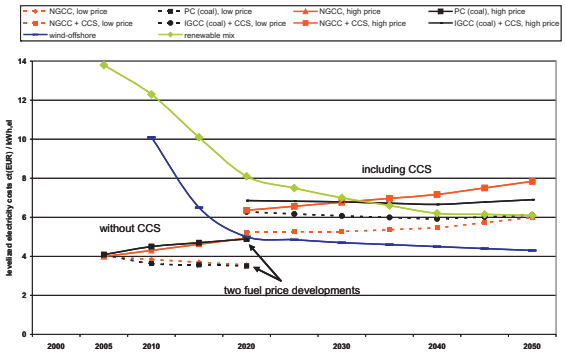



*Further impact categories illustrated by way of a hard coal fired pulverized coal power plant*

### (3) Electricity production costs

- Both $CO_2$ penalties for coal and natural gas and increasing prices of natural gas increase the levelised fossil electricity costs to 6.5 - 7 Eurocent/kWh until 2050,
- in addition, CCS technologies increase the electricity costs by about 50%,
- keeping the dynamic development in the past the renewable power plants can decrease their levelised electricity costs from 12-13 Eurocent/kWh today to 6 Eurocent/kWh until 2050.

This means, renewables will be competitive with electricity from CCS power plants from the beginning of CCS technology in 2020.




*Levelised electricity costs - comparison between "$CO_2$-free" fossil power plants and renewable power plants between 2020 and 2050 (each with low and high development of fossil fuel prices)*

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