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Analysis of an integrated carbon cylce for storage of renewables

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In order to mitigate the consequences of climate change the energy concept of the Government of Germany foresees the reduction of CO_2 emissions by 80 % in 2050 compared to the status in 1990. Different routes are followed to achieve this goal. Most advanced is the construction of renewable energy sources in order to replace fossil fuel driven parts of the electricity generation.
The increasing share of renewable energy sources in power production introduces the problem of high fluctuation of energy generated by windmills and photovoltaic. On top the production is not driven by demand but by availability of wind and sun. In this context, the “Power to Gas” concept has been developed. Main idea is the storage of excess renewable energy in form of hydrogen produced by electrolysis. If in a second step H2 reacts with CO_2 to form CH4 the current natural gas infrastructure can be used. In times of energy production by renewables below the actual electricity demand CH4 is combusted to produce electricity.
The emissions can be further reduced if CO_2 is captured in the power plant and buffered in a dynamic geological storage (CCS). Subsequently the CO_2 is back produced when excess energy is available to synthesise CH4. Storing CH4 locally also reduces energy for transport. Hence an integrated almost closed carbon cycle is implemented.
In the present study this extended “Power to Gas” concept is elaborated on a regional-scale for the State of Brandenburg and the control area of 50 hertz. Focus of the analysis is the energetic balance of the concept for the integration of a geological CH4 and CO_2 storage.
Therefore, the energy conversion efficiency for the “Power to Gas” concept has been calculated using available data from literature. According to our calculations approximately 33 % of the wind energy used can be regained by combusting the synthesised CH4 in a combined cycle plant. In order to fuel a peaking power plant with a power of 120 MW for 2,500 hours a year approximately 450 onshore wind turbines in full load or 16 % of the produced electricity of solar and wind assets in the State of Brandenburg in 2010 are needed.
In order to quantify the energy demand of the extended “Power to Gas” concept the following was done: The demand of electricity and the production of electricity by solar and wind assets have been analysed for the year 2010 in order to determine when and how much CH4 or CO_2 need to be stored or produced from the storage. Reservoir simulations were applied to determine the pressure elevation during cushion gas injection as well as the dynamic pressure behaviour in the reservoir during cyclic storage of CO_2 and CH4. Based on that data the well head pressures and the needed compression and injection power to store the gases were calculated.
According to these simplified calculations the overall efficiency of a combined “Power to Gas” - CCS concept is about 27%.