Carbon Dioxide Storage and Utilization

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It has become evident during the last decades that anthropogenic greenhouse gas emissions influence the natural carbon cycle, leading to a rise in global mean temperature. The recent Paris Agreement is the first legally binding global agreement for limiting the emissions and stop the temperature from rising more than 2 °C above pre-industrial levels. Carbon Capture and Storage (CCS) is one of the main climate change mitigation methods where CO_2 emissions are captured from power plants and industrial processes and transported to a permanent storage site. CCS is the only technology which can reduce emissions on a significant scale from fossil fuel power plants and industrial processes.

Currently the only demonstrated environmentally feasible method for permanent storage of CO_2 with sufficient capacity is storage of CO_2 in deep underground geological formations, such as depleted oil and gas fields or saline aquifers. Currently there are 15 large-scale projects operational in the world that have a total capacity to capture and store 28 million tonnes of CO_2 per year. During 2016-2017 this number is expected to grow with an additional 10 million tonne due to a handful of new demonstration projects becoming operational. However, the number of CCS project would need to rise substantially to help meet longer-term climate goals. IEA has projected that annual CCS capacity of 6,000 million tonne would be needed by 2050. Still, during recent years many large-scale projects in planning have been cancelled, especially in Europe. The development of CCS has mainly been held back by lacking economic incentives, missing political support and in some regions also by public opposition.

Simultaneously as the interest for CCS has declined in Europe the possibility for CO_2 capture and utilization has attained more attention. One driver for this has been the need for means for energy storage to balance the large fluctuation in electricity generation, coming from a rapidly growing share of renewable energy in the power grid in Europe. This fluctuation has led to occasionally extremely low and even negative electricity prices. During periods of high electricity generation, CO_2 could be converted into chemicals and synthetic fuels – a method which is currently being demonstrated in Germany. However, in order for these methods to have a climate mitigation impact the energy system must be based completely on renewables.

Recently, a pilot project in Iceland has shown that CO_2 could also be stored underground in basaltic rock formation. The project developed a method for achieving rapid mineralization of injected CO_2. The method could provide a low-cost and secure storage solution for certain parts of the world where suitable basaltic rock formations exist.

Ex-situ mineralization of CO_2 was in the early 2000's seen a promising alternative storage solution, but so far no method feasible for greenhouse gas emission reduction has been found: the methods require large amounts of energy or chemicals and generation of these assets lead in the most cases to more CO_2 being emitted than bound in the mineral. However, reactive slags and ashes mineralize more easily and processes for these are on the verge of commercialization. For instance, the first commercial plants for producing construction aggregates from CO_2 and industrial ashes have been built in the UK. In Finland, a lab pilot produces pure calcium carbonate from steelmaking slag and CO_2 that can be used as paper filler and coating material. In these cases the development is driven by other incentives (product price and waste regulation) and not CO_2 emission reductions, due to the low price for CO_2 emission allowances and very low storage capacity of the available ashes and slags.