Impact of applying novel Dry Potassium CO_2 capture (DPC) process at Renova

We are looking for 1-2 students to conduct a MSc project within the field of energy technology. The project would be most suitable for students with background in chemical or mechanical engineering, but interested students with other backgrounds could also work well.

Background:
Renova is a company owned by ten municipalities in western Sweden, with the stated mission to take responsibility for waste handling and recycling in the region. Certain waste streams that are deemed unsuitable for recycling are currently incinerated to generate power and heat. This results in annual emissions of about 540 000 tons of CO_2, of which about 40% is of fossil origin. To reduce climate impact, Renova has an ambition to outfit their large waste incineration facility located in Sävenäs in Göteborg with Carbon Capture and Storage (CCS). Earlier studies show that by applying current best practice (e.g. amine absorption or Benfield process), about one third of the energy generated would be consumed to capture and liquify 90% of the CO_2 in the flue gas. Consequently, exploring and identifying more efficient and less costly solutions is of high interest.

An unexplored possibility:
The Dry Potassium CO_2 capture (DPC) process has been successfully deployed at 10 MW scale in South Korea. In contrast, it is poorly explored in Europe. In the DPC process, CO_2 is captured using solid absorbent as follows:

$$K_2CO_3(s) + CO_2(g) + H_2O(g) \leftrightarrow 2KHCO_3(s)$$

The reaction is reversible and performed in fluidized-bed reactors. The particles are of similar size as fine sand (0.1-0.2 mm). K_2CO_3 is supported on a carrier material e.g. Al_2O_3. Particles can be produced by bulk methods such as spray drying or impregnation.

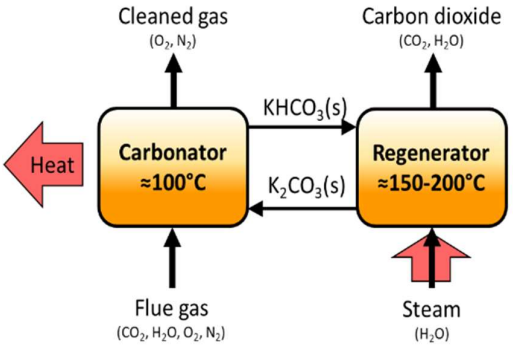

Illustration of DPC concept. Heat e.g. steam at ≈150-200°C is consumed in the regenerator, and returned at ≈100°C in the carbonator.

The DPC process could present significant advantages compared to conventional CO_2 capture methods. The solid absorbent used is harmless and has zero volatility. Since no liquid is carried around in the system the exergy losses from heating and cooling of water are eliminated. In contrast, the heat of reaction reportedly is quite high (143 kJ/mol$_{CO2}$). Still, the stated goal of the South Korean development effort is to reduce energy consumption and investment cost with 20% compared to amine absorption.

For Swedish conditions, where combustion facilities are used not only for power generation but also for district heating, DPC provides one additional feature which is of major interest. While significant amounts of heat at 150-200°C is consumed in the regenerator, the same

amount of is regained at about 100°C in the carbonator. This heat is of sufficient temperature to be applied for district-heating applications. Essentially, the temperature drop of this heat is the exergy cost for providing pure CO_2. This is a significant drawback for power production. However, if the main product is district heating, it may not translate to a big loss in plant efficiency. This possibility is unexplored in literature.

Question to analyze:
The principal question to answer would be if the DPC process could present significant advantages compared to currently available methods for CO_2 capture from waste incineration plants, such as amine absorption and the Benfield process. This includes to make a judgement about technology readiness level and availability in the near and medium term, and to examine how DPC could be integrated in the large plant at Sävenäs. Answering the principal research question will require a combination of information gathering and process modelling.

Methods:
- Learning about waste incineration for cogeneration about heat and power, possibly by visiting and participating in activities at Renova.
- Literature review and summary of work performed about DPC in South Korea and China.
- Process modelling of CO_2 capture by DPC at Renova. The model should include relevant chemical reactions, heat flows and mass flows, and calculate key performance indicators such amount of CO_2 captured and impact on power and heat production.
- Towards the end of the project the results should be summarized in a report.

The project will be performed at the Division of Energy Technology at Chalmers, in collaboration with Renova. The larger context of the work of the hosting research group is the development of novel and improved fluidized-bed processes for combustion, gasification and CO_2 capture.

About the possibility to do a 60 HEC MSc thesis: A typical master thesis at Chalmers encompasses 30 HEC. It is possible to make an extended thesis of 60 HEC, reducing the course requirements with 30 HEC. Our group is restrictive with this opportunity but will consider it for highly motivated students with above average marks. The expectation on a 60 HEC MSc is a significant increase in the scope of the work, an authentic interest in academic research and the ambition to reach a level that would allow for publication of the work in a scientific journal.

Contact persons:
Magnus Rydén (magnus.ryden@chalmers.se, +46 (0)31 7721457)