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Valorization of residual streams enable economic effective CO_2 utilization

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There has been a trend to claim that the use of CO_2 captured from industrial activities provides a credible option for moderate decarbonization. In this paper we make the case that for specific niches the use of oxidized carbon species produced in an industrial setting can generate revenues that exceed the cost of capture and can open an economically viable gateway for early implementation for deep decarbonization with storage.

In recent years, the public discussion on measures to reduce the worldwide CO_2 emissions have been focused on renewable electricity production and how to convert from fossil fuel to electricity as the main energy carrier. As a result, electrification of the transport system and the chemical industry is being studied. At the same time, a realization that this approach is a long term prospect is growing. This is especially relevant for the iron and steel as well as the cement industries. In addition, it is clear that carbon-based materials and chemicals remain of great importance to the society at large, and will remain so even well beyond 2050. Major examples include aviation fuels, synthetic polymers, urea and methanol. The question we will explore in this paper is whether it is attractive, from environmental and economic point of view, to combine the societal demand for these bulk chemicals with the industrial sectors that remain producers of CO_2.

The CO_2 use in chemical processes has the generic disadvantage that energy is required for the production of the target compound. In many concepts this energy originates from H_2 produced from, low cost, renewably produced electricity. Especially, the anticipated periods of near-zero pricing attract a lot of attention. However, the competition for this is expected to be very high and applications were the electricity is directly used for e.g. heating in the built environment and transportation are likely to be more attractive from an economic point of view.

For this reason, we suggest to consider residual streams with a low heating value, such as the works gases arising in the steel industry (see Table1). These gases are currently being used for internal heating purposes with the excess being used for electricity generation. Both application are likely to reduce over time as energy efficiency increases as the state-of-the-art improves, and renewable electricity generation becomes more dominant. So other options to use these gases are likely to arise.

Our overall philosophy is to convert the energy contained in these residual gases into value added chemicals with the concurrent production of storage ready CO_2. In the presentation the various uses of these gases into a number of applications, including methanol and urea, will be discussed. First assessment of economic feasibility and estimates for the CO_2 capture cost will be presented. We will present an overview of an industrial cluster in which a steel plant is combined with synthesis units for value added chemicals and excess CO_2 being sequestrated.

Table 1. Approximate compositions of common gases present in an integrated iron and steel mill.

Gas Type	CO_2 (%)	CO (%)	N_2 (%)	H_2 (%)	CH_4 (%)	LHV (MJ/Nm^3)
Blast Furnace Gas	24	23	49	4	--	3.5
Basic Oxygen Furnace gas	19	58	20	3	--	8
Cokes Oven Gas	2	5	7	62	24	18