Cost effective CO_2 reduction in the Iron & Steel Industry by means of the SEWGS technology: STEPWISE project

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Abstract

The Iron and Steel industry was responsible for an annual output of about 3 Gt_{CO2}/yr in 2013, with 10% from within the European Union. This represents approximately 6% of the total CO_2 emission, and approximately 16% of the total industrial emission of CO_2.

The STEPWISE project aims to decrease CO_2 emissions related to the steel making process from about 2 t_{CO2}/t_{steel} to below 0.5 t_{CO2}/t_{steel} by means of CO_2 removal from the Blast Furnace Gas. In the project a pilot is designed, constructed and operated at a 14 t_{CO2}/day capture rate. STEPWISE is a project executed within the European H2020 LCE program. It has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No. 640769 and started May 2015.

The heart of the advanced CO_2 removal technology demonstrated in the STEPWISE project is the Sorption Enhanced Water Gas Shift technology, or SEWGS. The SEWGS process was initially developed as a pre-combustion decarbonisation technology, and has the potential to reduce CO_2 capture costs versus conventional removal processes such as solvent based systems. The process combines three processes in one reactor system:

1) CO_2 separation
2) simultaneous acid gas removal (H_2S, COS)
3) the water-gas shift (WGS) reaction

Conventional approaches adopted for pre-combustion CO_2 capture can require at least two water-gas shift reactors with interstage cooling to effect a high conversion of CO to CO_2, see Figure 1. Downstream the water-gas shift section, further cooling is then necessary to enable the capture of CO_2 by absorption with a solvent. For a power application, the H_2-rich gas again requires heating prior to feeding in a combined cycle.

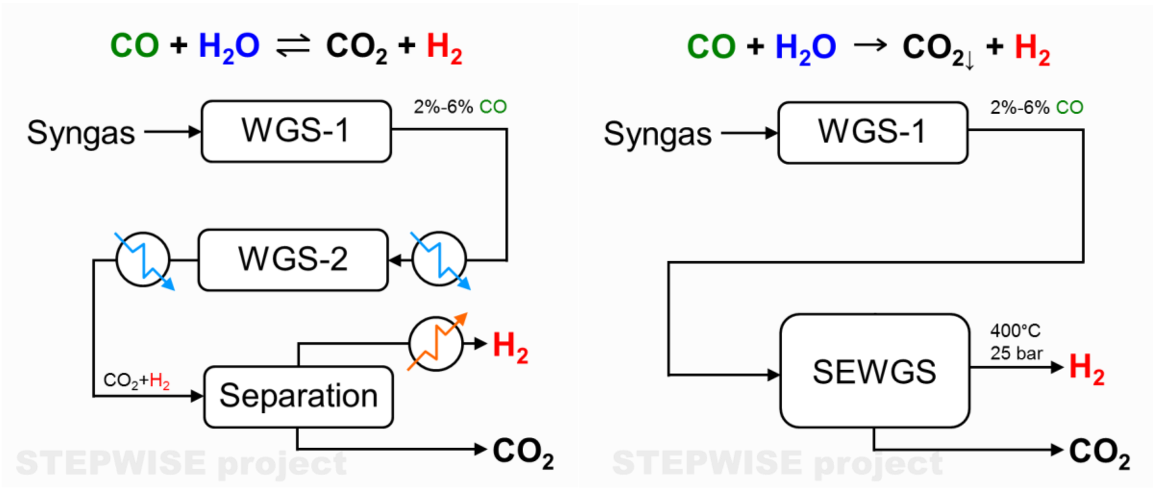

Figure 1: Schematic comparison of conventional CO_2 removal technology with the SEWGS technology

Using the SEWGS process, both the 2nd WGS reactor section and the H_2/CO_2 separation unit are replaced. An advanced WGS unit operating at a low steam/CO feed ratio takes care of the bulk CO conversion. In the downstream SEWGS unit the CO conversion is completed, and a hot, high pressure, H_2-rich product stream is directly produced. This H_2-rich product at 400°C can be fed to the gas turbine or used in other applications at the steel mill. This removes the inefficiency of inherent temperature swings that is an essential characteristic of the conventional process. In addition, the SEWGS technology can yield a CO_2 product stream at sufficient purity for storage.

Within the STEPWISE project, a pilot is going to be constructed, consisting of a Blast Furnace Gas compression section, a WGS conversion section and a SEWGS reactive separation section at a 14 t_{CO2}/day capture rate. The Pilot will be built at Swerea Mefos in Luleå, Sweden, and receives Blast Furnace Gas from the SSAB steel plant next door, see Figure 2. The pilot represents the essential demonstration step within the research, development and demonstration trajectory of the Sorption Enhanced Water-Gas Shift technology. This project will further reduce the risks associated with scaling up of the technology.

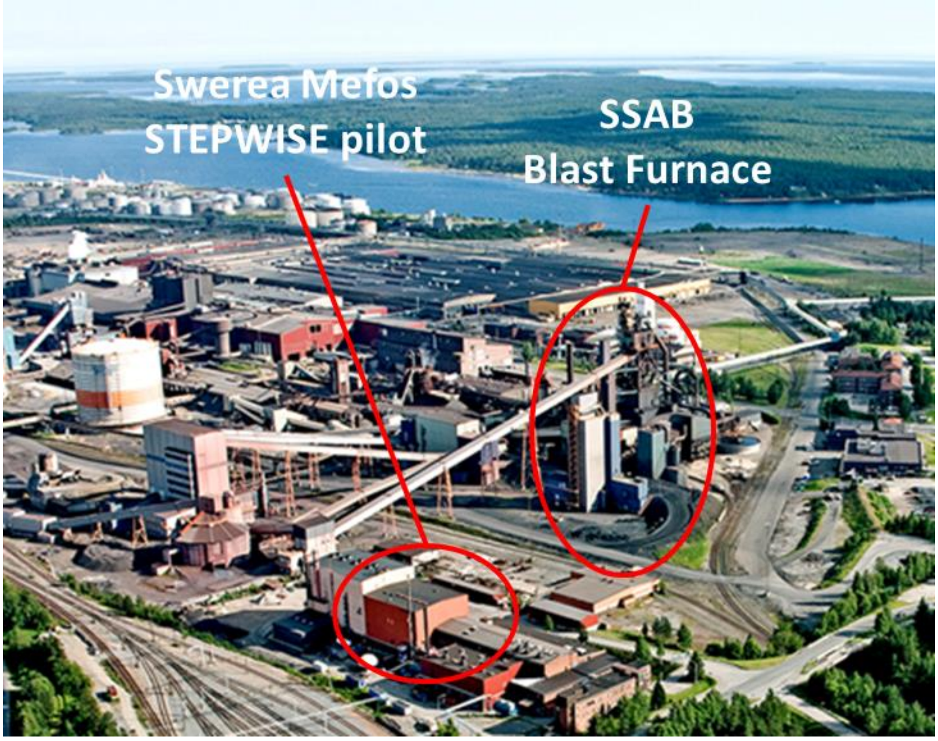

Figure 2: Areal picture illustrating the SSAB Blast Furnace and the location of the STEPWISE pilot at Swerea Mefos.

Translating the STEPWISE technology potential to worldwide scale, the technology being demonstrated in the Stepwise project has the potential to decrease the worldwide CO_2 emissions by 2.1 Gt/yr based on current emission levels. The conservative estimate is that by 2050 a potential cost saving of 750 times the project research costs will be realized every year, with a much larger potential. The overall objective is to secure jobs in the highly competitive European steel industry, a sector employing 360,000 skilled people with an annual turnover of 170 billion euro.

In the presentation, the STEPWISE project will be outlined and the progress will be discussed. The partners in the consortium represent the whole value chain from technology provider to an industrial end-user from the European steel sector. The consortium represents 9 partners from 5 member states, bringing together technology providers, adsorbent and catalyst manufacturers, to system design and engineering companies through to industrial end-users committed to proactive dissemination and information exchange with stakeholders and other CCS technology developments:

1) The CO_2 adsorbent and catalyst materials form the heart of the SEWGS CO_2 capture technology. Kisuma Chemicals (Netherlands) and Johnson Matthey (United Kingdom) are responsible for material development and production, while ECN (Netherlands) provides the SEWGS technology.
2) The Politecnico de Milano (Italy) and the Universitatea Babes-Bolyai (Romania) are performing the techno-economic analyses and the life-cycle analysis, to compare the SEWGS based technology with alternative CO_2 capture technologies on technical, economic and environmental impact.
3) The pilot plant will be built at and operated by Swerea MEFOS (Sweden). The pilot plant will receive BFG from the adjacent steel plant of SSAB (Sweden). Amec Foster Wheeler Italiana (Italy), with their experience designing IGCC plants, gas turbine combined cycle power plants and hydrogen plants and deep knowledge on technologies for CO_2 capture, guides the study on the large-scale SEWGS-integrated plant. Together, SSAB and Tata Steel Consulting (United Kingdom) as the end-users are able to support the project with deeper understanding of the processes and process systems involved in modern integrated steel

plants. They are the parties that can value the comparison of the SEWGS technology with alternative technologies to reduce the CO_2 footprint of today's and future steel plants.