“CCS is a logical option to meet net zero in the steel industry”

Steel industry consultant Rutger Gyllenram is known for his expertise, pragmatism and his direct talking. In a recent interview with CCW, he kindly gave his thoughts on the viability of carbon capture and storage as a route to decarbonization in the steel sector.

By David Sear

Steel is without question fundamental to a modern society. Strength and versatility make steel incredibly useful in the manufacture of items large and small, from cutlery to cars and from turbines to tower blocks.

Yet steel has a well-known downside – its emissions footprint. Reports suggest that steel contributes to some ten per cent of all global carbon dioxide emissions. And whilst more environmentally-friendly production techniques such as direct reduction are being developed to turn the raw material – iron ore – into usable steel, the sheer scale and lifespan of the conventional production infrastructure – blast furnaces – means that steel is considered a hard-to-abate sector.

Mr Gyllenram is far from being despondent, however. “New technologies are emerging, such as molten oxide electrolysis and direct reduction using hydrogen. It is however true that

such innovations are in their infancy so time is needed before all the start-up issues can be resolved This is why I for one firmly believe that continuing to develop and decarbonize blast furnace technology is a logical choice."

Knowledge base

Mr Gyllenram's words may raise eyebrows in some quarters, but his observations are based on many years of working inside the industry. "Consider this: blast furnaces are tried and trusted, they are omnipresent, and they represent a huge investment. It simply doesn't make sense to throw all that way. Moreover, over the years we have built up a very extensive knowledge base which is a huge asset to implementing modifications such as carbon capture."

"The steel industry really has two options," continues Mr Gyllenram. "Number one is to improve existing blast furnaces such as by modifying with oxygen instead of air - which incidentally is possible with top gas recycling - and combine this with carbon capture. That process may well be the new basis for iron-making in the world. The second option is direct reduction of iron, a process which is even easier to adapt to facilitate carbon capture and sequestration. It should be noted however that as yet we simply do not have access to all the green electricity that would be required for the large-scale roll-out of hydrogen technology. Be that as it may, adapting these two existing technologies to accommodate CCS will in the future be the most cost-effective and cost-efficient processes for low emission iron making."

Responding to challenges

Mr Gyllenram's positivity that researchers and technicians can integrate CCS into blast furnace processes comes from decades of experience. "A similar explosion of interest in new technologies was seen in the 1970s and 1980s, following the energy crisis. At the time I was a student conducting development work for my professor. Our calculations indicated that the new processes being developed had lower capital investment costs, leading to the conclusion that they would surely replace blast furnaces. But in the long run, the blast furnace developers managed to lower costs by applying economies of scale and improving the blast furnace process. Moreover, they also reduced operating costs by making blast furnaces more energy efficient. This meant that even though new processes perhaps had the potential to outperform the blast furnace, the incentive for the steel producers to opt for new, unknown technology simply diminished. What really emerged in those decades was a huge technological leap forward for the blast furnace. This gives me every confidence that the steel industry can respond to today's challenges and successfully deploy CCS."

Rutger Gyllenram .... as committed as ever to make a positive contribution to the steel industry. Photo: Pelle Berglund, Znapshot

Asked to sketch the technicalities of a possible CCS system, Mr Gyllenram answers as follows: "Consider the top gas which is produced when making iron via direct reduction. The top gas can contain a mixture of gases, such as carbon dioxide, carbon monoxide and hydrogen. When we separate these gases, the carbon monoxide and the hydrogen can be reinjected, which improves overall efficiency and reduce carbon emissions per ton of steel. The carbon dioxide could then be captured for storage or use elsewhere as a raw material. The traditional blast furnace also produces a top gas but, as this technique currently

"In the long term, incremental technology improvements will have a big impact on the steel industry transition," Rutger Gyllenram.

relies on hot air, the resultant top gas contains a significant proportion of nitrogen. This makes CO_2 capture unrealistic. Switching to oxygen instead of hot air would therefore facilitate CCS as there would be no appreciable nitrogen in the top gas. I am pleased to say that top-level research is already addressing this option. One final point: limits would need to be set for the amount of CO_2 that could be accepted from a blast furnace."

Methane emissions

Although he is an advocate of CCS in the steel industry, Mr Gyllenram notes the importance of considering additional sources of greenhouse gases. "If we genuinely want to address harmful emissions, then it is vital to look at steel industry as a whole. In this respect, I am referring to the use of raw materials such as coal and natural gas that are required in the blast furnace and the direct reduction processes."

Explaining further, Mr Gyllenram notes that methane can leak from natural gas pipelines, such as via valves, compressors and other items of equipment with bolted flanges. Coal is also problematic as it may contain significant amounts of so-called volatile organic compounds (including methane) which are released at various stages, including mining, transportation in open ships or waggons, and in the coking process. "I am not an expert but understand that methane is a much more potent greenhouse gas than carbon dioxide. Therefore, a lot can be gained by reducing methane emissions in these upstream processes," states Mr Gyllenram. "Let's be realistic: coal is an important commodity and especially so in developing countries. Hence coal mines are not going to be closed anytime soon. Again, I am a layman in this sector but I would urge all parties with an interest in coal to acknowledge the situation and address it."

MDI - MENA DRI Initiative

Discussing ongoing assignments, Mr Gyllenram indicates that he is currently acting as a consultant on a project In the Middle East looking at facilitating establishing low-emission DRI production facilities.

He explains: "MDI - MENA DRI Initiative is a project founded by specialists in finance and sustainable ironmaking with a mission to create business opportunities to produce direct reduced iron (DRI) with near zero emissions of greenhouse gases for global customers with an urgent need to lower their carbon footprint. The scope consists of raw material sourcing, ore agglomeration (pelletisation), natural gas leakage control, production and transport of DRI, CCS and finally ensuring that rules for investment in the production and the production itself are considered to be in line with near zero production and comparable to fossil free DRI."

A key to success, comments Mr Gyllenram, is to create economies of scale in everything from plant construction to transport of raw materials, energy and CO_2 including storage. "Systems for certification of the DRI as near zero emissions must also be efficient. In order to achieve this cost abatement, both vertical and horizontal cooperation must be in place regarding everything from research and development to execution, operation and financing."

It is understood that, when fully operational, the consortium will consist of representatives from the entire supply chain including construction and finance from a multitude of countries. The time frame for the initiative is 2025-2050.

Act today, push forward tomorrow

In summation, Mr Gyllenram confirms his perspective that cleaning up any industry requires adopting a viewpoint that is both holistic and practical. "I do not believe that in the iron and steel sector we can simply say 'oh well, hydrogen will solve everything' and use that as an excuse to sit back and carry on as normal. We cannot ignore or condone existing CO_2 or methane leakages. So, the message I wish to purvey is simple: let's do today what we can with the tools that are currently available. Individual tools may not be a panacea but every improvement helps. And as and when better tools are developed, then we must for sure use those as well."

Disclaimer and further reading

For ease of reading, descriptions of the steel making process have been simplified in this article. Any inconsistencies are the fault of the editor. For a more detailed explanation, readers are advised to listen to what Mr Gyllenram has to say on the ironmaking landscape in 2050 and the importance of CCS via: www.kobolde.com/archive/

"Adapting blast furnaces and DRI facilities to accommodate CCS will in the future be the most cost-effective and cost-efficient processes for low emission iron making," says Rutger Gyllenram.