Decarbonization – first things first

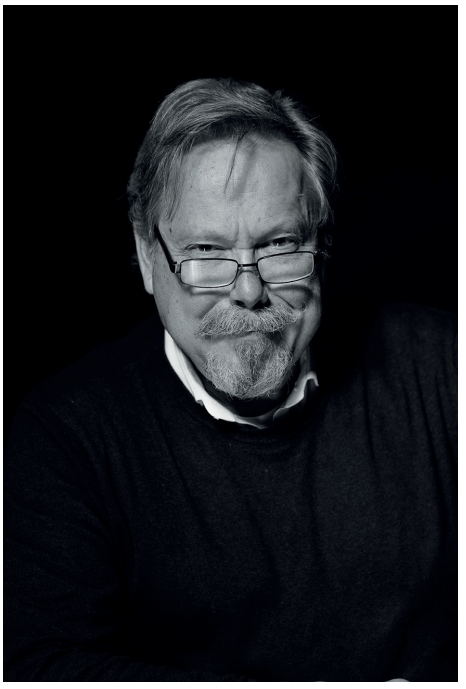
In the October 2024 issue of *Steel Times International*, I argued that we will have blast furnaces well after 2050 and that we must plan for decreasing GHG emissions from them. I ended by quoting Mark Twain stating: "The secret of getting ahead is getting started. The secret of getting started is breaking your complex overwhelming tasks into small manageable tasks, and starting on the first one." Is that what we are doing? By **Rutger Gyllenram***

"THE perfect is the enemy of the good." Another quote. This time from the French philosopher François-Marie Arouet, better known as Voltaire (1694-1778). In fact, he picked up this as an Italian proverb that has probably followed mankind since the dawn of civilization. You are so hungry for excellence that you disregard improvements that do not take you all the way to the end. The perfect can here be represented by the net zero goal and the good by an arbitrary improvement that does not lead all the way to net zero. A good example from our industry is the resistance from Non-Governmental Organizations, NGOs, and some politicians towards Carbon Capture, Usage and Storage, CCUS, that made advanced European decarbonization projects in the steel industry, short before implementation, to come to a halt.

The argument that CCUS makes fossil fuels legitimate is perhaps understandable but falls flat considering that we instead continue to run the blast furnaces, BFs, emitting CO_2. Of course, we are hoping that they in the end will be replaced by reduction with hydrogen and smelting in electric arc furnaces, EAFs, all powered by low-emission electricity, but will that ever happen? Nobody knows, and in the meantime the managers are turned into lame ducks since an improvement in the existing process does not constitute a profitable investment "as the process may soon be shut down".

Considering the perspective

Making a Life Cycle Assessment (LCA) study for a product is today the dominating method to assess its environmental impact on a number of areas like Global Warming Potential (GWP) depletion of various resources etc. The outcome of an LCA study depends totally on how the input data, the inventory, is selected. In Environmental Product Declarations, EPDs, that are published for products and that are mandated in EU legislation, like in Construction Product Regulation, CPR, a bookkeeping approach is used. That means that you look at (I) the actual impacts for the raw materials, (II) process data from the production process and (III) projected impacts from the use of the product and finally (IV) the deconstruction at end of life.



As an alternative to bookkeeping, a consequential method can be used answering: "what is the overall consequence of using this resource for this product?" When decisions are made for an existing process route and the action has a minor impact on the outside world, the bookkeeping method is quite adequate, but for major changes like switching from ore-based production to scrap-based production the impact on supply and demand on the global scrap market is such that a consequential method should be preferred. Europe is today a net exporter of scrap and if we decide to close a large number of BFs and use the scrap ourselves we should consider both possible social consequences of a scrap shortage in countries we used to export scrap to and the difference in environmental performance between the ironmaking units supplying the iron needed to compensate for the resulting scrap deficit and the BFs that are closed. It might not be worse but the question must be asked before considering the transition as responsible and as a progress in abating climate change. Having said that, for normal decarbonization work I guess the bookkeeping method serves us well when

*CEO and founder, Kobolde & Partners

we make an attempt to break down the decarbonization complexity.

Starting with scope 3: upstream and downstream emissions

1) Abating methane emissions: A steelmaker can lower the GWP value by, in the short term, selecting suppliers with low emissions, and in the long term put pressure on all suppliers to decrease their emissions. In recent years the focus has been on the methane leakage from coal mining and natural gas extraction and this might be one of the tasks with the highest success factor meaning that a small improvement has a big impact on the GWP for the produced steel. It is said that half of the natural gas leakages in the world can be avoided while making a profit from a higher gas yield. For coal it might be trickier but just extracting and burning the methane from the air ventilated from a coal mine improves the impact value.

2) Abating mining emissions: When it comes to metal mining, our studies at Kobolde on ferro alloys show that the main source for emissions is often diesel used for transport of ore before processing. Electrification has proven a solution in many mines, provided available low-emission electricity. Also, the ore properties are of importance for the processing so evidently different mines have different possibilities to decrease the GWP, however, pressure from steelmakers on mines and alloy producers to decarbonize is essential to make changes happen.

3) Promoting circularity: Finally, recycling steel in a way where the economic and environmental values of both iron and alloys are maintained provides a way to lower the GWP for a product. To preserve the metal value in a product to the next product lifecycle, we need to look at the entire chain from product design through deconstruction, recycling and steel and

metal production. For the steel customer producing a product, it means providing information on how to recycle it, and for the steelmaker it means having to deal with much more complex scrap flows and smaller lots. In between, the recycler needs to create a logistic web where the right scrapped product goes to the right recycler and the right scrap quality goes to the right steelmaker. For example, today we lose half of the ferritic steel volume to the non-alloyed scrap flow where most of the alloys become tramp elements. This may be avoided if products containing ferritic steel are scrapped according to certain recycling procedures.

Looking at scope 2: electricity

4) Decreasing the use: The obvious task here is to reduce losses and improve the energy efficiency in existing processes that use electricity. Easy-to-measure and follow-up are probably already on top of the steelmaker's to do list.

5) Selecting the provider: When it comes to decreasing electricity, GWP by choosing the electricity provider it becomes trickier in Europe. Whereas some European standards state that you can use the GWP of a certain provider if you can show that you are directly connected but otherwise use the country average, some countries suggest that an EU average should be used in the entire union. Building your own solar or wind plant would then probably be the only choice to lower the GWP.

When it comes to decreasing electricity consumption, understanding the potential for global warming simply by choosing the electricity provider can be challenging in Europe. While some European standards state that you can use the GWP of a specific provider if you can show that you are directly connected, the other alternative is to rely upon the country average. Some countries suggest that an EU average should be used across the EU. Building your own solar or wind plant would then probably be the only way to lower the GWP.

6) Balancing the energy types: Having a high electricity GWP for the country, the balance between use of electricity and use of fossil fuels becomes an interesting task. Such a study would most likely result in mothballing plans for EAFs and keeping BFs in service due to their higher energy efficiency. On the other hand, having a low electricity GWP has, for example, has led to Swedish steelmaker Ovako replacing LPG with hydrogen for its reheat furnaces.

Taking on scope 1: direct emissions from the processes

Well, this is what the debate has focused on for the last decades, the direct emissions from the iron and steel making processes. I choose to describe them as

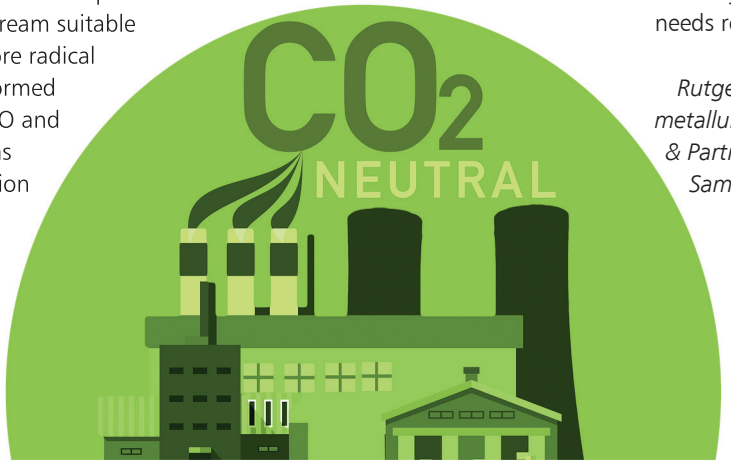
'implementation of disruptive technology characterised by high risk, impact and pace addressing an early-adaptor customer base accepting a higher price and evolutionary transition tasks characterised by medium risk, impact and pace, addressing an existing price-sensitive customer base. With risk I mean the technology risk that the project will not meet the goals set, with impact the disruptive effect it has on raw material markets and with pace the speed at which the net zero target is approached.

7) New principles: The most drastic way to work with emissions from the process is to invent a completely new process based on new principles. Molten Oxide Electrolysis, MOE, is such a process where molten iron oxide is reduced in an electrolysis cell creating a completely new supply chain and production environment. It will probably start as niche production for alloys and perhaps for special products where the process offers advantages. Reaching that stage who knows what will happen? MOE is sometimes thought of as a process that could deliver substantial amounts of net zero steel in the next couple of decades – but that is a bet with high stakes.

8) Radical redesign: Concepts where existing processes have been radically redesigned in order to decrease GWP substantially have been developed over recent decades. For processes using fossil fuels, deploying CCUS is the only way to reach net zero. A first example is the Oxygen Blast Furnace with Top Gas Recycling and a CO_2 stream ready for CCS. It was tested in the ULCOS project and was unfortunately never tested in full scale as originally planned. A second example is redesigning the reforming and gas heating systems in direct reduction plants using natural gas. By excluding steps where top gas is burned with air, a CO_2 stream suitable for CCS can be obtained. A more radical change is to substitute the reformed natural gas which is a mix of CO and H_2 with pure H_2 giving a top gas with H_2 and H_2O. Direct reduction with 100% hydrogen has been tested in pilot scale in the Hybrit project with reported good results on DRI quality. MIDREX has its own version called MIDREXH_2 which is due to be operational in a 2Mt/yr scale at the Stegra (formerly

H_2 Green Steel) plant in Boden, Sweden, in a couple of years. Finally producing a reduction gas from biomass is suggested in the FerroSilva project where capturing the biogenic CO_2 may create what is called a carbon sink. The redesigned processes above differ in choice of means but all aim to provide a ready-to-use process reaching net zero emissions immediately. Furthermore, they are all disruptive in that they have high demands on infrastructure for CCS, electricity or transport of biomass with a significant impact on these markets. The technical risk lies in the fact that none of them has been tested in full scale and they are in many ways just ideas.

9) Proven replacements: Once a process or process line is proven and can be bought off the shelf, older technology can be replaced or outcompeted by new, proven technology with better performance and lower GWP. As an example, we can look at direct reduction plants using natural gas and replacing or competing with older blast furnaces facilities.



10) Incremental improvements: In the end, this is the normal way the industry develops over time with minor well-controlled changes that improve performance. In the case of decarbonisation, charging Direct Reduced Iron (DRI) or Hot Briquetted Iron (HBI) and biocoke in the BF, increasing the H_2 ratio in the reformed natural gas in a DR-furnace, injecting biocarbon in the EAF and improving reheat furnaces by replacing fossil fuels with electric heating or hydrogen may all be considered as improvements that lower the GWP in steel. However, solutions from the radical redesign projects mentioned above may end up as toolboxes for improvements of a not-so-disruptive character and BF-plants may largely depend upon them if new designs can be implemented stepwise in the normal BF revamp cycle when the technology matures.

Is the net zero target the enemy of incremental improvements?

It may depend on how you perceive it. If you see it as a political goal that will be implemented in the short term at any cost, it probably creates a certain sense of resignation. "Why invest in facilities that will be closed anyway?" If, on the other hand, you see it as a distant goal and where it is the path that is important, where every step counts, then it doesn't have to be so bad.

Hopefully we are in a period of sobering up. New technology will come in the long term but it is not here yet. We need to do what we can with what we have and we cannot yet completely phase out fossil fuels. But we need to use them wisely – without dogmas and without goals based on wishful thinking. Decarbonising steel production is a tiring job that is far from the glamour of the headlines and the heroic reports of the newspapers. It is simply ordinary industrial development work that needs reasonable conditions to succeed. ■

Rutger Gyllenram is a Swedish metallurgist, founder and CEO of Kobolde & Partners AB and together with Dr Peter Samuelsson founder of FerroSilva AB.