Rutger Gyllenram with players from China, India, Australia and the MENA region. Players: WWF. Visual game design: Katarina Hamilton.
Photo: Pelle Berglund, Znapshot

The grand quest for green steel ...

The game is on, but who are writing the rules?

By: Rutger Gyllenram.

Research: Wenjing Wei, Kobolde & Partners AB.

Not all cards are good

Among the bright memories I have from my childhood, one is when the family came together to play a game of Monopoly. You walked around a gamepad where you could buy streets and railway stations, build houses and hotels. On some spots you had to pick up a card that could be either good or bad. You never knew what to expect.

Although I now look very much like the iconic millionaire from the box, I can still remember the joyful feeling of getting a card saying I had won some money in a beauty contest and of course the subsequent scorn from my siblings. But I also remember the despair from getting a card saying I had to renovate all houses and hotels at a huge cost. The rules came with the game, easy to understand, and equal for all and the same goes today when again picking up the box for some real estate gaming with my wife and children half a century later.

Trying to understand what is going on in the steel industry, I cannot help viewing how decarbonisation is managed as a new type of game where companies compete, as they have always done, but where greenhouse gas emissions have become both a cost factor and a product quality feature.

In our imaginary game, a player can start as either an integrated blast furnace plant (BF), integrated direct reduction plant (DR), minimill, startup or a mine. The goal is to reach the "GREEN STEEL-patch" in the middle with a product where cost, carbon footprint and quality determine the competitiveness. Furthermore, the players are supposed to pass one or more decarbonisation stations marked as yellow stars with the text "Coal+CCS", "NG+CCS", "Bio+CCS", "Hydrogen", "Green electricity" or "Improve yield" indicating the decarbonising technology steps that may be taken by the player. Here NG stands for natural gas, Bio for biogenic syngas and CCS for carbon capture and storage.

Finally, there are a number of cards to pick up ruling on the legislative framework, technology, market and finance, when stepping on the assigned dots. Some cards may be good and some bad just as in Monopoly.

The points that I want to make using this game metaphor are:

1. Steelmakers must be prepared for all types of surprises and must avoid wishful thinking. In this case, a player will surely get both encouraging and disappointing cards.
2. Furthermore, players must be aware that in real life the playbooks are constantly edited by a number of sometimes competing playwriters and they may not be equal for all. What is considered green steel today may not be green tomorrow and what is not considered green steel today may be green tomorrow. Nobody knows.
3. Finally, a game is just a game, and a responsible company must go beyond the rulebook to contribute to the intentions of the Paris agreement.
   We must not fool ourselves to think that just calling something green will actually result in a global decrease in greenhouse gas emissions over time. The concept is a tool to meet the end, not the end.

Roadmaps

There is a lot going on showing how to reach the green steel goal. Without providing an exhaustive list we can note that roadmaps have been developed for the world by the International Energy Agency, IEA, on the request of the Group of Seven, G7, for China by Rocky Mountain Institute, RMI, and for India by the Energy and Resource Institute, TERI. The European Union is now working on a roadmap for Europe in the Green Steel for Europe project. Companies may develop individual roadmaps according to a framework set up by the Science Based Target initiative, SBTi, and alignment of this work is at present addressed in the Net Zero Steel Pathway Methodology project, NZSPMP performed by SBTi and a consortium of companies and organisations. In addition, the UN campaign "Race to Zero" promotes breakthrough technology roadmaps across many industries including steel. Finally, an evaluation of the work going on has been published by the think tank E3G studying the six largest steel production regions China, Europe, India, Japan, South Korea and the US.

As technology develops and experiences are gathered these roadmaps must be revised on a continuous basis, for countries as well as for companies. An openness, to successes as well as problems and failures, is therefore of the greatest importance for the world to move forward. Recognising failure may be the best contribution to global success. Faking success is a sure path to global failure.

Technology

Decarbonisation efforts must, to be sustainable, take the entire life cycle into account. As shown in Figure 1 the steel life cycle starts in the mine, continues in production, and uses steps and goes on forever in the reuse and recycling cycles of steel. Four main areas for decarbonisation can be identified and are here described briefly.

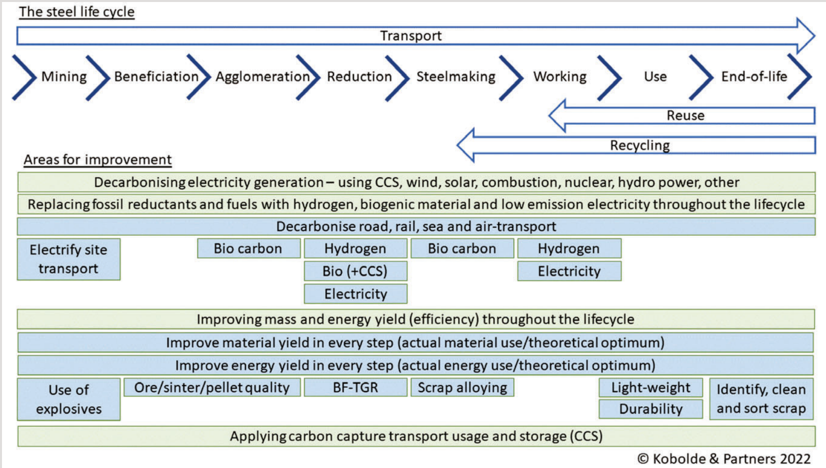

Figure 1. The steel life cycle and possible decarbonisation. The main areas, in green, are decarbonising the grid mix, replacing fossil fuels and reductants, improving the material and energy yield and finally applying CCS to the greenhouse gas flows that cannot be avoided. Examples of possible topics/applications to address are given in the blue boxes.

Decarbonising electricity is of concern not only to the steel industry since electrification is seen as one of the main ways to decarbonise society. This means that we not only have to decarbonise the existing production, but we also have to build new capacity with low emissions. As long as we still have large parts of the electricity mix in the grid coming from coal combustion it does not really make sense to replace coal as an energy or reduction source in metallurgical processes.

Replacing fossil fuels and reductants involves electrification and the use of hydrogen and biomass. Electrification of transport is a major issue not only in the steel life cycle. Using hydrogen and biofuels are other alternatives to fossil fuels.

Hydrogen is an alternative to fossil reductants and is at present also used as fuel in reheat furnaces. Biomass can be gasified to biogenic syngas used for reduction or turned into biocarbon used in processes like agglomeration and steelmaking. Using electrolysis for ore reduction is yet in the test scale but electric pig iron processes are again proposed as alternatives to the blast furnace. Furthermore, electric reheat furnaces may replace furnaces using fossil fuels.

Improving mass and energy yield is an ever-ongoing activity throughout the steel life cycle saving both money and the environment and some areas may be pointed out.

Although the biggest improvements in mines come from replacing diesel and using low fossil electricity an improvement in precision may result in **less use of explosives** and less material to move around. Ore beneficiation causes yield losses and is a cost to the ore producer but improves yield thereby saving more money and reducing environmental burdens in later process steps.

There is still a lot to do in the traditional processes. By using oxygen instead of air and applying top gas recycling in the blast furnace a considerable reduction of coke use can be achieved, and an off-gas obtained ready for CCS. Another example is that scrap upgrading and sorting at the end of the life of a product can be improved to make it possible to decrease the need for virgin alloys in scrap-based steel production.

Finally, the yield in the use stage is for example improved by lightweight constructions getting more functional value per kg of steel or by more durable steel with a longer lifetime and a possibility to reuse when the economic life of construction comes to an end. A higher quality may however result in a higher carbon footprint of the steel per kg but a lower carbon footprint over the product's entire life cycle.

Applying carbon capture, transport, usage, and storage, here just called CCS, is dependent on the ease with which pure CO_2 can be captured and the transportation and storage possibilities available. Storing CO_2 of biogenic origin creates negative carbon emissions often called carbon sinks.

The outlined possibilities above differ in impact, cost, and risk. Developing and implementing new technology is costly and takes time and there is always a possibility that it will take longer time to reach the planned performance than anticipated.

Any stakeholder must be prepared for surprises good as well as bad.

The regulatory framework

Let us for this discussion define the regulatory framework as the rules affecting the decarbonisation of the steel life cycle, originating from either product ecology with life cycle assessment, LCA, or GHG reporting on an organisational level. The two approaches differ in scope and data granularity and give different results when applied.

The standard ISO14044 is considered the basis for LCA and is a normative reference in ISO and CEN standards used for both multi-impact assessments like ISO 21930 and EN 15804 for building products, and single-impact standards that focus on GHG emissions like 14067 for all types of products. A new multi-impact European standard for steel and aluminium products, prEN17662, will be published in 2023. These standards make it possible to take emissions in the entire life cycle of a product into account when making an assessment. Other standards like the general ISO 14064 and EN 19694 and the 14404-series for steel production give guidance on quantification and reporting at the organisational level.

Most product standards apply the book-keeping approach making it for example possible to use the actual impacts from raw materials and resources. This means that buying for example wind electricity from an adjacent plant gives a low carbon footprint even though the main supply to the grid comes from coal combustion.

- A game-changer in the decades to come would be if standards start prescribing a mandatory use of a market mix of resources or in the most extreme case a consequential approach where the highest carbon footprint in the market should be used.

Companies around the world all experience a certain amount of political uncertainty. The European commission and parliament are very active in the field of decarbonisation which can be both good and bad depending on their level of understanding of the different topics. For example, we do not know how the Product Environmental Footprint, PEF, system will be applied for some steel products, what will be the demands from the new Construction Product Regulation, CPR, or how the new Ecodesign directive will work. A key question discussed at the moment is if protected forests are a better carbon sink than sustainably managed forests generating both material and residuals that can be used for bio-syngas and bio-carbon. Such a decision must be based on facts and not emotions.

A negative game-changer for the steel industry would be policies restricting companies from harvesting sustainably managed forests.

Ways to calculate and report GHG emissions for products have been developed for a long time starting in 2004 with the Greenhouse Gas Protocol. The World Steel Association, worldsteel, has been working for a long time to develop an LCA methodology for steel and gathering data for databases both for organisations and products. Eurofer is evaluating methods to use for the classification of near zero steel and other steel organisations like the American Iron and Steel Institute, AISI, the Global Steel Climate Council, and GSCC, have their methods. The list continues with the United Nations Industrial Development Organisation with the IDDI project and the not-for-profit organisation Responsible Steel, and there are many more.

A feature of some methods is using a sliding scale when classifying steel emissions depending on the scrap ratio. Ore-based and scrap-based industries do not agree on the merits of this procedure. At the end that dispute has to be solved and it is hopefully not impossible.

An interesting methodological twist is the mass balance method where all improvements after a certain date in an entire production volume are attributed to a fraction of the production which is then labelled green steel. The rest of the production volume is attributed to the original emission level and sold to customers less motivated to "buy green".

All the technologies presented in figure 1 matter and it is of the greatest importance that any accepted carbon footprint classification system for steel or products made of steel honour them.

Furthermore, a prerequisite for GHG mitigation in the steel industry is that labels should benefit only companies that invest in decarbonisation and obtain very low carbon footprint values, avoiding greenwash.

The systems use a variety of methodologies and system boundaries making results from different systems hard to compare and data not suitable for assessing an entire life cycle without additional information.

Financing

The transition to green steel or near zero steel or whatever we want to call it will need fabulous amounts of money. At present, the tax payers in Europe and the ETS fund have paid much of the investments in Europe. In the long run, it is important that the capital markets can assess the different projects and that more private money can come into the system.

SASB standards for sustainability info, the Task Force on Climate-related Financial Disclosures, Equator principles, Glasgow Financial Alliance for Net Zero, Climate Action 100+ and Climate Bonds Initiative are all examples of an active investor sector in this field.

Critical issues are whether the interest will keep, and enough funds will be available, and if occasional occurring project failures will scare off investors, public and/or private.

Customer demand

In the end, it is anticipated that green steel will be more costly than traditionally produced steel even though GHG emissions are punished according to the European ETS system, similar mechanisms, or tolls. Different ways to create demand are suggested in a number of initiatives like the First mover Coalition, FMC, the Industrial Deep Decarbonisation Initiative, IDDI, and SteelZero from the Climate Group.

A high willingness-to-pay, WTP, for green steel is crucial and is dependent on the trust that customers have for the system and that they can tell the difference between possible competing labels.

The nightmare for producers that have invested heavily to produce green (near zero) steel is that customers still expect them to sell at the same prices as producers using the traditional blast furnace route.

Conclusions

I am not saying that any of the efforts made today to promote solutions to decrease the carbon footprint of steel are wrong. What scares me is that very few actors on the market, if any, declare a plan B. What happens if the new processes do not deliver on the promise when expected? It is, to my knowledge, not even discussed.

Another distressing factor is that companies investing huge amounts in new processes and having high production costs may face a difficult market due to eased customer demands on carbon footprint and redefined rules for green steel.

We need an open discussion on how we shall meet the demands set by the Paris agreement facing different scenarios, which means getting both good and bad cards, and how we shall formulate a playbook equal for all, that is accepted globally and that leads to the goal.