Avoiding a bear's service to the climate

Why demands on 'recycled content' should not be used for steel, and what to do instead. By **Rutger Gyllenram***

IN the Rumi fables written in the 13th century there is a story about a man that helps a bear, and in return, the animal decides to protect its helper from evil. When the newly adopted protégé was fast asleep an insect settled on the forehead and immediately the bear killed it with a strong blow of its paw. Unfortunately, the man also died and the concept 'a bear's service', meaning an act with good intentions but fatal outcome, was born. We still use that expression in our daily life in many languages around the world; acting with good intentions with unintended, negative, results is evidently part of human nature and a close companion in our history. The relevance to circular economy and the concept of 'recycled content' is that an uncritical use may lead to more greenhouse gas emissions, not less, and that there are other concepts that better support decarbonization and circularity. Demanding a certain recycled content for steel might turn out to be a bear's service to the climate.

The steel life cycle

In order to optimise the environmental properties of a product, you have to look at its entire life cycle and the continuation of the used materials into the next. This is studied in Life Cycle Assessment (LCA) projects and used in Environmental Product Declarations (EPDs). For buildings the standard EPD, EN 15804, divides the assessment into a number of modules (as shown in **fig 1**). Module A describes the process that starts with virgin and recycled material as well as reused products, leading to a building that is ready to use. Module B describes the operations, environmental loads, and resource use during the building's life time, and module C shows the deconstruction stage where materials are recovered for either reuse or recycling, if not deposited as waste, which is almost never the case for metals. Building a bridge from stainless steel means having a high environmental burden in module A compared to other materials which becomes lower in module B when taking maintenance and product life into account.

The environmental value of reuse, including refurbishment or formatting of a product, and recycling including remelting, is calculated in module D, where calculation rules make sure greenwashing is avoided.

*Founder and CEO, Kobolde & Partners AB

Rutger Gyllenram with a not so dangerous bear.
Photo: Pelle Berglund, Znapshot

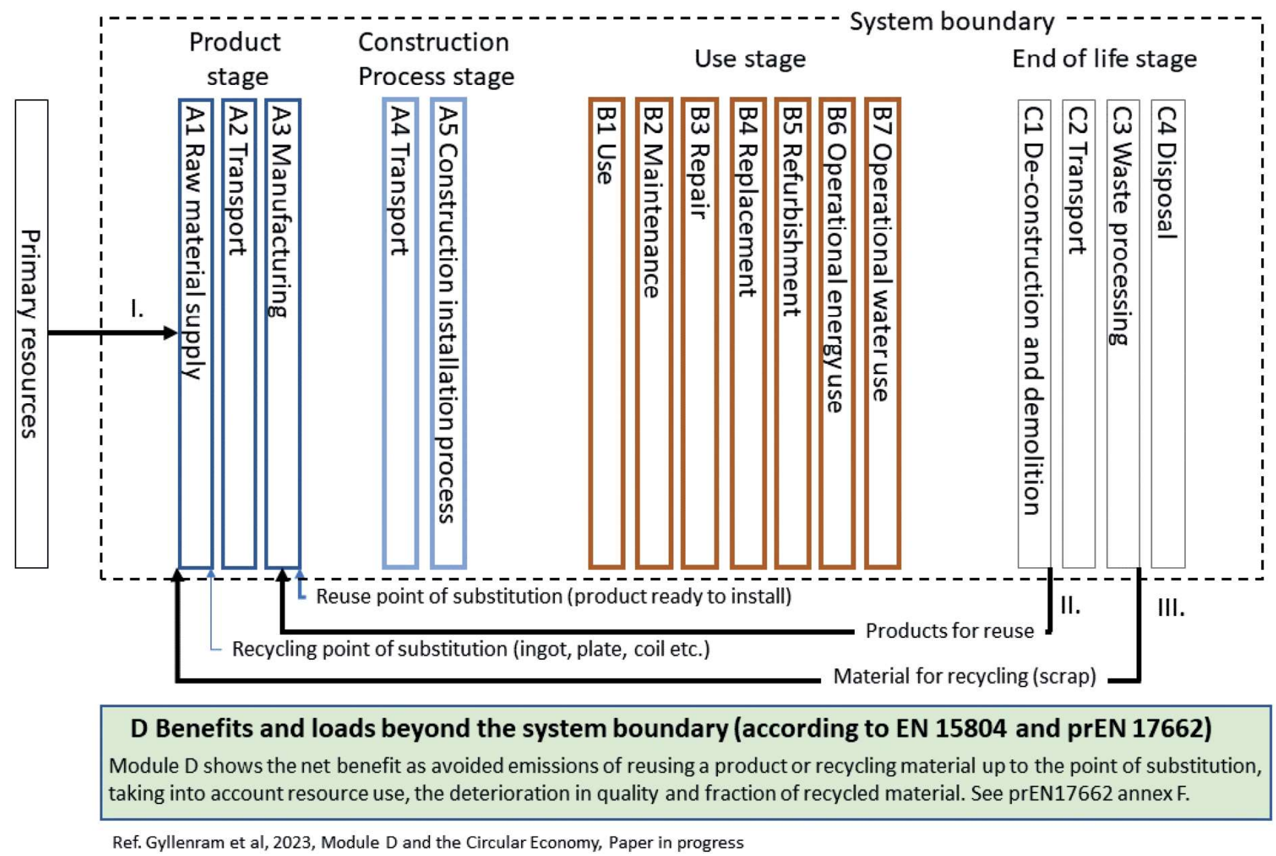


Fig 1. The life cycle of steel as it is modelled in the draft standard for steel and aluminium, outlined for buildings and civil engineering structures but applicable to most uses of metals in products. The steel is produced from a mix of primary and recycled material, used in a product and at the end of life either recycled or reused. The value of reuse and recycling is calculated in the so-called 'module D', taking into account any degradation of quality and loss of value

For both reuse and recycling, module D should take into account any deterioration in quality due to circulation. Since remelting is avoided in the reuse case, the gain is higher than for recycling if the quality can be kept at a reasonably high level. The quality of recycling is included in the model but unfortunately seldom analysed in depth.

What is discussed, however, is that using virgin material has a higher environmental impact than using scrap – and regardless of the fact that in a growing global economy both virgin and recycled material are necessary for the economy – the 'recycled content' measure is used as an index for good environmental performance while it at best is irrelevant, and this will be discussed further on.

Steel recycling in the circular economy

Steel is an 100% recyclable material which means that all collected steel scrap from industry, that is 'new' or often called 'prompt' scrap, or 'old' scrap, can be used in the production of steel. Scrap circulated within a plant belongs to a third category and is called 'home' scrap – this scrap is normally not reported in scrap statistics. Since the price of scrap is in the range of hundreds of euros per ton, the recycling rate is high – and with few exceptions steel stays in the circular economy. Losses occur for steel that are hard to recover, for example sunken ships and piping in the ground, material contaminated by radioactivity, material used in a way that it is consumed, and finally oxides in slag and dust. Even rebar, which for a long time was used for backfilling together with the surrounding concrete, is nowadays liberated and recovered for remelting. According to scrap dealers in Sweden, about 40% of traded scrap is prompt scrap and the rest is old scrap.

Alloys in scrap

Steel gets its properties from its chemical content with alloys and impurities, casting conditions, hot and cold forming, heat treatment, surface treatment etc. These operations together add to the performance as well as the environmental burdens of the steel. When reusing a steel product all these properties may be recovered in a new function whereas remelting may make use of only the iron and alloy content, but often only the iron is taken into account. In the same way alloys may give steel desired properties, the same elements may in other cases be considered unwanted 'tramp' elements. Furthermore, alloys have significantly higher carbon footprints than iron since they come from ores with lower metal content than iron and often use more energy-intensive processes for extraction. Carbon footprints that are double or 10 to 20 times that of iron or even higher is not uncommon and the same goes for alloy prices.

When it comes to valorising the alloy content in scrap, the business is about

Fig 2. A piece of a shredded electric appliance having escaped the final manual inspection of the ferritic scrap flow. No industrial processes for removing copper from liquid steel exist today and a rising average copper content is a major concern when a bigger part of the steel production comes from recycled material. Well sorted, this scrap could be used for weathering steel, with the copper replacing primary material in being used as an alloy.
Photo: Pelle Berglund, Znapshot

Fig 3. A piece of copper wedged in a piece of steel scrap after shredding. Note that the two pieces do not have to come from the same product. The steel may have a low content of unwanted elements, but the copper shrapnel makes the quality poor. If it had been a piece of lead or tin, the harm would have been even worse.
Photo: Pelle Berglund, Znapshot

separating and sorting at the scrap processing end and storing and blending at the steel plant. Information about the scrap average chemical composition together with lot sizes play important roles in optimising alloy recovery. Most important, however, is the ambition to actually make the alloys in scrap recoverable and to use the recovery potential of scrap alloys in full. Scrap with a known chemical analysis within narrow limits has a much higher environmental and economic value than scrap with just a maximum level for certain tramp elements.

Prompt scrap
For prompt scrap, the analysis of the scrap flows is normally initially known, but keeping scrap from different steel qualities separate requires scrap management to be included in the factory design. Unfortunately, that is often a detail that is omitted when trying to decrease the investment cost of a new plant. There is an abundance of examples where end cuttings in steel rolling mills, cuttings from steel coils in the automotive industry, and turnings from machining plants in the foundry industry end up in single scrap streams where alloys are difficult to recover due to widely varying chemical analysis and combinations of alloys that do not fit the steel products for which the scrap is used. Keeping track of scrap chemistry is seldom a priority down the production line where it is sometimes viewed as a problem and not an opportunity.

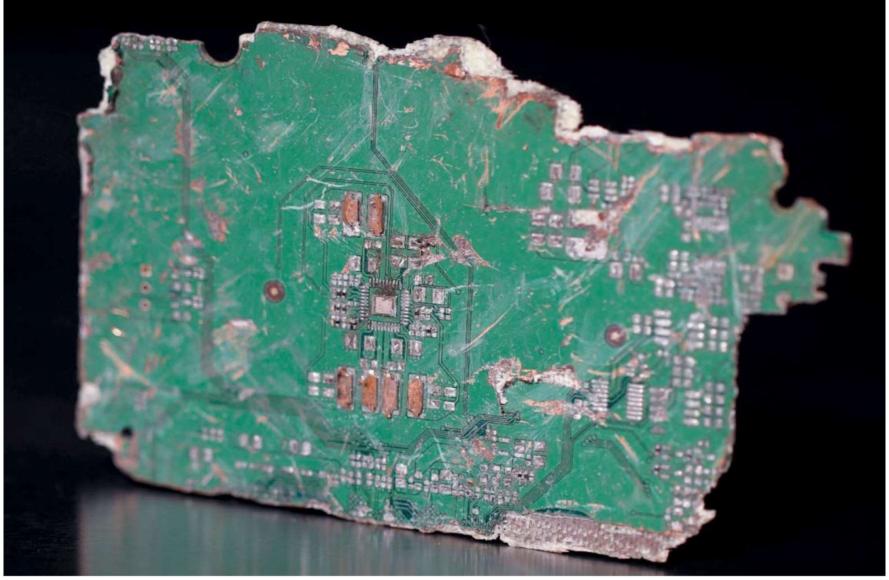
Old scrap
Old scrap is collected from discarded constructions, products or packaging and sorted according to one of many scrap classification systems. The sorting is done by skilled personnel often with an XRF, a hand-held instrument with which the chemical analysis of larger objects can be measured. Complex products like cars, are shredded and the resulting scrap is then automatically sorted in one magnetic and one non-magnetic fraction.

The non-magnetic flow is much smaller than that of the magnetic and contains scrap with higher metal/alloy value, and in modern shredding plants is then processed by copper, brass, different kinds of aluminium and different kinds of stainless steel being separated into different flows for further processing, which makes use of the full value of the content.

The magnetic fraction contains all ferritic steels like unalloyed steel with less than 1% of alloys and alloyed steel with nickel, chromium, molybdenum typically under 10%, ferritic stainless steel like the drum in a washing machine or the inside of a dishwasher, which typically contains more than 13% chromium. Non-magnetic metals may be trapped in ferritic steel parts and then go with the magnetic stream. The biggest problem is probably copper wire from motors that are wound up around iron kernels or wedged in a scrap piece. Examples of where copper goes with the ferritic flow are shown in **Fig 2** and **Fig 3**; with **Fig 1** showing a motor where the copper was part of the product and **Fig 2** representing a situation where two pieces of different origin are wedged together. This scrap is well-suited for the production of weathering steel that is alloyed with copper but in most steel qualities, copper is a tramp element and not valorised. The scrap piece shown in **Fig 4** may be non-alloyed steel, high strength steel with high manganese content, or ferritic stainless steel with high chromium etc. Such scraps increase the uncertainty of the chemical content and the loss of valuable alloys.

Fig 4. A piece of shredded scrap from the magnetic flow. It may come from a car roof and have a very low alloy content, be a high strength side of the car with high manganese, be part of the inside of a dishwasher with high chromium etc. The alloys cause concern in the following steelmaking process and may all end up as tramp elements which are unwanted. Well sorted, the alloys in the scrap piece could have come to use.
Photo: Pelle Berglund, Znapshot

Fig 5. A piece of a circuit board found in the ferritic scrap flow. If the solders are made of lead and tin, the circuit board constitutes an impurity hazardous to some steel qualities.
Photo: Pelle Berglund, Znapshot



Finally, the circuit board in **Fig 5** that also was found in a ferritic flow contains lead and tin in the solders which are detrimental in certain steel qualities.

With new technology, the magnetic flow can be processed where individual parts are identified with laser technology and directed into different streams for optimal alloy recovery and avoidance of tramp elements. The environmental benefit of such sorting both from a carbon footprint and a resource conservation perspective is evident, but costs for the new technology are still an obstacle. The EU directives for vehicles, appliances or waste are still focusing on weight and not the recycling value so little help is in place at the moment, but hopefully the next generation of directives will look in this direction.

Why is 'recycled content' a concept of the past that should be avoided for metals?

1) There is only a certain amount of scrap to make scrap-based steel from, and when it runs out, only steel from iron ore remains. Scrap from end-of-life products in society is used directly and there are no large reserves of unused scrap. This means that insisting on only buying scrap-based steel does not improve anything. It is irrelevant. It may however increase transportation and add to emissions from that sector.

2) Not buying steel from virgin sources in the western world may divert virgin production to countries with less efficient ore-based steel production. This may be detrimental when fossil-free ore reduction processes emerge.

3) In many cases, although not all, it has just been a way of making a virtue of something companies have done for a long time for cost reasons, which does not indicate a real interest in circularity. This makes the label less trustworthy and valuable and indicates complacency. Using a concept without real environmental impact and not fostering continuous improvement is, perhaps, the most serious flaw.

Preparing for the product label 'reuse and recycling ready'

How do you design a product that avoids the problems of poor recycling of alloys discussed above? It is a million-euro question that companies engaged in meeting circularity, climate goals, and other demands from society must ask themselves. If we invent the concept 'reuse and recycling ready' ensuring a smooth prolongation of the products' life and recycling of the alloys as alloys, what should it include? It is likely that we must look at the entire life cycle with repair and maintenance and then the end-of-life operations. For reuse, you need to make the product deconstruction-friendly, and for recycling you need to decide whether the product needs laser sorting or may do well with just magnetic separation. Deciding on that and dealing with labelling and documentation might be a first step. The second step would then be to make reuse and recycling work in practice with reuse-product management and different waste management streams – and finding entrepreneurs taking on the task. And sorting out the financing. That would be a real service to circularity and the climate. ■