

Written evidence submitted by Dr Barbara Rossi (GST0006)

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Barbara Rossi is Associate Professor and Tutorial Fellow in Engineering Science (Structures & Mechanics) at the University of Oxford where she leads the Sustainable Metal Structures Research Group. Her research focuses on the role of metals in structures to improve the construction sector sustainability and resilience. She leads a group exploring the structural behaviour of metallic structures. Her team studies materials such as ultra-high strength steel and stainless steel, or a combination of these, used in structures such as bridges, windmills, radioactive waste disposal facility, and wastewater treatment plants, with a special interest in harsh environments, where corrosion plays an important role. Advanced analytical and computational analysis are combined with experimental methods to perform both fundamental and applied research. Full-scale experiments are conducted on structures or part thereof in the Sustainable Metal Structures Laboratory, at Begbroke Science Park. Over the last 10 years Barbara Rossi also branched into the research area of life-cycle analysis and sustainability appraisal of (metal) structures.

This evidence is in response of the The Committee's invitation to submit written evidence on the key points:

- The technologies there are to produce "green steel"; how close they are to commercialisation; and the benefits and risks of each,
- The desirability or otherwise of establishing a low-carbon steelmaking pilot at a UK site.

The text is fundamentally based on the following reports from Prof. J M Allwood, head of the Use Less Group, at Cambridge University. The following references are an integral part of this response:

- A bright future for UK steel: A strategy for innovation and leadership through up-cycling and integration, J M Allwood, University of Cambridge, 2016, ISBN 978-0-903428-38-5
- Steel Arising: Opportunities for the UK in a transforming global steel industry, J M Allwood, C F Dunant, R C Lupton, A C H Serrenho, University of Cambridge, 2019, ISBN 9780903428477, DOI 10.17863/CAM.40835
- Reuse of structural steel: the opportunities and challenges, D Tingley, J M Allwood, Conference paper for European Steel Environment & Energy Congress, 2014, Teeside University UK

1. **Steel is the most commonly used metal in the world.** Blast furnaces and electric arc furnaces are present everywhere, all over the world. There is worldwide 1.9 billion tonnes of crude steel produced per annum. UK in 2020 (then still a EU member state) was the 8th largest steel producer in the European union, which produced in total >150 million tonnes of steel in 2019, only 8% of the world total. Japan alone produced roughly 100 million tonnes, while the biggest steel producing country is currently China, which accounted for above 50% of world

steel production in 2020. Globally, the steel industry emits 25% of all industrial greenhouse gases, which is more than any other industrial sector.

2. **The construction sector is the largest steel using sector and that is not likely to change.** It accounts for more than 50% of the world steel demand, with the other major uses being the manufacture of vehicles, industrial equipment and final goods. The global population is forecast to increase to more than 9 billion people over the next 40 years. The population growth rate in Europe (and the UK) is only expected to start decreasing slightly by 2050. And, by then, about 75% will live in cities (~50% today). We still have to build the buildings and infrastructures for these cities and replace those that are damaged. When our country needs more and more new homes, new buildings, new infrastructure, we will have to go higher, more slender and leaner in dense populated areas and the need for ultra-strong and highly ductile materials like steel will become increasingly pressing.
3. **Steel is indefinitely recyclable, and, while it is recycled, it does not lose its performance which is an extraordinary ability inexplicably often ignored.** It isn't the case of most construction materials: other than steel, aluminium or stainless steel, you can only recycle glass indefinitely provided that you sort the type of glass appropriately. Steel is not just downcycled into a less noble material, just like an old jewel can be turned into a new one, steel can be melted over and over again.
4. **Recycled steel is one of the industry's most important raw materials.** We have accumulated almost 1 billion tonnes of steel only in the UK, all of which must be recycled, and, today, we generate about 10 million tonnes of scrap a year. Studies show that in the next 10-15 years, that availability of steel scrap will rise from 10 million to 20 million tonnes (global flow of steel scrap are likely to treble in the next 30 years) because all the steel made in the past will be recycled. In 2018, in Europe, this exceeded 110 million tonnes, showing that there is no scrap shortage. Despite its weak position in the scene of steel production, this is one of the advantages by which the UK could profit in the current global change of steel production.
5. **We have already produced the steel that we will need tomorrow.** With increased availability of scrap and under our nation's commitment to cut its domestic emissions by 2050, we can anticipate a global shift from blast furnace to electric arc furnace production. Roughly 2/3 of today's liquid steel is made from iron ore, with the rest made from scrap, but at present >50% of the scrap originates from the manufacturing process, rather than from end-of-life recuperation. This is even though (1) on average, steel products have an approximate life horizon of 35-40 years, before being scrapped, and (2), apart from ~10% of steel that is buried (e.g., oil pipes or in building foundations), most end-of-life steel can be easily collected for recycling. Even if the total demand for steel production will increase, one can demonstrate that if most old steel is recycled, future requirements could be met entirely through increased production from scrap via electric arc furnaces. In America today, >50% of all domestic steel demand is already made by recycling domestic scrap. And since steel recycling causes significantly less greenhouse gas emissions than blast furnaces (topped by the fact that the UK already produces low emissions electricity grid, with high potential for further improvement, so recycling steel in the UK today leads to a reduction in emissions of > 2/3 compared to global average primary steel), UK need for steel recycling can be expected to grow significantly and rapidly. This will increase with more renewable generation capacity and will grow strategically important as global pressure to alleviate climate change increases.
6. **UK's commitment to decarbonization need to address the emissions which are released from within UK borders.** Although closing steel plants in the UK would lead to a reduction in the

emissions, our future demand for steel may lead to higher global emissions if the emissions intensity in other countries is greater than that in the UK. Rather than providing extensive efforts in technologies allowing reduced emissions in primary production which require major capital investment, a more effective contribution to global mitigation would be to produce our domestic steel through electric arc furnaces combined with a massive decrease of their emissions which are directly linked to the emissions intensity of local electricity generation.

7. **There is nonetheless a technical limitation on the extent to which scrap can be substituted for iron ore: contaminants.** Scrap composed of large pieces such as that from construction, have well controlled composition while scrap collecting from mixed waste streams have higher levels of contamination. The latter is usually sourced when scrap prices are high. As a consequence of contamination, the degree to which recycled steel can replace primary steel is capped by the inability of (a) imperfect control of metal composition in scrap steel collection and (b) today's technologies to adjust the chemical composition of liquid steel produced with electric arc furnaces. Therefore, steel scrap supplies have to date been mostly absorbed by the lowest grade products (such as reinforcement bars).
8. **It is possible to vaporise unwanted metal contaminants from liquid steel by vacuum arc re-melting.** This is already a commercial strength in the UK and used for making some of the highest quality steels for e.g., aerospace components. The innovation opportunity is to replicate this success at higher speed and lower cost. Other processes than vacuum arc re-melting have been tested in research laboratories but were abandoned due to lack of economic incentive. The UK, with its high volumes of scrap and its commitment to act on climate mitigation is well placed to lead the development of these technologies.
9. **We cannot replace steel, it's ridiculously cheap, ultra-strong and highly ductile, and completely recyclable, fitting into any story about a circular economy.** Not a single construction material taken alone can compete with steel today. But we can produce low carbon steel and build better structures, lasting longer, not harming our environment. If UK would recycle its own scrap to deliver high-quality steel satisfying its domestic demand in a closed loop it would lead to massive decrease of UK Iron and Steel emissions. This necessitates to (a) establish low-carbon steelmaking plants based on electric arc furnace, (b) develop technologies to make high quality steel from recycled scrap, i.e., examine and mitigate the causes of scrap contamination and develop the opportunities to control the chemical composition of liquid steel made via electric arc furnace, and (c) develop innovative business models to allow UK downstream steel supply-chains to prosper.

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