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The UK's net zero future will depend on making things in sustainable ways, with close attention to the whole cycle: the materials we use, the energy and carbon emissions involved in processes, and the opportunities for re-use, re-manufacturing and (last of all) recycling.

But for the time being the manufacturing sector in the UK — the sector that globally generates around a third of all carbon emissions — is mired in old ways. The sector has become stuck within a wasteful system based around imports of products and materials, and exports of materials that could have been re-used or recycled. There is still a take-make-dispose mindset. We have industries without the means or motivation to move away from energy intensive, carbon-heavy processes. And while the UK's carbon footprint is 'off-shored' to other nations, increasingly important materials, resources and business opportunities are draining away; consumers are misled over the actual environmental impacts of their choices.

There needs to be a new vision for the future. One that puts sustainable manufacturing at the centre of the UK's net zero ambitions and achievements. That means a long-term strategy integrated with plans for energy and net zero emissions as a whole, that moves away from limited, linear thinking to thinking about wider systems.

In this context, the lack of an industrial strategy at this stage is a massive void — particularly given the essential need for setting out the case for long-term investment: transformational, system-wide investment. Short-term financing of discrete projects based on an expectation of immediate payback is no longer an answer. Investment decisions need to be based on the bigger picture, on the much greater returns in terms of 'value': long-term reductions in carbon emissions, the impact on climate change, reduced use of scarce natural resources, reduced energy use — all helping to deliver sustainability and resilience to the UK economy, businesses and society.

As one example of how UK thinking is faltering compared with other nations, in 2021 a single Spanish steelworks was given €1 billion funding by government to become the world's first full-scale zero carbon emissions steel plant. In the UK, British Steel has been promised £300 million in instalments to secure jobs, only a proportion of which is to be used to replace blast furnaces with more sustainable electric arc furnace technology.

The strategy for sustainability needs to take into account the following five key issues.

We need to understand the full picture of the flow of materials and energy use in UK manufacturing: for example, Cranfield's TransFIRe research project has identified how CO_2 emissions per kg in the manufacture of a product such as cement in the UK is very similar to the average globally, but that processes here involve 15% more energy. Why? The 'foundation' industries — chemicals, cement, ceramics, glass, metals and paper — produce 75% of all materials in the UK economy and account for about 10% of the nation's total CO_2 emissions. If we know where the hotspots of materials and resources usage are, investment can be targeted to transformative technologies that will have a cumulative and much larger impact on reducing carbon emissions nationally (and internationally), as well as identifying opportunities for capturing energy and 'waste' materials for re-use.

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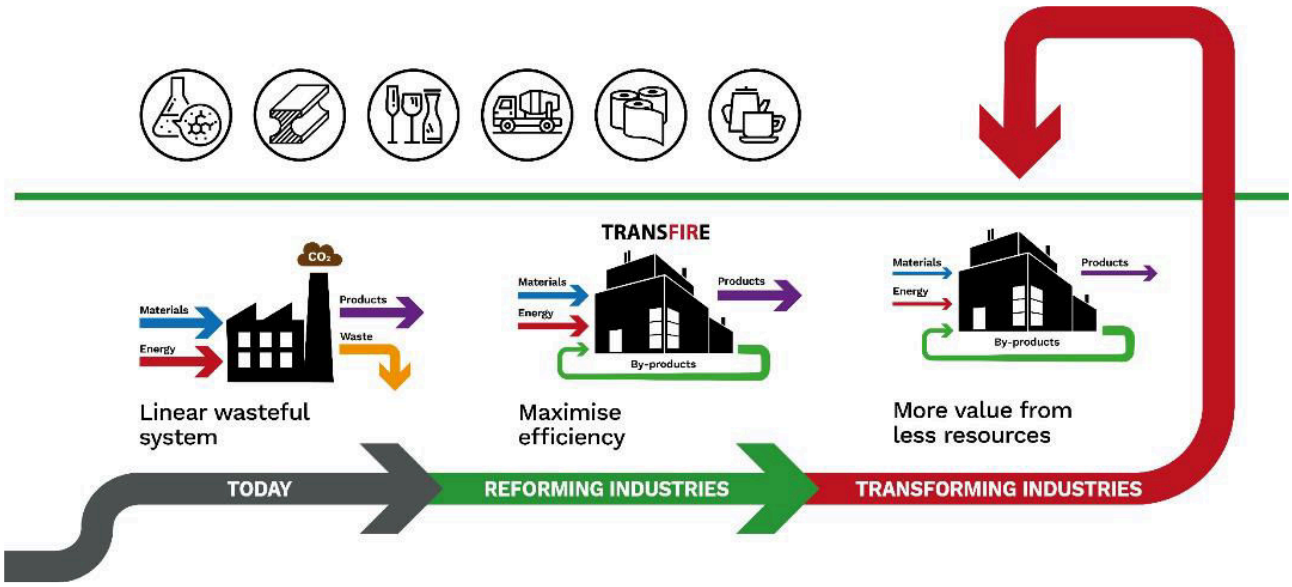

Figure 1: Showing the journey our foundation industries need to take to get to net zero. Moving first to reusing waste materials and improving process efficiencies and finally to reducing the amount of resources used with the concomitant change of business models taken the full value of materials into consideration.

Don't legislate around one measurement: it leads to short-sighted decisions and encourages the wrong kinds of behaviours among both manufacturers and consumers. The implications of the legislation on tailpipe emissions and CO_2 are a serious lesson in unintended and damaging consequences. This single measure, used around the world as an indicator of what makes for an environmentally-friendly motor vehicle, is misleading for consumers, governments and societies as a whole, and has the potential to drive up CO_2 emissions, given the number of cars on the world's roads is expected to reach 2 billion by 2035.

Cranfield's Sustainable Manufacturing Systems Centre has looked at exactly what the push for lower tailpipe emissions — more lightweight vehicles with aluminium engines — has actually meant. Less fuel is used, emissions are lower, but what about all the energy required for manufacturing the lighter engines? The production of each aluminium cylinder block consumes 1.8 to 3.7 times more energy than the production of cast iron. The almost fourfold energy increase results when the aluminium cylinder blocks are produced by casting. Overall, more than 70% of the global aluminium production is based on fossil fuels. Under these conditions, the energy intensive production of aluminium generates over 10 kg of CO_2 per kilogram of aluminium. That means a typical aluminium blocked car would need to be driven for between 120,000 km and 560,000 km before there were any environmental benefits at all from the lower fuel use involved. The average life expectancy of motor vehicles is only 210,000 km, so the great majority of cars aren't helping, they're just increasing CO_2 emissions.

Keep sovereignty over materials: because relying on imports of both products and materials exposes UK industry and society more generally to risks (as demonstrated during the Covid-19 pandemic). There needs to be more careful stock-taking and monitoring of the movement of materials, a recognition of the critical importance of keeping stocks of materials within the UK and not relying on imports — an appreciation of what materials should not be treated as 'waste'. Materials shouldn't ever be seen as something that can just be discarded. There needs to be a shift in the idea of 'value' in general, away

from the typical business model driven by cost per unit and where value is understood to plummet at the point of consumption, the instant that any product or material has been used.

The UK has fallen well behind other more developed nations in terms of the recycling and recovery of materials, having become reliant on the cheaper option (at least for the moment) of importing materials and sending ‘waste’ overseas. This has, so far, been a missed opportunity in terms of new enterprise opportunities for reprocessing and re-use — and for keeping materials stocks within the UK. Other nations have a much greater degree of sovereignty over materials. China, for example, is currently estimated to be responsible for 90% of the processing of the world’s materials, 80% of their extraction.

Steel and aluminium are good examples of where national requirements in industry far outweighs our local production, and yet we export large volumes of scrap steel (8.5 million tonnes according to 2019 figures) and aluminium which both could be processed locally — if there was the infrastructure available. At the same time, the UK also imported 400,000 tonnes of scrap steel in 2019.

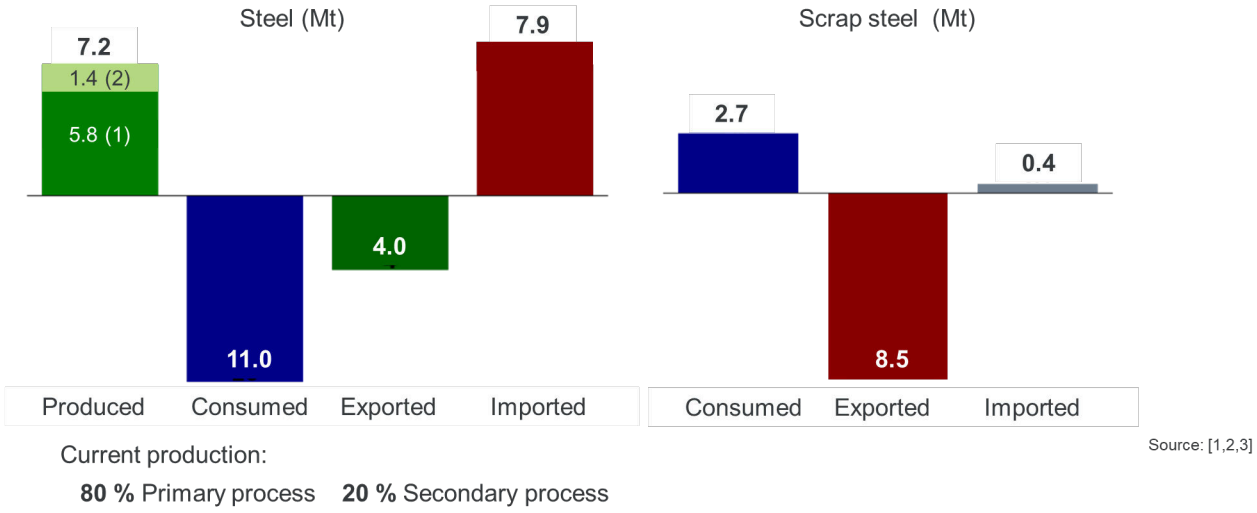

Figure 2: Chart showing production, import and export of Steel and Steel scrap for the UK in 2019.

[1] BGS. United Kingdom Minerals Yearbook. BGS, 2021
[2] International Trade Administration. “Steel imports report: United Kingdom”. ITA, 2021.
[3] International Trade Administration. “Steel exports report: United Kingdom”. ITA, 2021

Switching to light electric vehicles by 2035 is an example of the challenges ahead on the ownership of materials. Research carried out at the University of Nottingham estimates the demand for EV batteries alone would mean the need for access to an unlikely proportion of the world’s finite stocks of nickel, cobalt, manganese and lithium. Within five years of the 2035 target, the demand from the UK would come to exceed that of the entire European Union. Only through extensive recycling and re-use will there be a reliable supply of EVs. Keeping hold of and re-using stocks of EV batteries within the UK would mean there could be a 50/50 balance of imports of primary materials alongside the secondary materials from re-cycling and re-use by 2045.

Re-incentivise research and innovation within companies: to make UK manufacturers a source of new initiatives for transformation towards sustainability. The 1980s saw a trend of manufacturing companies divesting themselves of R&D capability, relying instead on work going on within universities. Many of the largest UK manufacturing operations are also only satellites of overseas parent companies, without their own R&D function and the passive recipients of innovations to implement. Given the scale of challenges relating to sustainability — the need for energy and carbon reductions, to introduce circular economy principles through recycling, re-use and re-manufacturing — there is a need for an active culture of research and innovation within businesses themselves.

Encourage more diversity in the leadership of manufacturing: because UK industries such as cast iron and steel have been using the same methods for a few hundred years; the macho culture and image have stayed the same, limiting the appeal to people who could bring new ideas, approaches and open attitudes to change. A future of making things sustainably needs a different team. The UK would benefit exponentially from encouraging new generations of leaders for manufacturing, by more actively promoting the career opportunities in driving the transformation of industry.

Technology alone will not enable the UK to achieve its net zero targets. There will need to be different attitudes to consumption: using less, making products last longer. In support of a new vision for manufacturing industries, we need to move forward as a society based on a shared sense of responsibility. Businesses need to manufacture with less, use a smaller bill of materials and be actively looking to simplify their products so materials are easier to re-use. We all need to be ‘good’ consumers, open to ideas of consuming less, as well as leasing and sharing rather than ownership. In this way the responsibility for end-of-life falls with manufacturers, there are more opportunities for re-use and re-manufacturing of their simpler products, and more of the value of the materials stays in the system. ‘Cheap’ should only ever be a dirty word.

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Make sustainable manufacturing the heart of the UK's net zero transformation

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