Steel's contribution to the circular economy through a life cycle approach

There is an increasing focus on environmental considerations on a global level, whether it be energy, resource consumption or zero waste. However, these issues do not address the overall environmental impact from products for different environmental impact categories, such as different types of pollution, nor for the full life cycle of a product from the raw material extraction to its end of life. This also means that it is possible that the environmental 'burden' is shifted from one life cycle phase to another.

The steel industry has a key role to play in contributing to a circular economy and is part of the solution in addressing environmental concerns for many products and services. This paper shows how the steel industry is addressing current environmental issues as well as how regulations can be utilised to generate overall environmental improvement of products and services.

Undertaking a full life cycle assessment of a product clearly shows the overall benefits of a product's design throughout its life cycle, as well as where the greatest potential for environmental improvements can be made.

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The climate change debate in recent years has evolved into a discussion on sustainable development and the circular economy. This debate is likely to continue for the forseeable future. What is certain is that our environment will undergo change in the future and that the objective is to aim for sustainability. Based on the United Nations definition of sustainable development [1], worldsteel describes the Green Economy [2] in the following way:

The steel industry believes that sustainable development must meet the needs of the present without compromising the ability of future generations to meet their own needs. Within this, a green economy delivers prosperity for all nations, wealthy and poor alike, while preserving and enhancing the planet's resources.

SUSTAINABILITY

The concept of sustainability is understood to include current economic activity and the changes in such activity to ensure that the activity can continue into the future. This implies that economic activity must continually strive to become environmentally neutral – that is, to not deplete natural and other resources as a result of its activity and, in so doing, reduce the ability of future generations to continue with such economic activity. For the steel industry, this implies different challenges that will be addressed in this paper.

The concept of the Triple Bottom Line expands the traditional accounting techniques to include performance on social and environmental impact, and is today widely used as a measure of sustainability of an enterprise. This approach measures the impact of an enterprise on three levels – economic (or financial), environmental and social. The aim is to show that positive financial results can be achieved without negative impact on the environment or society around the enterprise [3].

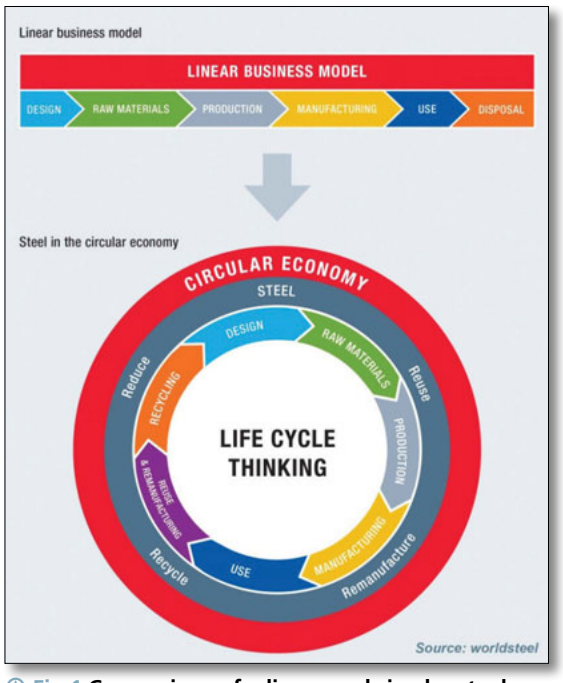

Fig 1 **Comparison of a linear and circular steel economy [*from ref 5*]**

THE CIRCULAR ECONOMY

The circular economy refers to a move from linear business models, in which products are manufactured from raw materials and then discarded, to circular business models where products or parts are repaired, re-used, returned and recycled [4] (*see Figure 1*).

In economic theory, the concept of the circular economy equates to optimal resource efficiency, which implies the most efficient allocation of resources to the areas of use that will maximise economic well-being. In economic terms, it assumes that all resources are correctly priced and therefore supports the re-use and recycling of resources as far as is possible. A circular economy ensures that value is maintained within products while reducing or eliminating waste. This concept is fundamental to the triple bottom line concept of sustainability, which focuses on the interplay between environmental, social and economic factors as a result of enterprise activity. This should all be based on a life cycle approach.

In a well-structured circular economy, the steel industry has significant competitive advantages over competing materials. Four keywords define these advantages: **Reduce, Reuse, Remanufacture, Recycle** (*see also Figure 2*):

- **Reduce** Reducing the weight of products, and therefore the amount of material used, is key to the circular economy. Through investments in research, technology and good planning, steelmakers have over the past 50 years drastically reduced the amount of raw materials and energy required to make steel. In addition, the steel industry is actively promoting and developing the use of high-strength and advanced high-strength steel grades in many applications. These grades contribute to the light-weighting of applications, from wind turbines to construction panels and automobiles, as less steel is needed to provide the same strength and functionality.

- **Reuse** Because of its durability, steel can be reused or repurposed in many ways, with or without remanufacturing. This already occurs with automotive components, buildings, train rails and many other applications. Reuse of steel is not limited to its original application; repurposing dates back to ancient times (turning swords into ploughshares). Reuse occurs in sectors where it is technically possible without reducing safety, mechanical properties and/or warranties. Rates of reuse will increase as eco-design, design for reuse and recycling, and resource efficiency become more commonplace.

- **Remanufacture** Many steel products, such as automotive engines and wind turbines, can be remanufactured for reuse to take advantage of the durability of steel components. Remanufacturing restores durable used products to like-new condition [6]. It differs from repair, which is a process limited to making the product operational, as opposed to thorough disassembly and restoration, with the possible inclusion of new parts [7].

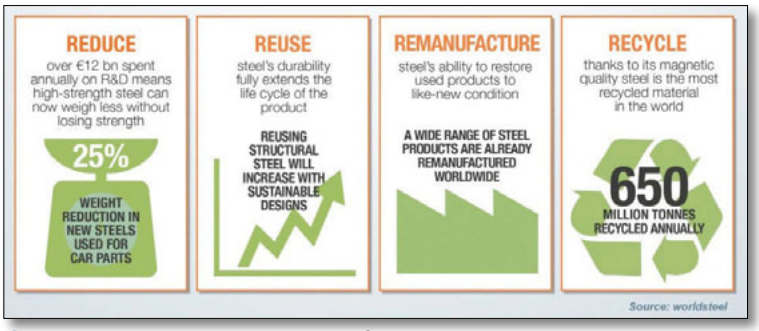

Fig 2 **Competitive advantages of using steel**

- **Recycle** Recycling has been carried out in the steel industry since steel was first made. Steel is 100% recyclable and can be recycled over and over again to create new steel products in a closed material loop. Recycled steel maintains the inherent properties of the original steel. The magnetic property of steel ensures easy and affordable recovery for recycling from almost any waste stream while the high value of steel scrap guarantees the economic viability of recycling. Today, steel is the most recycled material in the world, with more than 650Mt of steel recycled annually [8], including pre- and post-consumer scrap.

Steel has significant competitive advantages over material competitors in the circular economy and the industry will need to focus on these benefits as part of enhancing the attractiveness of steel in inter-material choices. It is an area that is as yet under-developed and under-utilised. In the future, manufacturers of steel products may also have an important role to play as certifiers of used steel products before they go to market, ensuring the integrity and safety of the product [9].

LIFE CYCLE THINKING

Life Cycle Assessment (LCA) is a tool that can be used to measure the 'circularity' of products, by measuring the costs and discounts to society of using specific materials and products throughout their full life cycle. Assessing the true benefits of conserving resources demonstrates the real savings due to the recycling and recyclability of steel and encourages the reuse and recycling of these products.

LCA becomes a tool to measure the impact of decisions taken in an enterprise with respect to production techniques, ▷

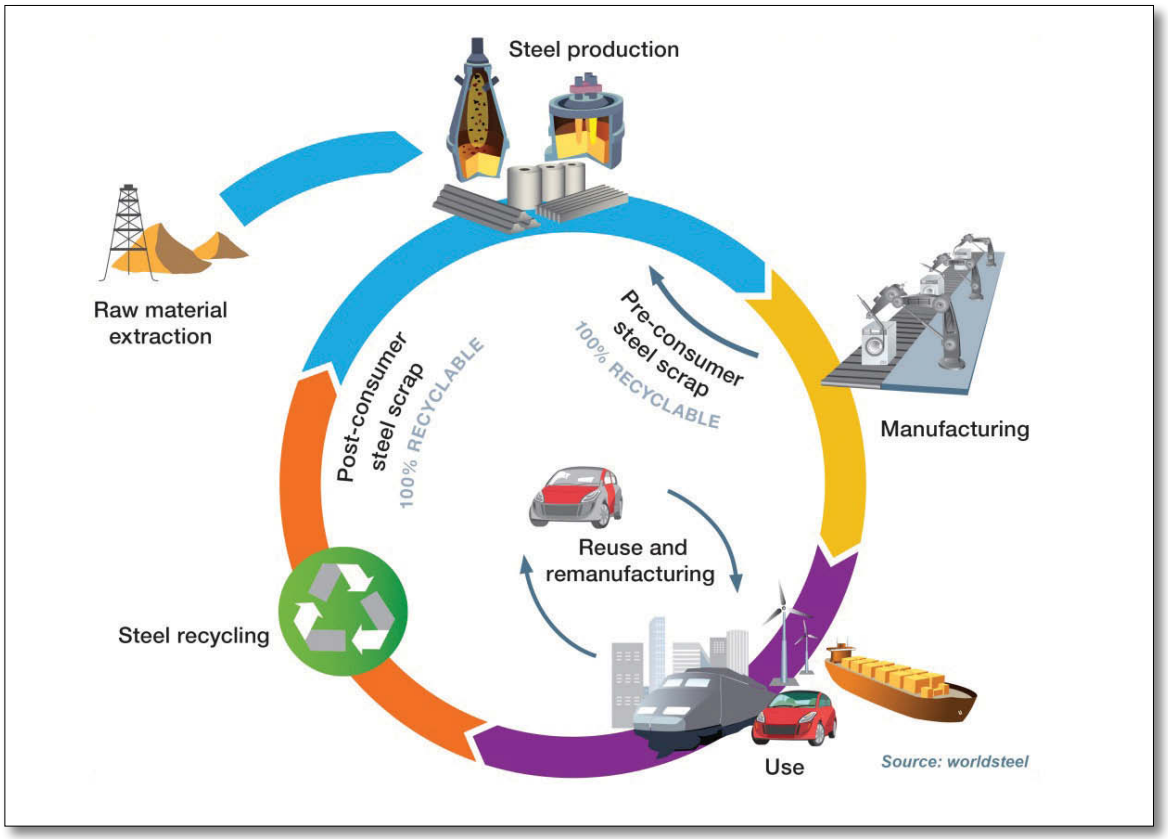

Fig 3 **The life cycle of steel [*from ref 5*]**

raw material and energy use and product allocation design on the environment. To this effect, LCA is presently the only tool by which an enterprise can truly measure the extent to which its actions are resource neutral. Without LCA, a true triple bottom line reflection is not possible.

A life cycle approach should be considered within the concept of the circular economy to create a more resource-efficient world, focusing on waste minimisation. The steel industry has been doing this for hundreds of years.

Its current form is shown in *Figure 3*.

In order to further contribute to the circular economy, a number of key areas that the steel industry should focus on include the following:

- Water used in the production process must be handed back to society in the same condition as it was received, and that air will not be polluted in any way.
- Regarding the raw materials consumed, such as coking coal and iron ore, strict adherence to sustainability is impossible as raw materials, once consumed, can clearly not be replaced, and as such would reduce the ability of future generations to produce steel in the same way as today. This challenge can be bridged by the construct of reuse and recycling, to design products for easy reuse and to encourage the recycling of steel from products when they reach the end of their useful life. Clearly this requires that in time, sufficient quantities of reusable and/or recyclable steel are available to satisfy market demand for steel.
- Emissions into the atmosphere (eg, carbon and other greenhouse gases) can be reduced by ensuring that the application of steel leads to reduced emissions during the product use phase. This can be done through the use of, for example, high-strength steels or more efficient steels used in motors.

CONCLUDING REMARKS

As steel is everywhere in our lives and is at the heart of our sustainable future, the steel industry is an integral part of the global circular economy. The circular economy promotes zero waste, reduces the amount of materials used, and encourages the reuse and recycling of materials – all fundamental advantages of using steel. A life cycle approach is very important in delivering true sustainability. Legislators and industry decision makers need to understand the importance of analysing the entire life cycle of a product before making legislative or manufacturing material decisions. Too many legislative bodies around the world still enact regulations which only affect the 'use phase' of a product's life, for example, water and energy

consumption for washing machines, energy consumption for a refrigerator or CO_2 emissions while driving a vehicle. This focus on the use phase can lead to more expensive alternative lower density materials being employed, but which typically have a higher environmental burden when the whole life cycle is considered.

This use phase limitation cannot continue. Life cycle thinking must become a key requirement for all manufacturing decisions. MS

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REFERENCES

[1] Brundtland Commission, *Report of the World Commission on Environment and Development*, United Nations, 1987

[2] worldsteel, *Sustainable Steel: At The Core of a Green Economy*, 2012

[3] Since 2004, worldsteel has been publishing its *Sustainability Report* and in 2012, published the *Sustainable Steel: At The Core of a Green Economy Report*, both of which provide a sustainability overview of the steel industry that mirrors the concept of the triple bottom line

[4] Scoping paper: *Mining and Metals in a Sustainable World*, World Economic Forum, 2014

[5] worldsteel, *Steel in the circular economy: a life cycle perspective*, Belgium, 2015

[6] Lund, R, *Remanufacturing: The Experience of the United States and Implications for Developing Countries*. World Bank technical paper, ISSN 0253- 7494, no. 31. Integrated resource recovery series 2. Washington, DC: World Bank and United Nations Development Program, The International Bank for Reconstruction and Development, 1984

[7] Lund, R, *Remanufacturing. In the American Edge: Leveraging Manufacturing's Hidden Assets*, ed. J Klein and J Miller, New York: McGraw-Hill, 1993

[8] Bureau of International Recycling, *World Steel Recycling in Figures 2009-2013*, 2014

[9] Allwood J M, Cullen J M, et al, *Sustainable Materials: With Both Eyes Open*, Cambridge, England: UIT, 2012