

Steel - the permanent material
in the circular economy

Introduction

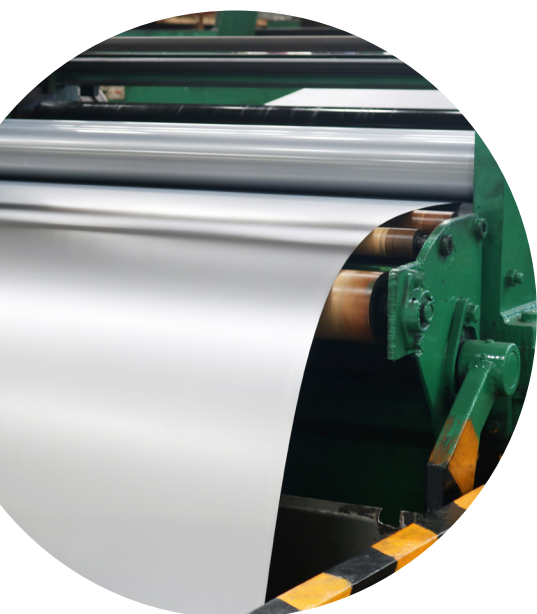
The circular economy is a move from linear business models, in which products are manufactured from raw materials and then discarded at the end of their useful lives, to circular business models, where intelligent design leads to products or their parts being reused, remanufactured and recycled.

The concept of circular economy drives optimal resource efficiency. It makes sure that resources are allocated to products and services in such a way as to enable a sustainable future for everyone.

All steel products need to be designed efficiently and to be durable, easy to reuse and remanufacture, and ultimately recycled.

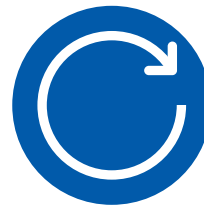
In a well-structured circular economy, the steel industry has significant competitive advantages over other materials.

Given the inherent properties of steel, many of the circular economy principles are already well established.



Reduce

Reduce means decreasing the amount of material, energy, waste and other resources used to create steel, and reducing the weight of steel used in products.



Reuse

Reuse is using an object or material again, either for its original purpose or for a similar purpose, without significantly altering the physical form of the object or material.



Remanufacture

Remanufacturing is the standardised industrial process of restoring used steel-containing products to as-new.



Recycle

Melting steel scrap from products at the end of their useful life to create new steels. Recycling alters the physical form of the steel object so that a new application can be created from the recycled material.



Case studies

We are seeing more and more initiatives and companies highlight steel's value as a circular material. Visit worldsteel.org/circular-economy for example.

Steel in the circular economy

Among the major materials used today, steel has one of the lowest levels of CO₂ emissions per tonne of material produced. However, due to the scale of the use of steel, the industry must reduce its impact and is exploring a number of decarbonisation paths.

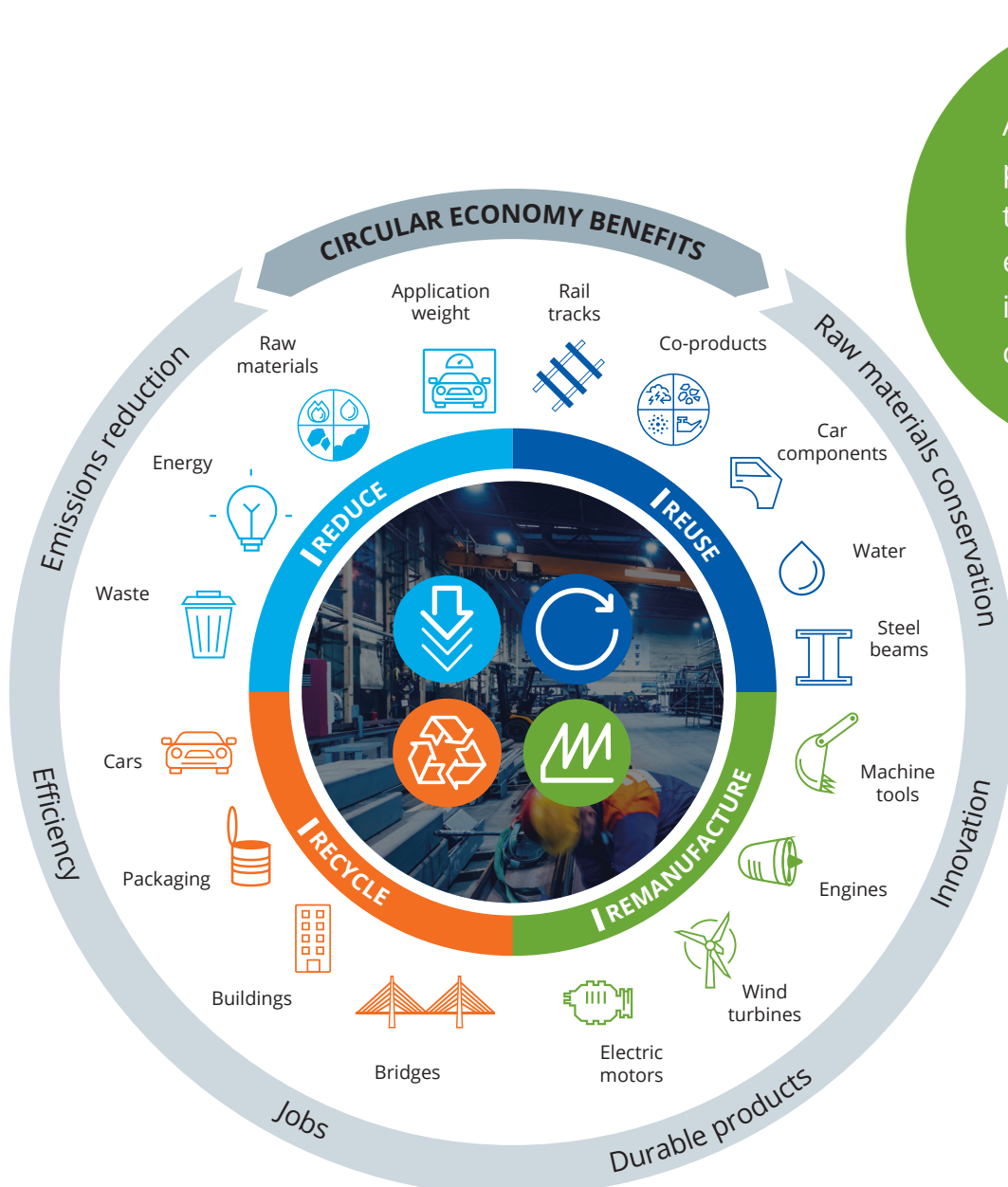
There is no single solution to reducing CO₂ emissions.

Adopting circular principles is an integral part of industrial and societal transformation and is an important contributor to meeting the targets of the Paris Agreement.

As a permanent material which can be recycled over and over again without losing its properties, steel is fundamental to the circular economy.

The industry is continuing to expand its offer of advanced high-strength steels which reduce the weight of applications, and encourage circular economy practices.

For society, the benefits of a circular economy include durable products, local jobs, reduced emissions, and the conservation of raw materials for future generations.



Adopting circular principles is crucial to tackling all environmental impacts, including climate change.



Reduce

Decreasing the amount of material, energy, waste and other resources used to create steel and reducing the weight of steel used in products. Integrating the concept of doing more with less.

Reduce in steel applications

Over the past 50 years, the steel industry has invested in research and technology to create new grades of advanced and ultra-high-strength steels. These grades have reduced considerably the weight of many steel applications.

Optimising the weight of products is an integral part of a circular economy. By reducing weight, the amount of raw materials and energy used to create the product is decreased, reducing pressure on raw materials.

Lighter weight applications which take advantage of high-strength steels, such as vehicles, also produce fewer emissions during the use phase of their life.

In construction, substituting high-strength steels for regular steels can achieve a CO₂ reduction of around 30% in steel columns and around 20% steel beams due to the reduced tonnage of steel products needed for the same function.

Whether it is a wind turbine, construction panel, a vehicle, or a steel can, the application of high-strength steels means that less steel is required to provide the same strength and functionality. This also has a knock-on effect by reducing the amount of other materials required, for example in foundations. In addition, the development of better coating systems results in an extended service life and hence reduced material demand.

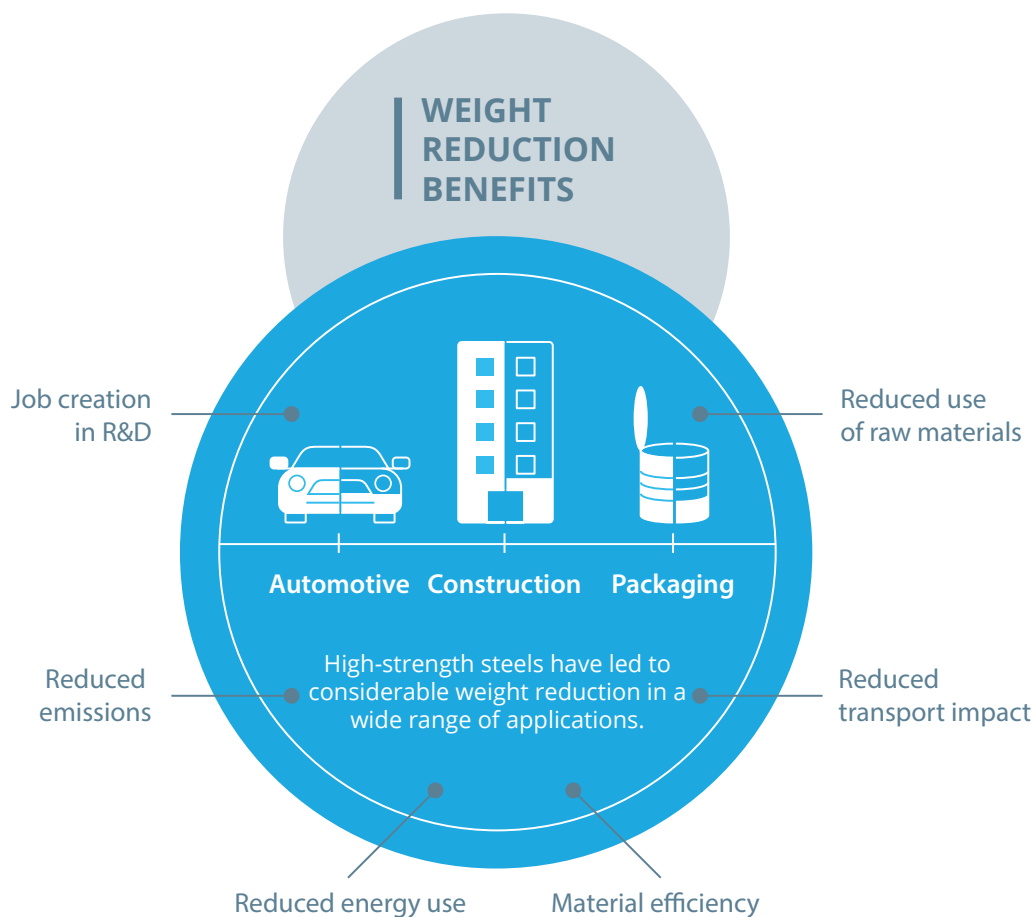


Sharing economy

In a sharing economy, individuals rent goods rather than own them. Today, on-demand services, such as Uber or DiDi in the case of mobility, are becoming increasingly appealing.

By maximising the utility of one unit produced, unnecessary manufacturing can be avoided leading to energy and raw materials savings.

Steel's durability, strength and environmental advantages in products have a vital role in this new, more sustainable economy.



Reduce during steel production

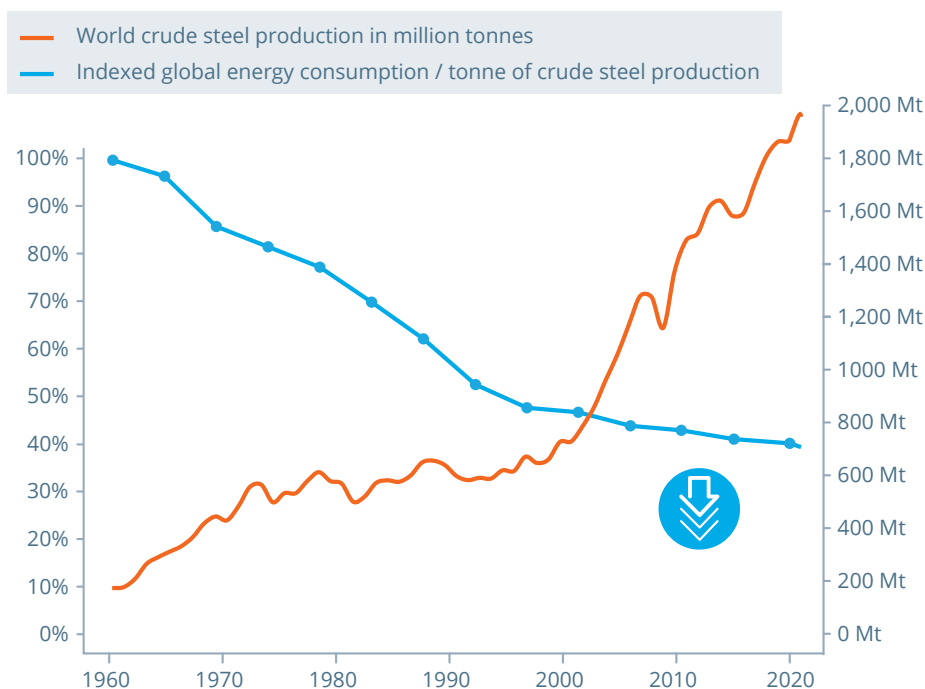
Since 1900 the global steel industry has recycled over 25 billion tonnes of steel. This has reduced iron ore consumption by around 33 billion tonnes, as well as cutting coal consumption by 16 billion tonnes.

The industry has also dramatically reduced the use of energy. Producing one tonne of steel today requires just 40% of the energy it did in 1960. Over the same period, steel production has increased nearly ten times.

Replacing energy produced from fossil fuels with energy produced by renewable sources is becoming increasingly more important for the steel industry.

Another area that the steel industry and its customers are working hard to improve is reducing the yield loss in downstream manufacturing processes by working together with its customers.

A common drive to diminish the percentage of offcuts, which are then re-melted to make new steel, will lead to greater productivity as well as energy and resource savings.





Reduce through material efficiency

Today, material efficiency is an integral part of the modern steelmaking process. Our goal is to use all raw materials to their full capacity, ensuring zero waste from steelmaking. This ambition guarantees that almost every co-product formed during steelmaking is used in new products.

This approach minimises the amount of waste sent to landfill, reduces emissions, and preserves raw materials.

Slag is a co-product of the steelmaking processes (electric arc furnace, blast furnace, and basic oxygen furnace) and can be used to make a range of products, including cement, fertilisers, and roadstone. Process gases from iron cokemaking and steelmaking are typically used within the steelmaking plant, replacing steam and electricity, or exported to the local grid. Other co-products such as dust are used for their high metallic content.

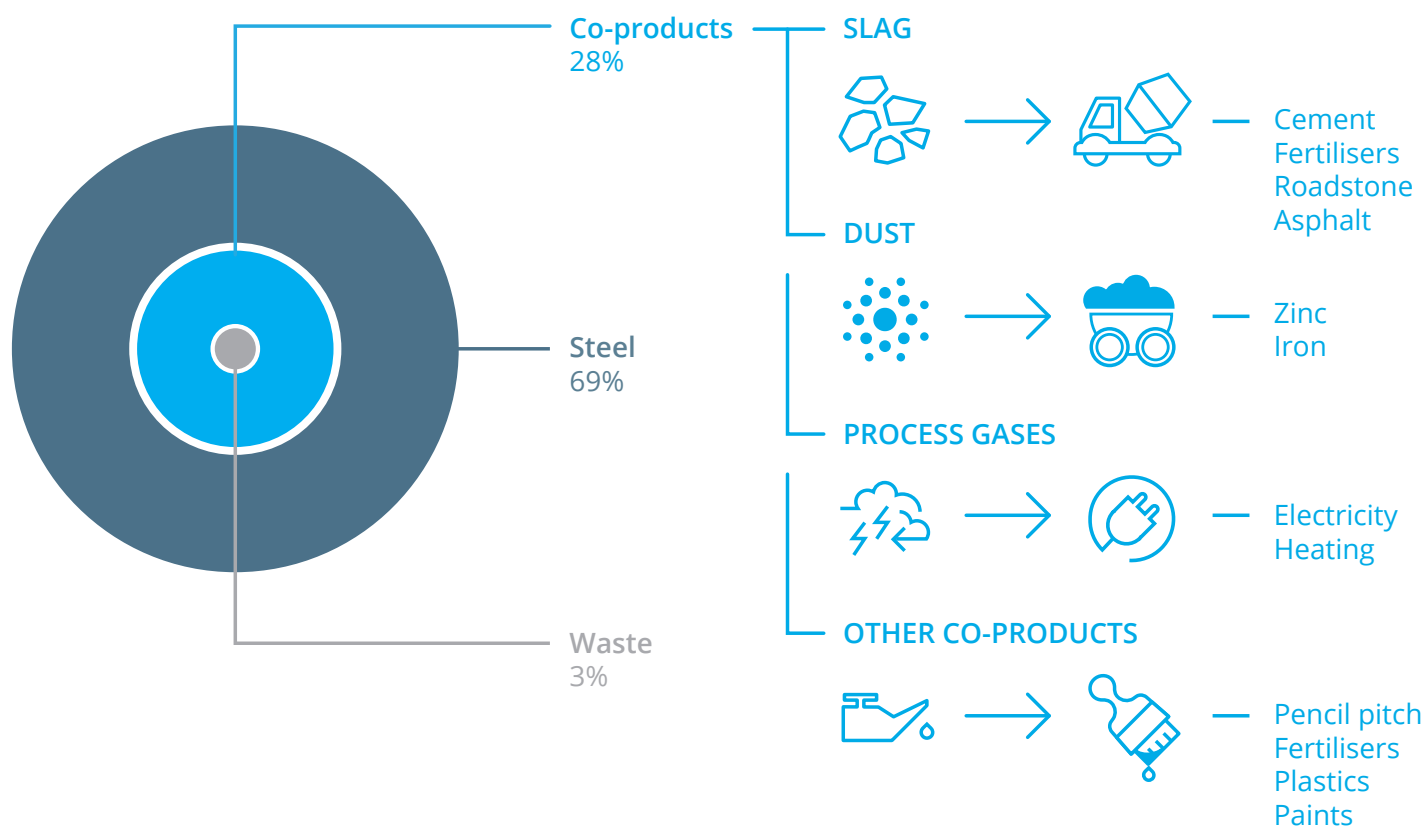
Water is recirculated within the plant, especially for cooling purposes; around 90% of the water used in steelmaking is cleaned and either reused or returned to its source.

The valuable co-products, including slag, dust, and process gases are fully utilised in other applications and industries, avoiding the use of primary materials such as cement clinker or electricity generation.

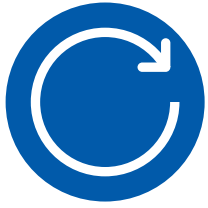
Waste is another area in which the steel industry has made huge gains over the past decades. Working with external partners, the industry has been able to find markets for around 97% of its solid and liquid production with only a 3% waste stream.



Material efficiency in steel production output



The steel industry finds markets for around 97% of its solid and liquid production.



Reuse

Reuse is using an object or material again, either for its original purpose or for a similar purpose, without significantly altering the physical form of the object or material.

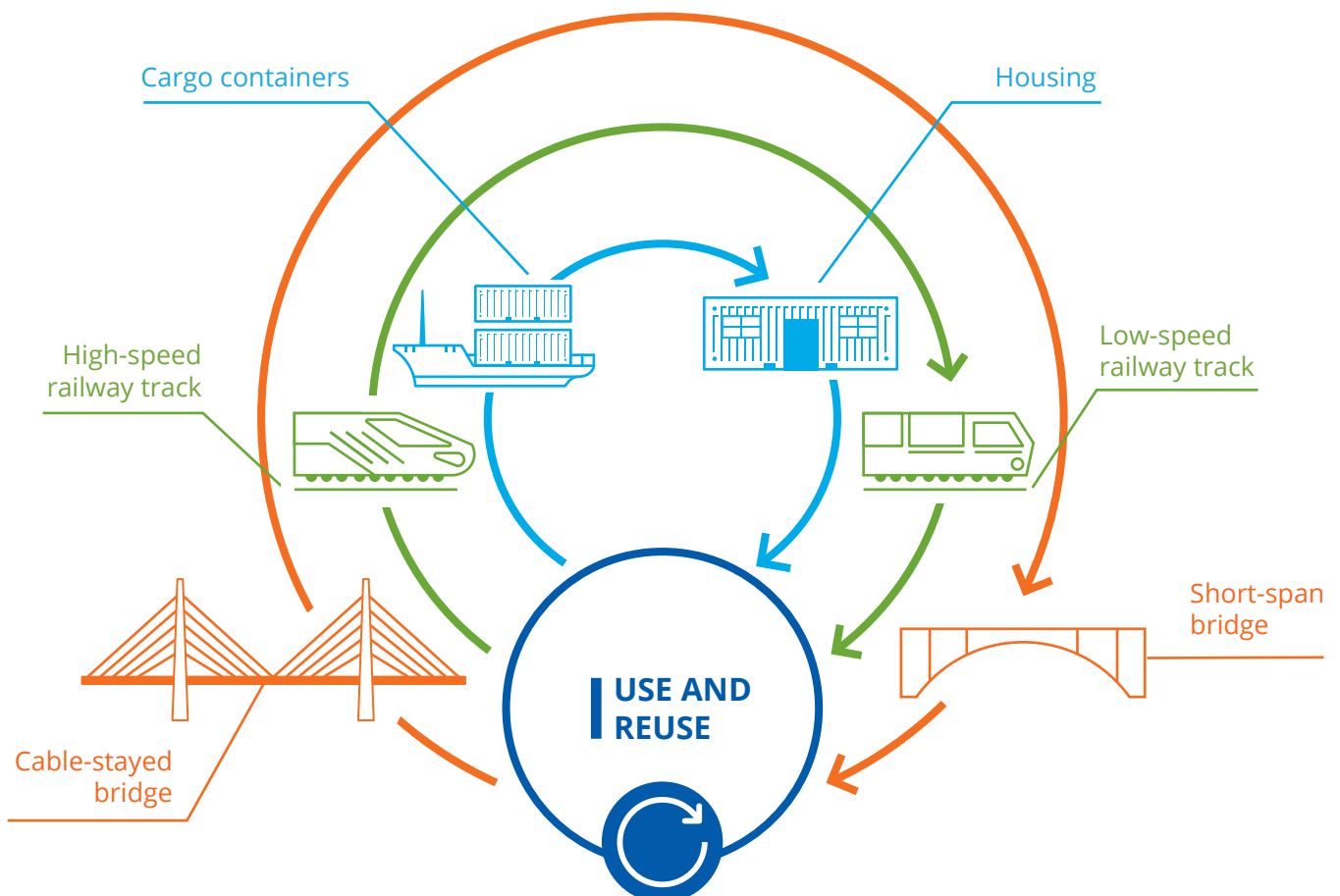
Reuse in steel applications

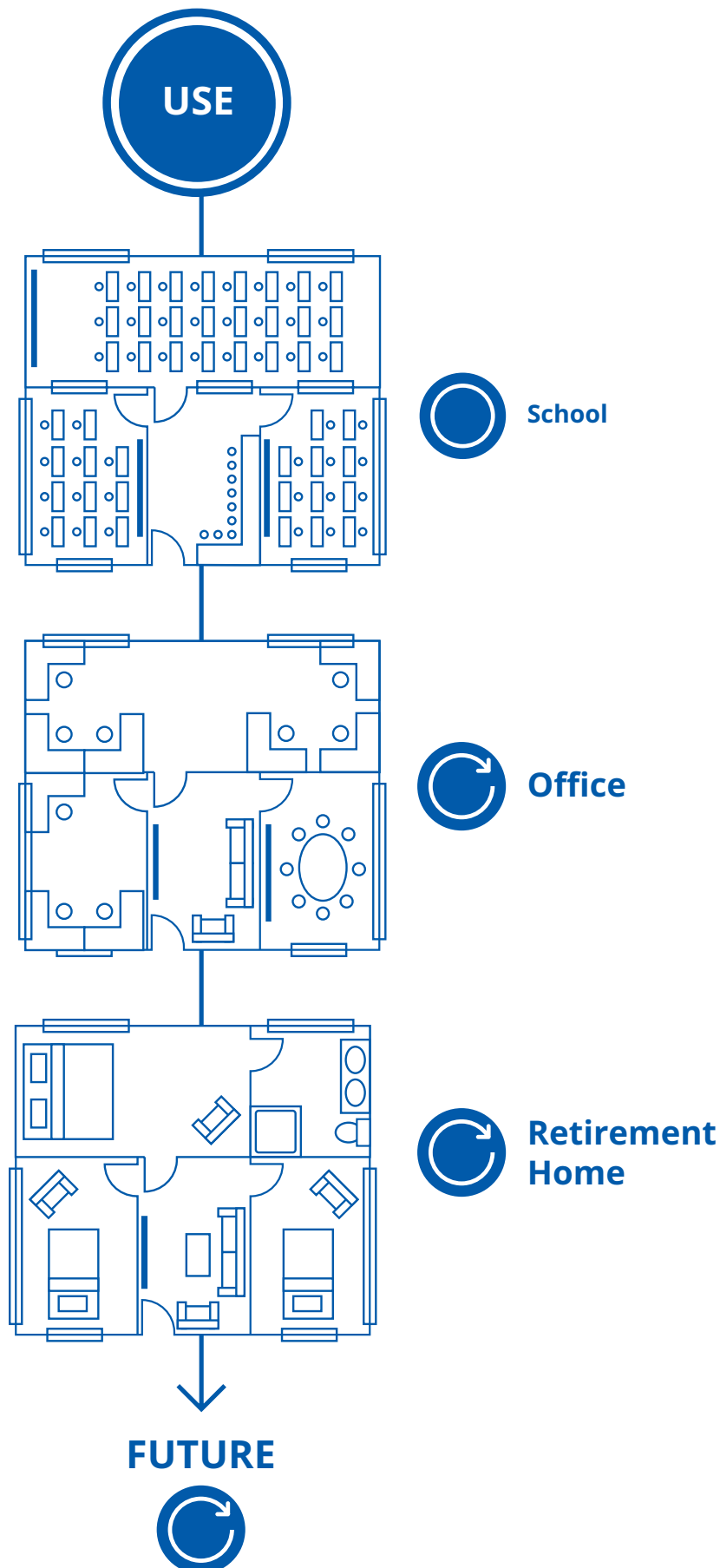
Steel's durability enables many products to be reused at the end of their life. As well as extending the product's lifespan, reuse avoids the need to transport and re-melt the steel, and to create new products. This has significant advantages for the environment and maximises the use of resources.

In a fully circular economy, the reuse of a manufactured product is considered in the earliest design phases of its creation.

This allows both small- and large-scale products to be repurposed for another use quickly and efficiently once their initial use is fulfilled.

High-speed rail tracks, for example, can be designed so that once they have been worn to a certain point and are no longer usable on high-speed lines, they become suitable for low-speed tracks.





Reuse in buildings

Buildings are a prime example of where designing for reuse is critical if we are to conserve resources.

Modular design using steel construction methods and demountable connections (screws, bolts) allows buildings to be repurposed quickly and cost effectively without remanufacturing, as needs change. For example, a community might build a school to meet the needs of a growing population.

As community needs change, the internal walls can be removed to create open spaces suitable for offices. Decades later the rooms can be re-divided to create retirement units. Integrating reuse into the economy presents a range of new opportunities for consumers and steelmakers.

In our current business model, buildings are typically constructed with new steel beams as their quality and strength is guaranteed by the steelmaker. In an economy where reuse is well established, steel companies will continue to examine new business models and may offer services such as testing and recertifying used beams before they are reused. Documenting the chain of custody will ensure the parts can be tracked and the quality guaranteed.

This provides the builder with the safety guarantee they require, low-cost fast remodelling solutions for building owners, and a source of revenue for the steelmaker.



Remanufacture

Remanufacturing is the standardised industrial process of restoring used steel-containing products to as-new condition.

Remanufacture of steel-containing products

In a truly circular economy, products which reach the end of their life are restored to as-new condition in a process known as remanufacturing.

Remanufacturing involves the disassembly of a product, during which each component is thoroughly cleaned, examined for damage, and either reconditioned or replaced with a new or upgraded part.

The product is then reassembled and tested to ensure performance to at least the original specification. The goal is to restore an application which can be offered with a guarantee that is equivalent to or better than that of the original product.

Remanufacturing differs from repairing/refurbishing, which is a process limited to making the product operational as opposed to thoroughly restoring it. In many industries, such as construction and farm machinery, production of truck and car engines, electrical motors, domestic appliances, and wind turbines remanufacturing is already in place. Remanufacturing takes advantage of the durability of steel components. It guarantees that the energy used to create the components is preserved – as only the faulty or worn components are replaced or reconditioned.

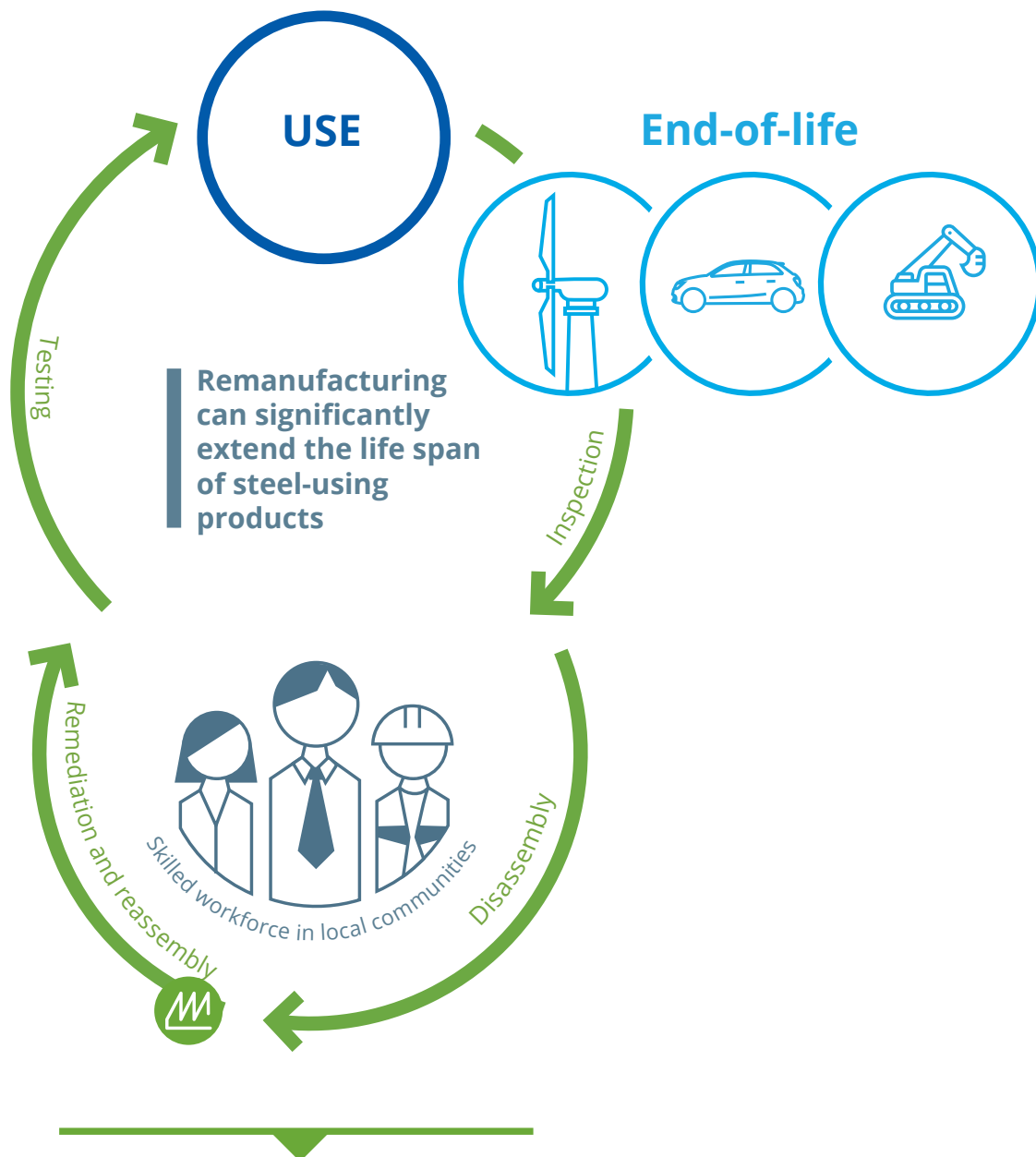
Once recertified, the application is then 'as-new' and can continue to be utilised for longer.

A key limitation to the growth of remanufacturing is a lack of awareness of and confidence in remanufactured products. Consumers who are used to the 'make, use and dispose' linear economic model, common in developed economies may be reluctant to adopt remanufactured goods. There is still a significant lack of awareness of the social, financial and environmental benefits generated by this process. However, many drivers could accelerate the adoption of remanufactured products.

The steel industry enables manufacturers to design their products with dismantling and remanufacturing in mind.

Ensuring that components are modular, standardised, and easy to remove means that they are more likely to be repaired or remanufactured.

Steel applications are particularly well suited to remanufacturing.



Examples of benefits

- Return on investment is increased significantly
 - 25 to 50% cheaper for the customer
 - 80% energy saving
- Substantial conservation of raw materials



Recycle

Melting steel scrap from products at the end of their useful life to create new steels. Recycling alters the physical form of the steel object so that a new application can be created from the recycled material while maintaining the inherent properties of the original steel.

Steel recycling: Attributes and benefits

Steel has been recycled ever since it was first made. All available steel scrap is 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. These properties can be modified during the steelmaking process or through mechanical processes to create the many thousands of advanced and commodity steel grades available. The quality of the steel product can also be improved on recycling.

The high value of steel scrap ensures the economic viability of recycling. With its inherent magnetic properties, steel is easy and affordable to recover from almost any waste stream.

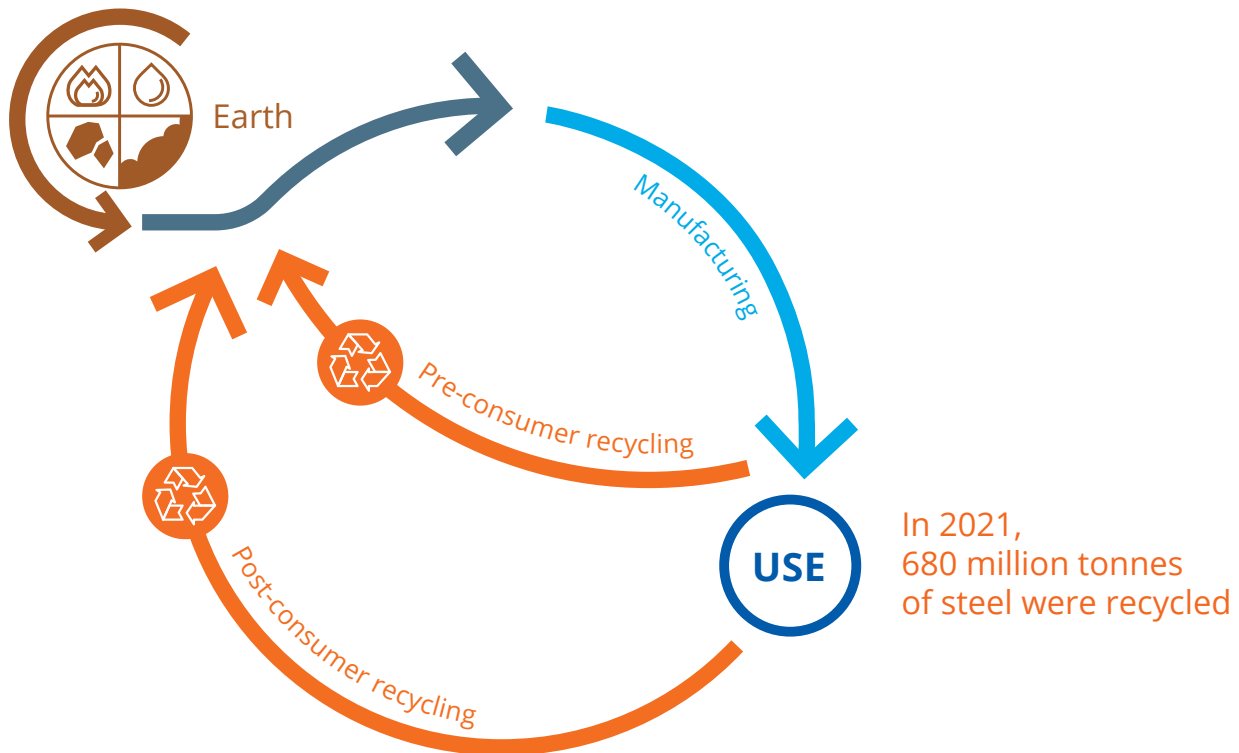
This is why steel is the most recycled material in the world. Around 680 million tonnes (Mt) of steel were recycled in 2021, avoiding over one billion tonnes of CO₂ emissions that would have been emitted from the production of virgin steel.

This includes pre-consumer scrap from manufacturing and post-consumer scrap from steel products at the end of their useful life.

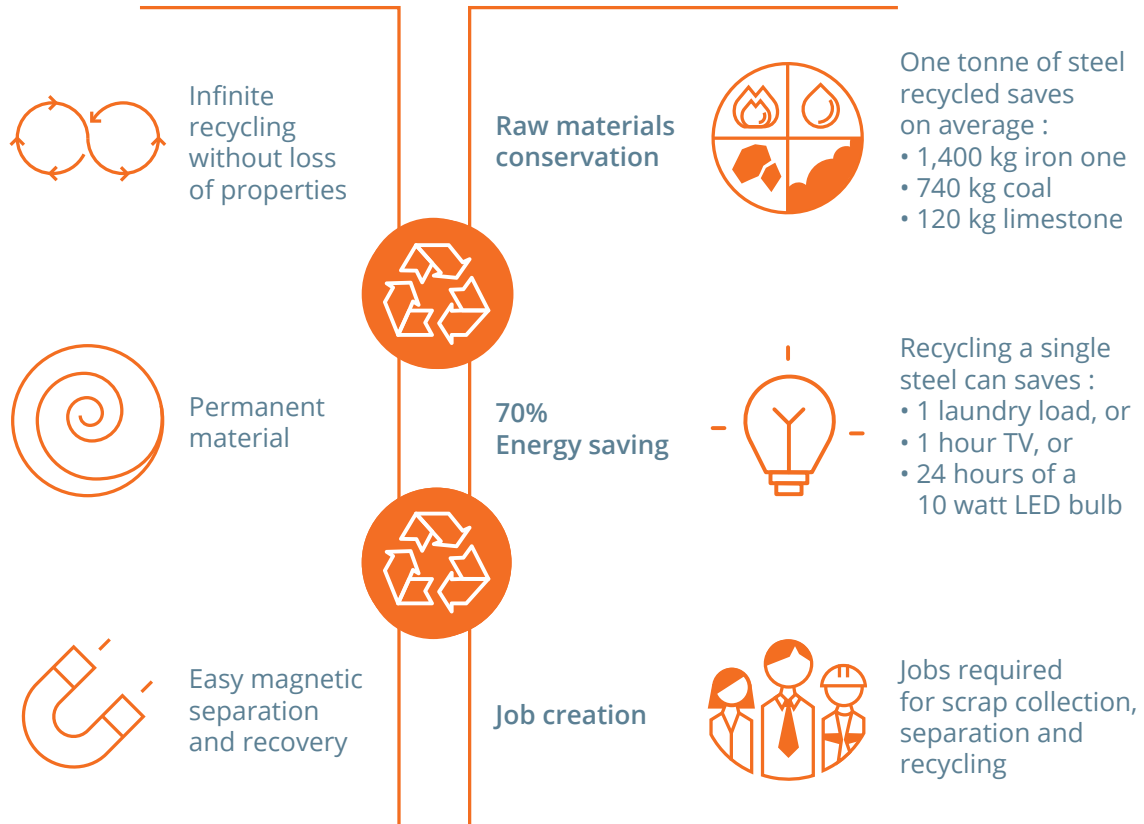
Although all available steel scrap is recycled, there is not enough scrap available to meet demand for new steel products.

While many steel products such as packaging and vehicles have a short to medium service life, large-scale products such as buildings and bridges are designed to last for decades or centuries.

In the future all of this material will be recycled to meet our ever-growing need for low-carbon steel.



Steel attributes — Benefits of steel recycling



Notes

The World Steel Association (worldsteel) is one of the largest and most dynamic industry associations in the world, with members in every major steel-producing country. worldsteel represents steel producers, national and regional steel industry associations, and steel research institutes. Members represent around 85% of global steel production.

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