GALVANIZED STEEL AND SUSTAINABLE CONSTRUCTION

SOLUTIONS FOR A CIRCULAR ECONOMY

European General Galvanizers Association (EGGA) is the industry organisation for Europe's general galvanizing sector. It is a federation of 14 National Associations that represent the industry in Europe.

The 'European Initiative for Galvanizing in Sustainable Construction' started with multi-stakeholder assessments in the early 2000s that culminated with the publication, in 2008, of '*Galvanizing in Sustainable Construction: A Specifiers' Guide*'[1] under the guidance of Professor Tom Woolley – a radical advocate of green building who prompted a fresh and exciting look at hot dip galvanizing and its consistency with sustainable design.

This latest publication explains how the galvanizing industry is moving forwards - keeping galvanized steel at the forefront of solutions for tackling climate change and delivering the circular economy that is now firmly established in both policy and practice.

Galvanized steel can provide innovative solutions that optimise durability and facilitate circularity of steel structures and components. These solutions can be easily implemented using this well-established and simple method of protecting steel.

Cover: MFO-Park, Zurich: Galvanized steel is used to revitalise an old industrial site

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EGGA
GALVANIZING EUROPE

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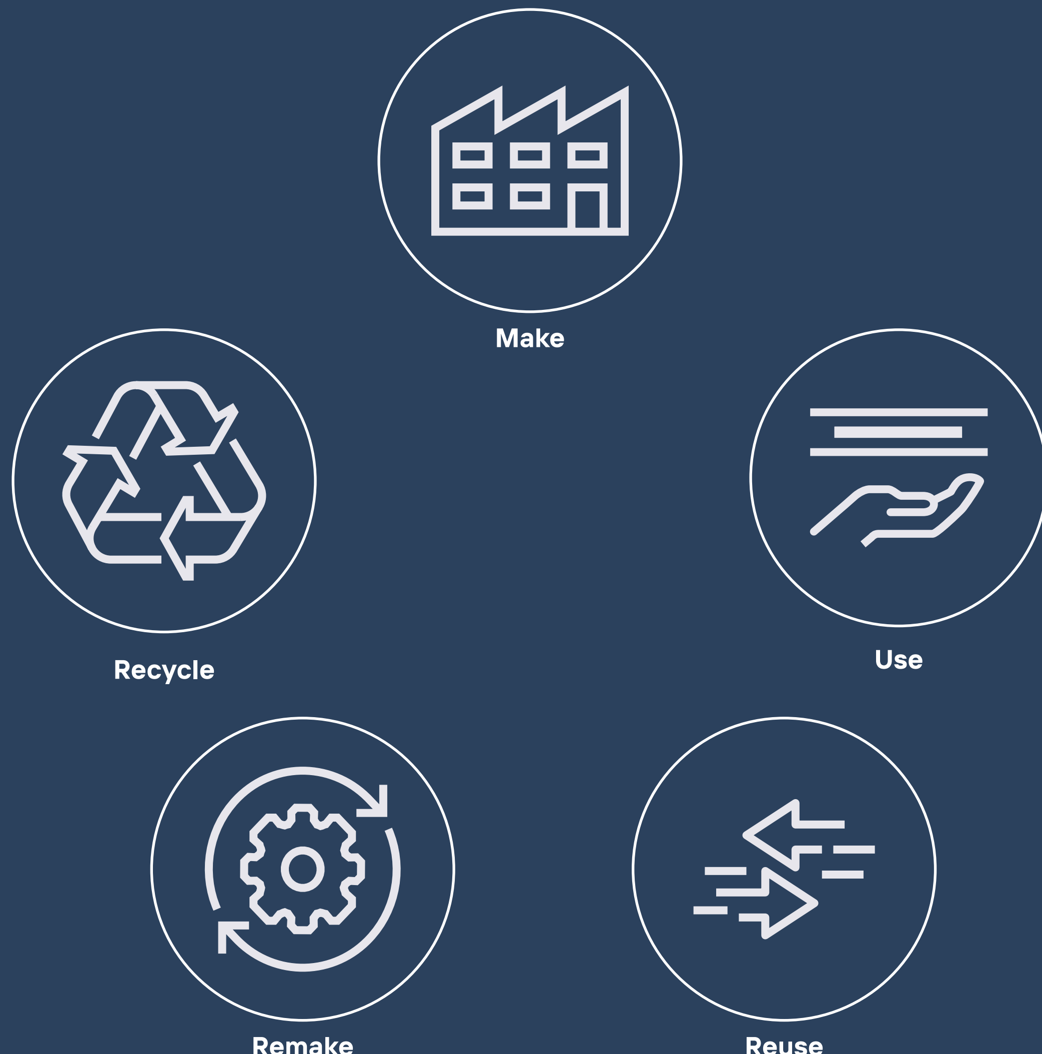

Make
Use
Reuse
Remake
Recycle

CONTENTS

EN ISO 1461

Throughout this document the term 'galvanized steel' refers to steel articles that have been immersed in molten zinc after the articles have been fabricated or manufactured. This is the process of batch (or 'general') galvanizing that is usually carried out according to EN ISO 1461 to provide a zinc coating that is thick, tough and gives complete coverage of the steel article. This combination cannot be achieved with other types of zinc coated steel.


THE GREEN HOUSE
eat·meet·relax·enjoy

THE CHALLENGE OF SUSTAINABLE CONSTRUCTION

Concerns about the effects of climate change are both serious and urgent

To avoid the adverse effects of climate change, The International Panel on Climate Change (IPCC) has recommended that global emissions of greenhouse gases, of which CO_2 is the most important, should be cut, to achieve climate neutrality by 2050. The objective is to limit global warming to 1.5°C above pre-industrial levels[2].

The concerns about effects of climate change are both serious and urgent. With a growing world population and a consequent increasing use of engineered materials, the need for a new approach to maximise the value of raw materials by keeping buildings, infrastructure, resources and materials in use for as long as possible is clear.

The first European Climate law[3], introduced by the European Commission in 2020, proposes a legally obligatory target of net-zero greenhouse gas emissions by 2050 as part of the EU Green Deal[4]. These ambitious objectives are supported by initiatives to transition industry to a sustainable model based on the principles of a circular economy.

The galvanizing industry has welcomed this increasing focus on the creation of a circular economy – embracing design for durability, deconstruction, disassembly and flexibility as well as on reuse, recovery or remanufacturing of materials. Galvanized steel structures and components are ideal circular materials for low carbon buildings.

Steel is essential to the technologies and solutions that meet society's everyday needs and will continue to do so in the future. Whether it is for transport systems, infrastructure, housing, manufacturing, agriculture or energy, steel is widely recognised as the 'permanent material in the circular economy'.

In the search for optimal sustainability in the use of materials, the combination of hot dip galvanizing and steel creates an almost unique partnership in delivering sustainable design choices.

Left
The Green House (see p12+13)

Make

Galvanizing is an efficient dip process – giving the highest level of protection for steel. Galvanizing of steel products maximises their durability, reuse and recycling.

Use

Galvanized steel is completely covered with a durable coating that can last the lifetime of the component – avoiding resource use for replacement or maintenance.

Reuse

Galvanized steel is robust and easily dismantled for reuse in multiple life cycles. The coating stays with the steel component in its next life cycle.

Remake

Galvanized steel products can be regalvanized and put back into service – avoiding production of new steel. Repurposing of galvanized steel products is often possible without regalvanizing.

Recycle

Steel and zinc are recycled together – without loss of properties – if the long life of galvanized steel eventually ends.

GALVANIZED STEEL IN THE CIRCULAR ECONOMY

Construction in the Circular Economy

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 repaired, reused, returned and recycled.

A circular economy aims to rebuild capital, whether it is financial, manufacturing, human, social or natural. This approach enhances the flow of goods and services. The concept of the circular economy drives optimal resource efficiency. It makes sure that resources are efficiently allocated to products and services in such a way as to maximize the economic well-being of everyone. In addition, products need to be designed to be durable, easy to repair and, ultimately, to be recycled. The cost of reusing, repairing or remanufacturing products has to be competitive to encourage these practices. Simply replacing a product with a new one should no longer be the norm.

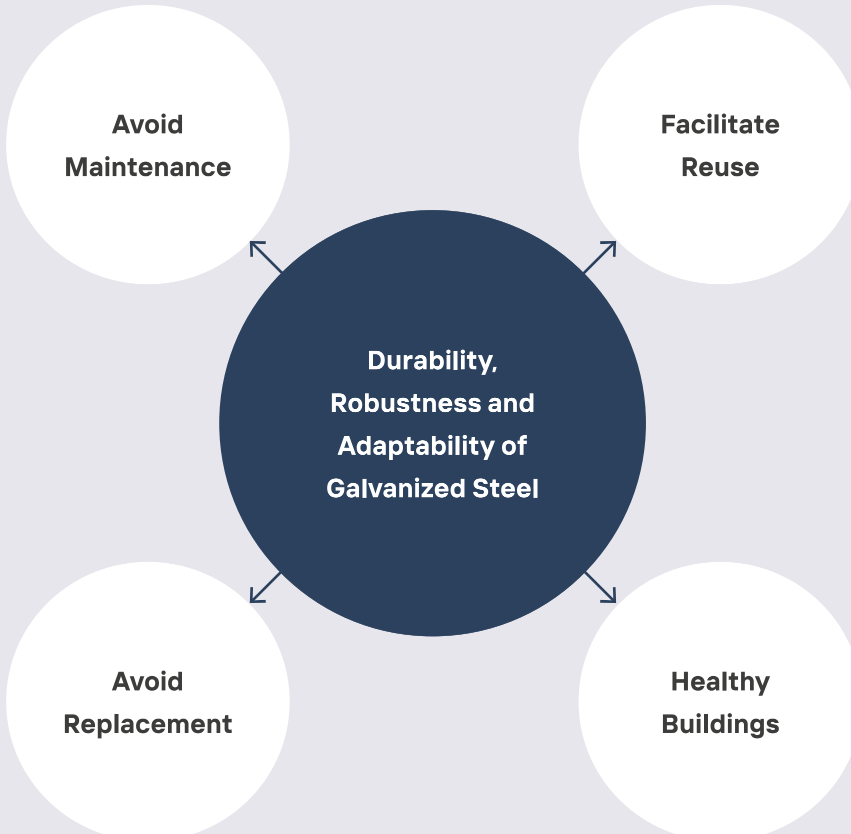
A circular economy also ensures that value is maintained within a product when it reaches the end of its useful life while at the same time reducing or eliminating waste. This idea is fundamental to the triple-bottom line concept of sustainability, which focuses on the interplay between environmental, social and economic factors. Without a life cycle approach, it is impossible to have a genuine circular economy.

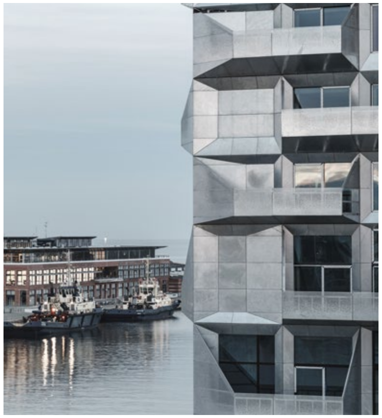
The construction sector is a priority for a circular economy because, based on a building's full life cycle[5] it is responsible for:

- 50% of extracted materials
- 50% of total energy consumption
- 33% of water use
- 35% of waste generation

Circular construction means thinking, from the outset, about how to design a building to be able to dismantle easily its components at the end of the building's lifetime in order to reuse them.

Features of galvanized steel





To achieve this, constructors are changing their way of thinking to:

- Design flexible and adaptable buildings, that provide basic functions for a long period, but at the same time can be adapted.
- Design in a 're-functionable' way. At design stage take into account future new functions and new users for a building.
- Make sure that components are re-usable and design the building accordingly.
- Use resources with a positive residual value.

Why Galvanized Steel?

Recognition that the concept of a circular economy is fundamental to optimising sustainability of materials has again brought the simplicity, robustness, durability and inherent recyclability of metal structures and components to the forefront of sustainable design. Hot dip galvanized steel perfectly illustrates this:

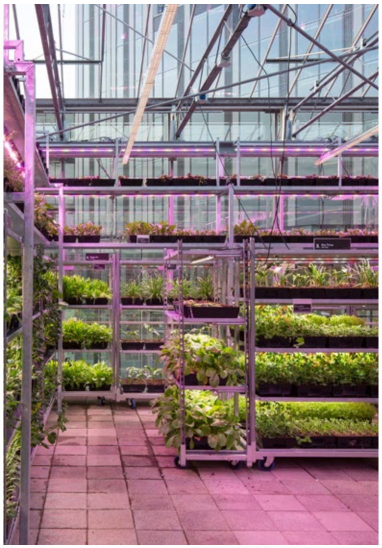
- Hot dip galvanizing of steel products after fabrication delivers the highest levels of corrosion protection – the steel structure or component will often achieve its design life with no maintenance.
- The galvanized coating can follow the steel structure through multiple cycles of reuse.
- A galvanized coating is inherently climate resilient as its protective ability is largely unaffected by changes in temperature and other climatic factors.
- Galvanized coatings are bonded to the steel, which allows the steel product to be reused along with the original coating without need for recoating (just think of those scaffolding poles that are repeatedly assembled and disassembled around our buildings).
- Galvanized steel components that have reached the end of their design life, or are uninstalled for any other reason, can be re-galvanized and returned to the original use.
- If the reuse cycles come to an end, both steel and zinc are recycled together in the well-established steel recycling processes – with the zinc being returned, without loss of properties, to zinc production plants and eventually back into the galvanizing process.

If a material system was specially designed for the circular economy, hot dip galvanizing would be an excellent example. But, it is here today and has been following these principles for decades.

Above
The Silo, Copenhagen

THE GREEN HOUSE – DESIGN FOR FLEXIBILITY AND REUSE

Reuse



The Green House could be completely taken apart and rebuilt at another site

The Green House houses a restaurant with its own urban farm and a conference centre. True to the principles of the circular economy, the entire building can be disassembled. Owing to their high degree of precision, steel components are easy to take apart and put together again. A special feature of the steel frame of The Green House is its square grid, with which multiple building configurations are possible with one-and-the-same construction kit.

In fifteen years, it is anticipated to be taken apart and rebuilt at another site. Reuse also played an important part in the choice of materials for the project.

The pavilion was designed as a generic construction kit with a steel frame comprised of hot dip galvanized steel sections that can easily be disassembled for reuse. Galvanizing was also used for trellis trusses for the façade, the roof (including roof construction for a small greenhouse), balustrades and the staircase within the pavilion.

The hot dip galvanized steel perfectly underscores the bold character of The Green House and the urban-farming greenhouse. The architects also recognised that hot dip galvanizing lends itself perfectly to disassembly and reassembly - as the coating will not be damaged in that procedure.

Hierarchical models of the circular economy illustrate the importance of galvanized steel

Priorities in the Circular Economy	Actions in the Circular Economy	Galvanized Steel in the Circular Economy	
High	Refuse	The highest level of durability and robustness – giving 'once-only' solutions that last the lifetime of a building	Make
	Reduce	Resource use for maintenance is avoided	Use
	Reuse	Robust and easily dismantled for reuse in multiple life cycles of a building or structure	Reuse
	Repair Refurbish Remanufacture Repurpose	Coating stays with the steel and no additional coating is needed in any new use Can be re-galvanized and put back into service – avoiding production of new steel	Remake
Low	Recycle Recover	If the long life of galvanized steel eventually ends, steel and zinc are recycled together – without loss of properties – to produce new galvanized steel	Recycle

Delivering the Circular Economy

The hierarchy models of a circular economy illustrate very well the important role of galvanizing to enhance the already favourable position of steel as a circular material because a galvanized coating becomes an integral part of the steel structure that will resist impact and abrasion during disassembly and reuse of the steel. This feature is of great value to the reuse, remanufacture and repurpose of steel structures and components.

Reducing the weight of products and therefore the amount of material used, is key to the circular economy. The steel industry has developed high-strength and advanced high-strength steel grades for 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. By providing maximum levels of corrosion protection, galvanizing allows thinner, lighter steel sections to be used because additional allowances for corrosion losses during service are avoided.

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). Rates of reuse will increase as ecodesign, design for reuse and recycling, and resource efficiency become more commonplace.

If designers want to integrate reusable steel elements in the structural part of a building, galvanizing is the ideal coating system. Galvanized steel will not suffer from demounting and remounting activities as opposed to painted steel that will need to be repainted or at least repaired. Moreover, galvanizing offers longer lifetime expectations to steel than other coating systems, which allows frequent reuse of the material.

In a circular economy, there will be a shift from a product-based economy towards a service-based economy. Repair/maintenance will be increasingly important as will efforts to limit the distance between the repair shop and the user, to minimise the environmental impact. This will stimulate local economies and increase ease of use for the end user.

Steel products are easily repaired or the entire repaired steel product can be re-galvanized.

Steel and zinc are 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 and its magnetic properties ensure 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. Over 650 million tonnes of steel are recycled annually, including pre- and post-consumer scrap[6].

INFORMATION POINT – READY FOR RELOCATION AND REPURPOSE

Remake **Reuse**

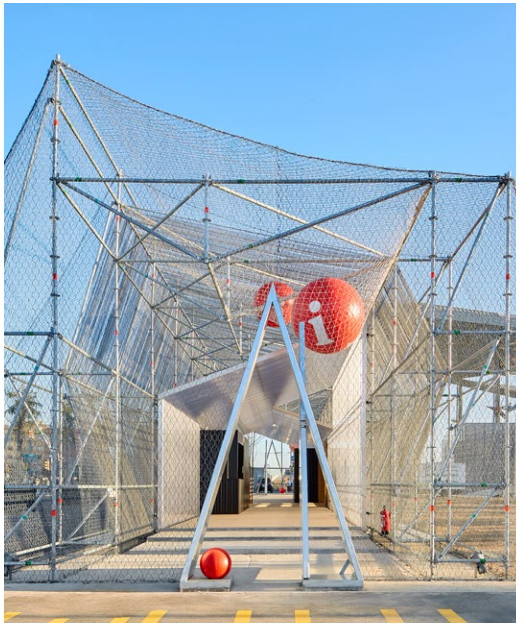
The Les Glòries development on the eastern flank of Barcelona has been one of the city's most significant urban upgrades. During the regeneration of the area, Barcelona City Hall wanted an Information Point that would inform local residents about the development but also provide information for tourists.

A closed competition was won by the local architects Peris + Toral for a temporary structure that could be moved to another location after its planned 4-year role as an Information Point.

After careful research of their intended materials, a structure that uses galvanized steel tubes for the external frame combined with a translucent polycarbonate skin and prefabricated timber internal modules was chosen. These modules serve as information desks and a bicycle rental point. All this was delivered within a budget of €170,000.

After serving its function gracefully since 2015, Peris + Toral have recently been tasked by Barcelona City Hall to repurpose the structure as a youth centre (*casal de joves* in Catalan) in the city's St Martí neighbourhood.

Below
The structure is easily demountable and can be relocated and reused with minimal impact on the site



Left

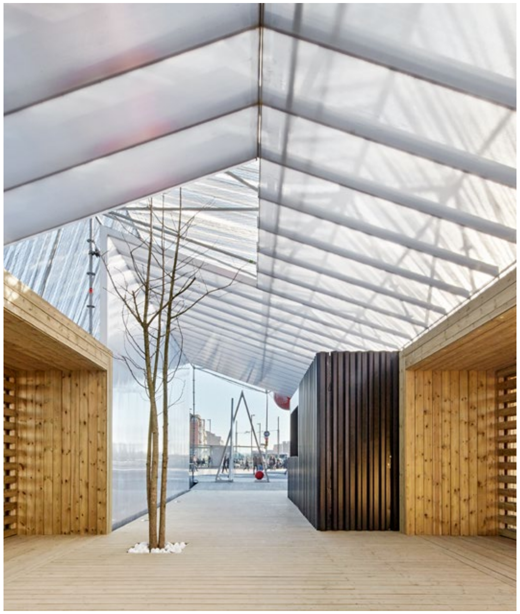
Galvanized steel was used to create a temporary structure to protect the building during the surrounding regeneration of the area. Materials were chosen that created transparency to the structure but could also be readily deconstructed for a new life

Below left

The structure is both an information point and rental location for electric bicycles

Below

The structure is now being repurposed by the architects as a youth centre in another part of the city



GALVANIZED STEEL – CIRCULAR ECONOMY POLICY INTO PRACTICE

The recently-launched European Commission *'Circular Economy: Principles for Buildings Design'*[7] envisages three key scenarios (or objectives) for achieving reduction of waste, the optimisation of material use and the reduction of environmental impacts of designs and material choices throughout the life cycle.

The Commission's three objectives are explained as:

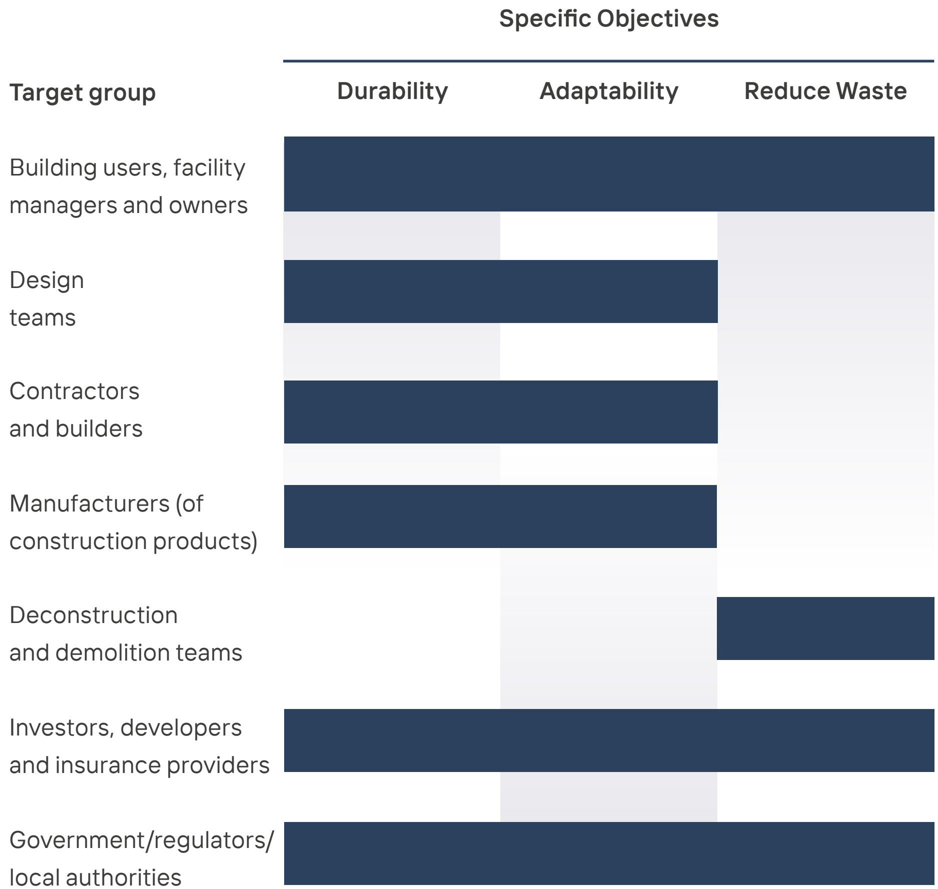
Durability

Durability of buildings depends on better design, improved performance of construction products and information sharing. Structural elements should last as long as the building does, whenever possible. If it is not possible because of intrinsic obsolescence or anticipated change in requirements, they should be reusable, recyclable or dismountable.

Adaptability

Preventing premature building demolishment by developing a new design culture.

Scope of the *'EC Circular Economy Principles for Building Design 2020'*



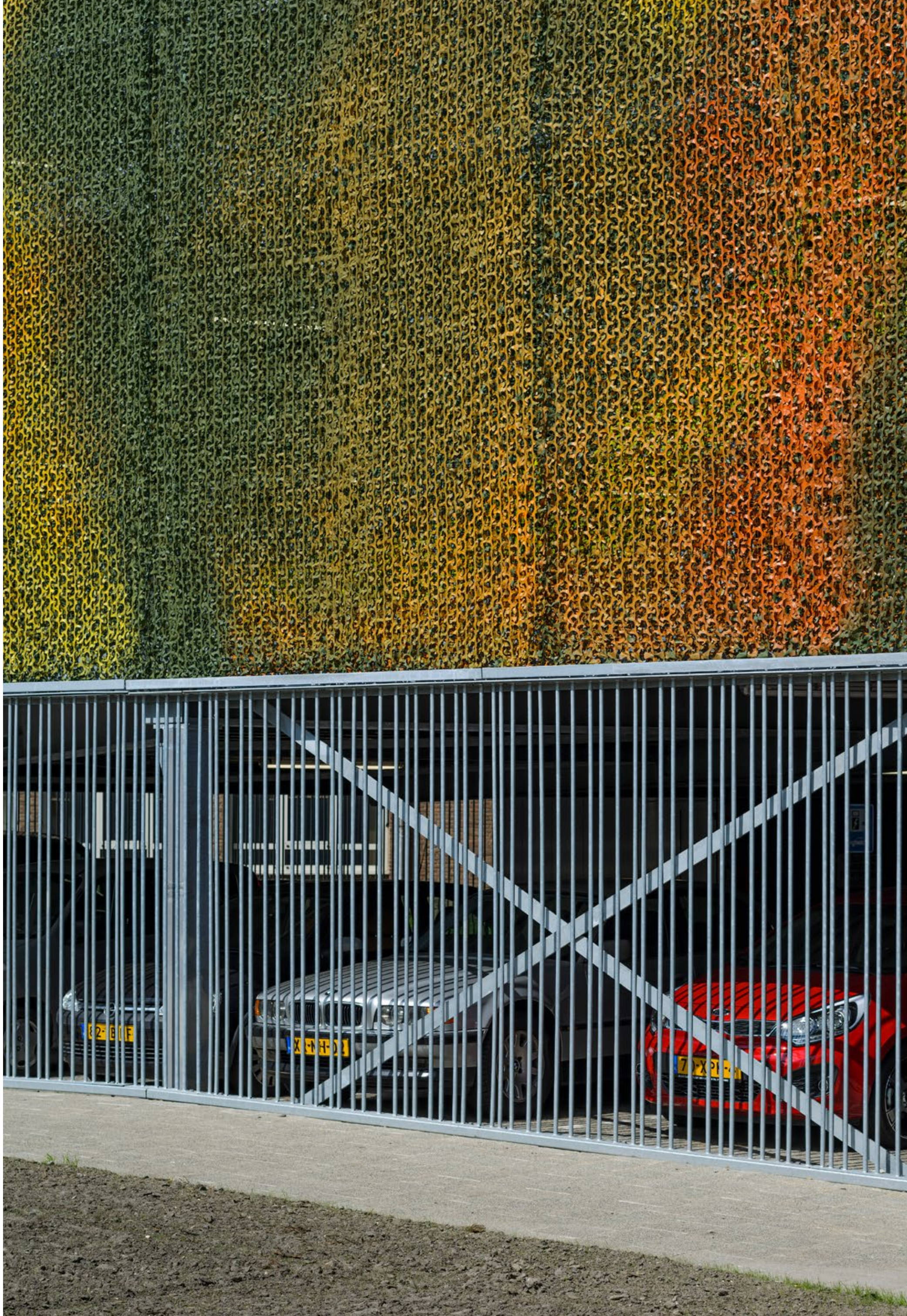
Reduce waste and facilitate high-quality waste management

Design products and systems so that they can be easily reused, repaired, recycled or recovered.

The wider use of batch galvanized steel is fully consistent with these new objectives of building design for the circular economy. The high level of durability of galvanized steel is proven. When constructing with galvanized steel, reuse can be an even more prominent solution than is implied by these objectives. Reuse is a valuable approach to both delivering adaptable buildings and to reducing waste.

The European Commission has identified ways in which these principles can be implemented by each of the main actors in the construction value chain. In the following table, the main principles of that policy highlighting the importance of the durability of galvanized steel have been extracted.

Right
Car park at Moorsport, Leiden



Key principles on durability and other aspects within the *'EC Circular Economy Principles for Building Design 2020'*

Target Group	Drivers for use of galvanized steel
Building users, facilities managers and owners	**Minimise the total cost of ownership over time** Owners and building users have an interest in overall and longer-term horizons – Reduce the total cost per square metre/comparative average – Use tools to enhance the building's value **Promote durability during the use phase** – Provide incentives through performance-based contracts that promote the optimal use of the building
Design teams (engineering and architecture of buildings)	**It is essential to have knowledge of circular economy principles to design buildings and materials** Architects and designers should be familiar with design requirements and strategies, the concept of life cycle assessment, the potential to increase the content of recycled materials in products, future reuse potential (product, component and building); (future) recyclability and transformation capacity (reuse potential and reversible building design score – Encourage designers to adopt a life cycle approach when designing new buildings – Use existing guides on DfD/A* and feedback from previous project examples **Architects and designers need to take into account whole life costs and benefits** The whole life cycle must take into account the operational cost of the building as well as the potential changes to the building's use. They include environmental and social impacts and benefits, transformation capacity, reuse and recyclability potential
Contractors and builders	**Use construction techniques that promote the durability of buildings and the resilience of the materials** – Simulate different scenarios of durability and compare costs – Include the resources needed for resilience to installation error – To enhance the building's durability, use construction techniques that facilitate maintenance and repairs to different parts of buildings and building products and systems

*Design for Disassembly and Adaptability

<table>
<tr><th>Target Group</th><th>Drivers for use of galvanized steel</th></tr>
<tr><td>Manufacturers (of construction products)</td><td>Consider the potential durability level for the whole life cycle of the building based on evidence from LCC of the product
– Use whole life costing and environmental assessment integrated with supplementary information beyond the building life cycle
– Use qualitative and resistant products for their environmental and use attributes

Ecodesign principles should be used and durability assessed
Product standards, if not yet developed, should include durability and a verification system to confirm such durability

Solutions should be developed for greater adaptability
For example, in works, prefabrication and modular systems</td></tr>
<tr><td>Investors, developers and insurance providers</td><td>Enhancing durability will decrease financial risk
The importance of durability of products and materials should be promoted within the overall approach to buildings and products, and how this can be appropriately accounted for financially

Life Cycle Costing should be promoted when preparing investment decisions
The increased revenue streams that can be generated through reversible design should be integrated into the whole costing analysis
– Capitalise future risks of difficulty to deconstruct buildings and cost of waste management
– Consider the residual value of buildings to help with savings in mortgages and money flows
– The use of the ISO standard for DfD/A credits within Green Public Procurement and sustainable building rating schemes provide an incentive to consider at this stage</td></tr>
<tr><td>Government/ regulators/local authorities</td><td>Reinforce policies that promote reuse and high-quality recycling of buildings/building materials
Integrate life cycle approaches in construction policies

Provide incentives for the development of design principles for circular and sustainable buildings
Reversible products might use more resources at the start (due to more robust design, for example), but make it possible to recover the resources but also reuse the product in multiple life cycles</td></tr>
</table>

DESIGNED FOR DECONSTRUCTION – FRAUNHOFER IWKS

Recycle Reuse

The Fraunhofer IWKS (Institute for Materials Recycling and Resource Strategies) is at the forefront of research into the responsible use of natural resources – based on the principle that resources should be used but not consumed. Their focus is on recovery of materials and reintroducing those materials into new product cycles.

The important work of Fraunhofer IWKS will now be carried out from a new building in Hanau, Germany that has been built in accordance with the same sustainability principles that drive their activities. This office and technical centre houses 80 employees in a 2600m^2 building that ensures short distances for good orientation and spaces for informal communication.

An important objective for the building was the target of silver certification according to the guidelines for sustainable construction for federal buildings in Germany (BNB).

Designed by hammeskrause architekten bda, the building is constructed of materials that are free of harmful substances and can be easily separated and reused or recycled when future deconstruction is necessary. This choice included extensive use of galvanized steel in the façades of the building. The galvanized coating of these façades will develop a highly stable surface patina over future decades and create an aesthetically pleasing as well as sustainable solution.

"Sustainable building and the most modern, high-tech research infrastructure, that's possible. Both outside and inside, sustainability and energy efficiency in construction were our top priority", said Andreas Meurer, board member of the Fraunhofer-Gesellschaft, at the official opening of the building, adding that *"The façade is clad with galvanized steel plates, for example. Steel makes an important contribution to zero waste management. The steel can be completely recycled. The material cycle is thus closed, without any loss of quality."*

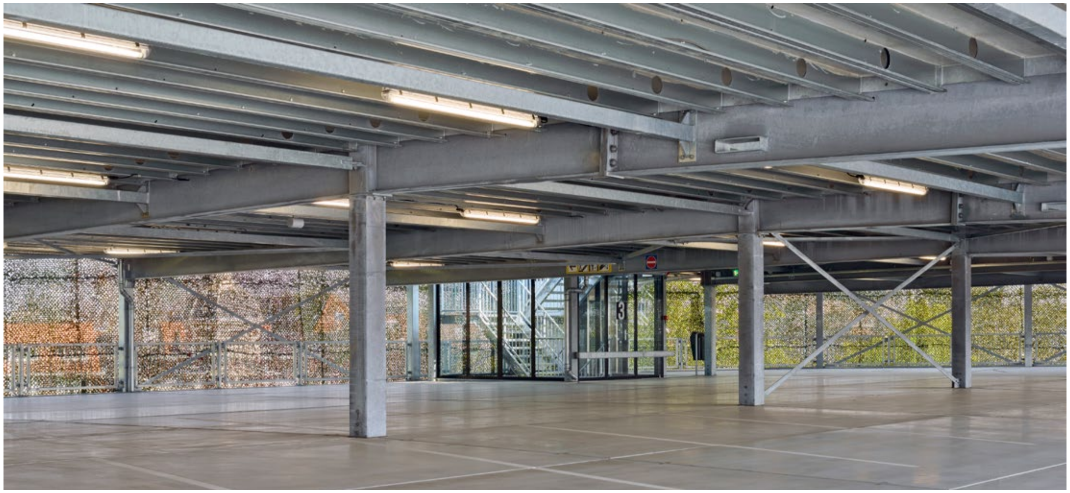
Above
Fraunhofer IWKS conducts research into the recovery and reuse of materials within the circular economy

Left
The galvanized steel façade was chosen to facilitate future deconstruction and reuse as well as for its natural aesthetics

DESIGN FOR REUSE OF GALVANIZED STEEL

Galvanized steel buildings and structures can be designed with maximum flexibility and to ensure their construction materials can enjoy multiple life cycles. Future designs of steel structures will become more modular, utilize bolted connections to ease deconstruction and make components more widely suitable for reuse. Galvanizing creates more value to these reused components as they do not require further protective treatment and the components themselves will be in good condition at the point of reuse.

This 450 space car park at Moorsport, Leiden, the Netherlands uses galvanized steel to ensure it can easily be dismantled and rebuilt at another location if, and when, urban development plans require it. Designed by Architectenbureau Paul de Ruiter, the entire demountable construction comprises galvanized columns, beams and façade panels in a structure that is 36.4 metres wide and 80.4 metres long. Galvanizing also facilitates the use of slimmer profiles that allow more natural light to enter the car park.



Left and right
This car park at Moorsport in Leiden was designed in galvanized steel to ensure it can be easily dismantled and relocated

Another example of the use of galvanized steel to create a flexible structure is this combined car and bicycle park in Frankfurt. The area close to the railway station is scheduled for regeneration in 6-7 years but was in need of short-term solutions for urban transport. The structure has been designed for deconstruction and uses galvanized steel for its ease of dismantling and subsequent reuse.

Single storey industrial and multi-use buildings are already taking advantage of the benefits of galvanized steel and future optimization of connections and other design details will further reinforce the partnership between galvanizing and steel construction[8]. For example, the use of bolted (rather than welded) haunched beams has the dual benefit of enhancing prospects of reuse whilst also increasing the size of structures that can be dipped in a hot dip galvanizing bath.

Below top
Bolted connections facilitate reuse and increase the size of structures that can be galvanized

Below bottom and left
Temporary car park and bicycle park, Frankfurt

THE ROBUSTNESS OF GALVANIZED STEEL FOR REUSE

Modular and standardised designs using bolted connections enable reuse

The ability of galvanized steel to withstand multiple life cycles of a reused structure is illustrated by the growing use of temporary parking systems that provide flexible solutions that are rapid to construct when and where additional parking capacity is needed.

Temporary parking systems can be dismantled and reused, either immediately or stored for future use. The same approach can also be applied to other steel structures if they are also designed for reuse and have the benefit of a tough, abrasion resistant and highly durable galvanized coating that will accompany the steel components through their multiple life cycles.

The 100-space example in Stuttgart, pictured below, went into operation in July 2018 and was dismantled in June 2019 after 11 months of operation. It took just 7 days to dismantle and store ready for its next phase of life.

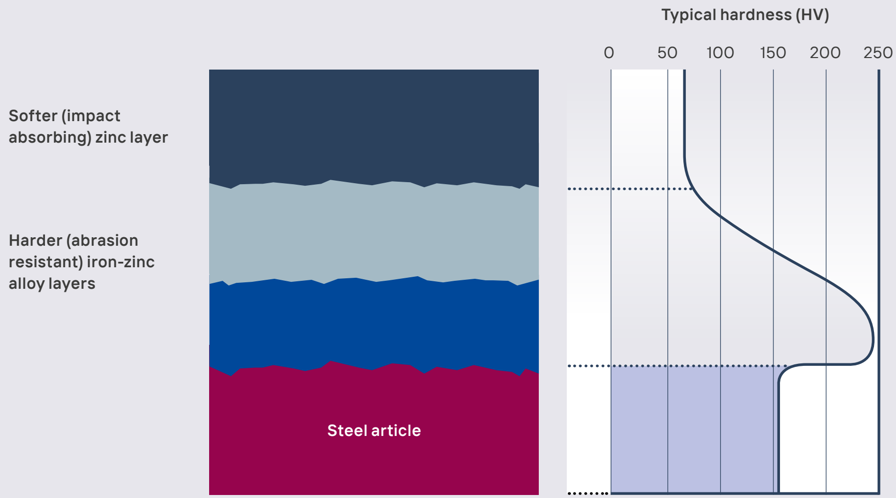
Right

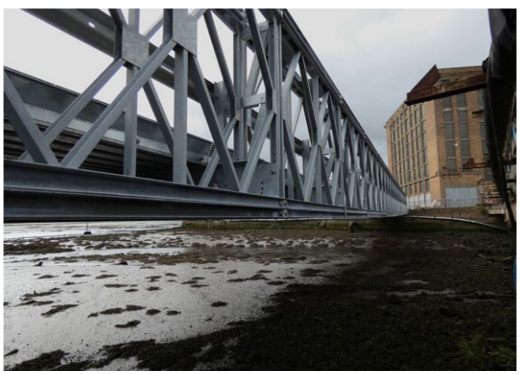
Temporary car park systems use modular and flexible designs in galvanized steel

The toughness and abrasion resistance of galvanized steel has proven itself in a wide variety of applications – from scaffolding that is reused countless times to temporary-permanent bridges that are designed for rapid deployment in disaster zones but often become a vital part of the local infrastructure and may enjoy many decades before moving on to their next location.

These same principles and experience with temporary structures and reusable components are now being applied to the design of more complex structures that require flexible solutions for the circular economy.

The toughness and abrasion resistance of galvanized steel explained





Above
The robustness of galvanized steel is important in uses such as temporary-permanent bridges

Galvanized steel is suited to a wide range of demountable and temporary applications

When the city of Rotterdam celebrated 75 years of its urban development, architects MVRDV had the idea to construct a giant temporary staircase to create a unique vantage point to view the city.

The 29 metre high galvanized steel staircase ('De Trap' in Dutch) could be constructed quickly and later deconstructed for future reuse. Visitors could walk from Stationsplein Groot Handelsgebouw to the roof of the Groot Handelsgebouw building. A rooftop cinema and catering facilities provided an additional incentive to walk the 57 metres to the top.

De Trap is an innovative evolution exploiting the well-proven robustness of galvanized steel scaffolding


S.V. GRAMSBERGEN
PLUS
GRAMSBERGEN - BAALDERVELD
REGELING
SCHOENMODE
HARDENBERG
Van Braak
Zonweringen
KERKDIJK
TUINTECHNIEK
Bakker

GRANDSTAND AT GRAMSBERGEN – REBIRTH AFTER 40 YEARS

Remake **Reuse** **Use**

An existing Elascon stand was saved from demolition thanks to the enthusiasm and decisiveness of one man. In summer 2011, Harry Haverkotte, former board member of SV Gramsbergen, heard that their neighbours from Hoogeveen would move to a new sports park.

The good condition of the main grandstand caught his eye so he bought it for €7,000 including the cost of disassembly. The stand was originally built in 1976. Back then, the board of Hoogeveen awarded the construction for 139,200 Dutch florins. If you convert this to today's value, that is ~€163,000.

Within two years, a wonderful 32 metre long stand arose from the ground. Eventually, the stand only cost €35,000 while a new building would have at least cost €200,000. Everything was reused, apart from the bolts, nuts and the old wooden boards.

The boards were replaced by new seats. The only decorative paintwork that had to be done was on the inside of the roof.

The excellent state of the galvanized steel was confirmed during disassembly. The outer structure had spent 40 years exposed to the weather, but the galvanized steel was in perfect condition and did not need to be regalvanized. The remaining galvanized coating is more than 100μm thick and the stand will last for many more decades.

Left
The new grandstand at SV Gramsbergen had already seen decades of use at another nearby club

Right
After decades of service, the galvanized steel was ready for direct reuse in the new location

Left
The original Elascon stand served the Hoogevens club since its construction in 1976

Far left
When Hoogevens relocated to a new stadium, SV Gramsbergen dismantled the stand for reuse at their ground

Left
Even the minor galvanized steel connections were in good enough condition to be dismantled for direct reuse

Left
The reconstructed stand at SV Gramsbergen ready for another life cycle for its galvanized steel that could reach 100 years in total

Provisions for greater reuse of steel structures

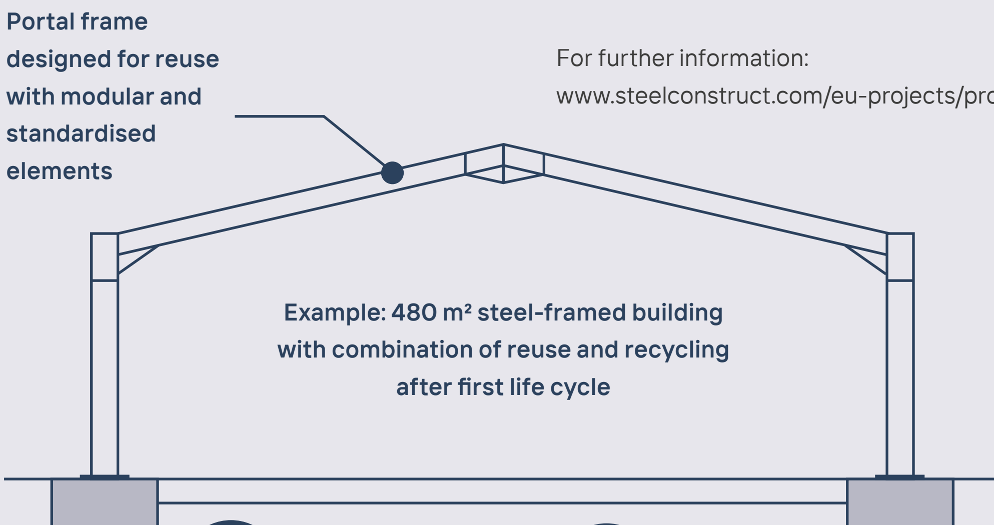
PROGRESS (PROvisions for GREater reuse of Steel Structures) was an EU RFCS-funded project focused on the reuse of single-storey buildings[8]. The study and its recommendations provide additional impetus to the future use of galvanized steel to maximise reuse opportunities.

The project has delivered recommendations and practical information on the fabrication and detailing of single storey buildings made from reclaimed steel, and on the design of buildings for future demounting and reuse.

Future optimization of connections and other design details will further reinforce the partnership between galvanizing and steel construction. For example, the use of bolted connections has the dual benefit of enhancing prospects of reuse whilst also increasing the size of structures that can be hot dip galvanized.

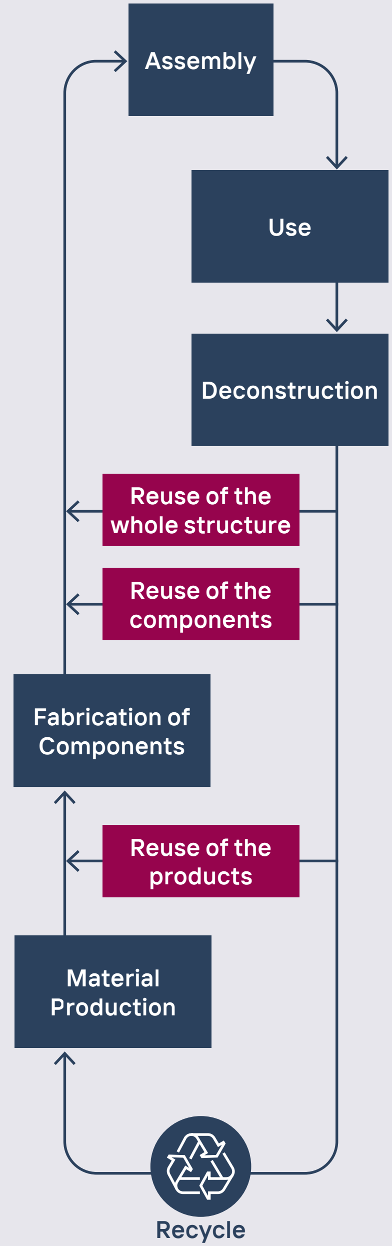
"Galvanized steel solutions are preferable for structures with possible multiple assembling and dismantling cycles"
European Recommendations for Reuse of Steel Products in Single-Storey Buildings

For further information:
www.steelconstruct.com/eu-projects/progress



CO_2 Carbon saving in next reuse life cycle - 98 tonnes CO_2

€ Life cycle cost benefit - €24,000



DURSLEY TREEHOUSE

Remake Reuse

Built on a small plot in the centre of Dursley, England, this house was designed to have minimal impact on the surrounding trees and to preserve the natural habitat of the site. The Treehouse attracted much interest for its beautiful cantilevered structure, its low environmental impact and for the romanticism of living in a 'treehouse'.

The client was adamant that the impact of the house on its site should be very low and as environmentally sound as possible.

Reuse of galvanized steel components was a very important part of the project. 76 steel mesh flooring panels, that had already seen 20 years of use, were reclaimed from a local engine manufacturing company – the panels were cleaned and then galvanized to form the main walkways around the house.

Balustrading for the walkways was initially specified as stainless steel, but after careful thought and consideration of costs, steel mesh sheep fencing was repurposed to create the infill panels within galvanized steel sections.

The spiral staircase was purchased for less than €200 from a scrap yard – having been used as a fire escape at a local store for the previous 15 years.

To continue the reuse theme, the first floor flooring is recycled slate from a local Rolls-Royce garage and second floor flooring is made from recycled beech wood from a local school gymnasium.

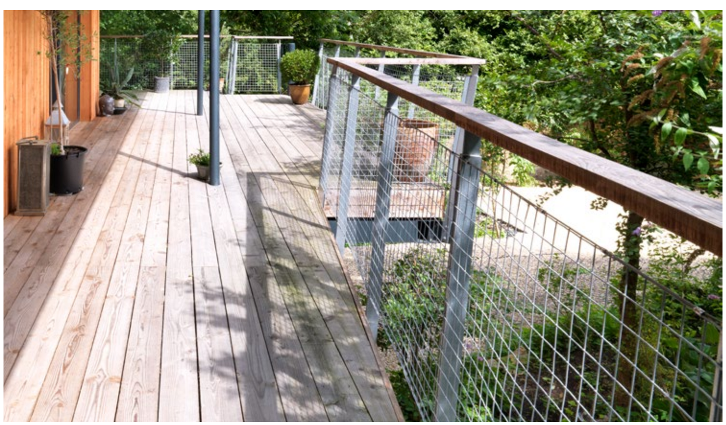
The 27 protected trees posed a big constraint and dictated the location of the building within the site. In order to protect the tree roots, the ground had to remain untouched, therefore an elevated building was proposed.

This complex building has steel piles (avoiding tree roots) instead of concrete foundations. The main structure of the house is a double stud timber frame that sits on a steel structure which itself sits on screw piles designed to keep ground disturbance to a minimum. Those galvanized steel screw piles are 10m long and are designed for future reuse.

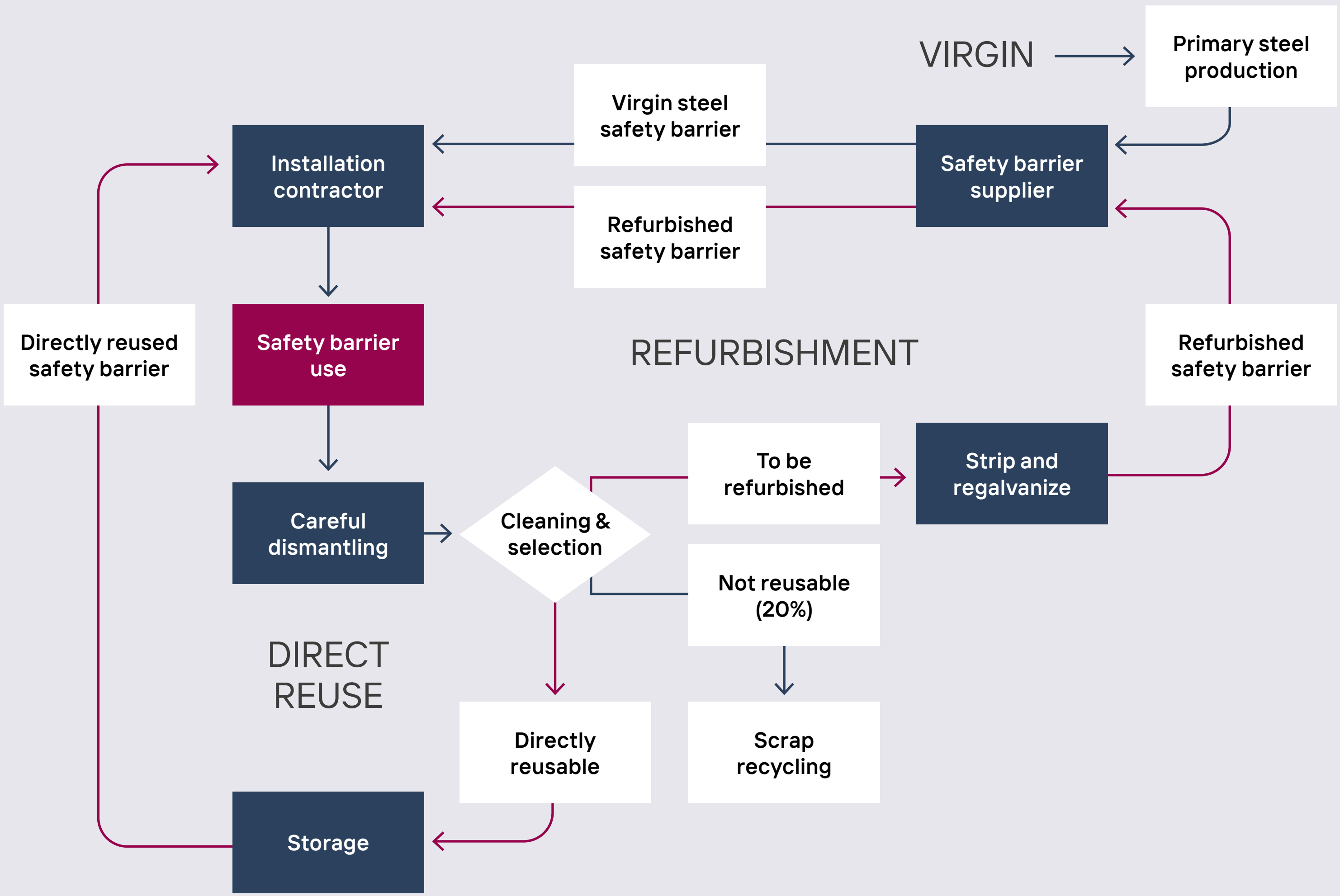
Above
Reuse of galvanized steel components was an important part of the project. Steel mesh flooring had already seen 20 years of use in a local company

The building achieved PassivHaus certification and adheres to the strict criteria for energy efficiency and thermal comfort to ensure that the heating is below 15kWh/m² per annum. The building also features thermodynamic solar panels and its own water supply reducing the carbon footprint further.

Right
The staircase was previously used as a fire escape at a local store



Refurbishment chain for galvanizing steel highway safety barriers (Rijkswaterstaat)



REGALVANIZING OF GALVANIZED STEEL INFRASTRUCTURE

Galvanized steel highway guard rails can be dismantled for reuse or regalvanizing with up to 70% savings in CO_2 emissions

Batch galvanized steel is extensively used in infrastructure applications to provide decades of maintenance-free service. The search for circular solutions has identified significant opportunities for renovation and reuse of these ubiquitous galvanized steel components.

A recent decision of the Dutch Directorate-General for Public Works and Water Management (Rijkswaterstaat) to implement both (i) direct reuse and (ii) regalvanizing and reuse of highway guard rails (safety barriers) is the result of an examination of the supply chain and its potential for improved circularity whilst maintaining road safety[9].

A project involving installation contractors, guard rail suppliers and galvanizers supported by specialist agencies, TwyntraGudde and LBPSight, placed the whole chain under the 'circular economy microscope'. The approach is already being implemented in a validation project on Dutch roads.

"We have determined together that it is both technically and economically achievable – thanks to an open attitude and enthusiasm from everyone. Renovation of guard rails is logical but does not happen automatically" says Henk Senhorst, project manager from Rijkswaterstaat.

Rijkswaterstaat's decision to move forward with reuse and regalvanizing was driven by some important evaluations. They found that often guard rails are replaced as a result of other road maintenance reasons but can have a remaining life of up to 24 years. These products can be directly reused on the road system.

Used guard rails requiring regalvanizing can be renovated with significant benefits compared to new 'virgin' installations, delivering:

- 40% reduction in environmental costs
- 70% reduction in CO_2 emissions
- 10% reduction in costs

Carbon savings with regalvanizing and reuse

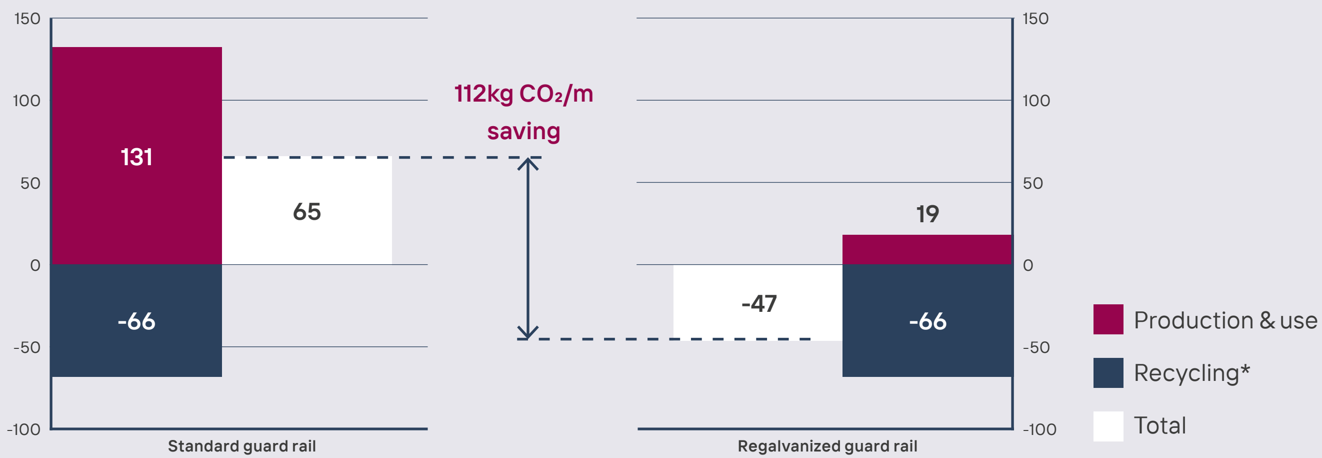
CE Delft first examined the opportunities for regalvanizing in the Netherlands in 2017[10]. They reported that every year 350 kilometres of highway guard rails were replaced, many of which were reusable.

Their study showed that, on average, 67% of these valuable components were suitable for reuse – which is entirely feasible by cleaning, stripping and regalvanizing.

CE Delft calculated that this simple procedure could save 26 ktonnes of CO_2. This equates to more than 8.3 million car kilometres. This is because for each one metre of installed guard rail, there is a saving of 112kg CO_2 when utilizing re-galvanized guard rails. That is a saving that can be seen immediately through implementation of the repair and reuse principles of the circular economy.

Reductions in Global Warming Potential by regalvanizing of used highway guard rails

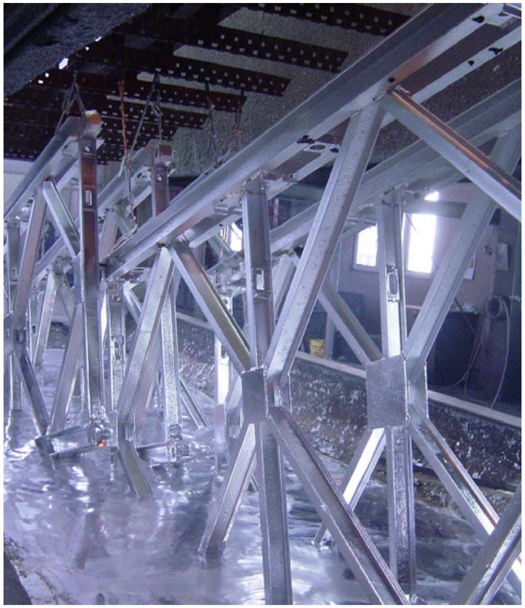
Kg CO_2/m (data for 1 metre of guard rail)



**at end of life*

Regalvanizing and reuse can also be applied to components that have not already benefited from galvanizing

These temporary bridges were initially painted but have been given a new life with galvanizing. Another example of repair and reuse brought to reality with galvanizing.



Top left
Painted bridge components at end of life

Top right
Used components cleaned before galvanizing

Bottom left
Regalvanizing of used components

Bottom right
New life in galvanized bridges

LEEUWARDEN ENERGY KNOWLEDGE CENTRE

Reuse

The Leeuwarden Energy Knowledge Centre is built on the former Skinkeskâns waste disposal site to the west of Leeuwarden in the Netherlands. This innovative office building is part of an Energy Campus and will house a wide range of research and knowledge institutions in the field of sustainability and is architecturally integrated into the landscape. The Centre has an adjustable foundation and was built with circularity at the forefront of its design and choice of materials.

Bart Cilissen of Achterbosch Architects has described their approach to circularity… *"The main guiding principle was: use your logical mind and don't get bogged down in the 'swamp' of sustainability certificates. The focus was on the right choice of building materials and their application. Make circularity visible, that's how you could describe it. As architects, we try to think circularly as much as possible in every project. In the design phase, you also need to think about the reuse of the building materials that have been used. When the building is finally dismantled, the fully galvanized steel structure can be unbolted."*

The architects' motivation for the choice of galvanized steel throughout the structure was strongly focused on its simplicity and sympathy with the surroundings…*"We have deliberately chosen galvanizing instead of powder coating, so that you stay as pure as possible with the material. People are initially surprised that the steel is not "dyed", but when you tell the story behind it they are immediately with it. I love that grey shade that fits perfectly with the aging wood of the slat façade. In addition, we also had considerable discussions with the residents in the neighbouring village who feared that this building would rise as a kind of lampion on top of the mound. That's why we chose a wooden façade that is ageing over time. The galvanized steel reflects to some extent a light or dark day and absorbs the colour of the surroundings"* says Bart Cilissen.

The architects sought prefabricated solutions wherever possible. The galvanized steel was assembled like meccano, the floor and façades are filled with timber frame elements and the ceiling consists of perforated profiles.

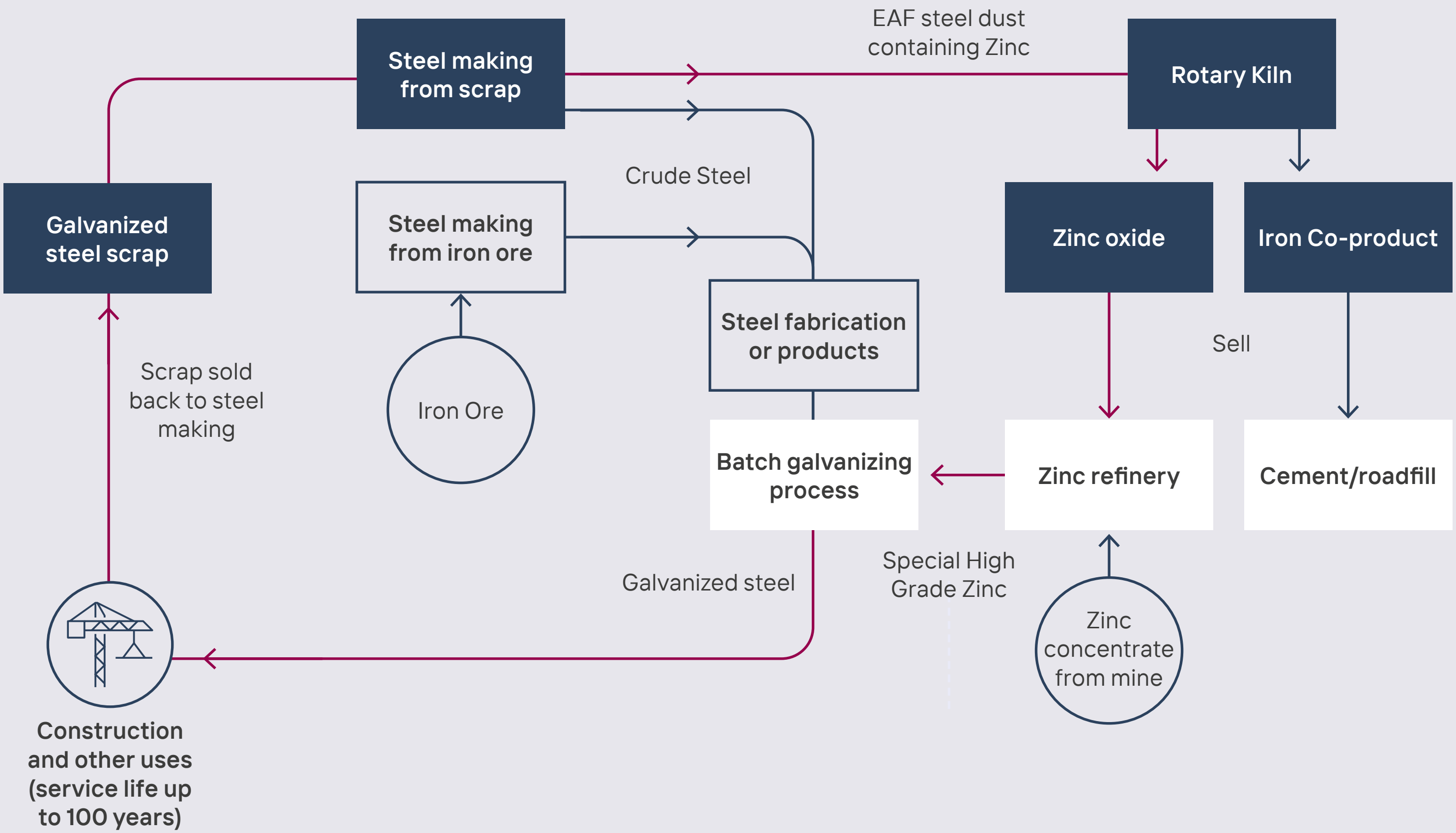
Right

The centre was built with circularity at the forefront of its design and choice of materials

Another objective was the lightest possible building. Building on a rubbish dump was a particular challenge. The waste below is covered with a foil that could not be damaged so heavy foundations were out of the question.

The building floats on slabs placed on the foil in a sand bed. The 108 steel columns were placed freely with each column on its own concrete slab. For a light and circular building a combination of steel and wood were obvious choices. Concrete was avoided for the building structure.

Recovery of zinc from galvanized steel, without loss of properties, after many decades of service



RECYCLING OF ZINC ON GALVANIZED STEEL AT END OF LIFE

Steel and zinc are recycled together and easily separated

At end of life – and if reuse is not feasible – galvanized steel can be recycled easily with other steel scrap in the electric arc furnace (EAF) steel production process. Any zinc remaining from the coating volatilises early in the steel recycling process and is collected in the EAF dust that is then recycled in specialist facilities and often returns to refined zinc production.

Since the early 1980s, a well-established rotary kiln process has been used to process EAF dusts that contain valuable zinc and other elements. An impressive 98% of EAF dusts produced by Europe's steelmakers are recycled[11]. This process is the most commonly-applied method to recycle these dusts but various other innovative processes have also emerged, including the rotary hearth furnace; multiple hearth furnace and low hearth furnace. The rotary kiln was originally devised for processing of leach residues during primary zinc production and EAF dusts are quite similar in characteristics to those residues – making the technology relatively easy to adapt for recycling. The first kiln to be used for recycling EAF dusts began in Duisburg, Germany in the early 1980s.

A key driver for the recovery of these dusts is their zinc content. The wider use of zinc for coatings on steel, in particular in the automotive sector, has increased EAF dust zinc contents to levels that make their recovery economically attractive. Generally, zinc contents > 15% in the EAF dust make recovery economically viable and most dusts are at this level.

The main product of recycling EAF dust using the rotary kiln process is 'zinc oxide'. This is sold to a primary zinc refinery where it is substituted for mined zinc concentrates. The zinc refinery then produces the same zinc ingots (or other high purity zinc products) that can be used directly in the galvanizing process. This loop can continue infinitely and there is no loss of quality of the zinc that follows this path.

HOUSE D6 – SUSTAINABLE, REVERSIBLE HOUSING

Reuse

Left
All connections are reversibly designed to facilitate future deconstruction

The design task for this house in the Oberberg region of Germany was to construct a sustainable single-family dwelling, which incorporates the surrounding landscape into the living space and creates covered outdoor spaces for the rainy summer days in the region. The building follows the traditional, one-room deep longhouse concept with main rooms that take up the entire width.

The living room in the middle of the building reaches up under the roof and forms the central common room, from which the bedrooms, bathrooms and master bedroom on the upper floor are accessed. A galvanized steel walkway with a translucent grating connects the two independent units and leads to the common gallery in the two-storey living area. The slender steel and wooden skeleton construction are reversibly joined at all points.

The main galvanized steel beams are bolted to the columns and serve to carry the slender wooden beam ceilings. This ensures that the building is capable of deconstruction and reuse of the galvanized steel structure. The beams remain visible and create a warm atmosphere for living. Aretz Dürr Architektur's result is an architecture that focuses on the essential minimum to achieve the best outcome possible. The building was 'House of the Year 2020' in Germany.

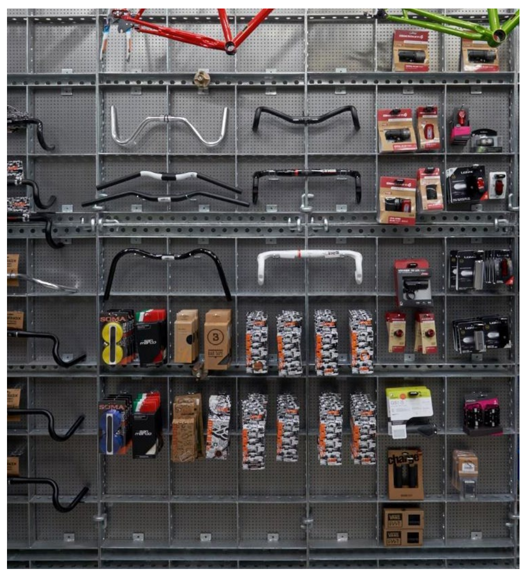
THINKING AHEAD – REPURPOSING OF GALVANIZED STEEL

Remake Reuse

Galvanized steel components are standard solutions in a wide range of applications. In this innovative example, BeL - Sozietät für Architektur anticipated a viable next use phase by selecting components from a modular galvanized steel formwork system that would otherwise be used during concrete construction.

By adapting this galvanized steel formwork system into the fixtures, fittings, shelves and dividing walls of this cyclo-cross store in Cologne, the possibility to repurpose these items when these fittings are no longer required by the shop is assured. The galvanized steel components are certain to have a positive value in future and today create a robust and creative backdrop to the store.

Standard galvanized steel building components used as shop fittings can eventually be repurposed for their intended use



Far left
Staub & Teer Cycle Shop, Cologne

Left
Shop display in standardised formwork components ready for later repurpose

REDUCING CARBON THROUGH AVOIDANCE OF MAINTENANCE

Lack of attention to optimal corrosion protection can leave a damaging economic legacy of repeated maintenance costs that can significantly increase the life cycle carbon footprint of buildings and infrastructure.

Galvanizing's ability to optimise the durability of steel structures and components has important environmental, economic and social advantages.

There are high economic and environmental costs associated with the repeated maintenance painting of steel structures. These burdens can be significantly reduced by an initial investment in long-term protection.

The long-term durability provided by galvanizing is achieved at relatively low environmental burden in terms of energy and other globally relevant impacts, especially when compared to the energy value of the steel it is protecting.

Whether it is by reducing maintenance operations or avoiding the premature replacement of steel products, galvanizing will reduce the embodied carbon of construction.

A study by the Environmental Technology Systems Department of the Institute for Environmental Protection Technology at the Technical University of Berlin involved a comparison between a paint coating (EN ISO 12944) and hot dip galvanizing (EN ISO 1461) for a steel car park in a life cycle assessment[12].

Central to LCA comparisons is the functional unit – the reference quantity for the comparison. An objective comparison cannot be made without identical comparison variables.

The way these values were defined in the study was that the two systems had to provide corrosion prevention for a steel structure which was to be used for 60 years, and which was applied to a 500 tonne steel structure such as a multi-storey car park with a steel area of 20 m^2/t. It was assumed that the structure was externally exposed to a medium level of corrosion (corrosion category C3 from ISO 9223).

The hot dip galvanizing system is a 'one-off' corrosion prevention treatment by immersion in molten zinc. With a galvanized coating thickness, for this example application, of 100 µm and an average corrosion rate for category C3 of 1 µm/year, the calculated durability far exceeds the required 60 years.

To guarantee corrosion prevention for 60 years using the paint coating system, the components are first abrasion-blasted to remove any rust. Then they are painted in the works with a three-coat application with a total coating thickness of 240 µm. On-site maintenance operations are then needed after 20 and 40 years, involving partial cleaning and some renewal of the coating.

A summary of the two systems is shown in the figure opposite.

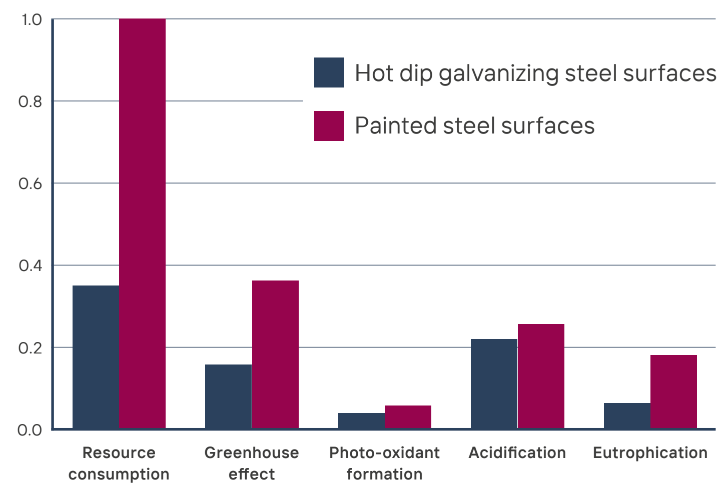
The results are represented by five different environmental impact categories. The bar chart shows these environmental impacts. The results are normalised to the largest contributory factor (consumption of resources).

The contributory factors for the hot dip galvanizing system are lower in all impact categories than for the paint system. In several impact categories there are marked differences. In comparison with paint, hot dip galvanizing's score in the category of eutrophication is only 18%, in the resource consumption category it is only 32%, and in relation to the greenhouse effect it is only 38%. Hot dip galvanizing is distinguished by lower consumption of resources and less pollution throughout its service life.

The study shows that life cycle assessment is a meaningful method of ecological comparison of products. It brings out marked differences between two established corrosion prevention systems for steel structures. The hot dip galvanizing system displays lower environmental impact for a steel structure with a long service life, than a paint system.

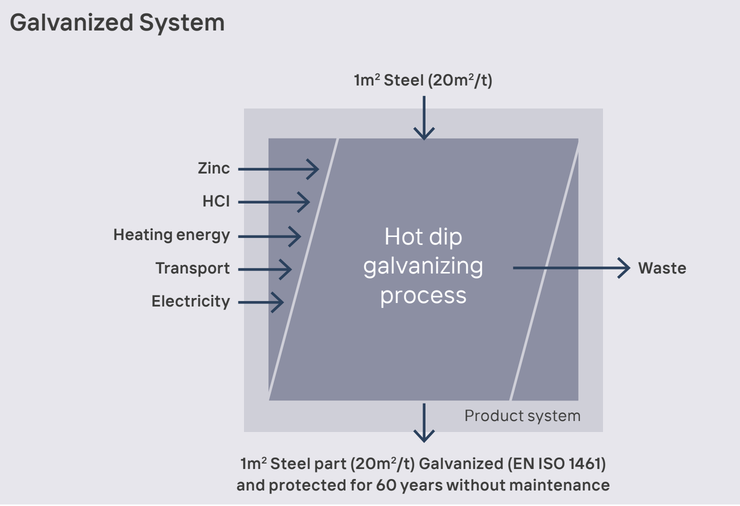
Long service life and freedom from maintenance, the well-known advantages of hot dip galvanizing, are the basis for these environmental benefits. In this example, as shown in the table opposite, a saving of 57 tonnes of CO_2 were achieved over the 60 year life of the car park.

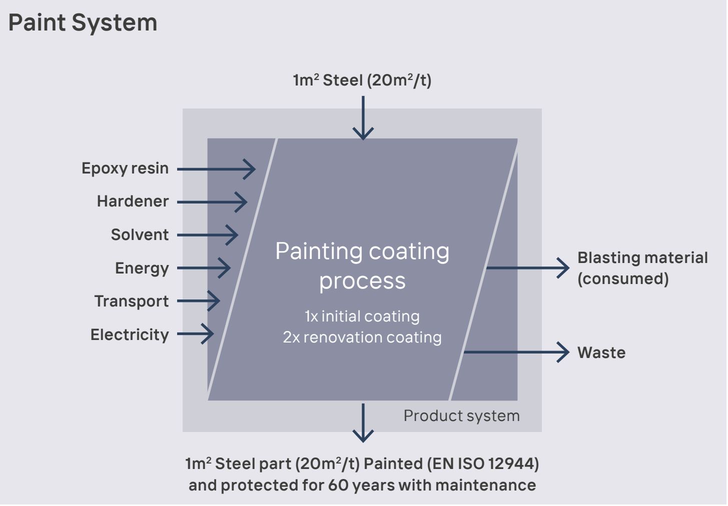
Comparison for steel-framed car park over 60 year life:
LCA results normalised to the highest contributory factor



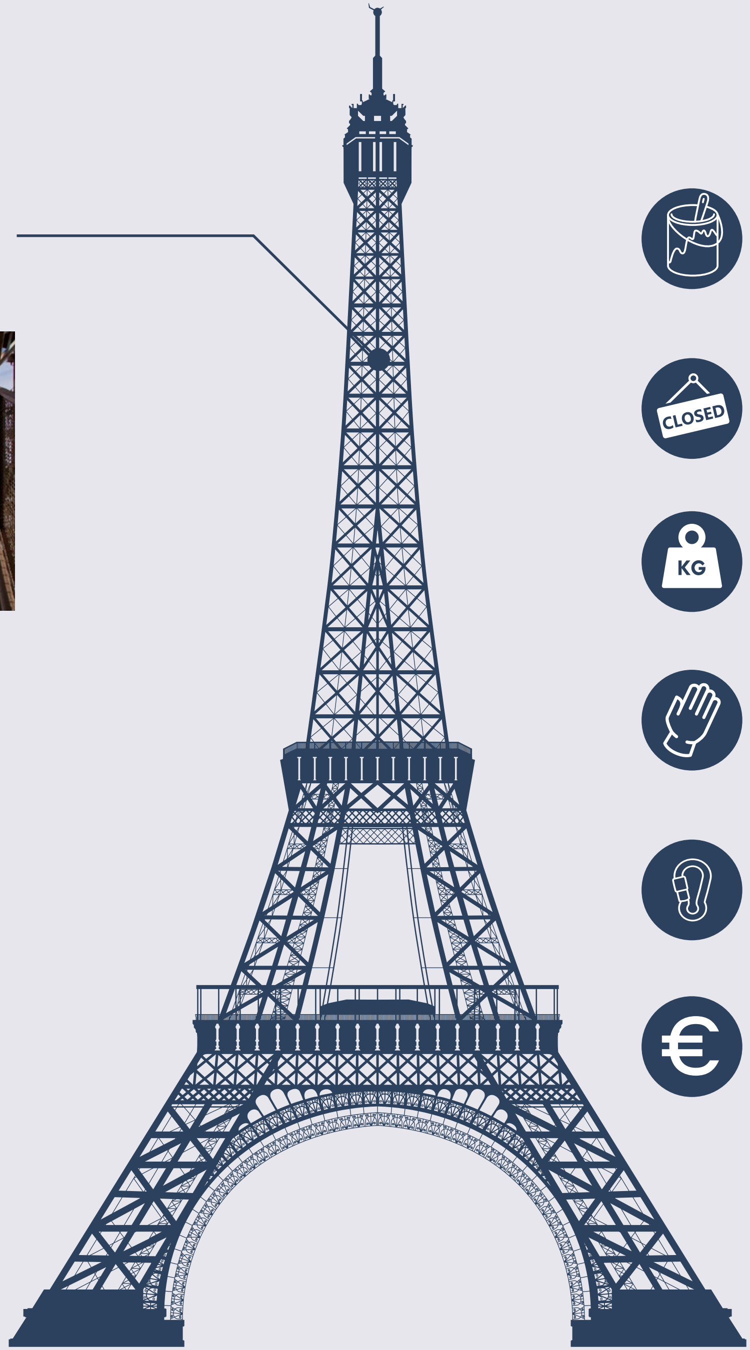
Comparison for steel-framed car park over 60 year life: CO_2 emissions

Service Life (Years)	Hot Dip Galvanized Steel Structure (kg CO_2 equivalent)	Painted Steel Structure (kg CO_2 equivalent)	Saving by hot dip galvanizing (kg CO_2 equivalent)
60	41,500	98,600	57,100
40	41,500	71,600	30,100
20	41,500	60,500	19,000





The upper sections of the Eiffel Tower are painted every 5 years and the lower sections every 10 years



Each repaint applies 60 tonnes of paint and 15-20 tonnes of paint are eroded between each repaint

Removal of all existing paint before repainting cannot be done without lengthy closures

Each repaint adds ~40 tonnes of paint – making it 700 tonnes heavier than its intended design

25 painters, wearing 1,500 sets of work gear and 1,000 pairs of leather gloves

Relying on 50km of safety lines and 8000m^2 of safety nets, 1,500 paint brushes and 5,000 abrasive discs

€4 million for most recent repaint

THE EIFFEL TOWER – A MAINTENANCE LEGACY

Built in 1889, The Eiffel Tower's ironwork has been repainted 19 times

When Gustave Eiffel constructed his famous tower in 1889 for the International Exposition and centennial celebrations of the French Revolution, it was envisaged to be a temporary structure. Little did he know that it would still stand as the much-loved landmark of Paris over 130 years later.

But this longevity has come at a price. The Eiffel Tower's ironwork has been repainted 19 times and a maintenance painting cycle takes 18 months at a cost of €4 million[13]. The repainting costs are estimated to be ~14% of the current construction cost of the tower.

But it is the costs in resources, risks for worker safety and the structural consequences of this repeated painting that goes unseen by the millions of tourists that visit this iconic structure. With ~40 tonnes of residual paint added to the structure at every repaint, the structural consequences of this additional mass will eventually have to be solved.

In recent painting programmes, it has been necessary to start to remove all 19 previous paint layers from certain areas of the tower to maintain its structural integrity.

A lesson for today's structures which are far too often built without durability and avoidance of maintenance in mind.

LIFE CYCLE SUSTAINABILITY OF GALVANIZED STEEL STRUCTURES

There are significant reductions in life cycle costs and environmental impacts when galvanized steel is used for structures.

These benefits have been quantified in a study by the Federal Highway Research Institute (BASt) in Germany that concluded that galvanized bridges are significantly more economical and environmentally-advantageous than painted bridges when considered over the full life cycle of the structure[14].

The study, by the University of Stuttgart and the Karlsruhe Institute of Technology, considered a bridge with a span of 45 metres that is typical for highway overpasses. The expected service life was 100 years. Over this period, the painted bridge would undergo complete replacement of its paint coating on at least two occasions. The galvanized steel bridge would not require maintenance.

A surprising outcome of this study was the very significant reduction in indirect costs that otherwise arise when extensive maintenance activities are required. These indirect cost benefits are even greater than the reduction in direct life cycle maintenance costs.

The life cycle sustainability advantages of galvanized steel have been demonstrated in similar studies, including a valuable comparative assessment by Rossi et al[15] that showed that the life cycle cost benefits of galvanizing are achieved even after shorter structure service lives.

Below
Galvanized bridge over the Rur, Monschau, Germany

Summary of BASt study on life cycle sustainability of steel bridges

Life cycle costs over 100 year scenario	Economic costs - €	Environmental costs

Direct

Installation, maintenance, repair and decommissioning of the entire structure

10% reduction with galvanized steel

(€ million)

Direct Life Cycle Costs

Reductions in all impact indicators

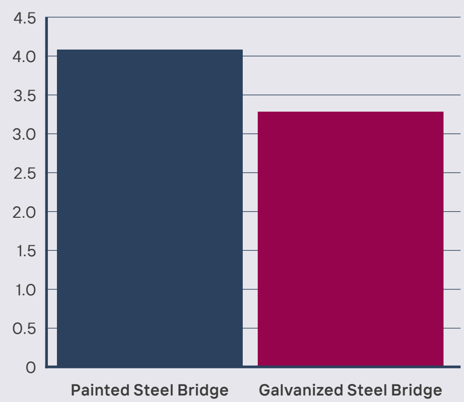
Impact Indicator	Savings with a galvanized steel bridge
Global Warming Potential	5%
Ozone Depletion Potential	2%
Acidification Potential	1%
Eutrophication Potential	3%
Photochemical Ozone Creation Potential	40%
Primary Energy Demand	10%

Indirect

Consequences of maintenance – including traffic delays, longer journey times and increased fuel consumption (also termed 'external costs')

20% reduction with galvanized steel

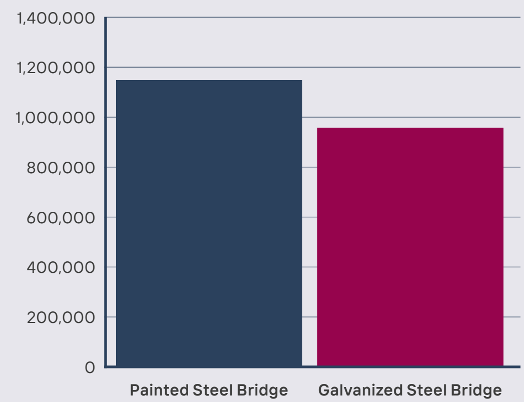
(€ million)



Indirect Life Cycle Costs

Over 200,000kg of CO_2 saved

(kg CO_2 equiv.)



Global Warming Potential(GWP_{100})

LYDLINCH BRIDGE – BUILT 1942 AND IN GREAT CONDITION

Use

As early as 1942 the Ministry of Defence was considering outline plans for the D-Day invasion. Where and when the landings would take place were top secret, but the speedy movement of the invasion force to the south coast ports was a common factor to all alternatives.

One such route, the A357 through Dorset, needed to be improved at Lydlinch. The picturesque narrow stone bridge over the River Lyden would not withstand the weight of heavy tanks. In 1942, Canadian army engineers erected a temporary galvanized steel Callender-Hamilton bridge alongside the older structure. The tanks and heavy equipment were diverted over the galvanized bridge on their way to Europe.

The bridge was not intended to be a permanent structure but has stayed in service having been passed into Dorset County Council's control. It has carried the road's eastbound traffic ever since.

The bridge has seen only minor changes to its original design since it was erected. Timber deck repairs were carried out in 1985 and 2009. The only work of any structural significance was to strengthen the bridge in 1996 to enable it to conform to new standards in order to carry 40t lorries.

At the time, Ted Taylor, Dorset's chief bridge engineer said *"We have had no real trouble ensuring that this 'temporary bridge' is brought up to the new standard and the bridge was in remarkably good shape"*.

The strengthening consisted of bolting 'T' sections to the existing transverse deck beams and the addition of some longitudinal beams but the two main trusses were left as they were in 1942. On a few sections where a lot of cutting and readjustment of design had taken place, the sections were re-galvanized.

The bridge was inspected in 2014 and was in very good condition.

The components inspected included the main truss diagonals, joining plates and some bolt heads. Average coating thicknesses on the diagonal trusses ranged from 126µm to 167µm. On the plate sections the average thicknesses were 131µm to 136µm. On bolt heads average galvanized coating thicknesses ranged from 55µm to 91µm.

Having started life as a temporary structure, the Callender-Hamiliton bridge at Lydlinch, is still in good condition 78 years after it was first erected and can be expected to provide a life well in excess of 100 years.

RAILWAY BUILDING IN BAVARIA – 120 YEARS LIFE AND STILL GOING STRONG

Use

In June 1898, the Royal Bavarian State Railways commissioned the section of the Ammersee Railway from Mering to Schondorf along with the station in St. Ottilien. The station building was a small hot dip galvanized corrugated iron hut, which served as both ticket office and personnel room.

With the construction of a new station building in 1914, the hut became largely obsolete and in 1925 was abandoned, surrounded by undergrowth at the edge of a meadow, where it was used as a shelter for a water pump until the 1980s. In 2001, the hut was restored by the monks of St. Ottilien Archabbey. The restoration consisted mainly of cleaning the sheets and the hut is now reinstated at St. Ottilien train station, near the platform.

After 120 years of service, the majority of the hot dip galvanized corrugated sheets are still largely intact - providing undisputed evidence of the longevity and flexibility of galvanized steel in construction.

Left

When inspected in 2016, many of the galvanized steel sheets still showed their typical 'spangle' and the coating thickness was measured at > 90 microns

HOW GALVANIZING PROTECTS STEEL

Above top
Immersion in molten zinc gives complete coverage of the galvanized coating

Above bottom
Galvanized bridge beams awaiting despatch

Batch galvanizing to EN ISO 1461[16] is a corrosion protection system for steel, in which the steel is coated with zinc to prevent it from rusting. It is a simple but highly effective process in which cleaned iron or steel components are dipped into molten zinc (which is usually around 450°C). A series of zinc-iron alloy layers are formed by a metallurgical reaction between the iron and zinc - creating a strong bond between steel and its protective layer.

A typical time of immersion is about four to five minutes, but it can be longer for heavy articles or where the zinc is required to enter internal voids. Upon withdrawal from the galvanizing bath, a layer of molten zinc is deposited on top of the alloy layer. Often this cools to exhibit the bright shiny appearance typically associated with galvanized steel products.

In reality, there is no demarcation between steel and zinc, but a gradual transition through the series of alloy layers which provide the metallurgical bond. Conditions in the galvanizing plant such as temperature, humidity and air quality, do not affect the quality of the galvanized coating.

One of zinc's most important characteristics is its ability to protect steel against corrosion. The life and durability of steel are greatly improved when coated with zinc. No other material can provide such efficient and cost-effective protection for steel.

When left unprotected, steel will corrode in almost any exposed environment. Galvanized coatings stop corrosion of steel in two ways - a physical barrier and electrochemical protection. The coating provides a continuous, impervious metallic barrier that does not allow moisture and oxygen to reach the steel. The coating reacts with the atmosphere to form a compact, adherent patina that is insoluble in rainwater.

Typical coating thicknesses can range from 45µm to over 200µm. Research over many years has shown that the life of this barrier protection is proportional to the zinc coating thickness. In other words, doubling the coating thickness will double the life of the coating.

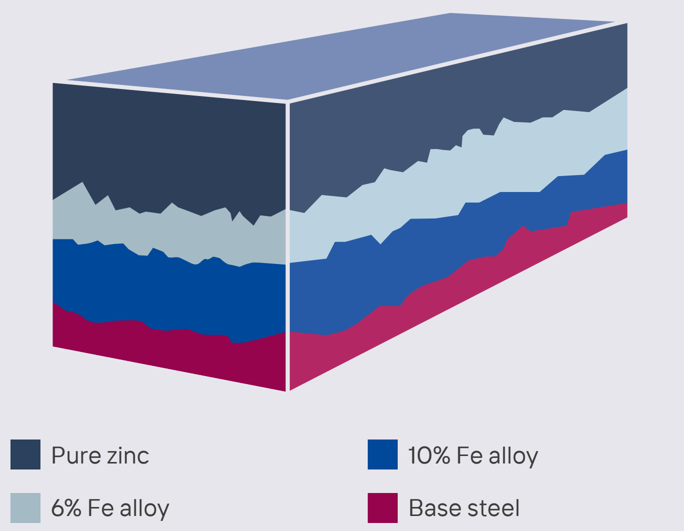
Zinc will also galvanically protect steel. When bare steel is exposed to moisture, such as at a damaged area, a galvanic cell is formed. The zinc around the point of damage corrodes in preference to steel and forms corrosion products that precipitate on the steel surface and protect it. There is no sideways corrosion at points of damage.

The hardness of the alloy layers is often significantly higher than the underlying steel. Therefore, galvanizing offers unique protection against mechanical influences. Hot dip galvanizing is 20 times harder, 10 times more resistant to abrasion, 8 times more impact resistant and has up to 4 times higher adhesive strength than a typical paint system[17]. Steel components can rust at their edges when they are painted or made from steel sheets that have been coated before they are cut or formed. This is not the case for batch galvanized steel. Hot dip galvanizing gives complete coverage and optimal edge protection as the coating normally grows thicker at corners and edges.

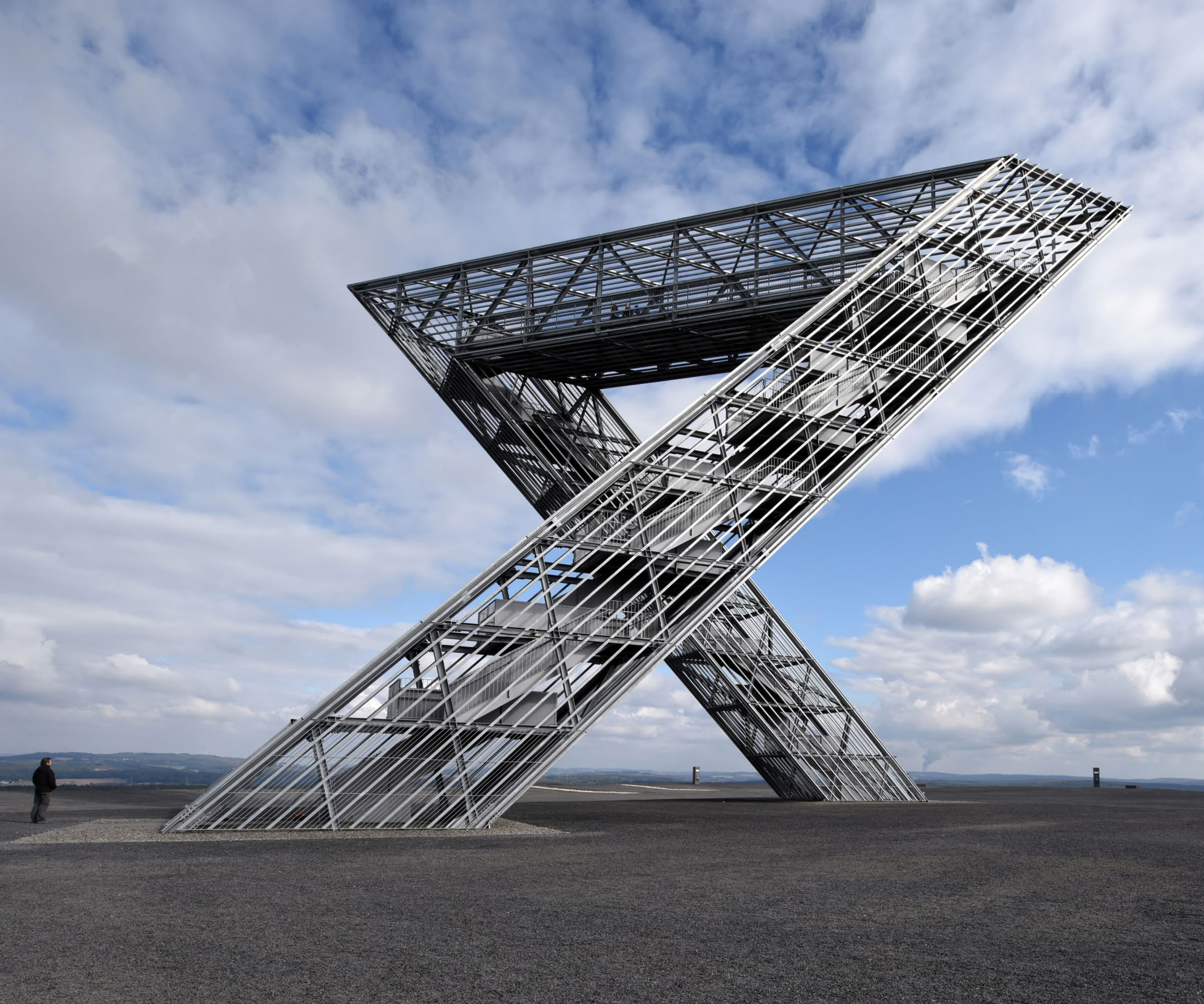
Galvanizing offers excellent chemical and thermal resistance. An important factor influencing the corrosion behaviour of zinc coatings in liquids is the pH value. Zinc coatings show stable behaviour in solutions with a pH above 5.5 and below 12.5. Within this range, a protective layer forms on the zinc surface, so that the corrosion rate is very low. Thermal resistance is also excellent. Hot dip galvanized steel structures, such as ski lifts, in Alpine regions and in the research stations of the Antarctic are examples of extreme low temperature performance.

By dipping steel into molten zinc even inaccessible areas are protected against corrosion. Hot dip galvanizing protects hollow profiles inside as well as outside.

Schematic section through a typical hot dip galvanized coating



Hot dip galvanizing also improves the fire resistance of certain steel structures[18]. This improvement in fire resistance is based on the reduced emissivity of hot dip galvanized steel surfaces compared to normal steel surfaces. Emissivity is a measure of how much a material exchanges thermal radiation with its environment. Especially in the initial phase of a fire, a low level of emissivity leads to a significantly delayed heating of the components. This effect, in combination with other aspects of fire engineering, is often able to achieve a required fire resistance duration and avoid over-sizing of steel beams and columns or other fire protection methods that consume both energy and resources.



GARSINGTON OPERA – DEMOUNTABLE PAVILION

Reuse

Garsington Opera's move to Wormsley, a lush English pastoral estate between London and Oxford, has significantly upgraded their facilities in line with the expectations of 21st Century opera goers. The new pavilion offers superb acoustics and a perfect setting in which to experience opera performances of the very highest quality. The 600-seat summer pavilion is designed to be demounted annually within 3-4 weeks and will leave no permanent trace when removed.

The pavilion was constructed using pre-fabrication techniques which minimised material waste, ensured a consistent level of workmanship, reduced the construction time spent on site and allowed the galvanized steel building to be assembled/disassembled as quickly and economically as possible.

The whole steel structure was prefabricated and galvanized, providing a maintenance-free, corrosion resistant protective finish.

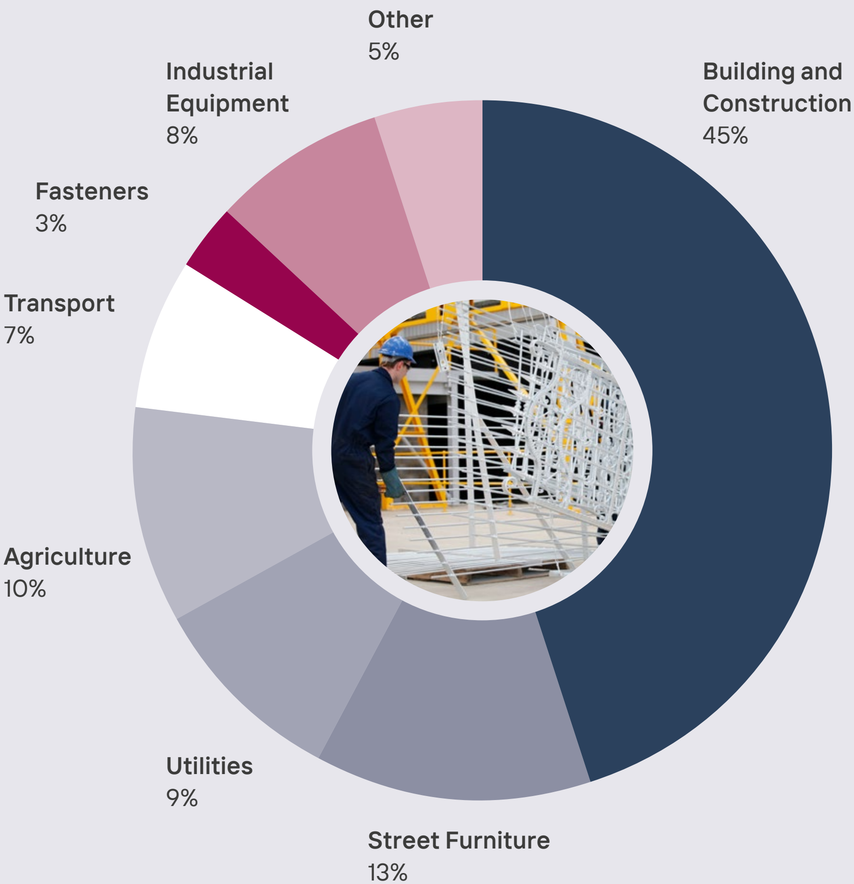
The galvanized coating was selected for its long-term protection – Garsington have a 15 year lease on the site and the building has been designed for a working life of at least this period – and for its durability, a key aspect considering that the building is designed to be annually installed and demounted. The longer-term environmental aspects of a maintenance free coating were also of paramount importance to the design team.

Innovative acoustic research facilitated the use of a lightweight galvanized steel and fabric construction that is not normally associated with auditorium construction – all capable of being repeatedly erected and dismantled without damage to the components.

Above
Galvanized steel facilitates annual construction and deconstruction of the pavilion

Right
The opera pavilion hosts performances throughout each summer

Batch galvanizing, to EN ISO 1461, is used widely in construction, infrastructure and manufacturing



Source: EGGA

1836

First industrial patents for the galvanizing process

~22,500

People employed directly

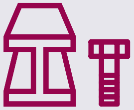
8 million

Tonnes of steel products protected annually

700

Galvanizing plants keeping galvanizing local across Europe

Mainly SME or mid-sized companies providing local employment and social value



Can be applied to everything from small fasteners to large structural beams over 20 metres long

THE GALVANIZING INDUSTRY

Europe's batch galvanizing industry is conveniently spread across the continent, ensuring galvanizing capacity is locally-available to the manufacturing and construction industries. Steel does not have to travel great distances to a nearby galvanizing plant keeping transport costs and environmental impacts as low as possible.

Each plant is configured to suit the demand of certain applications and to reflect the local demand. Smaller plants will specialise in lighter components whilst larger structural steelwork would be processed by larger plants. This natural evolution of the industry has created a highly efficient and competitive sector.

Galvanizing is used in a wide variety of uses. Although construction creates the highest demand, there are important uses of batch galvanized steel in renewable energy, transport, agriculture, utilities and a range of industrial engineering applications. Where steel is used, galvanizing follows.

The majority of the companies in the galvanizing industry are SMEs or mid-sized companies that are very often long-standing family businesses.

The plants have an important role in local employment and economic development of their regions. It is estimated that the European batch galvanizing industry employs approximately 22,500 people and has a economic value of €3,200 million.

Galvanizing is always carried out in an industrial plant which contains all stages of the process. Steel comes in at one end of the plant and the finished galvanized product goes out at the other.

The main raw material, zinc, is used very efficiently in the galvanizing process. The dip operation ensures that any zinc that is not applied to the steel remains in the galvanizing bath. Zinc that oxidizes on the surface of the bath (termed 'ash') is removed and is readily recycled (sometimes on the same site). Dross formed at the bottom of the bath is removed periodically and also has a high market value for recycling.

Energy is required to heat the galvanizing bath and is usually supplied by natural gas or, in some cases by electrical furnaces. Although the galvanizing industry is not considered to be amongst the most energy-intensive sectors of industry, it has made great efforts to manage its energy use efficiently. In some countries, the galvanizing industry has set targets for energy efficiency and encouraged improved energy management and new technology to achieve these targets. Examples of these advances are:

- Introduction of solar power for plant energy requirements
- improved burner technology for greater energy efficiency
- more efficient bath lids (used during maintenance and/or down time)
- greater use of waste heat for heating of pre-treatment tanks
- electric power for on-site transport and lifting

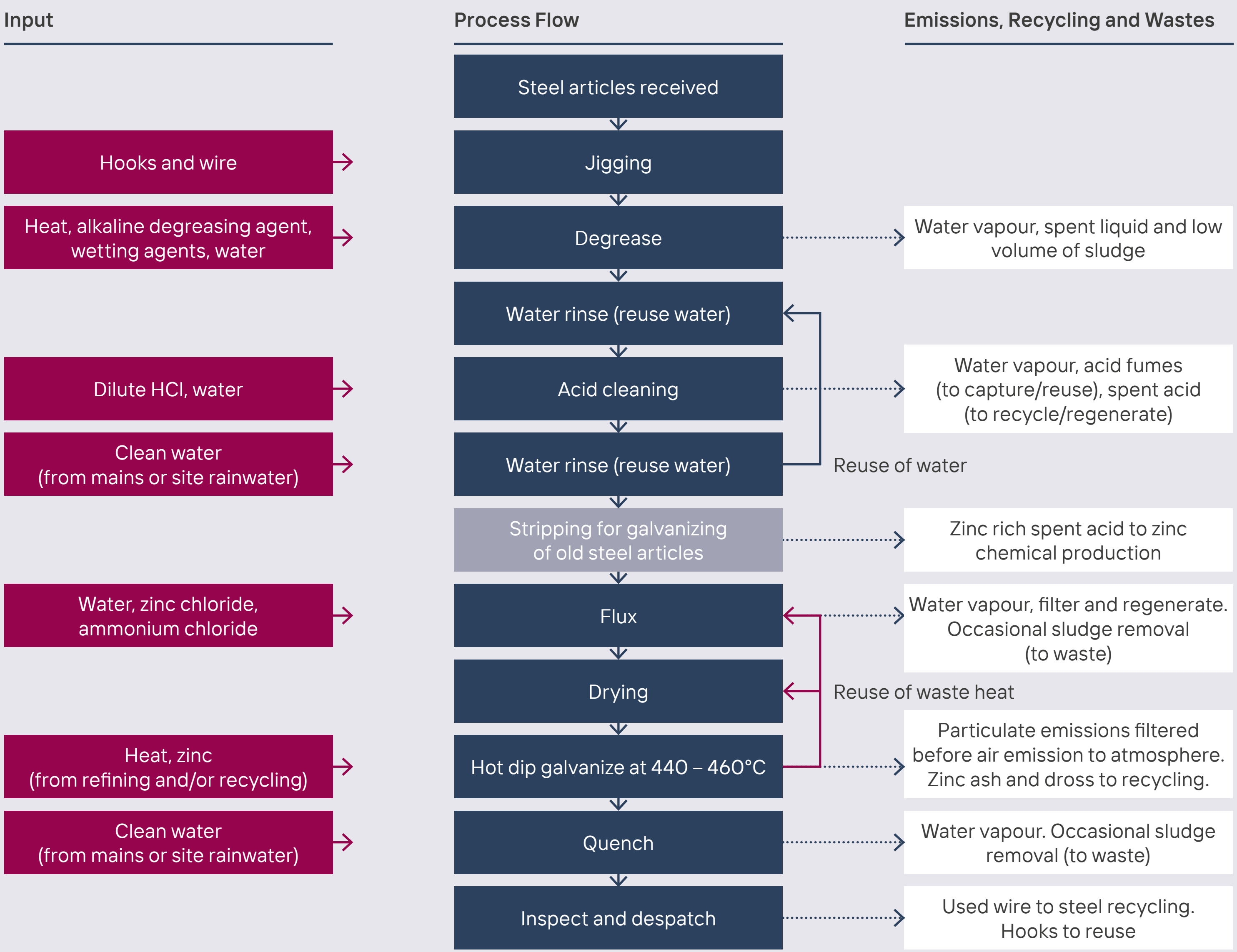
Emissions within the plant are carefully controlled to avoid disturbance or problems for the surrounding neighbourhood. Galvanizing plants are regulated under the EU Industrial Emissions Directive[19] and a Best Practice Reference Note (BREF)[20] for hot dip galvanizing encourages common levels of control across Europe.

Pre-treatment steps in the process are mainly aimed at cleaning the steel articles. Process consumables, such as hydrochloric acid and flux solutions all have important recycling and/or regeneration routes. For example:

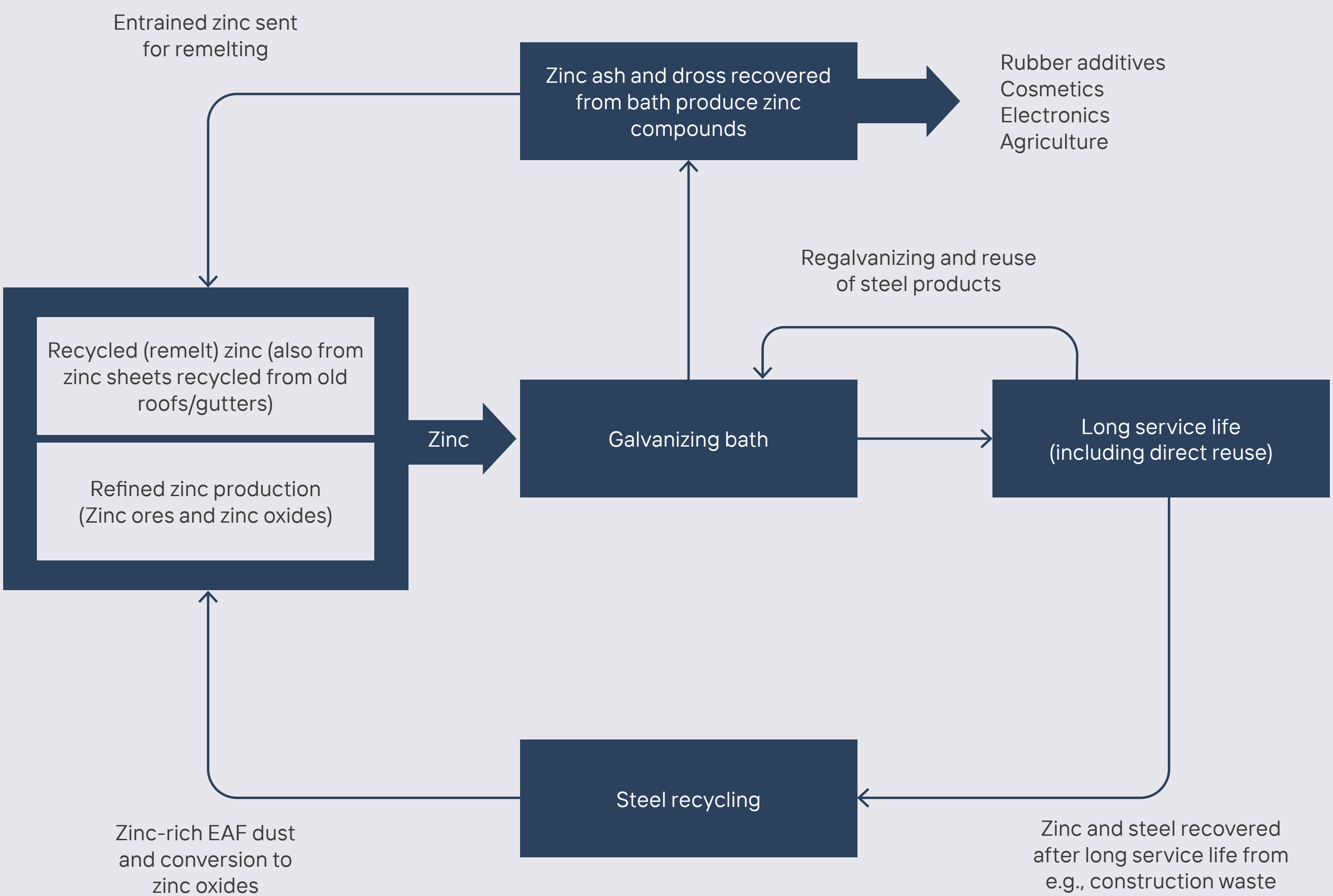
- spent hydrochloric acid solutions are used to produce iron chloride for use in treating municipal wastewater
- improved monitoring and maintenance of flux tanks means that these are rarely discarded to waste and only small volumes of sludge require periodic disposal. Closed-loop flux recycling is used in many plants
- ambient temperature acidic degreasers have been developed

Galvanizing plants use relatively low volumes of water compared to other coating technologies. In fact, it is very rare for a galvanizing plant to discharge waste water. Any water that is generated can be returned to the process, with only low volumes of stable solids sent for external disposal. In some cases, it has been possible for galvanizing plants to eliminate the use of mains water by harvesting rain water falling on the site.

The galvanizing process: inputs, emissions, wastes and recycling flows



Flows of recycled zinc within the galvanizing process and after decades of service



Zinc Facts

The world is naturally abundant in zinc and the metal enjoys a mature and economically attractive recycling loop.

7 million tonnes of zinc recycled each year

1,900 million tonnes of known resources

0.5 million tonnes of zinc used in batch hot dip galvanizing, protects 8 million tonnes of steel in Europe each year

12 million tonnes of zinc from annual mine production

One of the most abundant elements in the earth's crust

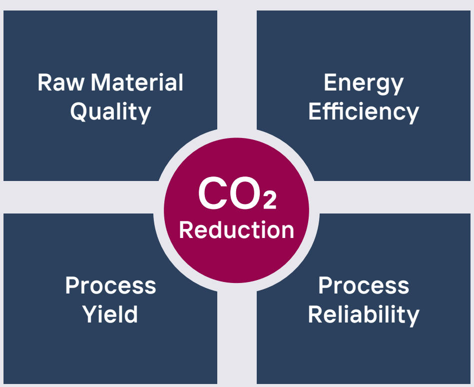
19 million tonnes of zinc in all uses each year

Source: International Zinc Association; US Geological Survey; EGGA

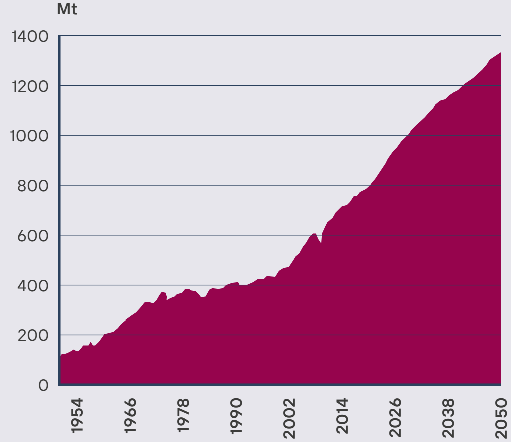
Decarbonisation of steel production

Steelmakers are setting ambitious targets for CO_2 reduction and investing in transformational projects. The World Steel Association brings together the world's leading steelmakers and advocates a 3-track approach that will not only reduce CO_2 emissions but will also help create a more sustainable operation of the global economy:

Track 1 – Reducing Impact
Improving operational efficiency - through a 4-stage efficiency review process ("Step Up").



Global Steel Scrap Availability



Maximise scrap use – steel is already the world's most recycled material and global scrap availability is expected to reach one billion tonnes by 2030, leading to further reductions in the CO_2 per tonne of steel produced.

Breakthrough technology – to revolutionise steelmaking through the use of hydrogen to replace fossil fuels and carbon capture and storage to prevent emissions.

Track 2 – Advanced steel products to enable societal transformation
Steel makes huge contributions to reducing emissions in other sectors – in mobility, renewable energy and zero energy buildings.

Track 3 – Promoting material efficiency through the circular economy
Steel industry is working with its customers to encourage a whole life cycle approach to steel products and their design and material choices.

For more information: www.worldsteel.org

ENVIRONMENTAL PRODUCT DECLARATION

Environmental data for batch galvanizing is available for users and policy makers

Life Cycle Inventory (LCI) data is a vital tool for the detailed study of the life cycle environmental impacts of products and services. However, LCI data is not easy for product users to interpret and it is now increasingly common to communicate environmental performance through the simpler format of an environmental product declaration (EPD).

EGGA has developed a Pan-European LCI study of an average galvanized steel product. The final result of that work was a life cycle inventory data set for the batch galvanizing process, based on data submitted by members of EGGA National Associations from their own operations according to ISO 14040/14044[21]. The average energy, resource consumption and emission of substances to the environment, resulting from a LCI of a representative sample of plants operating at European level, were calculated according to the defined system boundaries.

Hot dip galvanizing is a service of corrosion protection that may be supplied from a variety of operators that will not be identifiable at the specification stage in, for example, construction projects. A 'corporate' EPD may therefore be less useful for this type of corrosion protection service. Against this background, EGGA appointed the Italian consultancy, Life Cycle Engineering, to generate a 'sectoral' EPD for the hot dip galvanizing of steel products.

The EPD is based on a sample covering more than 1 million tonnes (~19%) of the production from 66 companies in 14 countries for plants that were deemed highly representative of the European industry[22].

In accordance with rules provided by the International EPD® System: PCR 2011:16 "Corrosion protection of fabricated steel products"[23] the declared unit (the reference unit to which results are related) is presented for 1 year of protection of 1 m² steel plate of 8 mm thickness, calculated on the basis of the life span of 63 years predicted by EN ISO 14713-1. The results show that the environmental burdens of galvanizing are a very small proportion of the overall product (~5% for Global Warming Potential).

A simplified summary of the EPD results for the main environmental impact indicators required by the PCR are shown opposite. For details of the full EPD, visit www.egga.com.

The galvanizing industry also works closely with the steel construction industry at national level to ensure that transparent and robust environmental data is available for galvanized steel products where it is required:

- In Germany, bauforumstahl e.V. and Industrieverband Feuerverzinken e.V. have cooperated to publish an EPD "Hot-dip galvanized structural steels: Open rolled sections and heavy plates" in accordance with the requirements of the Institut Bauen und Umwelt e.V.[24]
- In the Netherlands, Zink Info Benelux has worked with steel industry partners to include data on galvanized steel in the national Milieu Relevante Product Informatie (MRPI) database for construction products.
- In France, Galvazinc has prepared a Fiche de Déclaration Environnementale et Sanitaire (FDES) for galvanized steel.

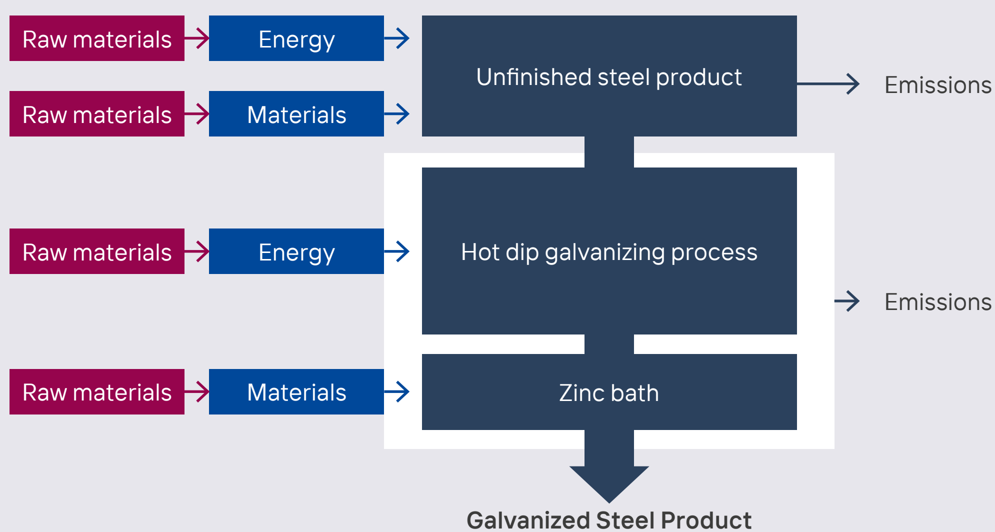
Basis of the EGGA sectoral EPD for batch hot dip galvanizing

Substrate	Steel plate with dimension 1m x 1m x 8mm and weight of 62.4kg
Galvanized coating thickness (as EN ISO 1461)	85 microns
Exposure environment	Corrosivity category C3 (as defined by ISO 9223) with an average zinc corrosion rate of 1.35 microns per year
Predicted maintenance-free galvanized coating life	Minimum 63 years
Functional Unit (results)	Burdens per year of protection

EGGA sectoral EPD results (burdens per year of protection for a 1m x 1m x 8mm steel plate).

Environmental Impact Indicators	Contribution to galvanized steel product from galvanizing to EN ISO 1461
Global Warming Potential, GWP [kg CO_2 eq]	0,12
Ozone Depletion Potential, ODP [kg CFC-11 eq]	1,28E-08
Photochemical Ozone Creation, POCP [kg C_2H_4 eq]	3,50E-05
Acidification Potential, AP [kg SO_2 eq]	1,05E-03
Eutrophication Potential, EP [kg PO_4 eq]	9,30E-05
Depletion of abiotic resources-elements, ADP-elements [kg Sb eq]	1,19E-05
Depletion of abiotic resources-fossil, ADP-fossil fuels [MJ]	1,55

EGGA life cycle inventory for galvanized steel: system overview



GALVANIZING FOR HEALTHY BUILDINGS

The average person spends just 10% of their time outside, with 90% of time spent indoors[25]. Good indoor air quality is therefore vital to control health risks and maintain productivity in the workplace.

Volatile Organic Compounds (VOCs) arising from building materials, furnishings and finishes such as paint coatings play a significant role in indoor air quality. The importance of indoor air quality is now being brought to the attention of politicians because of its impacts on health and wellbeing and the effect it can have on performance and productivity. Although it is difficult to associate particular VOCs or products directly with particular health complaints, evidence is growing and for some chemicals the effects are known.

As an inert, metallic zinc coating that is comprised from a naturally-occurring essential element, galvanized steel is the perfect choice for optimal indoor air quality – eliminating presence of VOCs and other synthetic materials.

Zinc – the healthy construction material

Zinc is essential for human health and vital for a healthy immune system

Zinc enhances our memory and thinking by interacting with other chemicals to send messages to the sensory brain centre. Zinc can also reduce fatigue and mood swings.

Because zinc is used to generate cells, it is especially important during pregnancy, for the growing fetus whose cells are rapidly dividing.

In women, zinc can help treat menstrual problems and alleviate symptoms of premenstrual syndrome.

Zinc is vital for taste and smell, it is needed for renewal of skin cells and to keep our hair and nails healthy.

We use zinc in shampoo and sun-block products.

In men, zinc protects the prostate gland and helps maintain sperm count and mobility.

Zinc has proven effective in fighting infections and can even reduce the duration and severity of the common cold. Zinc's role in mitigating the effects of COVID-19 is becoming increasingly clear[26].

Zinc helps keep us going... and enjoying healthy active lifestyles. Among all the vitamins and minerals, zinc shows the strongest effect on our all-important immune system.

Zinc is vital in activating growth in infants, children and teenagers.

For more information on zinc and human health: www.zinc.org/essential

PLEASE BE SEATED

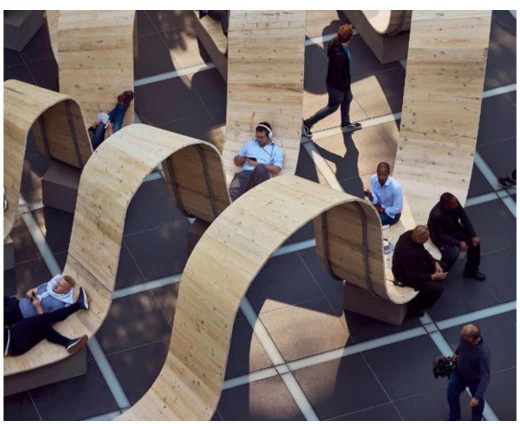
Remake Reuse

Please Be Seated, comprises of a series of rising and falling concentric circles, providing benches and arches for people to sit on and walk under. It is a collaboration between Arup and British designer, Paul Cocksedge, to transform Finsbury Avenue Square at Broadgate, London with a large-scale community installation and was part of the annual London Design Festival.

The unique installation uses timber sourced from reclaimed scaffolding planks and galvanized steel scaffolding poles to bring focus to the reuse and repurpose of construction waste.

Having been moved from London's Broadgate, there are plans to re-erect the installation in a new location.

This unique installation uses reclaimed galvanized steel scaffolding poles and timber from reclaimed scaffolding planks



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CIRCULAR ECONOMY TERMS

Life cycle assessment
Compilation and evaluation of the inputs, outputs and the potential environmental impacts of a product system throughout its life cycle

Life cycle costing
Methodology for systematic economic evaluation of life cycle costs over a given period of analysis

Recycling
Any recovery operation, by which waste materials are reprocessed into products, materials or substances, whether for the original or other purposes

Refurbishment
Modification and improvements to an existing building or civil engineering works in order to bring it up to an acceptable condition

Remanufacturing
Remanufacturing is the process of returning a used product to, at least, its original performance that is equivalent to or better than that of the newly manufactured product

Repair
Returning a product, component, assembly or system to an acceptable condition by renewal or replacement of worn, damaged, or degraded parts

Repurposing
Using an obsolete item considered by its owner as a waste, with another use totally different from the initial one

Reuse
Any operation by which products or components that are not waste are used again for the same purpose for which they were conceived

FURTHER INFORMATION ON GALVANIZED STEEL

Austria
Fachverband Metalltechnische Industrie
www.fmmi.at

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