worldsteel
ASSOCIATION

steel FACTS

A collection
of amazing
facts about
steel

CONTENTS

WHAT IS STEEL?

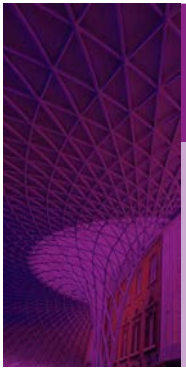
Discovered more than 3,000 years ago, continuously perfected, today **steel is one of the world's most innovative, inspirational, versatile and essential materials.** Explore what goes into its making.

Pages 6-25

WHAT IS STEEL'S VALUE TO SOCIETY?

Produced in every region of the world, **steel is the backbone of modern society,** generating jobs and economic growth.

Pages 56-69



WHY ARE WE PROUD OF STEEL?

Infinitely recyclable, steel allows cars, cans and buildings to be made over and over again. Zero waste strategies and optimal use of resources, combined with steel's exceptional strength, offer an array of sustainable benefits.

Pages 26-55

THE USES OF STEEL

Steel is the world's most fundamental engineering and construction material. **It is used in every aspect of our lives**: in cars and cans, refrigerators and washing machines, cargo ships and energy infrastructures, medical equipment and state-of-the-art satellites.

Pages 70-127

WHAT IS STEEL?

When **iron** is combined with carbon, recycled steel and small amounts of other elements, it is transformed into a much stronger material called steel, used in a huge range of human-made applications. Steel can be

1,000

times stronger than iron.

STEEL

is an alloy of iron and carbon containing less than

2%

carbon

1%

manganese and small amounts of silicon, phosphorus, sulphur and oxygen. Stainless Steel is a steel alloy with a minimum of 10.5% chromium content by mass.

All steel is originally made from

IRON

Iron is the **4th** most common element in the Earth's crust after oxygen (46%), silicon (28%), and aluminium (8%).

When liquid iron is converted into steel it reaches temperatures of up to

1,700°C,

significantly hotter than volcanic lava.

Steel is the most commonly used metal in the world. It is

everywhere

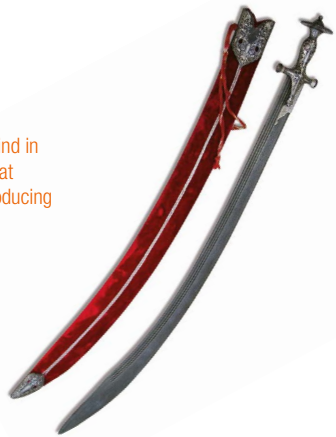
in our lives

As early as the

11th

century BC,

an archaeological find in Cyprus indicates that craftsmen were producing quench-hardened steel knives.



One of the earliest references to steel-working comes from the Greek historian Herodotus, referring to a bowl inlaid with steel by Glaucus of Chios in the

7th century BC

"A great bowl of pure silver, with a salver in steel curiously inlaid. Glaucus, the Chian, made it, the man who first invented the art of inlaying steel."

In the **3rd century BC,** craftsmen in southern India were using crucibles to smelt wrought iron with charcoal to produce 'wootz' steel – a material that is still admired today for its quality.

A British inventor, Henry Bessemer, is generally credited with the invention of the first technique to mass produce steel in the

mid-1850s.

Steel is still produced using technology derived from the Bessemer Process of blowing air through molten pig iron to oxidise the material and separate impurities.

Steel is produced via two main routes: The blast furnace-basic oxygen furnace (BF-BOF) route and the electric arc furnace (EAF) route. Today about

71% of steel is produced using the BF-BOF route. **29%** is produced via the EAF route.

Crude steel is then rolled into finished steel products, such as coil, plate, sections or bars.

Steel Production - Route 1:

Blast furnace or integrated route

To produce 1,000 kg of crude steel, the main inputs are roughly:

- 1,370 kg of iron ore,
- 780 kg of coal,
- 270 kg of limestone, and
- 125 kg of steel scrap.

Steel Production - Route 2:

Electric arc furnace route

The primary raw materials are steel scrap, direct reduced iron (DRI) and/or hot metal, and electricity. To produce 1,000 kg of crude steel, the EAF route uses roughly:

- 710 kg of steel scrap,
- 586 kg of iron ore,
- 150 kg of coal and
- 88 kg of limestone, and
- 2.3 GJ of electricity.

An electric arc furnace can be charged with

100%

steel scrap. A basic oxygen furnace can be charged with as much as **30%** scrap. Most steel products remain in use for decades before they can be recycled. Therefore, there is not enough recycled steel available to meet growing steel demand.

Steel is a permanent material that can be infinitely recycled and is

100%

recyclable without loss of quality.

Steel closes the material loop

without being confined to a single application.

ALL

types of steel can be recycled back into new steel of various grades, keeping their inherent material properties.

Steel scrap from lower value steel products can be

converted into high value steels

by using appropriate processing and metallurgy. For other materials this is not typically possible; in the case of concrete, wood and aluminium the quality of recycled material is often downgraded or downcycled and the material has a limited number of lives.

On average, new steel products contain **30%** recycled steel.

Today's steel products will become tomorrow's cans, trains, bridges, or buildings.

New and innovative steels are continually being developed. In 2022, the steel industry invested

6.3%

of revenue in capital investment projects, research and process improvement.

Steel is not a single product. There are more than

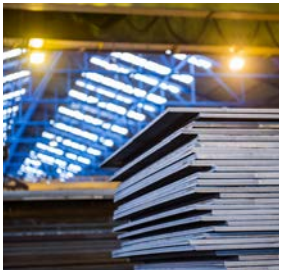
3,500

different grades of steel with many different physical, chemical, and environmental properties, allowing a range of thicknesses and shapes. Each grade of steel has properties designed for its specific application.

Over

75%

of the 3,500 steel grades in use today did not exist 20 years ago.



On average,

1.91 tonnes of CO_2 are emitted for every tonne of steel produced.

The steel industry generates between 7 and 9% of direct emissions from the global use of fossil fuels.

The majority of the CO_2 comes from the chemical reaction of steelmaking.

The industry is working together on many initiatives to develop breakthrough steelmaking technologies that could reduce CO_2 emissions by more than

50%

potentially revolutionising the way steel is made.

To prevent the chemical reaction resulting in rust (iron oxide) forming when steel is exposed to water and oxygen, many steel products will be

metallic coated.

Paint is then used on cars, enamel is used on refrigerators and other domestic appliances, and so on.

Weathering steels

are designed to rust, with the oxide coating providing protection, eliminating the need for painting.

WHY ARE WE PROUD OF STEEL?

Steel is

fundamental

to achieving a circular economy.

It ensures the maximum value of resources through recovery and reuse, remanufacturing and recycling.

The steel industry uses its resources efficiently and produces very little waste. According to the data reported by our members, in 2022:

97%

of steel industry raw materials were converted:

70%

were converted into steel products.

28%

were converted into co-products. As little as

2%

became waste.

Nearly

100%

of the steel industry's co-products can be used.

Slag

is used in cement, road construction, fertilisers, hydraulic engineering and sea forestation.

Process gases

are used to produce heat and/or electricity.

Emulsions and oils

are used as reducing agents.

Iron oxides and zinc

are recovered from dust and sludges.

Chemicals

are used as input material for the chemical industry.

Slag is the highest volume steel industry solid co-product. On average, for the blast furnace route approximately,

400kg of slag is produced per tonne of crude steel.

In the electric arc furnace, around

170kg of slag is produced per tonne of crude steel.

In Europe,

77%

of steelmaking slag is used to produce cement and materials for road construction. The rest of the recovered slag is used in other applications, such as fertilisers, metallic applications, hydraulic engineering, etc.

According to the International Energy Agency, substituting cement clinker with slag cement would allow significant reductions in annual energy consumption and CO_2 emissions - up to 500 million GJ, and

200 Mt of CO_2.

Steelmaking process gases

are used to produce heat and electricity.
When process gases are fully reused
they can provide between

60-100%

of the plant's electricity requirements.

Technologies are being developed to convert steelmaking process gases into methanol and ethanol, thereby conserving energy, and

reducing the need for fossil fuels

in other sectors, such as transport.

Energy consumption per tonne of steel has been

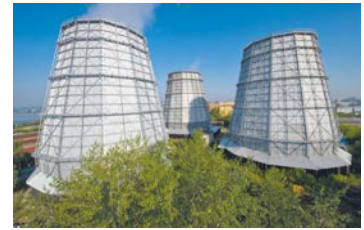
reduced by

60%

since the 1960s, which has contributed to a significant decrease in CO_2 intensity.

The average energy intensity per tonne of steel produced has dropped from 50 GJ/t in the 1960s to its current level of around

20 GJ/t



Around 90% of water

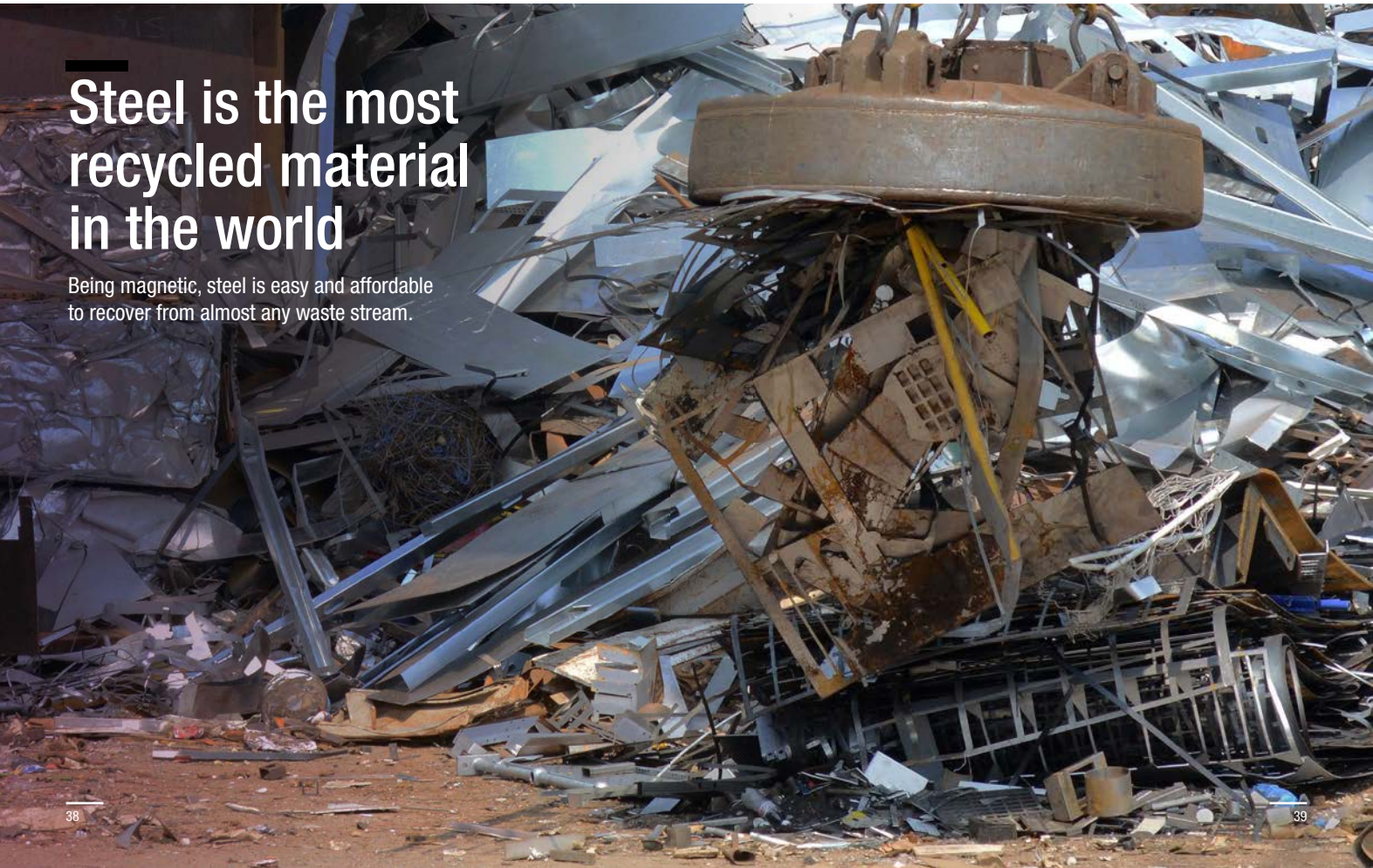
used in the steel industry is cleaned, cooled and returned to source. Most of the loss is due to evaporation. Water returned to rivers and other sources is often cleaner than when extracted.

HBIS Tangsteel's new waste water treatment centre located in North China has a water treatment capacity of 6,000 m^3 per hour: 3,000 m^3 of the water treated is industrial waste water and 3,000 m^3 is urban waste water. Annually the centre saves 24.5 million tonnes of fresh water and boasts a

100% waste water recovery rate

Steel is the most recycled material in the world

Being magnetic, steel is easy and affordable to recover from almost any waste stream.



In 2021,

680

million tonnes

of scrap, saving nearly 1 billion tonnes of CO_2 emissions that would have been emitted from the production of virgin steel.

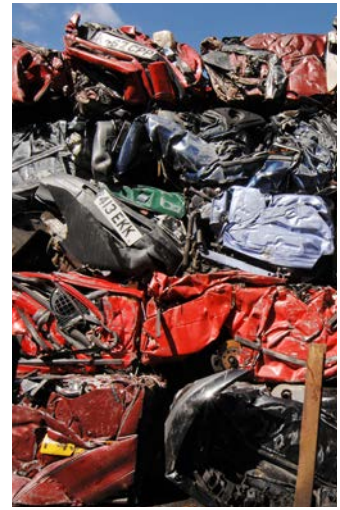
By sector, global steel recovery rates for the following areas are estimated to be at least:

85%	90%	90%	50%
Construction	Automotive	Machinery	Electrical and domestic appliances

Over

25 billion tonnes

of steel scrap have been recycled to make new steel since 1900. This has **reduced iron ore consumption by around 33 billion tonnes**, as well as **cutting coal consumption by 16 billion tonnes.**



Recycling accounts for significant energy and raw material savings.

Recycling one tonne of steel scrap saves 1.5 tonnes of CO_2, 1.4 tonnes of iron ore, 740 kg of coal, and 120 kg of limestone.

Steel products are durable and simply last a long time.

The average life for steel products is approximately

40 years.

In applications with a long service life, such as buildings or infrastructure, we will need to wait up to 100 years or more to recycle. In the case of steel packaging the time between production and recycling can be just a few weeks; in the case of vehicles this may be up to 15-20 years.

Steel's durability enables many products to be reused at the end of their life. Reusing a steel product

extends its product life cycle

and therefore conserves resources. Many steel companies and steel product manufacturers are increasingly designing products for reuse.

A warehouse built in 2000 in Slough, UK, with a floor space of 3,320m^2 was re-erected in a different location in 2015, using the same steel structure. The savings associated with this project were quantified as follows:

56%

less embodied carbon at completion compared to a comparative new build.

25%

saving in costs compared to an equivalent new build.

Steel products can easily be remanufactured, restoring used products to like-new condition, such as automotive engines and wind turbines.

Remanufactured turbines can keep wind farms at peak capacity long beyond their designed lifetime. Remanufacturing can almost

double the return

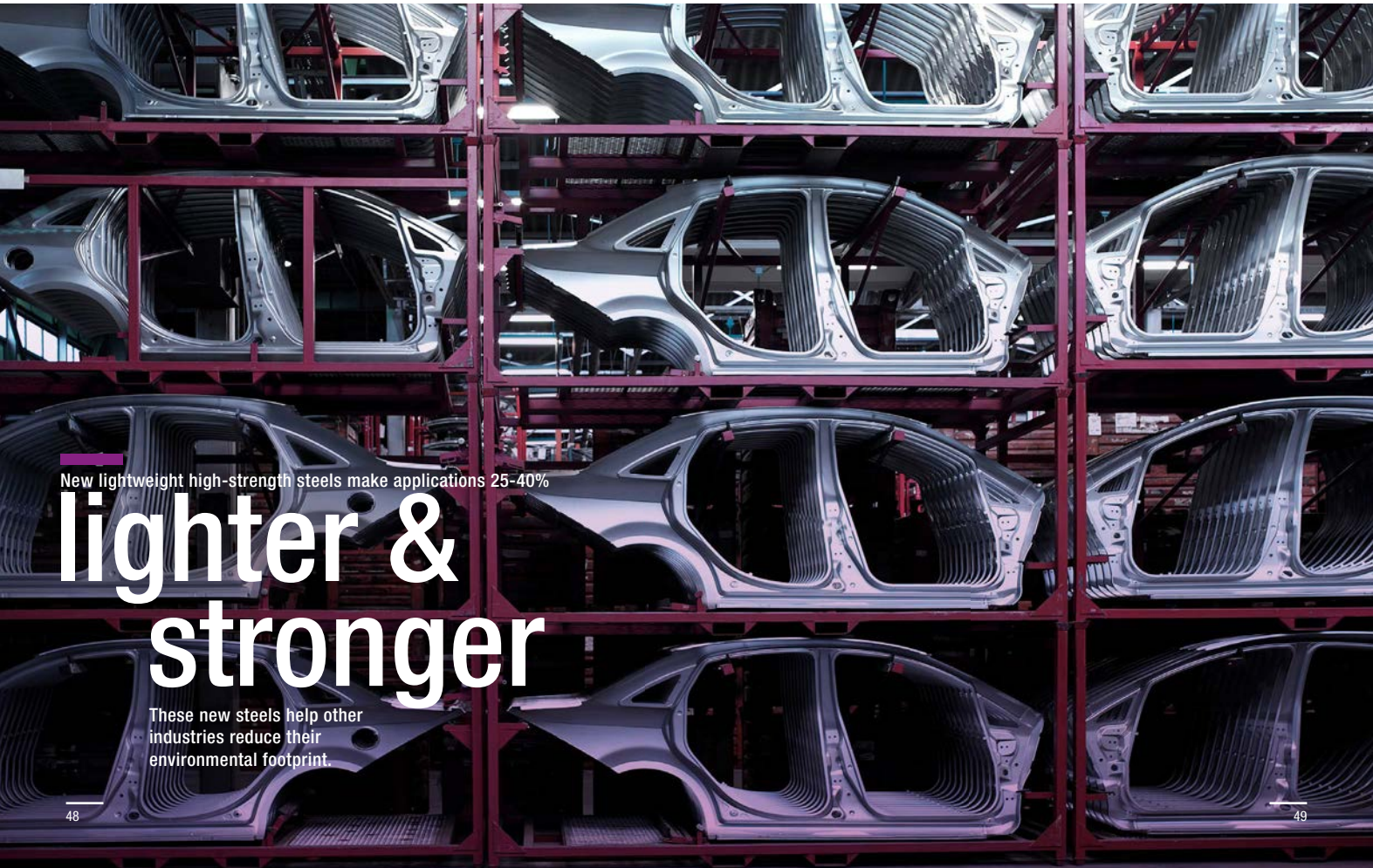
on the original investment by extending turbine life by up to

20 years

Remanufactured engines can be produced with up to

83%

less energy than the energy needed to produce a new engine, and emitting up to 87% less CO_2. Consumers can also save up to 53% on cost over a new engine.



New lightweight high-strength steels make applications 25-40%

lighter & stronger

These new steels help other industries reduce their environmental footprint.

Air quality

control is a major priority for the steel industry.

The industry has access to technologies to manage most common emissions (SOx, NOx, dust, heavy metals) that can meet increasingly stringent regulatory requirements.

100% of steel plants around the world have environmental permits regulating their emissions.

Fabric dust filters in steel plants typically have a collection efficiency rate of more than

99%

even when particle size is very small.

thyssenkrupp has equipped its Duisburg sinter plant with one of the largest fabric filters in the steel industry. The filter reduces dust emissions by 99.99%. It is made up of more than

44,000 extremely fine filter bags, each almost three meters long and with a total fabric area of 45,000m^2.

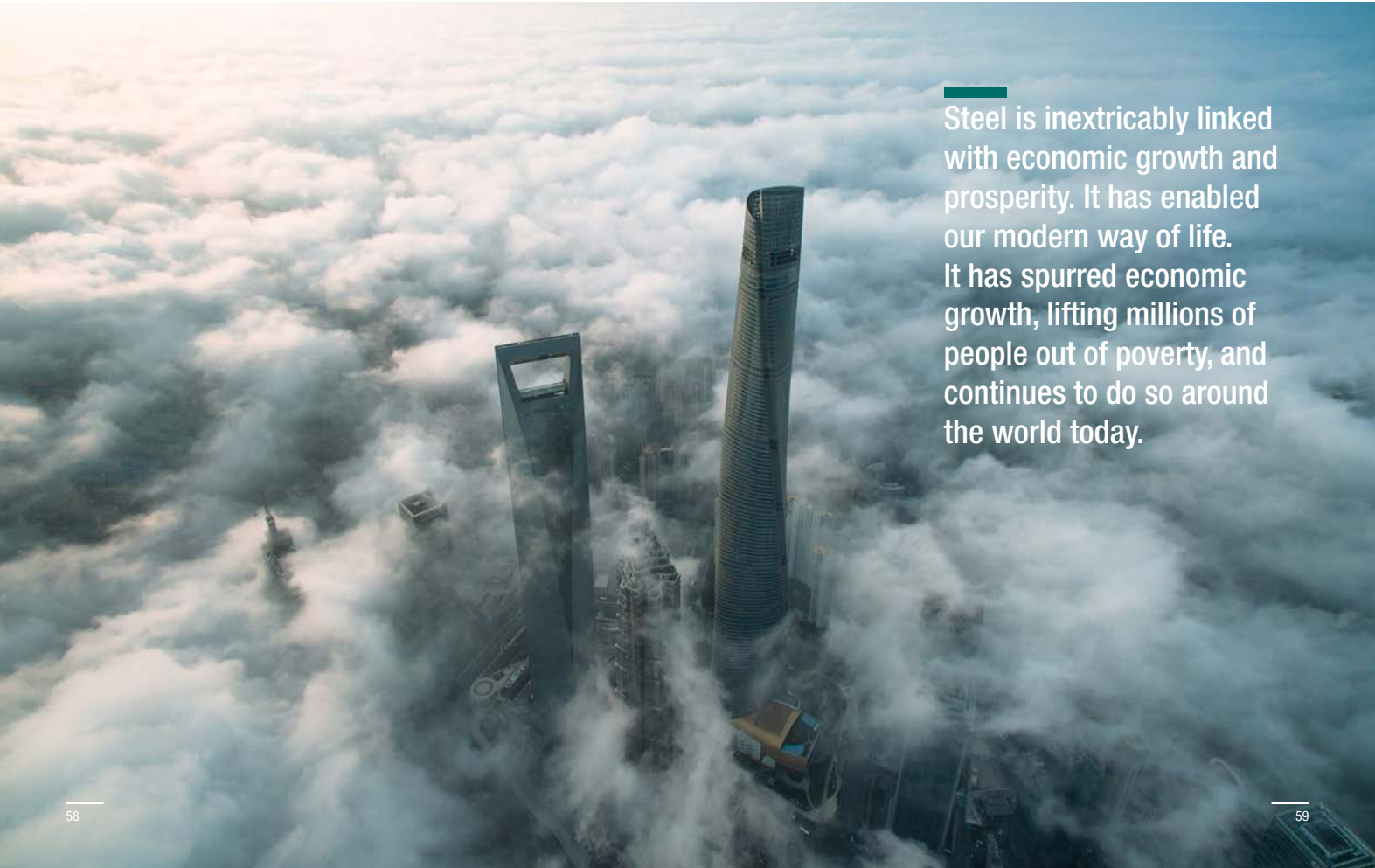
Almost every greenhouse gas mitigation technology relies on steel,

including the generation of thermal and renewable energy, electrification, mass transport and the hydrogen economy. Without steel, the Paris Agreement will not be met.

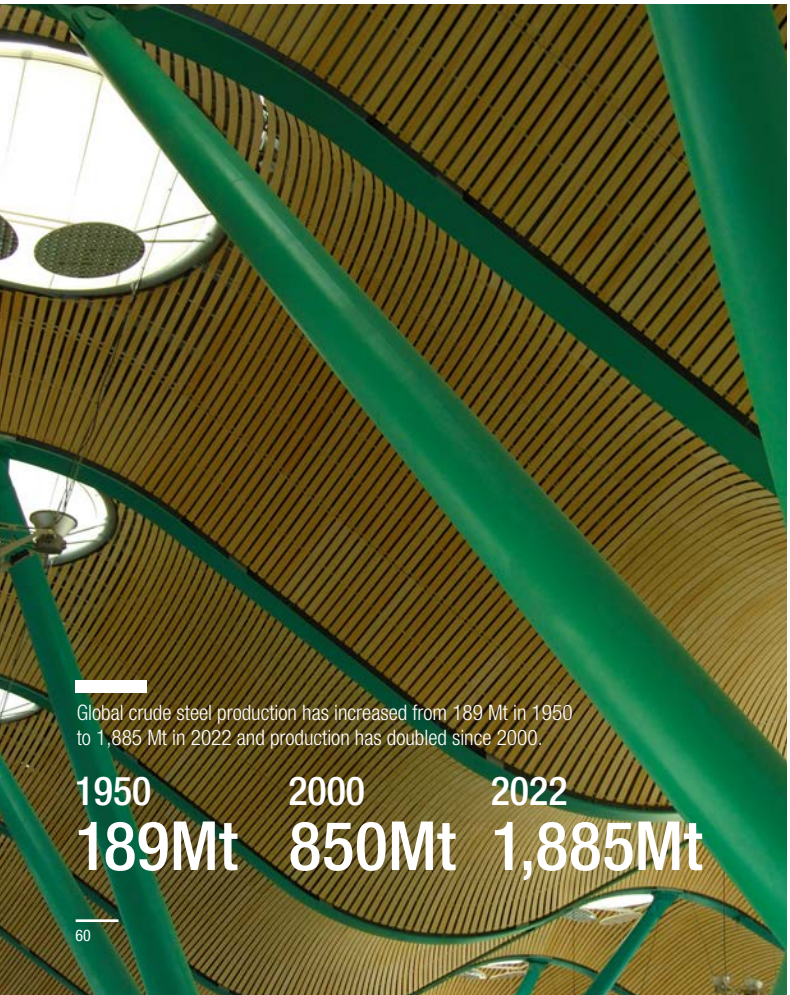
The steel industry is committed to the goal of an injury-free workplace.

In 2022, the Lost Time Injury Frequency Rate fell to 0.65, the lowest global rate achieved for this Sustainability Indicator.

WHAT IS STEEL'S VALUE TO SOCIETY?



Steel is inextricably linked with economic growth and prosperity. It has enabled our modern way of life. It has spurred economic growth, lifting millions of people out of poverty, and continues to do so around the world today.



Global crude steel production has increased from 189 Mt in 1950 to 1,885 Mt in 2022 and production has doubled since 2000.

1950	2000	2022
189Mt	850Mt	1,885Mt

The weight of the crude steel produced in the world in 2022 is equal to the steel required to produce

44,880 Beijing National Stadiums.

In 2022, the top steel producing countries were:

China	India	Japan	United States	Russia
1018.0 Mt	125.3 Mt	89.2 Mt	80.5 Mt	71.5 Mt

In **2022**

The top **5** producing countries accounted for **73%** of global steel production.

The top **10** producing countries accounted for **84%** of global steel production.

The top **50** producing countries accounted for **99%** of global steel production.

Steel production % split

	2000	2022
China	15.2	54.0
Europe	24.7	9.7
India	3.2	6.6
North America	15.8	5.9
Other Asia & Oceania	12.6	4.9
Japan	4.2	4.7
Russia & Other C.I.S. + Ukraine	11.7	4.6
Africa & Middle East	2.9	3.8
South Korea	5.1	3.5
South America	4.8	2.3

The biggest single facility we have on record is POSCO's Gwangyang Works, which produced 21.4 Mt of carbon steel in 2017. Considering that the average car contains 900 kg of steel, this is equal to the production of

23,800,000 cars a year or

65,205 cars a day.

About

25%

of steel is traded internationally.

The amount of steel in use in the world today is equal to around

224

kg per person per year.

By

2050

steel use is projected to increase by around 20% compared to present levels in order to meet the needs of our growng population.

In 2019, the steel industry reported distributing

$1,663

billion USD

to society directly and indirectly, 98% of its revenue.

Globally, over

6 million people

work for the steel industry.

2 million

people are employed within the mill (direct steelmaking employment).

1.5 million

people work in support services (contractors).

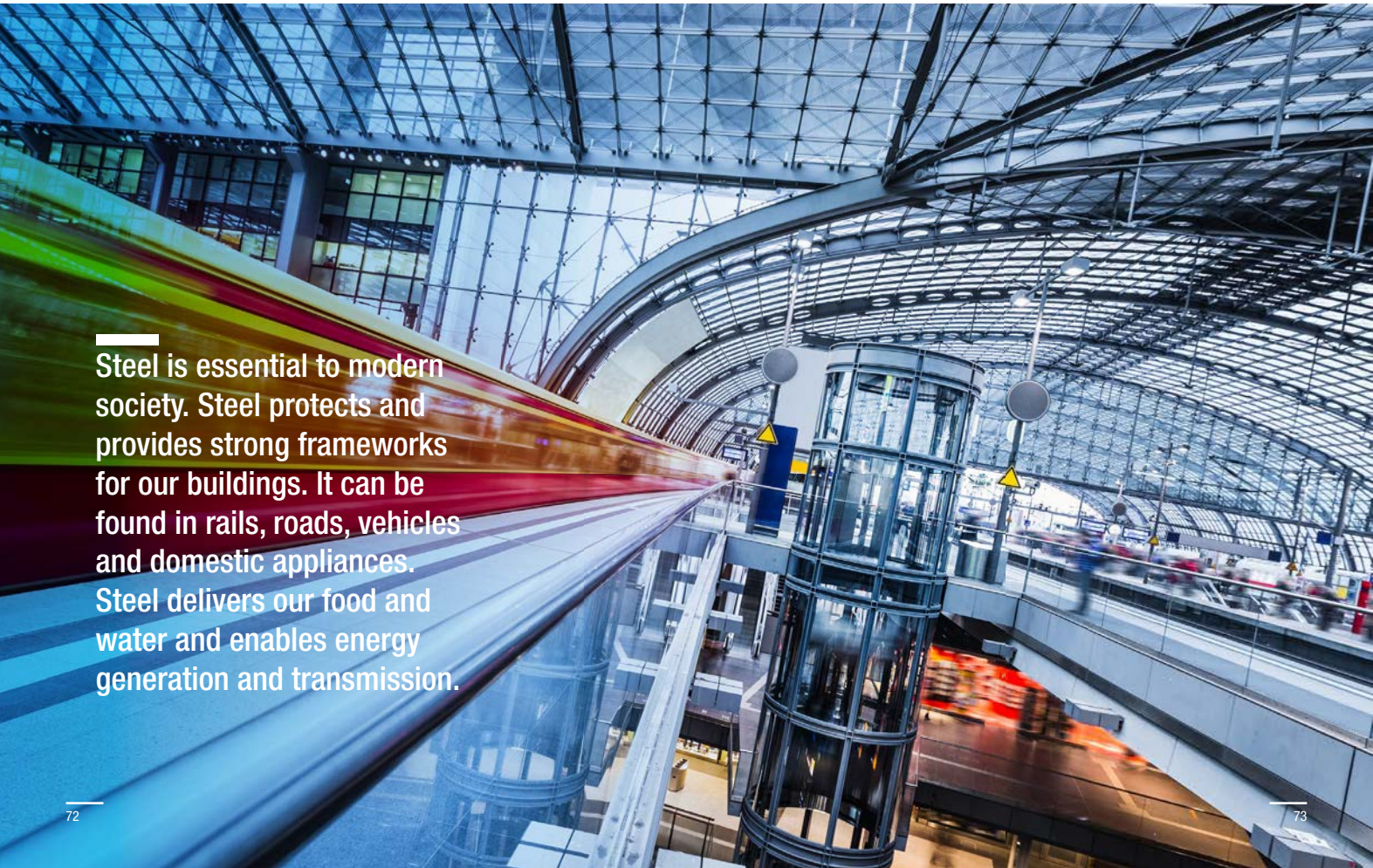
2.5 million

people work in secondary employment in the steel industry (rolling, stamping, service centres, trading etc.).

For every job created in the steel industry, 8.1 indirect jobs are created, or in other words, the steel industry supports the employment of

49.3 million people.

THE USES OF STEEL

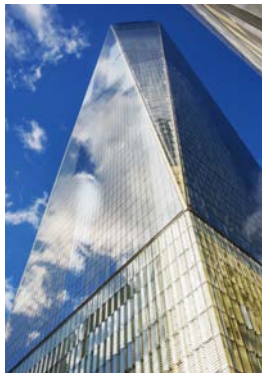


Steel is essential to modern society. Steel protects and provides strong frameworks for our buildings. It can be found in rails, roads, vehicles and domestic appliances. Steel delivers our food and water and enables energy generation and transmission.

The amount of steel used in the world reached 1,768 Mt in 2019. Steel markets are distributed as follows:

Buildings and infrastructure	52%
Automotive	12%
Metal products	10%
Mechanical equipment	16%
Other transport	5%
Domestic appliances	2%
Electrical equipment	3%

Steel offers the most economic and the highest strength to weight ratio of any building material, resulting in lighter buildings requiring less extensive and costly foundations.



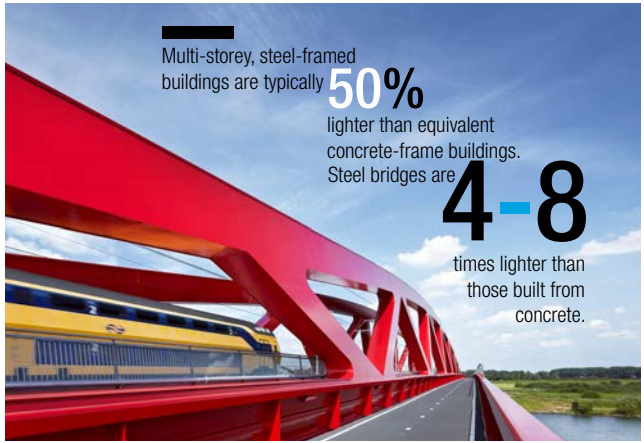
Substituting regular steels for

Advanced High-Strength Steels

makes it possible to build high-rise buildings with

50%

less steel compared to the amount needed 50 years ago.



Multi-storey, steel-framed buildings are typically **50%** lighter than equivalent concrete-frame buildings.

Steel bridges are **4–8** times lighter than those built from concrete.

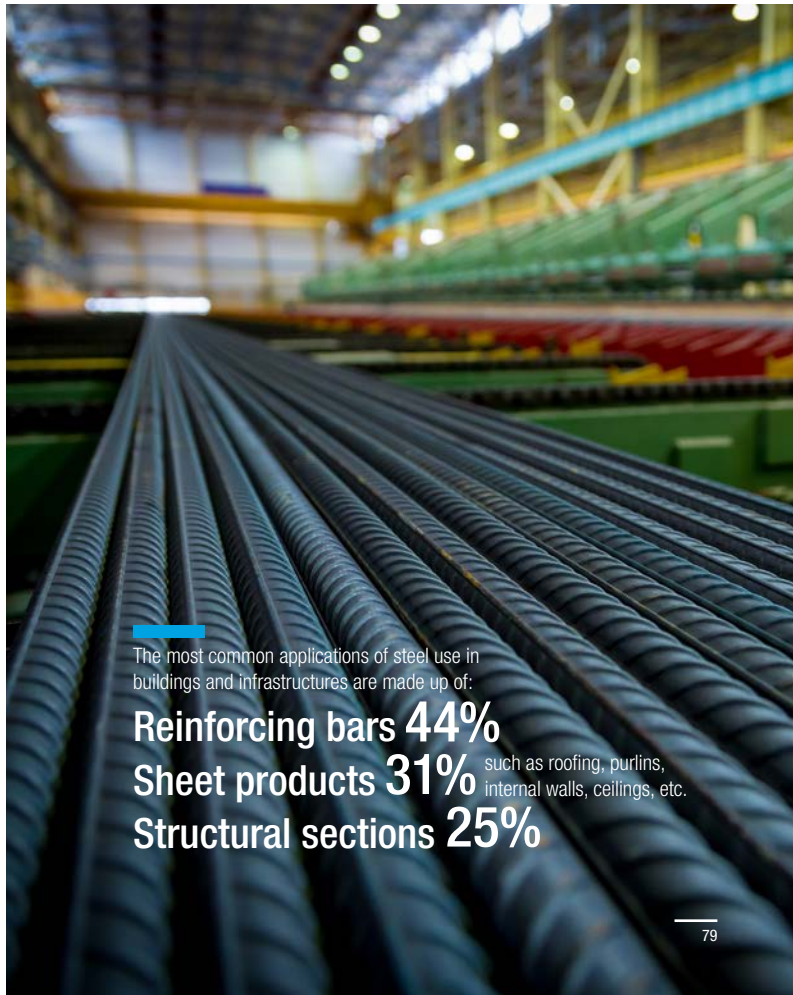
SKYSCRAPERS

are made possible by steel. Completed in 1885, the New York Home Insurance Building in Chicago, Illinois is the **first 10-storey building** to be supported by a structural steel frame.

In 2020, the total number of buildings in the world over **200** metres high, was

1,737

a 557% increase from the year 2000, when there were only 263.

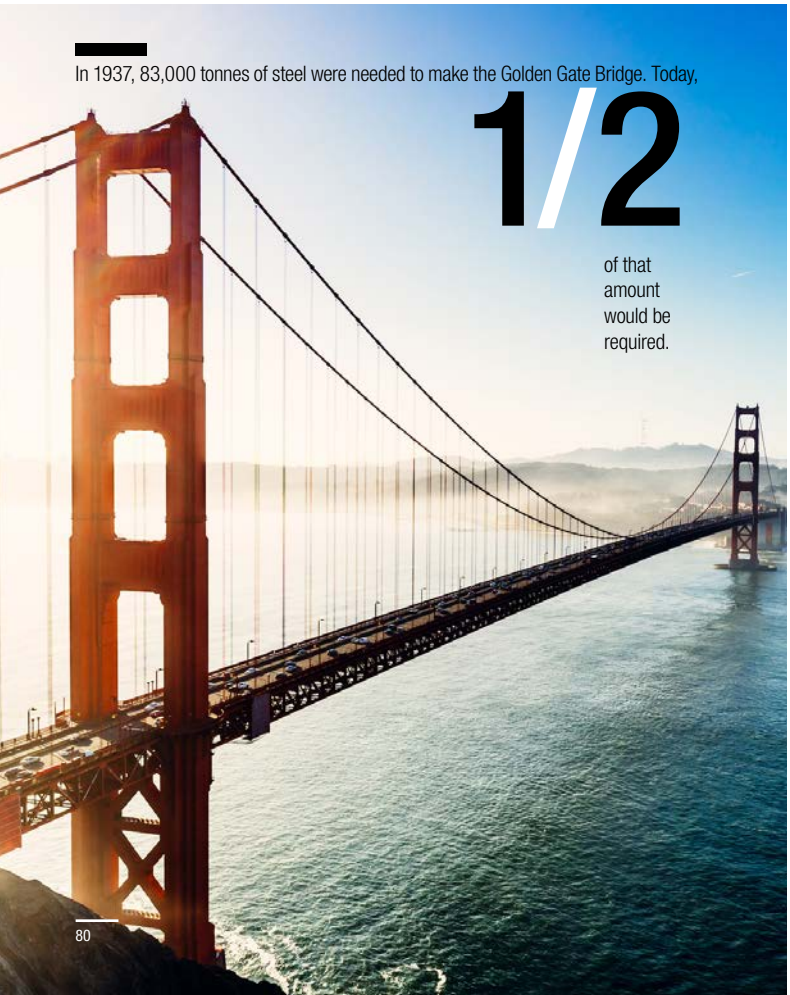


The most common applications of steel use in buildings and infrastructures are made up of:

Reinforcing bars 44%

Sheet products 31% such as roofing, purlins, internal walls, ceilings, etc.

Structural sections 25%



In 1937, 83,000 tonnes of steel were needed to make the Golden Gate Bridge. Today,

1/2

of that amount would be required.

Steel has enabled bridges to be even longer. Longer bridges reduce travel time and distance saving fuel and thus reducing CO_2 emissions.

Bridges are built to last. In 1883, New York's Brooklyn Bridge became the world's first steel bridge to carry traffic. More than 130 years later it still carries around 150,000 vehicles and pedestrians a day.

Evidenced by ArcelorMittal's peer-reviewed Steligence® programme, best-in-class steel solutions for an 8-storey building with a span of 13 metres between columns can be erected up to twice as fast as concrete equivalents, resulting in up to

24%

construction cost savings, and more usable space.

Steligence® is a registered trademark of ArcelorMittal.

Steel buildings are increasingly designed to be reused and are therefore easy to assemble and disassemble, ensuring major environmental savings. CO_2 emissions savings from building reuse are estimated at

1 to 1.5 kg CO_2/kg steel.

In earthquake prone zones, the foundations of a concrete building are

up to 75% heavier

compared to light steel-framed solutions. Steel frames have the added advantage of ductility and flexibility.

It takes 20 trees to build a typical 180 m^2 wood-framed home. A steel-framed home will require just **5** recycled cars.

Steel-framed buildings do not

warp, twist, split, swell, shrink, suffer from termites and mould or rot, unlike wooden ones.

Termites damage approximately 600,000 homes in the U.S. each year. A homeowner who discovers termite damage will spend an average of

$3,000 USD

to repair the damage.

Steel-framed structures are inherently non-combustible, and do not burn nor contribute to the spread or intensity of a fire.

To prevent steel framing's load-bearing capacity from diminishing at excessive temperatures, steel structures are coated with a

fire-resistant layer,

or surrounded with fire-resistant materials.

Car manufacturers use

Advanced High-Strength Steel (AHSS)

to reduce vehicle weight to achieve better fuel economy for internal combustion engines and increased range for battery electric powertrains.

The much acclaimed

first mass-produced car,

the Ford Model T, came off the production line in 1908. Already then, engineers made use of a highly strong and light material - vanadium steel - in critically stressed parts, such as the crankshaft, forged front axle, and wheel spindles.

Automakers are increasingly using Advanced High-Strength Steels (AHSS) to meet new stringent fuel efficiency regulations. Today vehicle body structures contain more than 50% AHSS.

Today the strength of steel in a vehicle's body structure can reach

1,900

MegaPascals.

This is nearly 10 times stronger than 50 years ago.

When taking a life cycle approach to compare

functionally equivalent automotive components,

Advanced High-Strength Steels consistently outperform lower density competing materials, emitting in the production phase

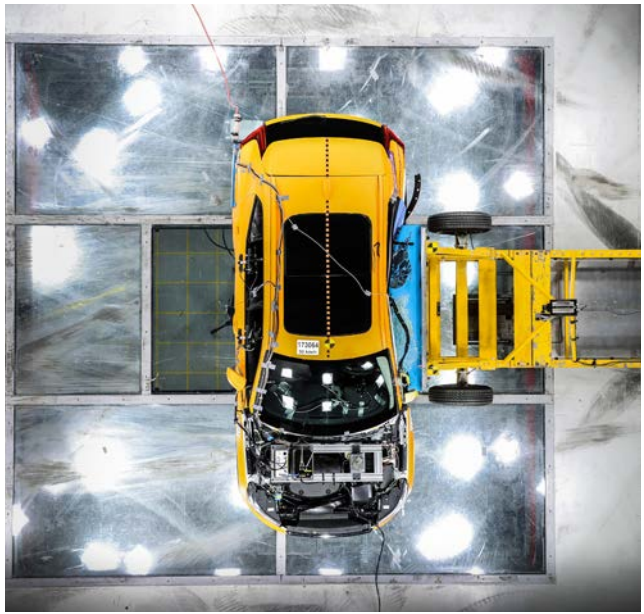
5 times less CO_2

than aluminium or carbon fibre, and

7 times less CO_2

than magnesium.

Car manufacturers use Advanced High-Strength Steel (AHSS) for safer vehicles. Some AHSS grades are engineered to absorb crash energy, such as in a front crash, and some are engineered to deflect crash energy such as in a side crash.



The Volvo XC40 has been designed for maximum occupant protection in all types of crash scenarios through the usage of

hot-formed boron steel

in the safety cage. This steel comprises 20% of the total body weight. The XC40 was selected as the 2018 EU Car of the Year.

There would
be no electric
mobility without

steel.

Electrical steel is an essential material in the construction of generators and motors for electric vehicles.

Automakers are opting for steel in the body of electric cars for

lightweighting, safety, battery protection and cost reduction.

The Chevrolet Bolt electric vehicle uses: **80% steel, of which 44% is Advanced High-Strength Steel (AHSS)**
The Hyundai Kona electric vehicle uses: **52% AHSS.**

Canned foods

preserve high levels of nutrients and vitamins. Contrary to popular belief, canned fruits and vegetables use

NO chemical preservatives

but are conserved via high-pressure processing techniques that also kill bacteria.

Steel cans are used to pack more than

1,500

food and drink items as well as paint, health and beauty products and household products. Canned foods are the most tamper-resistant food packaging option available today.

In the last 20 years, the weight of steel cans has been reduced on average by

33%.

The thickness of a 3-piece food can is down from 0.2 mm in 1986 to 0.12 mm today.

In **2019** average steel packaging recycling rates in Europe reached an all-time high of 84%. Germany, France, Belgium and the Netherlands reported rates of over 90%. In Japan in 2019, steel packaging recycling rate reached an impressive **93.3%**

Each can recycled saves about

1.5x

its weight in CO_2

The recycling of a single steel can saves energy equivalent to:

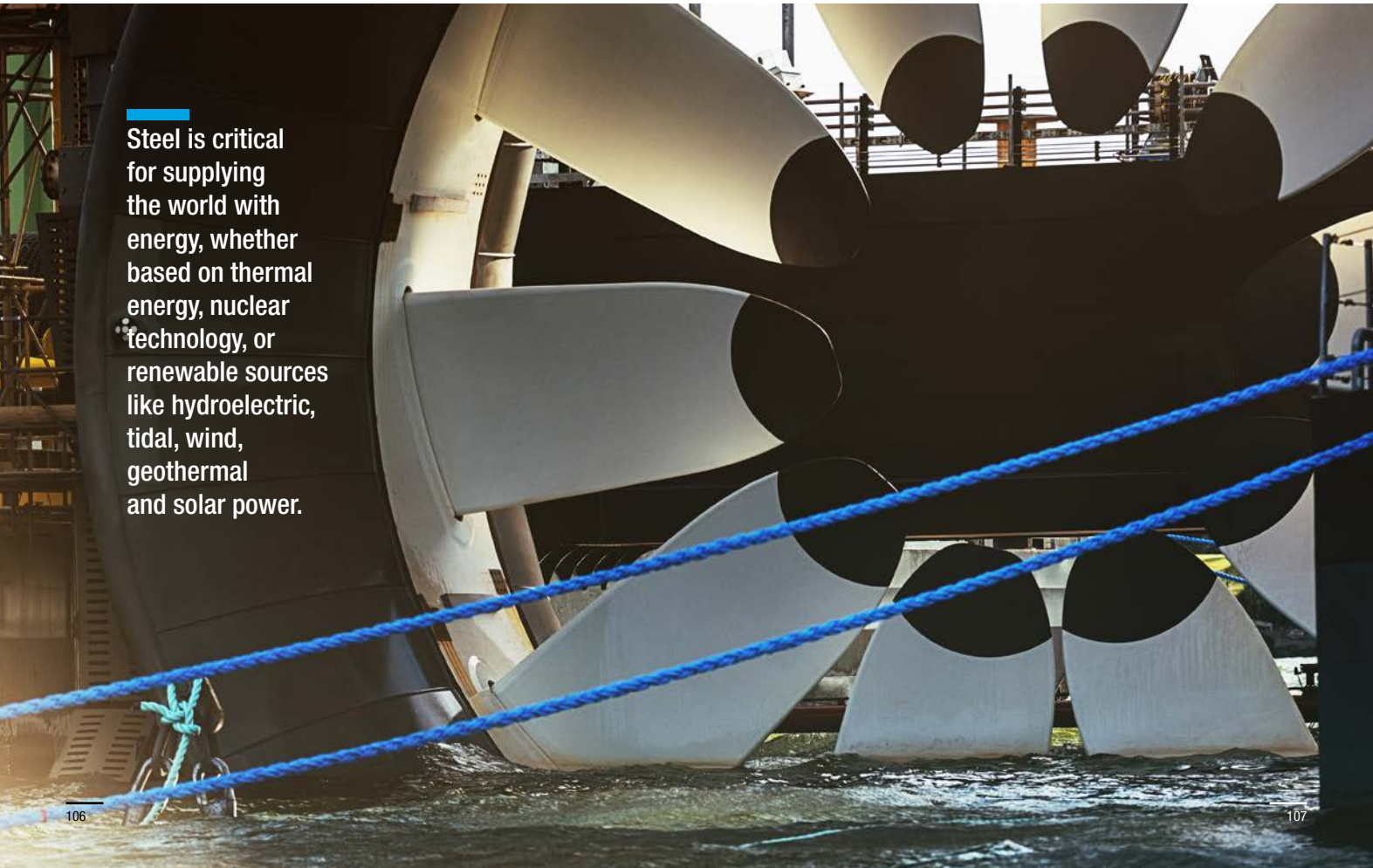
1 laundry load

1 hour of TV, or

24 hours of a 10-watt LED bulb.

In Europe, the market split for steel cans is as follows:

Processed food	54%
Beverage	12%
General line	14%
Closures	9%
Aerosols	8%
Other	3%



Steel is critical for supplying the world with energy, whether based on thermal energy, nuclear technology, or renewable sources like hydroelectric, tidal, wind, geothermal and solar power.

Steel

is essential

in the oil and gas industry, from drilling and extraction to processing and distribution. Pipes must meet specific needs in highly challenging environments.

Pipes can be made to withstand extreme temperatures of **over 400°C and below -40°C.**

They have to provide absolute reliability throughout their entire life cycle, which can last

up to 50 years.

The world's longest extended-reach oil well lies

15,000

meters deep in the sea of Okhotsk, Far East of Russia.

Steel is a material used throughout the nuclear industry due to its inherent strength, durability and other metallurgical properties.

Renewable energy sources rely heavily on steel and will play a key role in achieving the Paris Agreement target.

Hydropower is currently the leading renewable source, accounting for around 53% of the world's global renewable installed capacity in 2017. The Three Gorges Dam is the world's largest power station. The dam used

750,000 tonnes of steel in its construction, enough to build 102 Eiffel Towers.

A wind turbine is comprised of between 84% and 90% iron and steel materials, used in the tower, nacelle and rotor. An average of

300-600 tonnes

of steel are required for a typical 4 MW onshore wind turbine.

Amongst all renewables, solar power has experienced the fastest growth and currently accounts for approximately

25% of the world's global renewable installed capacity. Steel is used in the base, pumps, tanks, and heat exchangers of solar power installations.

Steel is crucial to rail transport. There are clear environmental benefits to rail transport over the alternatives.

Rail tracks are

100%

steel. Under normal circumstances a rail track has a life span of between 30 to 35 years. Sections which endure high pressure intensity such as tight curves on metro lines will last 12 years. An additional 5.5 years can be added when the rail track is moved to lower speed routes.

The world's longest rail line in a single piece is

150

metres long. This is 6 times longer than 50 years ago.

Today the length of the worldwide rail network spans

1,051,767 km. This is equivalent to going round the world 26 times.

Traveling by train can reduce CO_2 emissions by

91% and 88%

compared to flying and driving respectively. For an equivalent travel distance of 600 km, a plane will emit 93.0 kg of CO_2 and a car 67.4 kg, compared to only 8.1 kg of CO_2 for a high-speed electric train.

Steel makes up around

10-15%

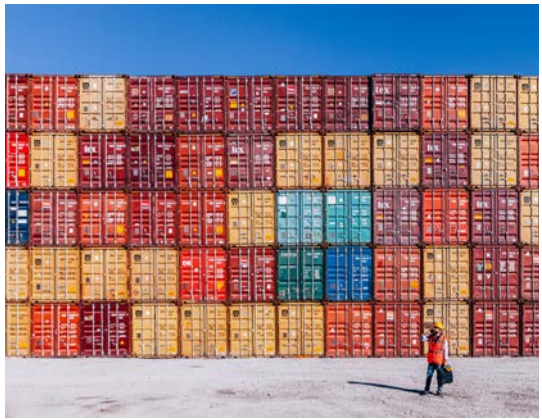
by mass of high speed trains. The main steel components of these trains are bogies (structure underneath the trains including wheels, axels, bearings, bogie frames and motors). Most freight wagons are made of steel.

Shipping goods by sea is the most environmentally-friendly and economical means of transport.

Ship hulls are made of steel plates that are welded together. CO_2 emissions per tonne of cargo transported over 1 km by ship is 3g, whereas by train and lorry it is 45g and 560g respectively.

Shipping goods by sea typically costs 12-16 times less

than sending them by aeroplane.



Around

17,000,000 shipping containers are currently in use across the world and the majority are made of steel.

The OECD estimates that levels of water loss vary from 17-30% in many developed cities. In Tokyo, replacing the old lead and ductile iron pipes with stainless steel pipes reduced recorded water loss from

17% to just 2%.

Heavy agricultural machinery compacts the soil and reduces the land's long-term ability to produce food. High-Strength steels can help to make machinery up to 30-50% lighter without compromising on durability.

Stainless steel is ideal for use in hygienic applications because it is inert and is easy to clean and to sterilise. It is resistant to wear and to scratching, which gives it a longer useful life than competing materials, which, in turn, gives it a significant life cycle cost benefit.

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.

Source information and photography credits are available at https://www.worldsteel.org/about-steel/steel-facts

This publication is printed on paper certified by the Forest Stewardship Council as environmentally-responsible paper.

steelFacts

ISBN 978-2-930069-90-6

Design: Make Alias London Limited

World Steel Association

Avenue de Tervueren 270
1150 Brussels
Belgium

T: +32 2 702 89 00
F: +32 2 702 88 99
E: steel@worldsteel.org

C413 Office Building
Beijing Lufthansa Center
50 Liangmaqiao Road
Chaoyang District
Beijing 100125
China

T : +86 10 6464 6733
F : +86 10 6468 0728
E : china@worldsteel.org

worldsteel.org

worldsteel
ASSOCIATION