

Beyond Green:

5 SHIFTS SHAPING THE STEEL INDUSTRY

– from Green Transition to Everlasting Era

“The world is undergoing a profound industrial revolution aimed at significantly reducing environmental impact. When we look at the entire steel sector, it is a steel-hard fact that the industry currently accounts for 10% of global greenhouse gas emissions – yet our society will still require significant amounts of energy and steel in the future.”



JOHANN STEINER

Executive Vice President for
Sustainability, Strategy and People at [Outokumpu](#)

“This report identifies five critical shifts for leading the industry into a new era – going beyond green, towards everlasting:

SHIFT 1. The focus is on carbon, for now

SHIFT 2. A hotter (geopolitical) climate

SHIFT 3. On the brink of full circularity

SHIFT 4. Manufacturing the demand

SHIFT 5. Aesthetics of the future

The report is primarily focusing on the Western world, with insights drawn from interviews with key stakeholders, primarily at the C-level, across the steel industry value chain.

With this document, we aim to provide a comprehensive understanding of the challenges and opportunities that lie ahead for the steel industry – for both carbon steel and stainless steel. The five shifts encompass the growing importance of sustainability, the significance of a stable regulatory environment, the need for the industry to move up the circularity value chain, the shared responsibility of the green transition costs, and the necessity for a repositioning of the green transition to gain wider public support.

To follow the next transformation path, we need to make the invisible visible. The question is: who will lead it?”

TABLE OF CONTENTS

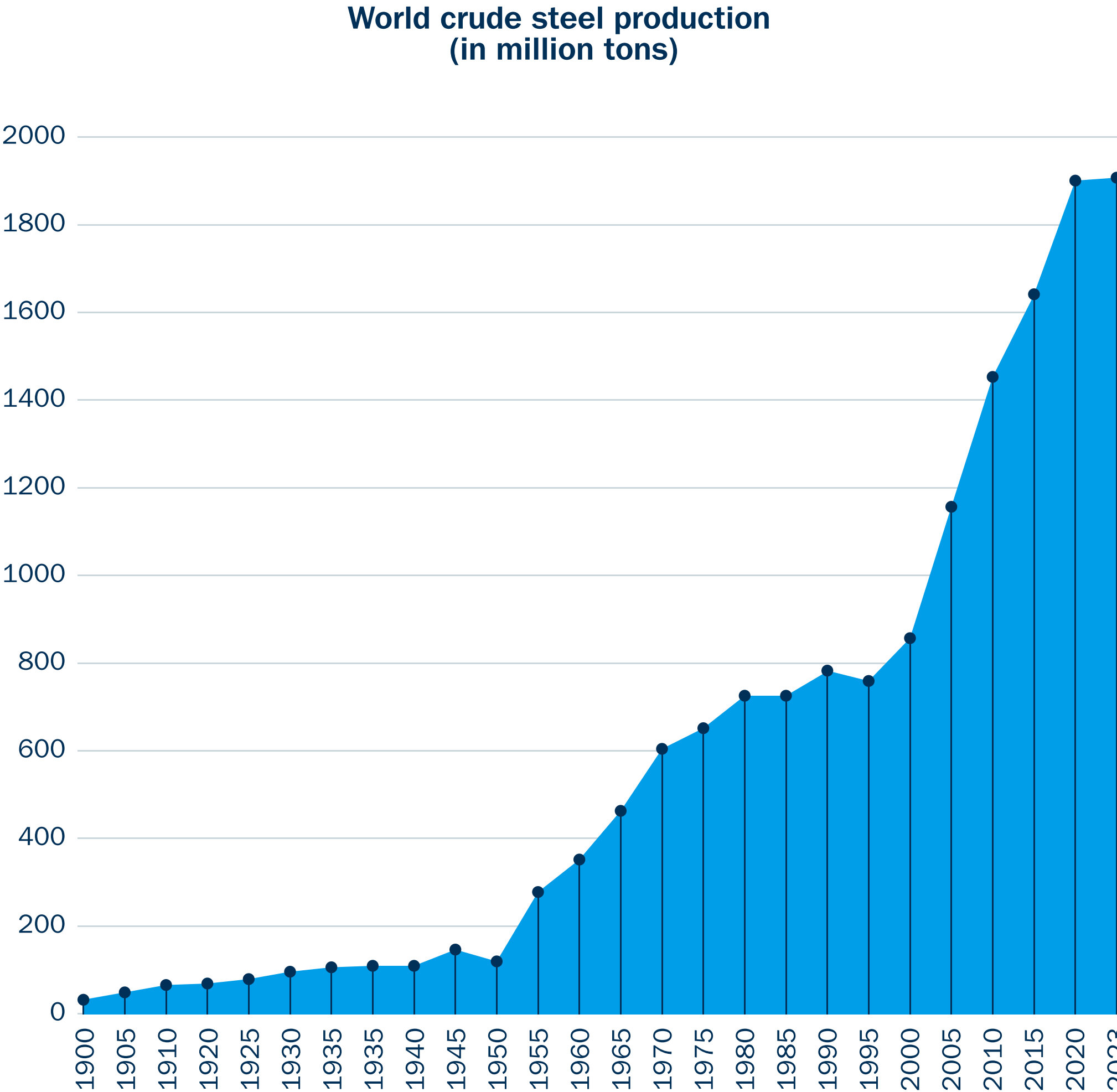
| | | |
|-------------|--|----|
| Backgrounds | UNSTOPPABLE MOMENTUM: STEEL’S RAPID RISE IN GLOBAL MARKETS | 04 |
| Shift 1. | FOCUS IS ON CARBON... FOR NOW | 09 |
| Shift 2. | A HOTTER (GEOPOLITICAL) CLIMATE | 22 |
| Shift 3. | ON THE BRINK OF FULL CIRCULARITY | 35 |
| Shift 4. | MANUFACTURING THE DEMAND | 44 |
| Shift 5. | AESTHETICS OF THE FUTURE | 53 |
| Conclusion | MAKING THE INVISIBLE VISIBLE | 61 |



Backgrounds

UNSTOPPABLE MOMENTUM: STEEL'S RAPID RISE IN GLOBAL MARKETS

In 2023, the steel industry reached a market value of \$928 billion, producing nearly 2 billion tons of steel. Over the past few decades, this sector has experienced significant transformations: new players have entered the global stage, and both economic and environmental challenges have intensified. At the same time, there is a global focus on developing innovative approaches to decarbonize production processes.



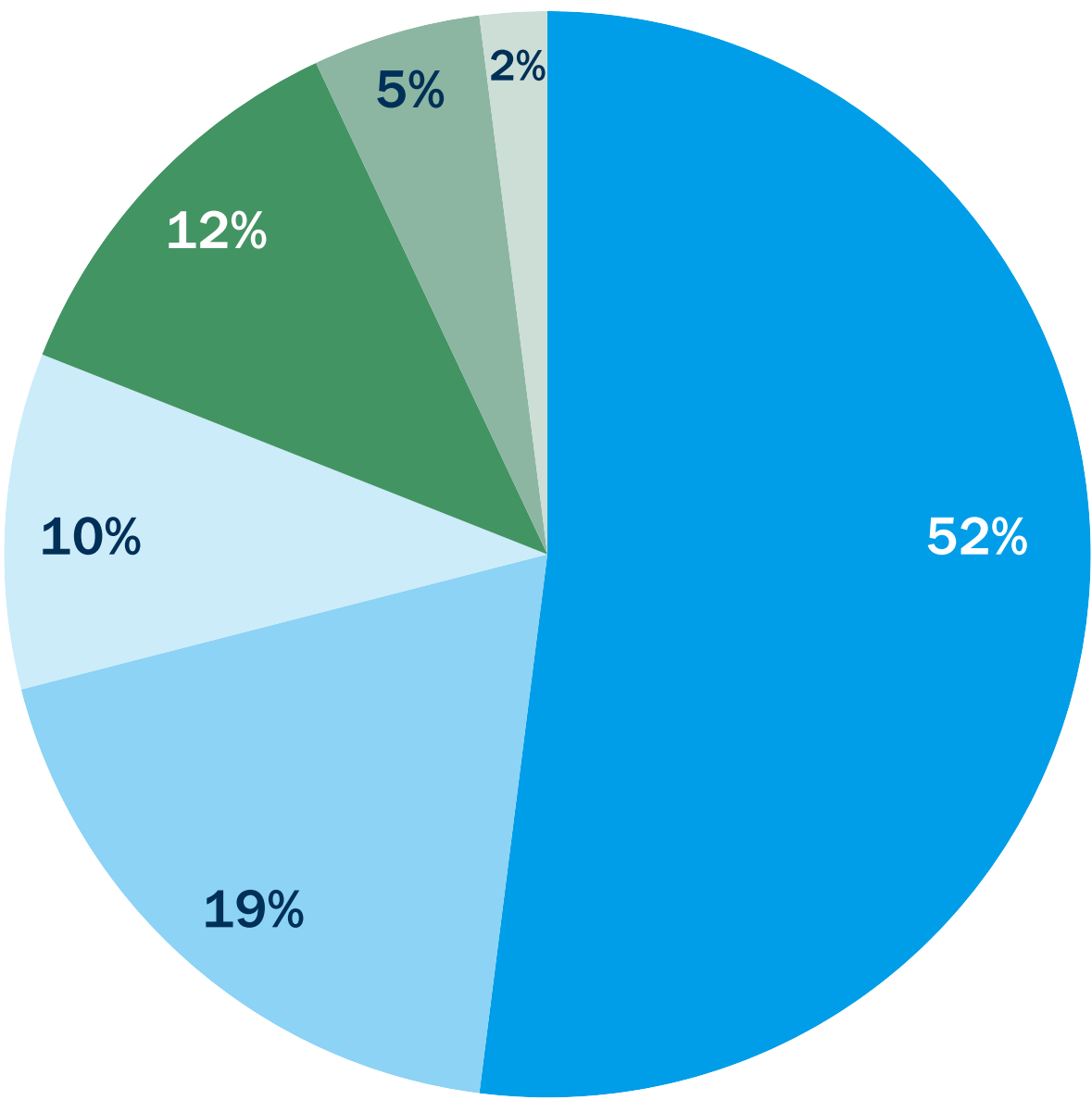


WHERE IS STEEL USED?

Steel, both carbon and stainless, is one of the most versatile and widely used materials in the world. It can be found in almost every aspect of life – in construction, transportation, manufacturing, energy, agriculture, and household appliances. Its strength, durability, and malleability make it an essential material in modern society.

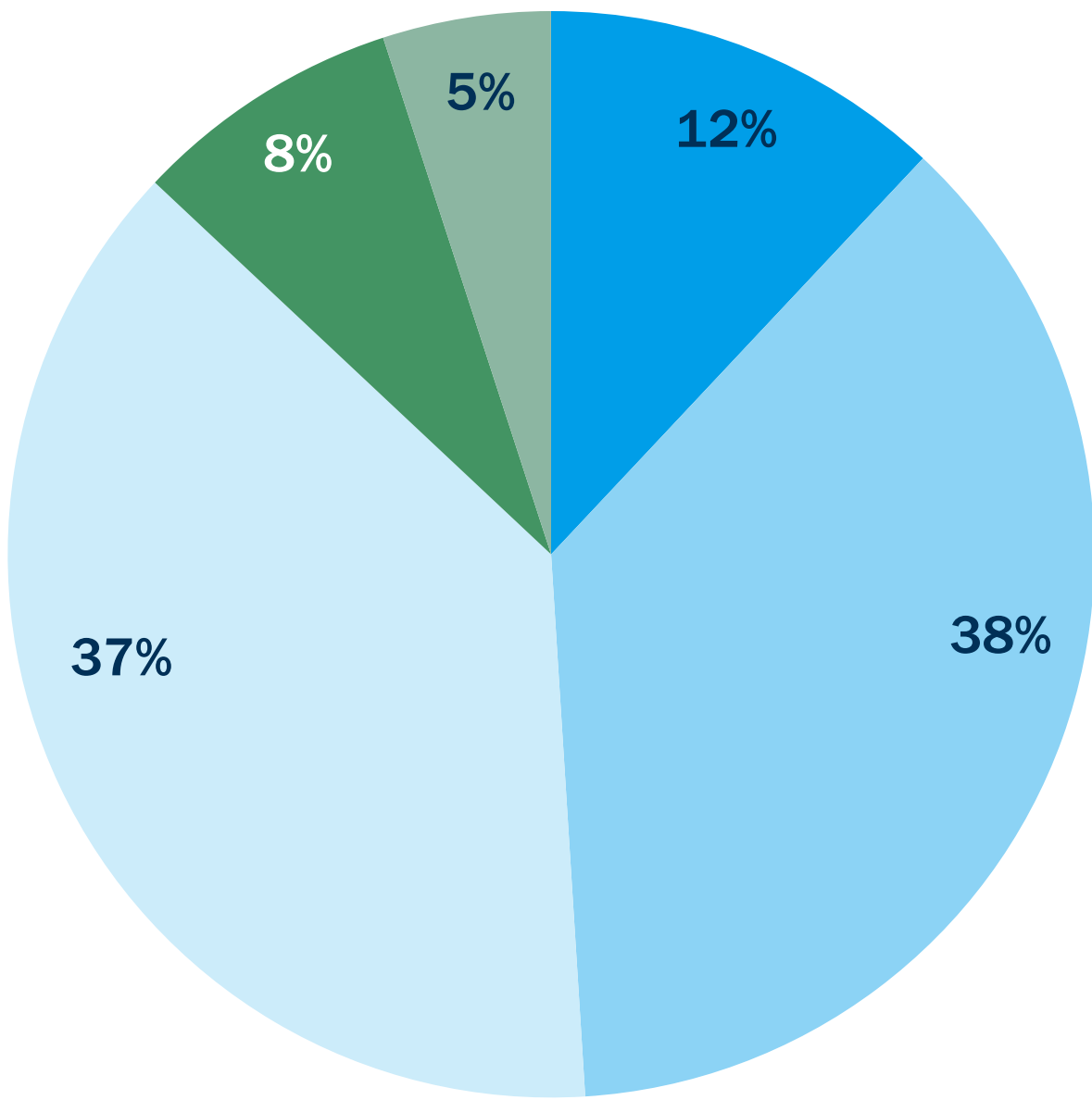
Source: World Steel Association

Where steel is used, 2022



- Building and infrastructure
- Automotive
- Electrical and mechanical equipment
- Transports (not automotive)
- Metal products
- Domestic appliances

Where stainless steel is used, 2022

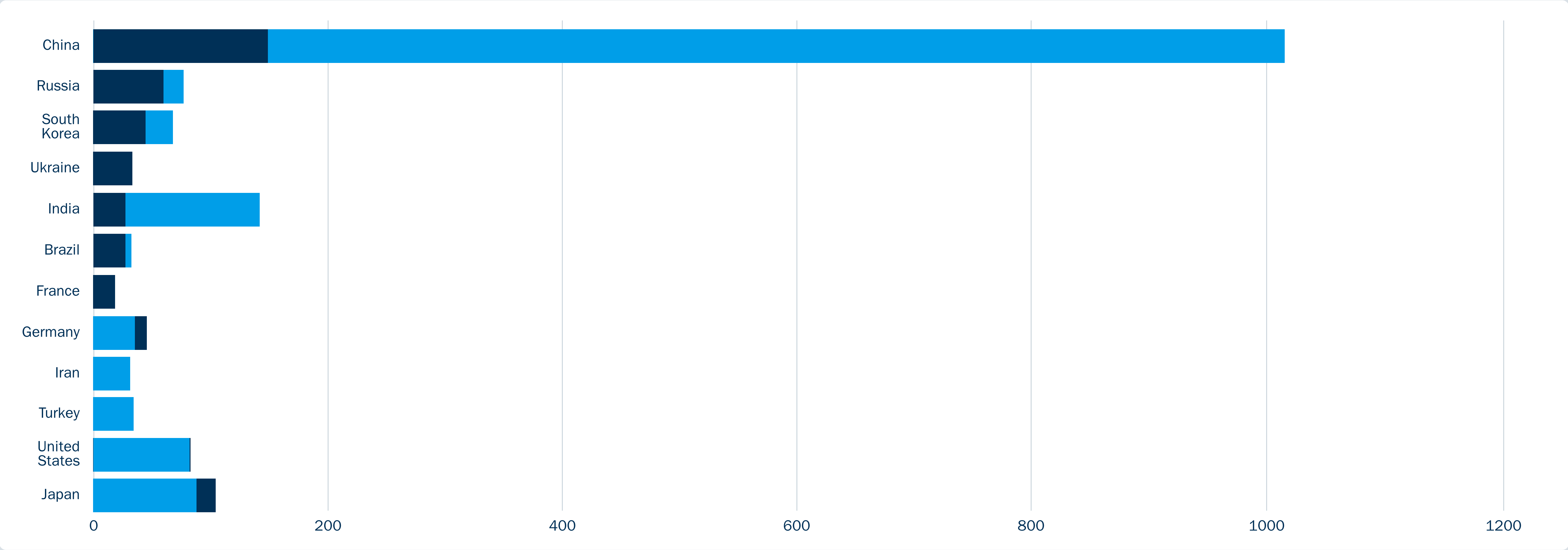


- Building and infrastructure
- Automotive
- Electrical and mechanical equipment
- Transports (not automotive)
- Metal products

AN EXPONENTIAL ACCELERATION

The exponential aspect is well illustrated in China’s meteoric rise as the world’s largest producer by far. In 2000, China represented approximately 17,5% of global steel production. In 2023, this number was 54%. This exponential rise also meant that the global impact of steel has risen sharply. Today, the industry is responsible for approximately 10% of global greenhouse gas emissions. By 2050, steel industry emissions need to be reduced by 90% compared to 2022 levels, a monumental change that requires a deep transformation of steel actors from around the world.^[1]







Crude steel production per country in million metric tons ● In 2000 ● In 2023





MAIN CHALLENGES FOR STEEL INDUSTRIES IN EVERY REGION

Source: World Steel Association, Kairos Future, from a compilation of sources.

| | | | | | | |
|-------------------------|---|--|--|---|--|--|
| |  |  |  |  |  |  |
| Continent | NORTH AMERICA | SOUTH AMERICA | EUROPE | AFRICA | ASIA | OCEANIA |
| Share of production | 5,8% of global steel production | 2,2% of global steel production | 13,8% of global steel production | 3,5% of global steel production | 70,1% of global steel production | 4,6% of global steel production |
| Dominant technology | Electric Arc Furnace (EAF) using scrap, some Direct Reduced Iron (DRI) | Mix of BF-BOF and EAF, potential for increased DRI (Brazil) | Blast Furnace-Basic Oxygen Furnace (BF-BOF) | Growing DRI production using natural gas | BF-BOF, with some EAF and DRI (India) | Mostly EAF using domestic scrap |
| Decarbonization pathway | Lower carbon footprint than Europe due to high scrap-based EAF production. Further decarbonization will focus on increasing scrap usage and some adoption of H2-DRI, although scale may be limited by already high scrap utilization rates. | Potential for increased DRI production in Brazil using ample natural gas reserves. Decarbonization will involve optimizing current production mix and gradual transition to lower-carbon technologies. | Dominated by BF-BOF route, presenting a significant decarbonization challenge requiring transition to hydrogen-based direct reduced iron (H2-DRI) and electric arc furnaces (EAF). | Transitioning from natural gas to H2-DRI is a decarbonization pathway as renewable energy capacity expands in the region. Increasing steel demand will drive technology choices for new capacity. | Decarbonizing massive BF-BOF capacity is a monumental challenge requiring multiple pathways including H2-DRI, carbon capture utilization and storage (CCUS), and increased scrap usage. Transition pace will vary across the region based on policy support, access to key inputs, and age of existing assets. | Positioned to be a major supplier of hydrogen and high-grade iron ore to support DRI production in Asia. Domestic decarbonization will focus on renewable energy for EAF production. |



Shift 1.

FOCUS IS ON CARBON... FOR NOW

From carbon reduction
to expansion of
sustainability

The steel industry – in common with many industries – is seeing carbon reduction emerging as its most urgent imperative. Responsible for approximately 10% of global emissions, the sector faces mounting pressure to decarbonize. The stakes are high: in Europe, carbon pricing mechanisms are already in place, while in the USA substantial incentives for carbon-neutral processes are deployed. This has ignited a silent but fierce race to develop zero-impact steel, a pursuit that could redefine the industry's future in an increasingly decarbonized world.

Yet, as the industry grapples with its role and responsibilities in climate change, it must not lose sight of a broader, increasingly complex sustainability landscape. And while carbon emissions are just one of the nine critical planetary boundaries, they are also crucial focus area, as they significantly contribute to the degradation of other boundaries, such as biodiversity loss. As the steel industry embarks on this transformative journey, a crucial question looms: what unforeseen challenges and responsibilities await beyond the carbon horizon?





“When I started in the steel industry, there were only a few discussions ongoing about CO₂ even though the industry created more CO₂ than steel. China was just starting, and that was only less than 20 years ago. Things have changed a lot.”

JUHA ERKKILÄ

Vice President, Innovations at

[Outokumpu](#)

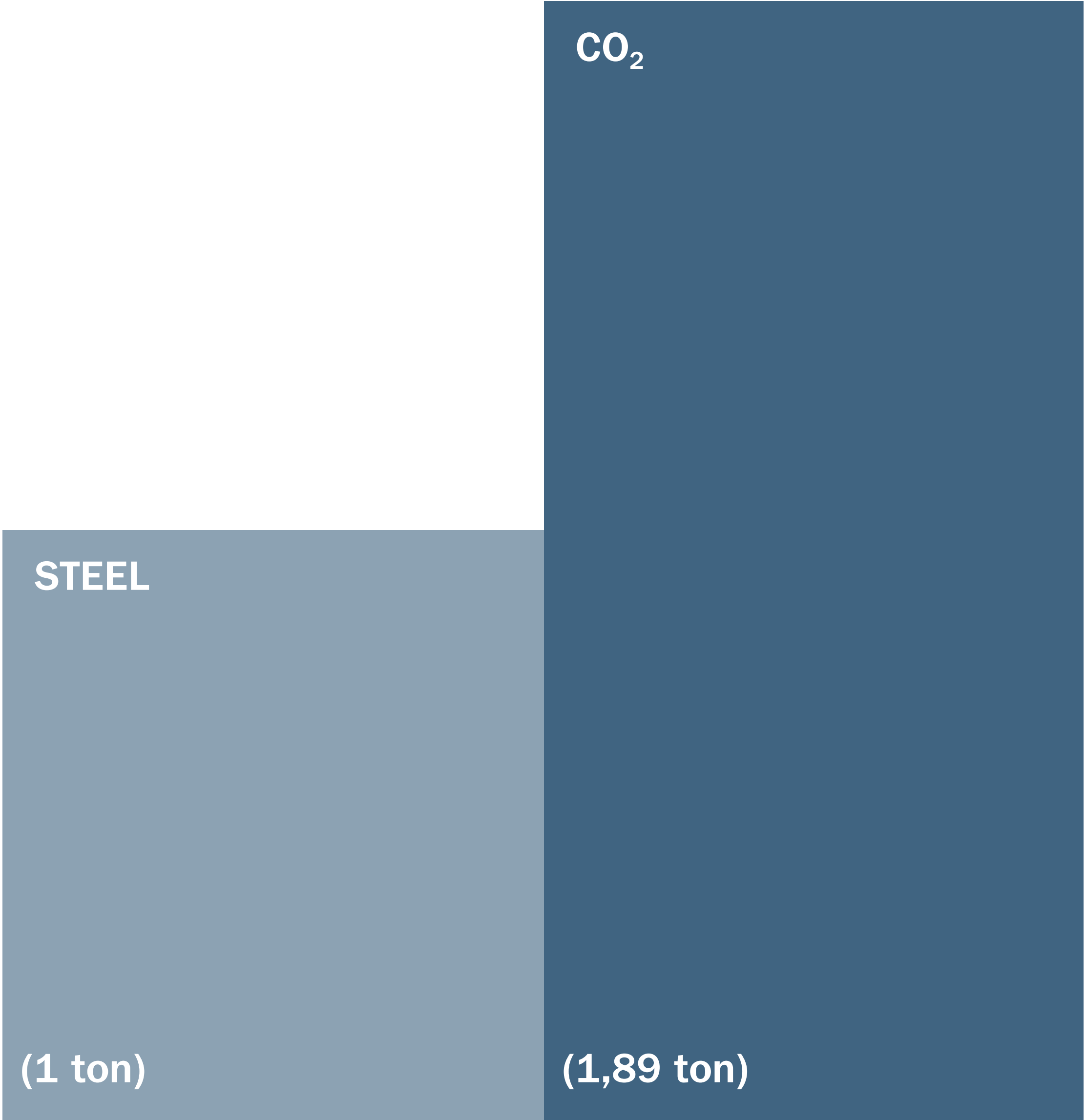
EFFICIENCY AT THE CENTER

For every ton of steel produced today, almost two tons of CO₂ (1.89t) are released. This makes steelmaking a fundamentally emission intensive process.

In a world where most countries have agreed to limit climate change to the 1.5°C increase of the Paris agreement, we need to move towards the pricing of externalities^[1]. In other words, it is becoming increasingly important to ensure that the cost of environmental damage is reflected in the market price of goods or services.

^[1] www.imf.org/external/pubs/ft/fandd/basics/38-externalities.htm

Current steel production average





ALL ROADS LEAD TO CARBON REDUCTION

There are currently a few mechanisms in place to reduce emissions and price in one of the main externalities – carbon. Some are meant to stimulate low-carbon industries by subsidies (such as the Inflation Reduction Act in the US), while others are focused on giving carbon a price in the hopes of motivating industries to innovate their way out of high carbon costs.

The difficulty is that for globally traded commodities like steel, unilateral carbon pricing can lead to carbon leakage^[1] if production shifts to countries with laxer regulations. In that case, global CO₂ emissions are rather likely to increase.



STEPHAN MAY

CEO Electrification and Automation Business unit at [Siemens](#)

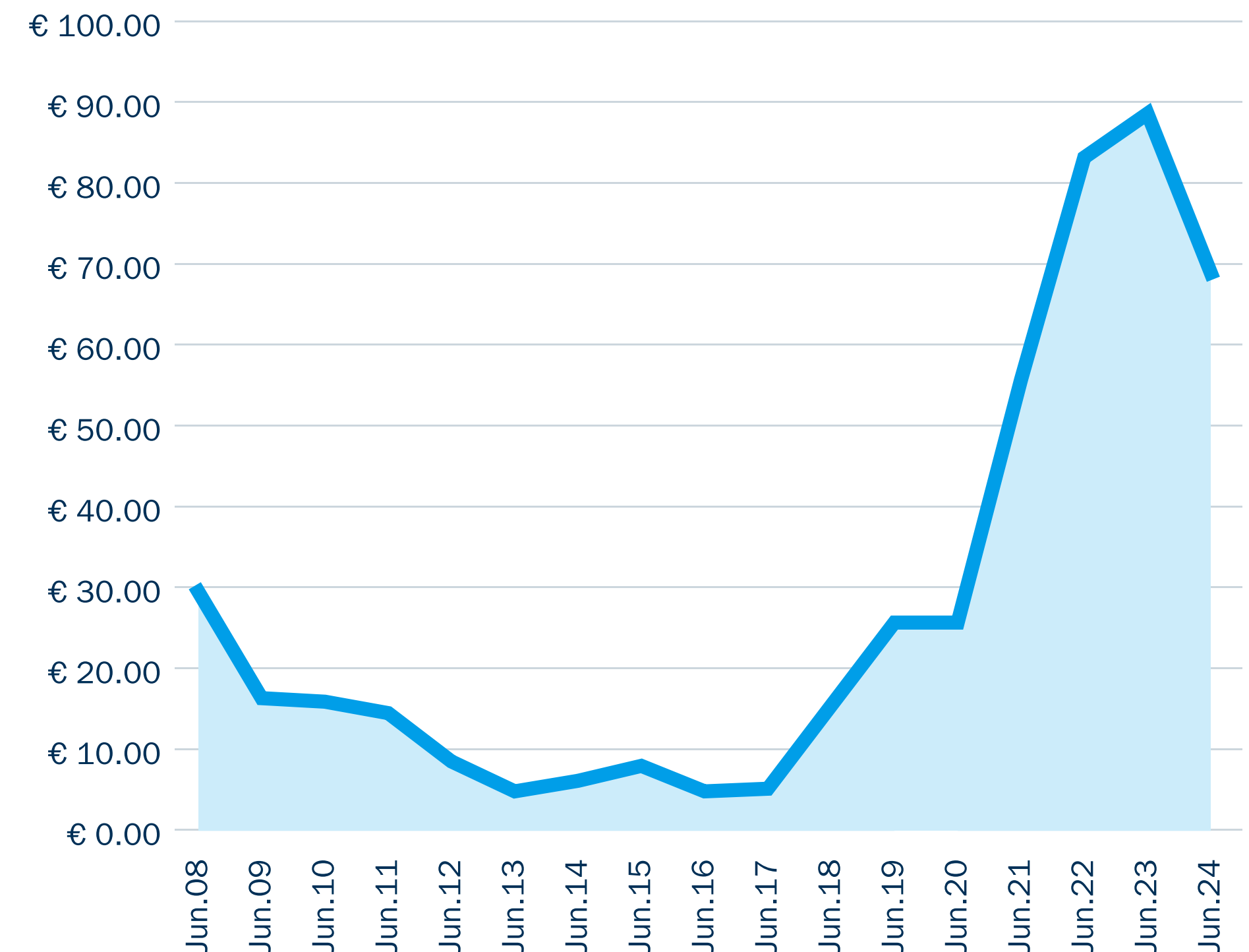
“As a global business, we encounter diverse perspectives on CO₂ footprint reduction. In some regions, particularly within the EU, there is a strong focus on minimizing carbon emissions, while in others, the interest is less pronounced. There isn't a uniform approach, but overall awareness is growing. Our relationship with customers has become more collaborative – moving beyond the traditional model of setting specifications and receiving responses. Together, we explore alternative solutions that reduce CO₂ footprints while still meeting our objectives.”

^[1] Carbon leakage refers to the situation where companies relocate their carbon-intensive production to countries with less stringent emissions regulations, often leading to an increase in total emissions.

PUTTING A PRICE ON CARBON

Economists at the London School of Economics argue that carbon pricing is the most efficient way of decarbonizing the economy^[1]. Not only does it lead to more efficient behavior in consumers and industry, it also provides a way to fund the transition. Many governments have implemented schemes to put a price on carbon emissions, such as emissions trading systems (ETS). The European Union currently has the most advanced system, where the price of emitting a ton of carbon has increased almost tenfold in 5 years. China, California, Canada, all have carbon pricing systems as well, albeit significantly less encompassing.

Carbon price for the EU Emissions trading system
(1 tonne, June ever year since 2008)



Source: Sandbag

^[1] www.lse.ac.uk/granthaminstitute/explainers/what-is-a-carbon-price-and-why-do-we-need-one/



“Rules are important. There is significant confusion about what qualifies as green steel. Clearer rules are needed to define what constitutes real green steel and what needs to be included. Europe currently lacks these rules. Once established, communication will improve, and decision-making will be easier.”

CLAUDIA ALFIERI

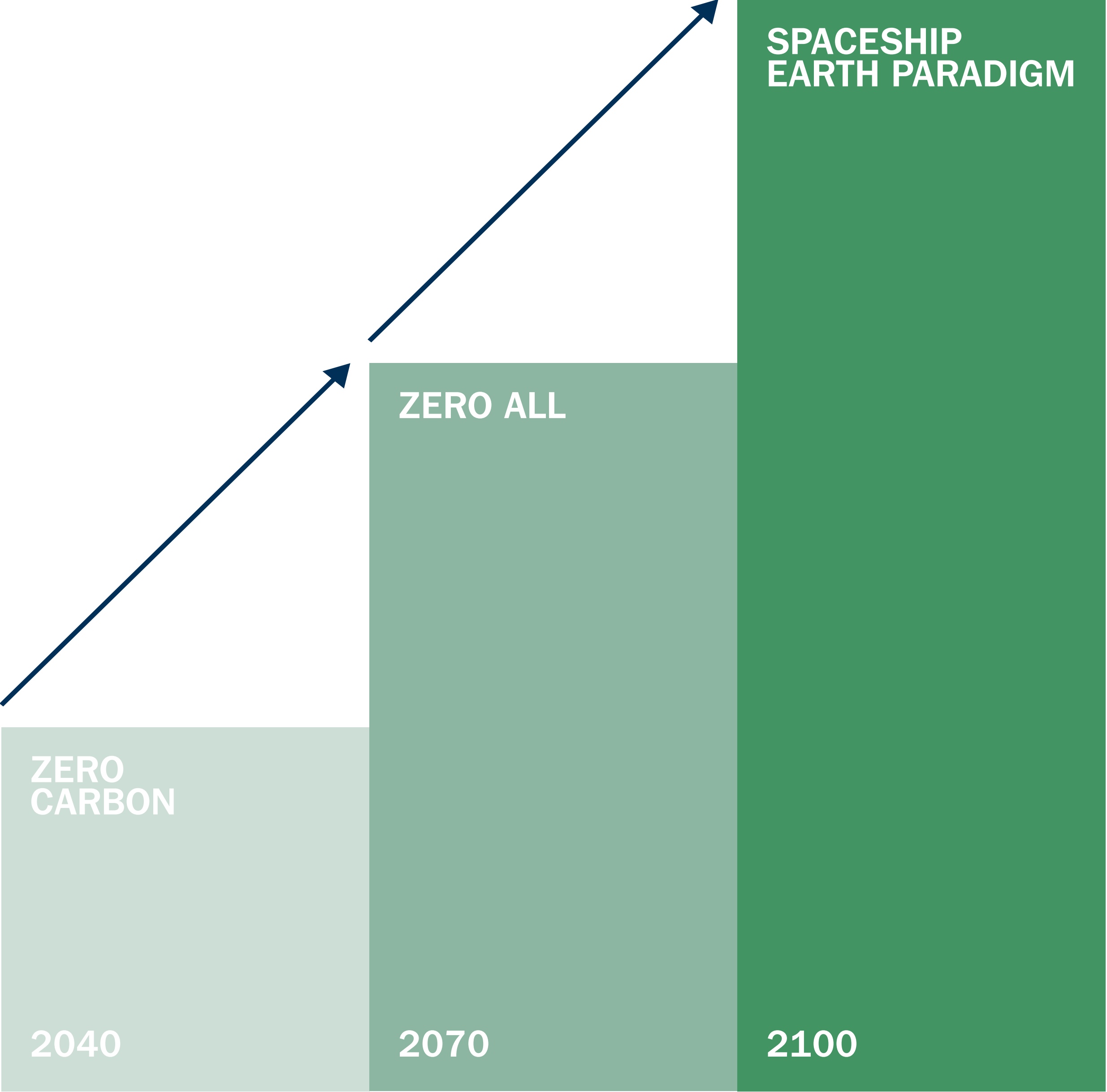
CEO at [Padana Tubi](#)

BEYOND CARBON

The road to decarbonization is long and costly, but one that the steel industry is particularly well placed to travel. The carbon free processes already exist, and the industry already has high collection rates (around 85% of end-of-life steel collected for recycling today). While tackling decarbonization, other challenges emerge on the horizon that will need to be addressed simultaneously. When asked, experts interviewed for this study expect biodiversity or water to be the next major sustainability challenge for manufacturing companies to quantify and address.

Greenhouse gas emissions are linked to both water scarcity and biodiversity loss. Climate change caused by emissions leads to more frequent droughts and alters precipitation patterns, exacerbating water shortages in many regions. Emissions also contribute to rising temperatures and changing climatic conditions that threaten many species and ecosystems^[1].

Protecting biodiversity and ecosystems is also the 4th most common type of climate related lawsuit. Zooming out, the long-term vision is for a regenerative industry to reach the potential for a “spaceship earth” paradigm^[2].



The quest for an emission-free world is just the beginning of humanity's journey towards becoming an advanced civilization. After tackling the carbon challenge, we must focus on minimizing our impact on all aspects of the environment, from biodiversity to water usage. Ultimately, we need to undergo a paradigm shift and view Earth as a closed-system, akin to a spaceship, where resources are finite and must be managed with utmost efficiency. By adopting the mindset of astronauts on a spaceship and striving for maximum efficiency in all human activities, we can ensure a sustainable future. Source: Kairos Future.

^[1] IPBES-IPCC, Biodiversity and Climate Change Synopsis, 2021

^[2] "Spaceship earth" was popularized in the 1960s by American systems theorist Buckminster Fuller to describe the closed system of our planet that humans ought to manage responsibly, recognizing our shared dependency on its limited resources.



"To accelerate the green transition in our society, companies need to commit to sustainability beyond their own operations. By decarbonizing, we do not only reduce the carbon emissions of our production and supply chain, but also provide low-emission solutions to critical industries from infrastructure to renewable energy and automotive. The positive impact companies can create through carbon handprint also accelerates the business case for sustainability – and that is the transformation many industries, including the steel industry, are now facing."

HEIDI PELTONEN

Vice President, Sustainability at [Outokumpu](#)

LOOKING AT THE FUTURE DIRECTION OF SUSTAINABILITY

For those who want a glance at what sustainability regulation might encompass in the future, the Planetary Boundaries provides a good overview. Produced by researchers at the Stockholm Resilience Centre, the planetary boundaries model is the best to date accounting for the interdisciplinary nature of human impact^[1].

The planetary boundaries model identifies nine essential, quantifiable boundaries within which humanity must operate to maintain long-term sustainability. These boundaries encompass various aspects of the Earth's systems, from climate change to biodiversity loss to chemical pollution. The model also strengthens the argument of biodiversity being the next major concern for industry to address.

● Safe operating space

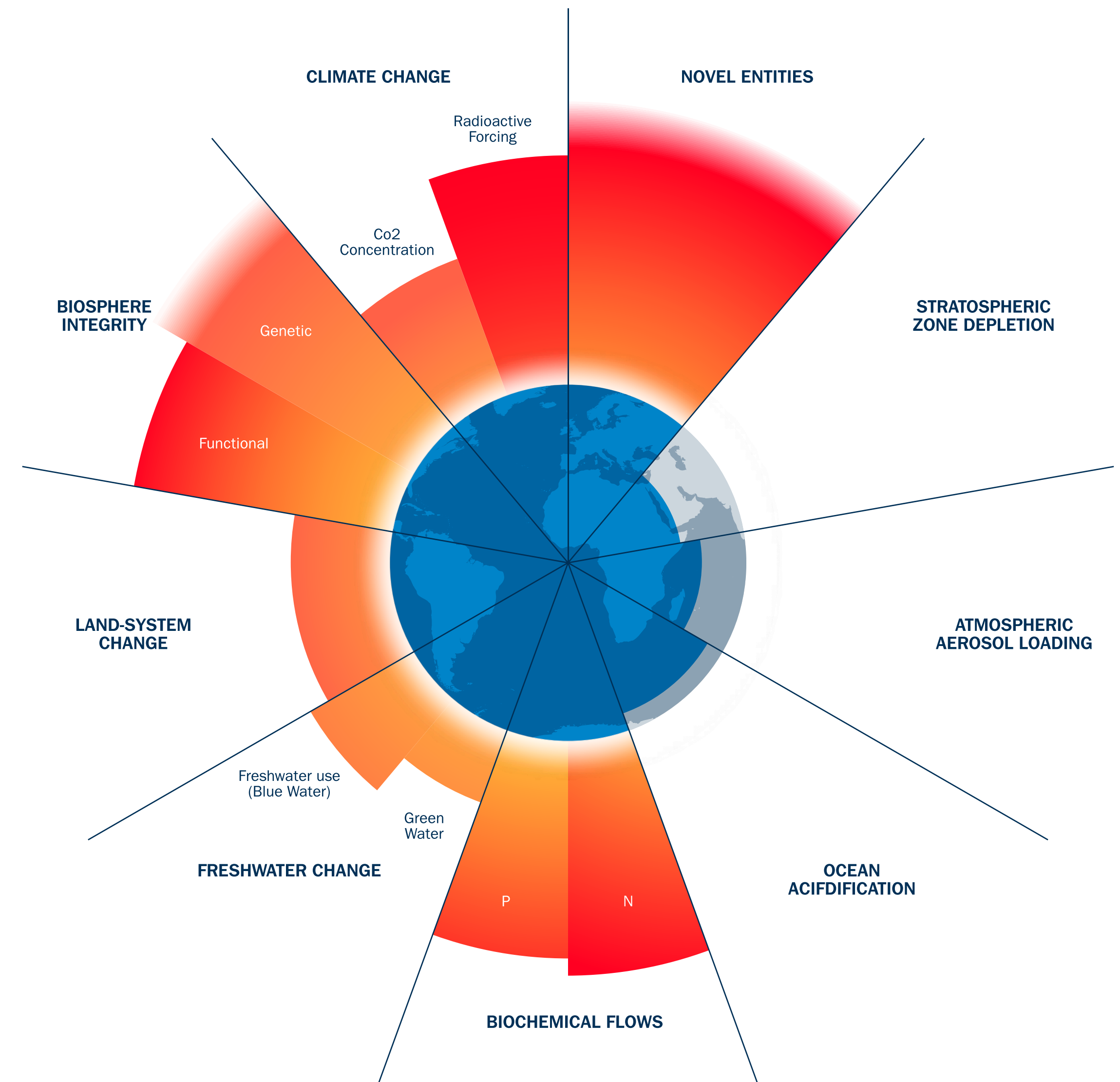
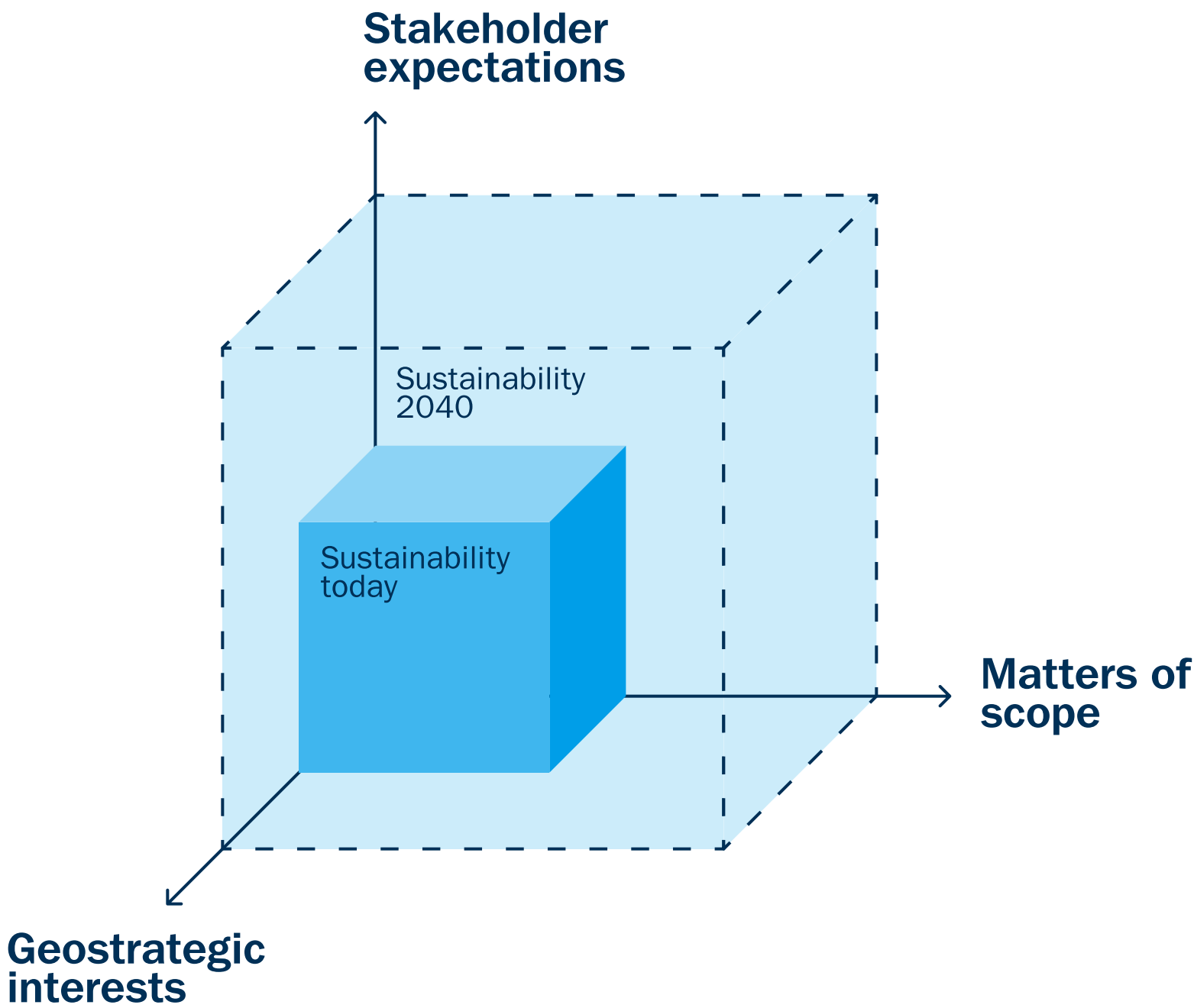


Figure 1: Planetary Boundaries model, developed by the Stockholm Resilience Centre.
Licensed under CC BY-NC-ND 3.0

^[1] www.stockholmresilience.org/research/planetary-boundaries.html

THE EVER-EXPANDING SUSTAINABILITY MATRIX

The global business landscape is experiencing a significant shift towards heightened complexity across various domains. This trend is characterized by a confluence of factors, including population growth, rapid technological advancements, evolving regulatory frameworks, and the proliferation of diverse interests and stakeholders. Navigating this intricate terrain requires a comprehensive understanding of the multifaceted nature of sustainability and its expanding scope in the 21st century.



Growing strategic importance

- Critical material extraction
- Material refinement and processing
- Materials recovery
- Export markets
- Low carbon technology

Widening stakeholder expectations

- Consumers
- Investors
- Employees
- Regulators

Expanding matters of scope

- Climate
- Materials
- Biodiversity
- Water
- Other planetary boundaries
- Working conditions
- ESG reporting



"The steel industry stands at a crossroads. Decarbonization is not merely a goal; it's a necessity, requiring a paradigm shift. To achieve this, we must invest in cutting-edge but affordable technologies and collaborate with industry leaders and suppliers. Clean energy transition combined with a strong energy efficiency and renewable energy sources will play an important role in the puzzle. Companies should further accelerate the progress towards a decarbonized future – a new era of steel production. Smart and focused decarbonization is the key to success in this important transition."

STEFAN ERDMANN

Chief Technology Officer at [Outokumpu](#)

UNDERSTANDING THE SHIFT

While today's focus is carbon-centric, tomorrow's challenges will demand a holistic approach, likely increasingly encompassing more planetary boundaries and higher social requirements. The industry's journey from carbon reduction to sustainability expansion will redefine its role in a world where environmental stewardship is no longer only about emissions, but about multiple sustainability dimensions.

Key future questions

- 1.** How does your organization leverage decarbonization innovations to also benefit other environmental aspects?
- 2.** How can your organization finance its green transition and what will be the cost if you do not?
- 3.** What kind of pricing mechanisms and regulation do you need to accelerate sustainability?



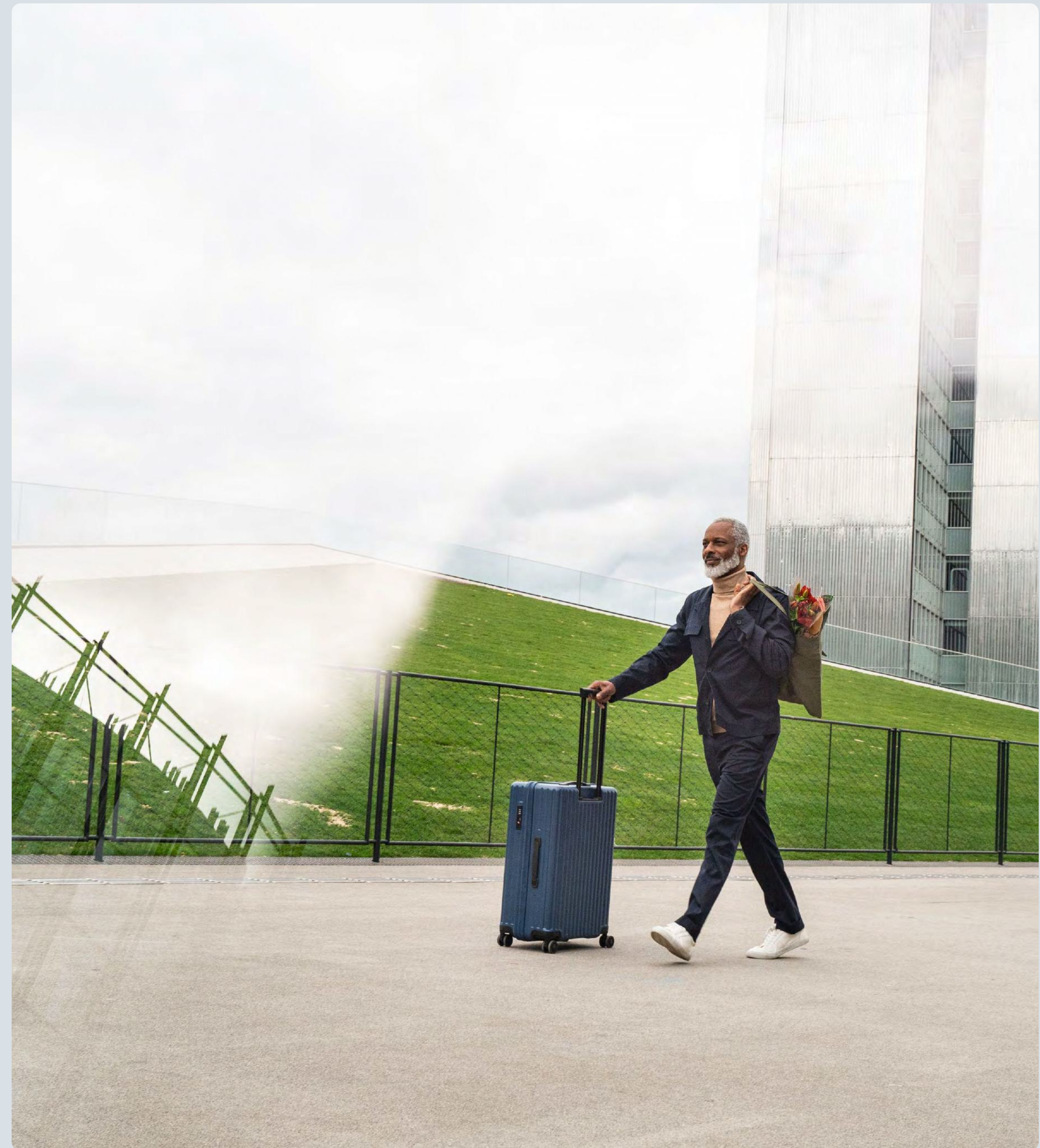
Shift 2.

A HOTTER (GEOPOLITICAL) CLIMATE

From
geopolitics
to policy

Being at the infrastructural core of both civil society and military industry puts steel in a strategically ambiguous place. For most of its existence steel production grew linearly and the largest players in the field did not change very quickly.

But since the end of the 20th century, exponential growth has massively changed the steel landscape. With globalization as we know it heading for an uncertain fate and the rise of protectionism, the steel markets look set to grow in a more risk-oriented environment.



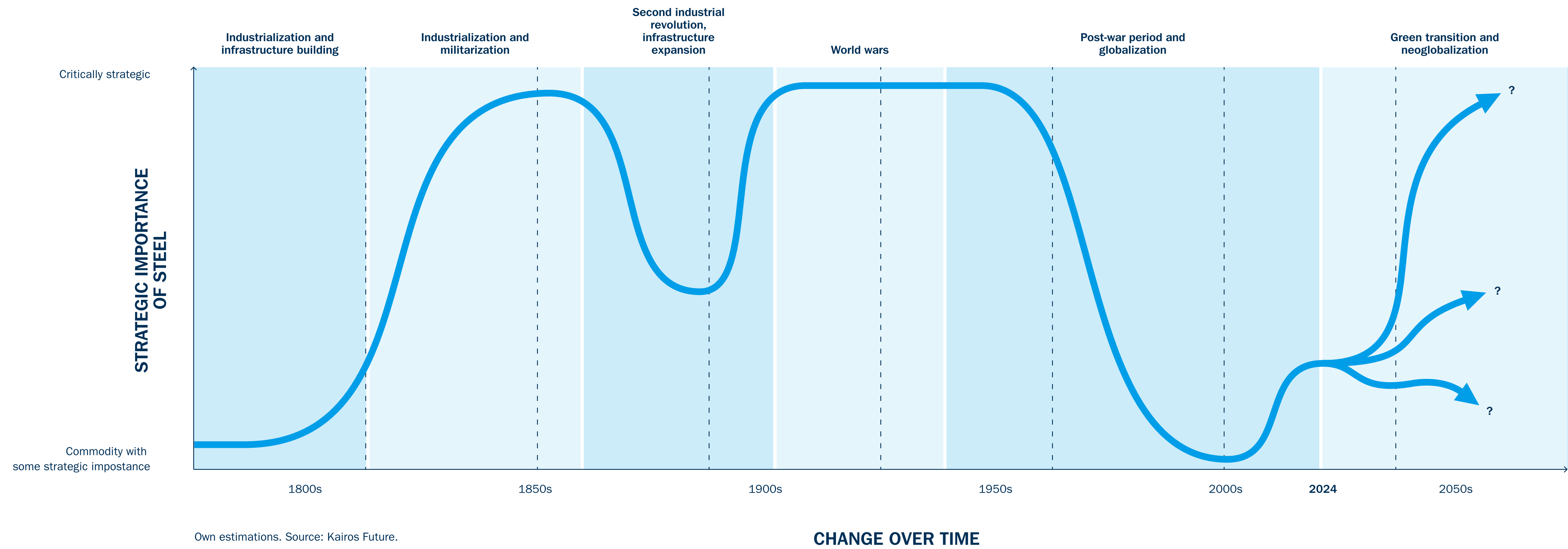
THE STRATEGIC ASPECT OF STEEL

After the Second World War, Western European countries – with support from the USA – pooled their production of coal and steel and entered a free-trade agreement to ensure peace and stability. The European Union as it exists today is based on that historical steel alliance. Because of this dual identity as both a resource necessary for war and peace, steel has always had an inherently political aspect.

The free trade era of steel that accelerated throughout the end of the 20th century also ensured that participants could industrialize despite not having their own full production capacity of steel, coal and other strategic resources. In a way, steel, as with other resources, has alternated between being a strategic resource, to being more of a commodity (while always maintaining a base strategic aspect).



STEEL’S STRATEGIC CYCLE



Model of variations in strategic importance of steel as a resource. We illustrate the shifting perception of steel as either a strategic resource or a commodity, influenced by historical, technological, and geopolitical factors. The variations reflect steel's role during key periods such as industrialization, world wars, globalization, and the ongoing energy transition. This oscillation attempts to capture how external demands and innovations drive steel's strategic importance and its broader economic impact over time.

THE RISE OF NEW PLAYERS

Many countries have benefitted immensely from the open globalized world. But perhaps there is no better example than China's massive expansion into the industry, going from 8.6% to over half of the world's share of produced crude steel (54%) in the matter of a few decades – an impressive industrial feat.

It has been a major opportunity for everyone, but has also come with a share of challenges, among which is the notable difficulty for other producers to compete with cost-efficient Chinese steel. Rising protectionism, trade wars and other confrontations between global and regional powers threaten to change the dynamics of the past 30 years.

Are we leaving a period in which products and materials have flowed freely on global markets? Is steel shifting back into the category of strategic resource?



WHEN SUSTAINABILITY BECOMES GEOPOLITICS

With rising geopolitical tensions in the world, all the market givens of the post-cold war globalization seem to be gradually fading, breathing new air into the geopolitical aspects of steel – one among many strategic industries. The potential vulnerability of global supply chains for strategic resources is being questioned and talks of reshoring (or friend-shoring) industrial activities are growing.

According to the Center for Economic Policy Research, ambitious climate policies in many countries have indeed led to carbon leakage – the transfer of production to countries with laxer emission constraints^[1]. To address this issue, the European Union has for example introduced the Carbon Border Adjustment Mechanism (CBAM). The CBAM aims to equalize the carbon price paid by EU and non-EU carbon intensive products by imposing a carbon price on imports. This mechanism is just one example of how sustainability efforts are becoming intertwined with geopolitical considerations.

Disregarding immediate confrontations, the energy transition is intrinsically connected to steel. The new low-carbon economy is creating winners and losers, but most of all new opportunities. Novel energy production capabilities in new locations with new technology, means that some areas are seeing renewed interest, while other regions need to spend current existing political capital in delaying the transition to catch up. As a result, the status quo is in flux.



^[1] cepr.org/voxeu/columns/carbon-leakage-additional-argument-international-cooperation-climate-policies



"Implementing the green transition required by the Paris Agreement demands tremendous efforts across all sectors. For the steel industry, which operates in global markets, globally harmonized mechanisms are essential to accelerate this transition. Among these, effective carbon pricing has proven to be the most impactful mechanism. However, currently, less than 25% of global emissions are covered by carbon pricing, indicating substantial room for improvement."

TUULI KASKINEN

Chief Executive Officer at
[Climate Leadership Coalition](#)



QUESTIONING THE WORLD ORDER?

The interconnectedness of the world in the 21st century is however making it difficult to rapidly change the world order. The notion that globalization is ending likely amounts to drawing conclusions too early. The KOF Globalization Index from the Swiss Economic Institute shows continued globalization even during challenging periods like the Cold War and recent conflicts^[1]. The DHL Global Connectedness Index supports this view, showing record levels of globalization in the 2020s^[2].

But while globalization continues, there is a noticeable shift in global dynamics. The severance of ties between the West and Russia, and the cooling of relations between the U.S. and China, suggest a trend toward regionalization and the potential division of the global value chain into blocks centered around China, the EU, the U.S, India, and other regions.



SILVIO VANZO

Chief Procurement Officer at [Grundfos](#)

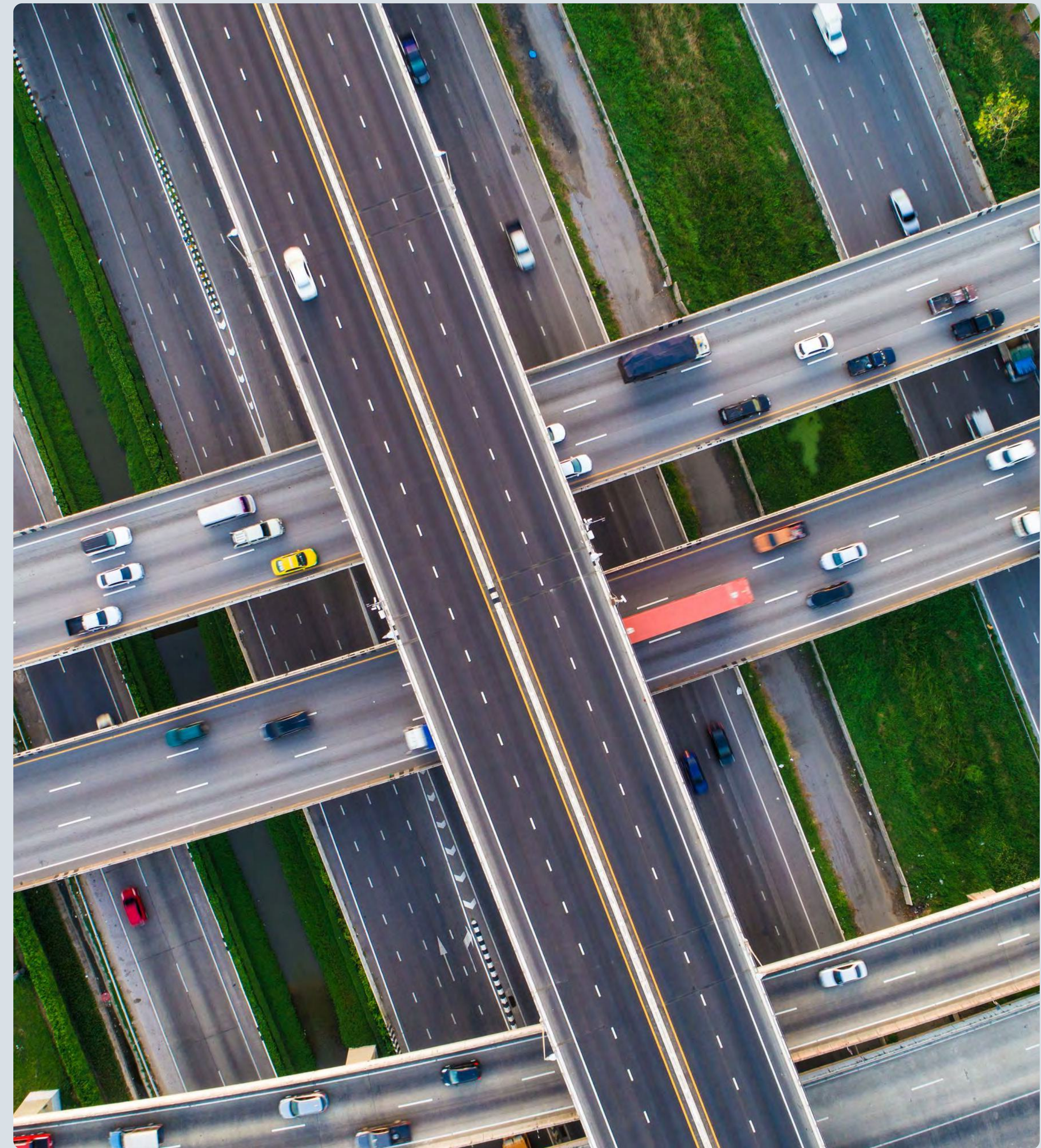
“The current geopolitical landscape is a critical factor to consider. Over the past 30 years, unmanaged globalization has led to significant disparities in economic growth among nations, resulting in unbalanced economies and political instability. This has given rise to the clusterization of the global economy, where political and economic alliances create their own rules and trade agreements. These clusters – whether in Europe, the U.S. and Asia, or emerging markets in Africa and Latin America – each have their own agendas, which can shift priorities, particularly in terms of sustainability. This evolving dynamic necessitates a different approach to sustainability, one that recognizes the diverse priorities and strategies of these global clusters.”

^[1] kof.ethz.ch/en/forecasts-and-indicators/indicators/kof-globalisation-index.html

^[2] www.dhl.com/global-en/delivered/globalization/global-connectedness-report.html

NEOGLOBALIZATION RATHER THAN DEGLOBALIZATION

Given how global flows of people, capital, goods and services have evolved, one way to understand the global context for the future is that it is not facing deglobalization, but rather a form of neoglobalization. A situation where the world is not becoming less global, but where globalization is taking new paths due to greater security risks and new patterns. One where democracy cannot be seen as something that follows naturally from deeper relations and idealistic aspirations: a realpolitik. The mental shift consists in the realization that a global world can also consist of authoritarian states that have relations with each other.





IT'S POLITICS, NOT GEOPOLITICS

Some of the more important threats to industrial transformation identified among the interviewees were primarily linked to a perceived short-sightedness in rule-setting. Some rules, dictated by external players, global competition and innovation, cannot be overcome.

Other rules however, like regulations, can be agreed upon collectively. The need for stable rules that do not fluctuate too much over the course of a political election cycle was deemed central for long-term bets to pay off. In other words, it may be politics, not geopolitics that is the bigger problem. The geopolitical situation creates favorable winds in terms of public support of large infrastructure and reconstruction projects, albeit at a cost of inflation, interest rates hikes and prices. The political situation in comparison, creates cynicism, indifference and worse: inaction.



A TRANSITION WITH HEADWINDS...

The narrative surrounding the green transition can sometimes fall into the trap of zero-sum thinking, where advancements in one region are seen as detrimental to another. An analysis of over ten thousand European press articles shows the U.S. Inflation Reduction Act (IRA) was met with suspicion in European media, frequently portrayed as a threat to the EU's green economy^[1].

Viewed through a different lens, this viewpoint misses the bigger picture. The IRA created competition, yes, but has also invigorated the entire green industry, fostering a global market ripe for innovation and growth^[2]. It is likely that US policy has created momentum for others places as well.

One of the significant obstacles to the green transition is also its relative invisibility. While AI technologies like ChatGPT capture public imagination, essential green technologies such as heat pumps remain in the shadows and could often be considered as “boring”. This disparity in visibility can lead to a lack of public support and investment.

The narrative of the green transition as being central for economic resilience and outside shock resistance is key to maintaining high public support, especially among those fundamentally disinterested in environmental matters. It also serves as a useful diplomatic point of common ground.



STEPHAN MAY

CEO Electrification and Automation Business unit at [Siemens](#)

“I believe that the EU has opportunities in the current geopolitical situation. Why? We face significant challenges. For decades, we enjoyed a relatively stable environment with established supply chains and globalization. If we navigate the current situation effectively, I remain confident in the capabilities of European engineers. Doing this correctly will make us more resilient than we have been in the past.”

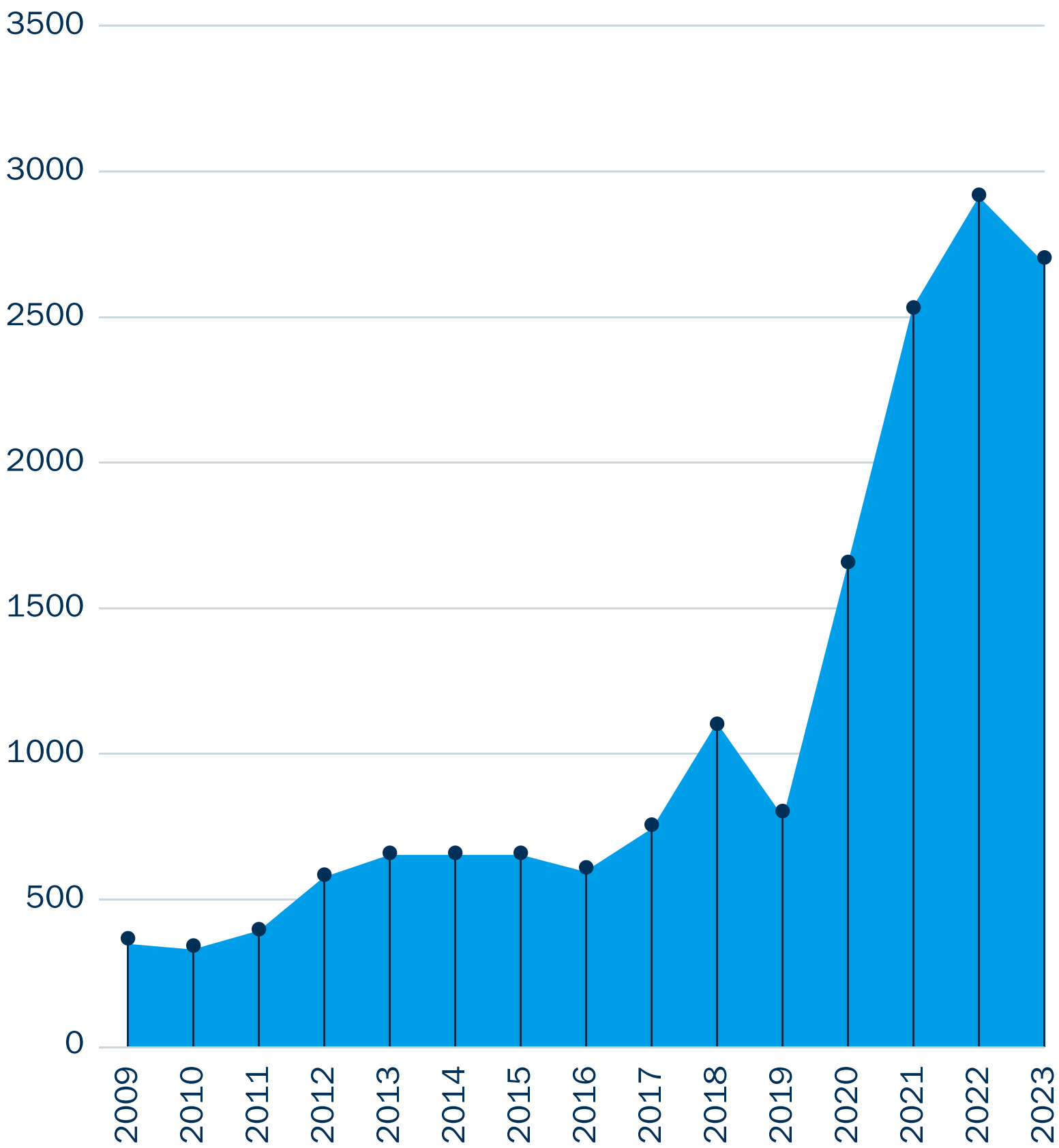
[1] Kairos Future, 2024

[2] www.cesifo.org/en/publications/2023/working-paper/global-impact-us-inflation-reduction-act

IS BIG CHANGE LOOMING?

If the transition primarily depends on politics and not geopolitics, this should be visible in the form of future industrial policies, which are essentially government interventions aimed at supporting specific domestic firms, industries or sectors. This trend is currently visible by looking at the number of industrial policy measures globally, mostly confined to advanced economies. The International Monetary Fund has stated that industrial policy is back. These policies can address market failures when carefully designed, but require high standards of effectiveness, transparency, and economic stability. Rising industrial policies seem to correlate well with the perceived sense of neoglobalization.

Industrial policy measures globally



Source: International Monetary Fund, Policy Papers, 2024

UNDERSTANDING THE SHIFT

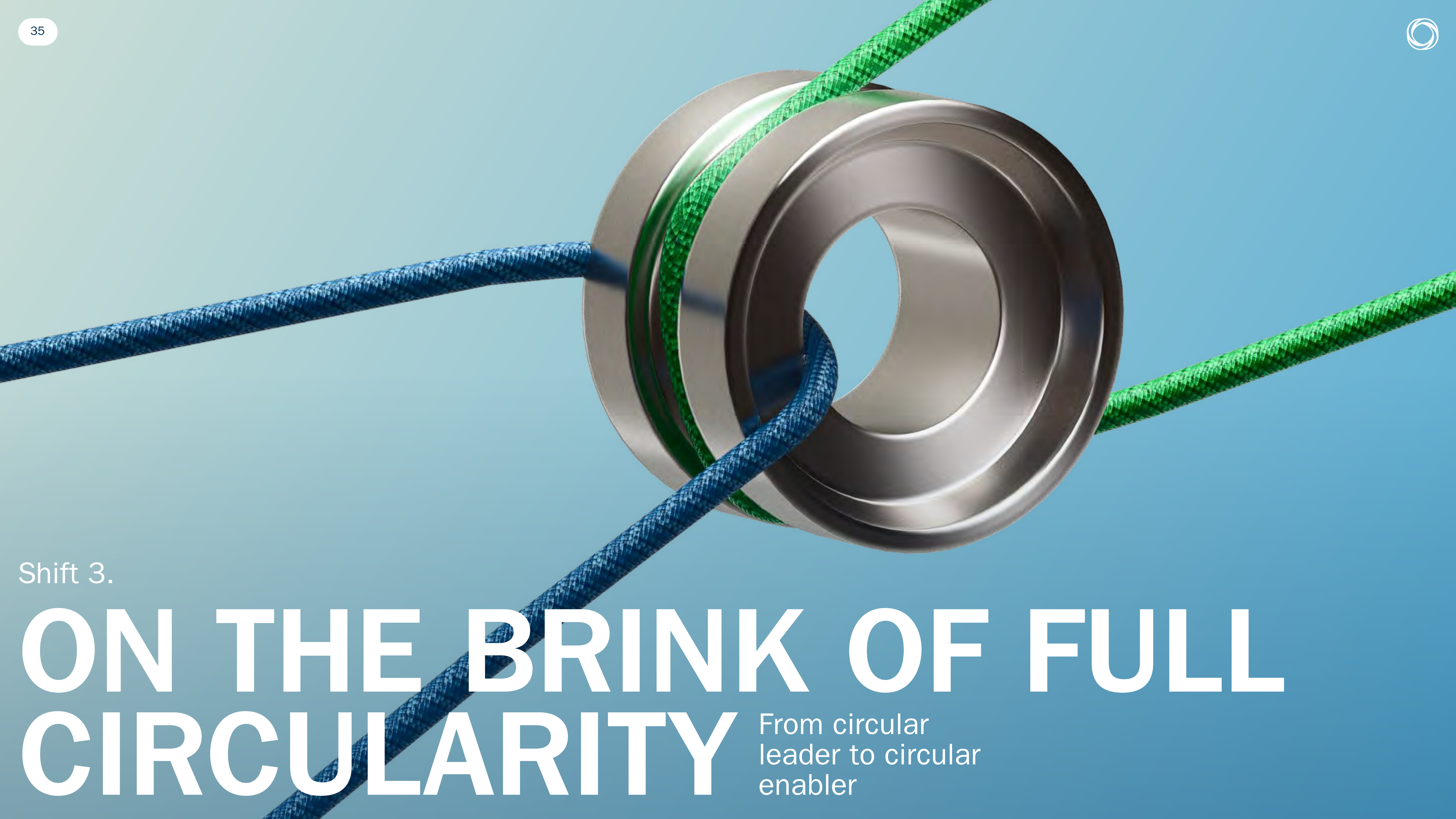
The shift from geopolitics to policy is becoming increasingly evident. While globalization takes on a new form characterized by regionalization and the emergence of new power dynamics.

The strategic importance of steel and other resources is once again in the spotlight, as nations grapple with the challenges of ensuring industrial resilience and navigating the green transition.

The path forward lies not solely in geopolitical maneuvering, but in crafting effective and stable policies that foster innovation, growth, and public support. Organizations navigating this new terrain must remain vigilant, adaptable, and forward-thinking.

Key future questions

1. Considering your organization's current supply chains and the potential division of the global value chain into regional blocks, which specific regions or countries are likely to become increasingly critical for your operations? What proactive steps can you take to strengthen your presence and partnerships in these regions to ensure long-term resilience and competitiveness?
2. As the energy transition reshapes global power dynamics, what specific risks and opportunities does it present for your organization?
3. How can your organization contribute to making the green transition more visible, exciting, and appealing to the public? What innovative education, and engagement strategies can you employ to build broader enthusiasm?
4. How can you turn the green transition into a new competitive advantage and ensure green growth?



Shift 3.

ON THE BRINK OF FULL CIRCULARITY

From circular leader to circular enabler

Since the dawn of manufacturing, we have been constrained by material scarcity. Following the great acceleration – the exponential post-war period – we were briefly under the impression of being finally liberated from these shackles. Multiple new industries were born with little to no regard for waste or material collection – the dark side of abundance.

Steel holds the distinction of being both the world's most recyclable and most recycled material^[1], placing the industry at the forefront of the circular economy. The steel industry is the sector closest to circularity to date, with approximately 85% of end-of-life steel being collected for recycling globally^[2]. In new steel produced today, approximately 30% comes from recycled steel – leaving room for much improvement in this regard. Being ahead, the industry must embrace its leadership position, re-emphasize the strategic benefits of materials recirculation and above all, continue leading by example to close the last remaining percentages and climb higher up the circular value chain.

^[1] World Steel Association, 2021.

^[2] Iron and Steel Technology Roadmap, International Energy Agency, 2020.



CIRCULARITY FOR THE WORLD

The world has a circularity problem. We are becoming less and less circular when we should be moving in the other direction. In 2023, it was calculated that the world is 7,2% circular^[1]. This effectively means that over 90% of all materials used that year were extracted from the earth in the form of virgin materials. In 2018, the same methodology put the world at 9,1% circularity. Of course, we are building more infrastructure and global population is growing, but these numbers are still alarming.

It may be particularly discouraging given that the prospects for circularity are perhaps more promising than ever: a worldwide growing focus on climate action and sustainability with supportive political momentum, a rapidly developing infrastructure and innovation scene, a stronger consumer demand for circular and reused products, and technological advancements paving the way for a circular economy. All this, and yet we seem to be slipping backwards.



^[1] Circular Gap Report, Circle Economy, 2024.



“We need to design for circularity. Which means incorporating long-term durability and ease of repair into our products. For instance, components should be assembled with screws rather than with glue as screws allow for easier disassembly and repair. While screws can be more expensive and may extend production times, it's essential to find ways to streamline these processes, particularly when using more sustainable materials. This approach not only extends the lifespan of appliances but also ensures they can be seamlessly integrated into a circular infrastructure, where they can be reused and recycled with ease.”

PETER SPIRIG

Chief Executive Officer at [V-ZUG](#)

CIRCULARITY IS NOT EQUAL

Recycling rates for steel are high, and in some industrialized countries, the rates come close to 98%. On the other hand, the amount of recycled steel only constitutes about 30% of the input for new steel production^[1]. Still, these are recycling rates significantly beyond what other industries could currently even dream of. In plastics, around 9% is recycled^[2] and most other major materials, such as concrete, are closer to 5%^[3]. Although recycling is first on the circularity value chain^[4], recycling rates can serve as an indicator for each industry's progress towards achieving full circularity.

This means that different industries are clearly in different stages: for some it is about catching up, while others are about closing the loop of the last remaining percentages.

^[1] worldsteel.org/wp-content/uploads/Fact-sheet-on-scrap_2021.pdf

^[2] ourworldindata.org/plastic-pollution?insight=only-a-small-share-of-plastic-gets-recycled#key-insights

^[3] www.mdpi.com/2071-1050/13/19/11077

^[4] Potting et al. 2017



Achieving circularity varies significantly across industries, but it can generally be divided into three key categories: business model innovation, product longevity, and material efficiency. Within each category, a set of strategies — referred to as the "10 R's" — offers practical guidance for driving change, helping businesses adapt to evolving practices and embrace incremental paradigm shifts.





WHAT IT MEANS TO BE FIRST

Being significantly ahead of the circularity curve, the steel industry is faced with a new, emerging challenge: defining what's next in circularity. While other industries are aiming to catch up and obtain results comparable to those of steel today, steel players need to think about where their future lies and if staying ahead is a goal. Of course, attaining a near 100% recycling loop for end-of-life steel is an immediate goal. But what are the next goals?

Players in the industry will likely need to start climbing the circularity value chain, and improving their efforts along three major axes:

- **Resource and materials efficiency (recycle and recover):** Focus on enhancing recycling and recovery processes to minimize waste and optimize the use of raw materials
- **Product lifespan extension (reuse, repair, refurbish, remanufacture, repurpose):** Implement strategies to help clients extend the lifespan of steel products through reuse, repair, refurbishment, remanufacturing, and repurposing
- **Business model reshape (reject, rethink, reduce):** Rethink existing business models and help clients do the same, to incorporate principles of circularity, such as rejecting unnecessary materials, reducing waste, and promoting sustainable practices throughout the value chain, utilizing waste streams from the steel industry to create markets for by-products.

Being first and most ahead in circularity means being able to use this as a competitive advantage and value proposition for clients. Being first also comes with the responsibility to sketch out the next steps.



“For those of us involved in industries like energy efficiency or renewables, it looks odd if we don’t help our clients secure energy and materials efficiency for their own clients’ scope 3 emissions.”

TOM ERIXON

Chief Executive Officer at [Alfa Laval](#)

UNDERSTANDING THE SHIFT

As the steel industry continues to lead the way in circularity by providing the world's most recyclable material, it is crucial to recognize the importance of this position and the opportunities it presents. By focusing on resource efficiency, product lifespan extension, and business model innovation, steel companies can not only maintain their circularity advantage but also shape the future of sustainable manufacturing. The transition from being a circular leader to becoming a circular enabler is a journey that requires vision, collaboration, and a willingness to explore new frontiers.

The path ahead is clear: to continue climbing the circularity value chain and redefine what it means to be a leader in the circular economy. With its strong foundation and commitment to progress, the steel industry has the capacity to assist clients in embarking on the same success story.

Steel has a major advantage of being almost endlessly recyclable. Steel players should therefore make the most of this, though it also means competition for recycled metals will intensify.

Key future questions

1. What does it mean for our bottom line to be a leading circular industry?
2. What is the next frontier in circularity and circular business models for the industry? Who is leading?
3. How can new value propositions be created that move up the circularity value chain?



Shift 4.

MANUFACTURING THE DEMAND

From shaming
players to changing
the game

So far, the business of green transition has largely been a moral affair. While few might doubt the usefulness or necessity of sustainable materials and goods the main levers for change have been guilt and sacrifice. These two combined elements have worked like this: Guilt tripping consumers that they should consume sustainable products and rewarding those that do with praise for their sacrifice. This lever has largely been ineffective, on the grand scale demand for sustainable products is dwarfed by the consumption of status quo goods. In other words, we need a shift from a moral to a pragmatic economy.



THE GREEN PREMIUM TRAP

A key reason for the lack of sustainable consumption and the failure of the moral economy is found in the green premium trap. Because sustainable goods usually come with a premium price compared to their ordinary counterparts. This can be due to new manufacturing costs, R&D costs or even the cost of new technologies, such as carbon capture.

Due to this trap, opting for the sustainable good will be at odds with short term austerity. Studies^[1] show that while the long-term societal costs of choosing unsustainable goods outweigh the short-term savings, this alone is not sufficient to escape the trap. On its own, all it can do is to pull harder on the guilt lever in the moral economy. To put it in terms of game theory: Sustainability has a coordination problem. Due to unpriced externalities, that is negative impacts that is not reflected in the market, it still seems too costly for many to be a first mover in the green transition. Green premiums exist, but they do not have to be a barrier to progress.



TOM ERIXON

Chief Executive Officer at [Alfa Laval](#)

“I am not overly concerned about green premiums. We simply need to learn pricing with practice. It’s not a huge deal, it’s always the case with new technology, there is a premium yes. But compare EV prices today with 10 years ago, prices have gone down significantly. With a reliable ETS system, it can work.”

^[1] www.imf.org/external/pubs/ft/fandd/2019/12/pdf/fd1219.pdf



“Let's take the example of electric vehicles (EVs): Despite certain disadvantages such as limited range and charging options, people are convinced of the way forward for this technology in mobility and some are even willing to pay up to 20% more for it. The steel industry needs to take a similar approach and agree on a common goal. Governments should also play a role in driving change in the steel industry. A unified and credible voice is essential to effectively reach the end consumer, which would be the most effective strategy.”

DANIEL KREBS

Chief Executive Officer at [Stahl Krebs](#)

THE ROLE OF PUBLIC POLICY

A current trend to act against the trap is of course in increasing policy demands for sustainability. Since consumer demand is not enough to carry the demand for sustainable products one strategy is to counteract the price advantage of unsustainable products by forcing markets to internalize their externalities to better mirror the true costs of a good. The example of carbon pricing shown in the first shift, with the European Trading System (ETS) is specifically designed to be a mechanism forcing players to internalize the cost of one externality (carbon).

The effort to reconfigure price points in the goods economy to overcome the green premium trap has historical parallels. Just as most societies now use government regulations to enforce the 'humanitarian premium' – ensuring fair wages and safe working conditions – this reconfiguration aims to promote sustainable practices.

While it could be argued that there are moral imperatives to paying fair wages and ensuring that workplace dangers are minimized, there still has been a need to enforce these norms with regulations. The same can be said against the argument that good pay and working environment is always in the interest of companies to take care of their human resources. By enforcing regulations, it became harder for bad actors to deviate from the moral economy and long-term interest related to human resources. What we now are seeing is perhaps the same movement when it comes to the outputs of said labor processes.





“We see a significant move towards more sustainable solutions and materials within our client base. That said, it is also fair to say that there is still a high degree of variation across customers and market segments in terms of their sustainability maturity level. The market needs to take the last few steps to get there. Some of it will come through government regulation and new standards, while other aspects will come naturally as companies start to make progress on their own sustainability journey. Apart from responding to customer needs, we also take a very active role in driving the market in a more sustainable direction in close collaboration with our partners.”

PETER FAARBORG-ANDERSEN

Chief Commercial Officer at [Lemvigh-Müller](#)

THE ROLE OF GOVERNMENT

Besides regulation to create new set points for the economic incentives and philosophy, government spending in form of procurement and direct investments can act as a guarantee of demand while the economy is in transition. In the messy middle from a dysfunctional moral economy to an aligned sustainable economy the public dollar is likely to serve as a way to create demand for sustainable goods. As shown in the previous chapter, the transition is increasingly being solved by industrial policy.

One of the fundamental reasons for the existence of 'big governments' is their ability to use public spending to fund large-scale investments that are beyond the capacity of any individual or business.

This role has clear precedents, making government involvement crucial for driving transformative initiatives like the green transition. By providing “uneconomic” investments that pay the green premium in the mid-term, public spending is showing signs of carrying the green economy until it stands on its own feet. Such a promise from the public sector would, for example, solve the current dilemma when it comes to sustainable materials for construction. From a market flooded by inexpensive but unsustainable steel and concrete, the problem would shift from that of over capacity to severe shortage. That in turn would send a strong signal to the economy that money was to be made for those able to meet the increased real demand.



BEHIND THE RISE OF A GIANT

One such example is Tesla's early growth, that was significantly supported by government loans, grants, tax incentives, and consumer subsidies, such as the \$465 million loan from the U.S. Department of Energy^[1] and various state incentives that reduced costs and boosted sales. These forms of support were crucial for the company at a time when its future was uncertain and its investments in electric vehicles appeared uneconomic.

However, Tesla's success also hinged on its innovation and subsequent ability to carve out a desirable niche in the emerging electric vehicle market. Public investments in seemingly risky ventures can yield substantial long-term benefits, driving technological progress and economic growth. But these investments sometimes need to weather a few storms on the way...



ALEXANDER GULDEN

COO/CTO at [Zwilling](#)

“We produce products for people to buy, but without demand, even the most sustainable products will not succeed. Therefore, we must focus on how to raise awareness among customers and communicate the benefits of sustainable steel and materials. The key question is: How do we convey that we are doing the right thing? When a consumer sees a product on the shelf, what motivates them to choose it over another? If we can effectively combine this awareness with a sustained demand for green products, that would be a significant achievement from a European perspective.”

^[1] www.energy.gov/lpo/tesla

UNDERSTANDING THE SHIFT

As we navigate the messy middle between the old moral economy and a new, sustainable one, the role of public policy and government spending will be crucial. By internalizing externalities, guaranteeing demand, and supporting innovative ventures, we can overcome the green premium trap and accelerate the transition to a pragmatic, sustainable economy – shifting the game from one of guilt and sacrifice to one of aligned incentives and long-term prosperity.

Key future questions

1. How can you redesign your business model to align incentives with sustainable practices and overcome the green premium trap?
2. What role can your organization play in advocating for policies and regulations that internalize environmental and social externalities?
3. How can you tap into government spending and procurement to drive demand for your sustainable offerings?
4. How can you more efficiently convey the use of sustainable but invisible materials to citizens?



Shift 5.

AESTHETICS OF THE FUTURE

From “Made in EU/
USA” to “Made to
last”

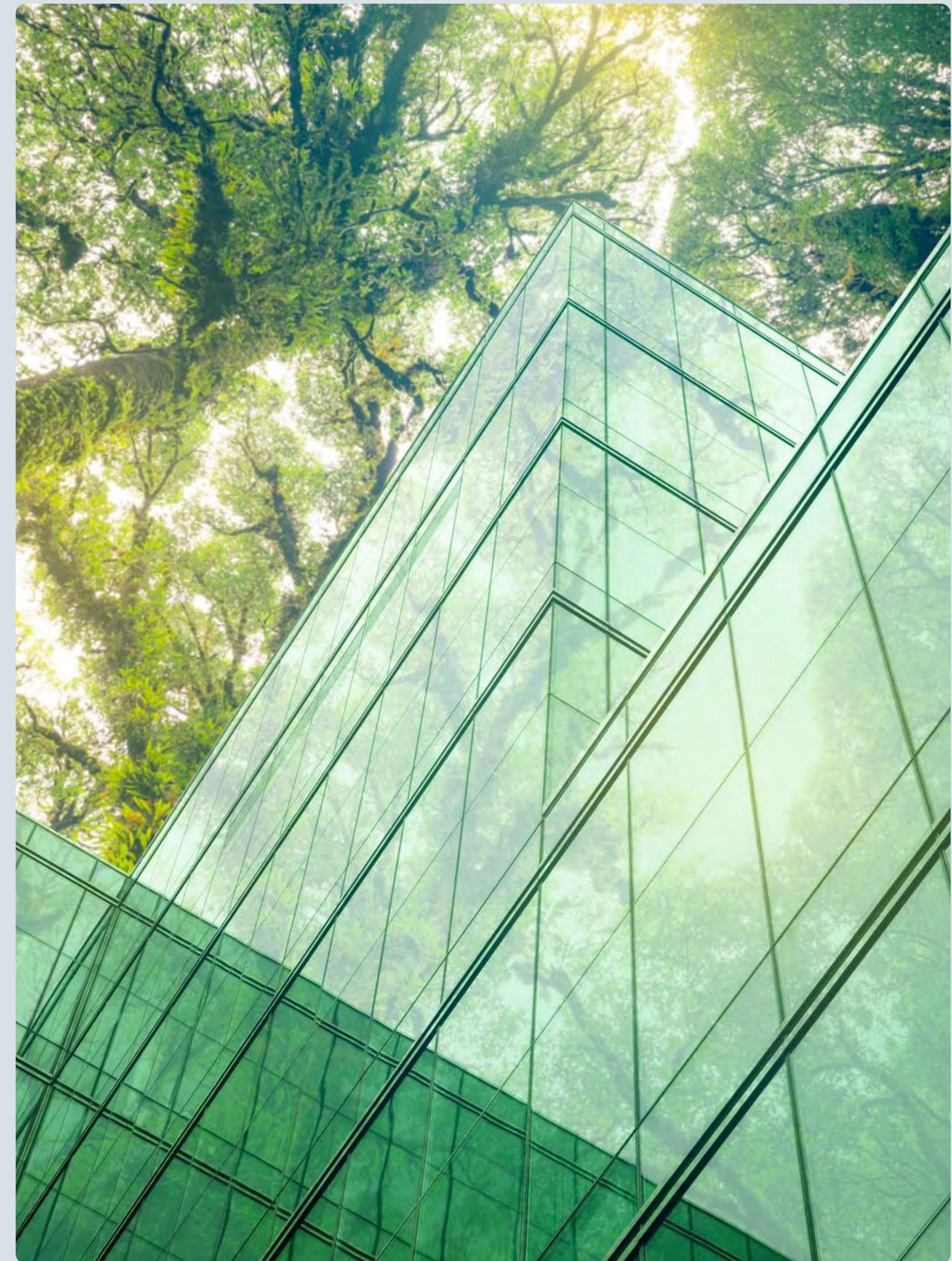
ONE LAST PROBLEM: MAKING THE GREEN TRANSITION TANGIBLE

Although awareness has risen, climate action has yet to succeed in mobilizing enough action to meet sustainability goals. In 2015 the global agenda of sustainable development towards 2030 was adopted. We are now halfway through and as expressed by UN Secretary-General of the United Nations Antonio Guterres “woefully off track”. Perhaps one cause of this inability to mobilize positive action is the systemic nature and complex causality of climate danger.

In system terms, it took a long time for the feedback of our unsustainable behavior to be tangible in the form of climate change.

The causal link between everyday life and climate impact has been abstract and largely invisible. For the public, the abstractness of climate action raises either indifference and denial or anger and hopelessness^[1].

One Gallup poll finds that the US population is split, with 44% believing that climate change will pose serious threats in their lifetimes, while 55% disagree^[2]. Kairos Futures’ polling on the Swedish population for example, finds that a majority believes that the green transition will be led by the experts and policy makers – only 18% agreeing that engagement from the public will be the main driver.



^[1] www.sciencedirect.com/science/article/abs/pii/S2214629614000218?via%3Dihub

^[2] news.gallup.com/poll/643850/seven-key-gallup-findings-environment-earth-day.aspx

WHERE AESTHETICS COME INTO THE PICTURE

The green transition simultaneously needs to be tangible, positive, and exciting. So, it might need a more epoch-defining expression. Looking back in history, societal shifts have usually brought with them a shift in aesthetics. If you were transported back in time, it would likely be possible to identify what era you are visiting just by looking at the newly constructed buildings, the clothes that people are wearing, and the overall aesthetic expression of objects around you.

Adopting a design identity that makes an impression in both the built environment and products will not only serve as a time marker for generations to come. Its real value at this point in history is to be a marker of progress. When climate action makes a visual impression in the world, it bridges the gap from abstract and uncontrolled to tangible and actionable. Then, it becomes a real issue of rebuilding.



WELCOME TO THE EVERLASTING ERA

So, what can we say about the aesthetics of the future? For one, it isn't only the color green. While the language of sustainability up to this point has been much shaped by ideas about returning to the organic world, green plants and organic visual wood have an ephemeral nature that does not fully capture the demands or ambitions of the sustainable world. Plants rot, and wood ages, needing replacement. True sustainability comes when the life cycle expands.

Another aspect of new aesthetic areas is that they are negatively defined against previous epochs. The long hair of the 1970s hippies revolted against the clean-shaven aesthetics of the post-World War era. Strict functionalism was a reaction of the classicists, and so on.

A coming aesthetic revolt will likely, in part, be against the wear-and-tear ethos of the fast-moving consumer goods markets. Against the “what I want when I want it”-mentality, a future aesthetic will likely try to signal timelessness.

The focus on timelessness that transcends whimsical demands for personalization is already visible in many high and premium products. For several years, the premium line of Apple computers had a matte-steel finish with little room for customization. The same is true for the high-end watchmaker Patek Philippe, which encapsulates the timeless values of contemporary conspicuous consumption in the slogan, “You never actually own a Patek Philippe. You merely look after it for the next generation”.





“To contribute to sustainability, design must not only ensure a long lifespan but also an enduring appeal. Our goal is to create products that are as minimalistic and modern as possible, avoiding fleeting trends. We want our customers to look at our designs in 2030 and still feel they are stylish and relevant. Therefore, our design philosophy emphasizes timelessness and minimalism, ensuring that our products remain both functional and aesthetically pleasing over time.”

PETER SPIRIG

Chief Executive Officer at [V-ZUG](#)

STEEL HAS A NATURAL PLACE

The green transition still needs to solve the problem of visual change. The challenge is to encourage a new look at the future as the transition progresses – transforming society itself as all of the familiar progress bars of the computer. The particular expression of timelessness and sustainable values will be up to the designers and influencers to decide whether green stainless steel has a natural place alongside the organic expression of green plants and wood. By being forever recyclable, it would seem stainless steel is a clear front-runner.

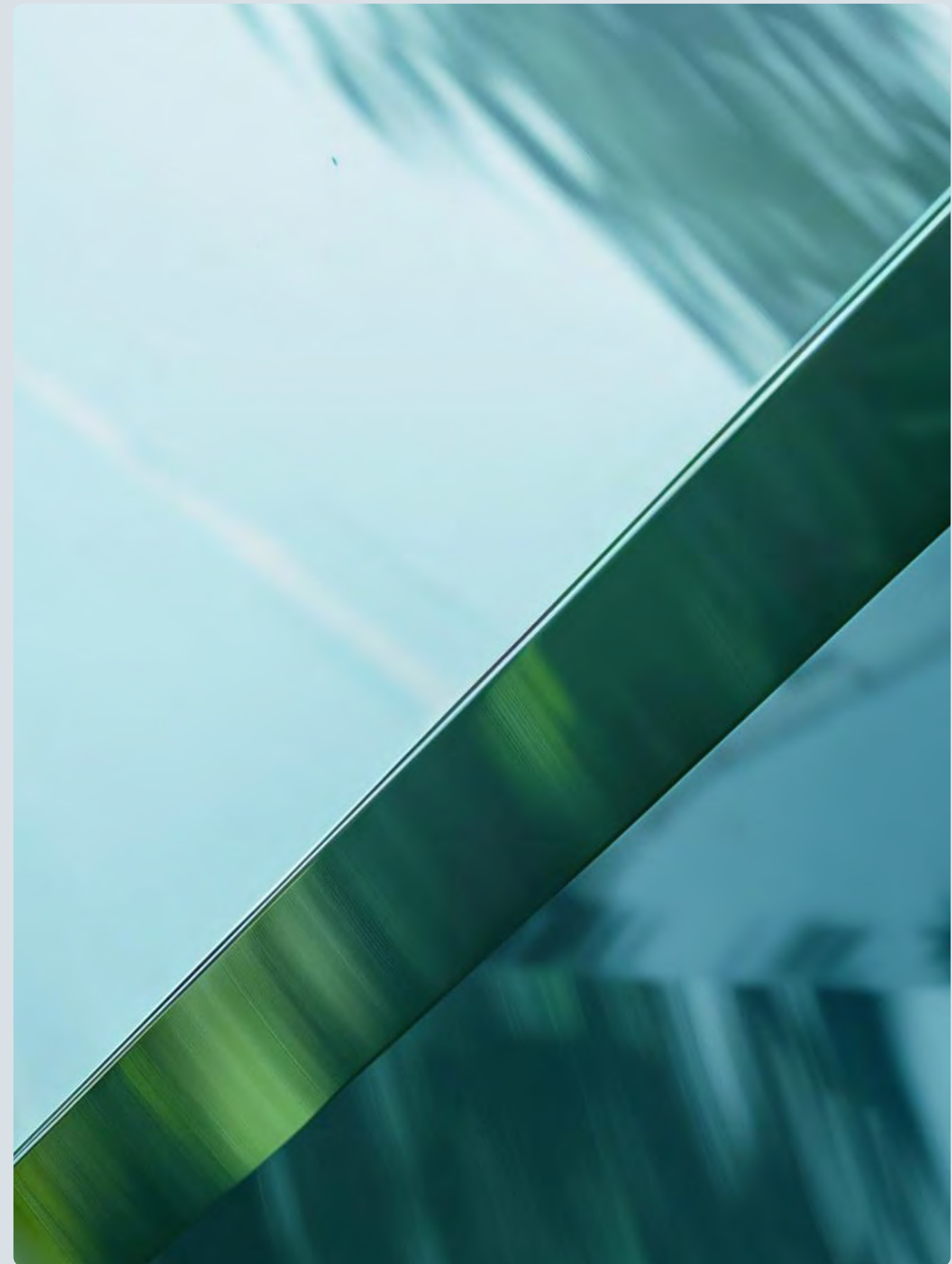


CREATE A COALITION FOR THE EVERLASTING

Let this highlight the importance of aesthetics and serve as a call to action for the industrial leaders, influencers, designers, architects, and arbiters of procurement to create the coalition needed to make the transition visible. The goal should be what the philosopher R.G. Collingwood called magic expression—the ritualized expression of useful emotion. Useful in the way that lets the built environment and consumer goods gradually manifest positive change, allowing a preferable future to manifest.

The goal should be a set of principles around what defines products in the everlasting era. To suggest a few: circulated materials, a sober yet forward-looking appearance, a purchase contract between seller and buyer that always includes repairs. With these combined, this movement can help set an even higher expectations bar for consumers, one that guarantees that all invisible aspects of sustainability and circularity are embedded.

In other words, we need to make the invisible visible. The question is: who will lead it?



UNDERSTANDING THE SHIFT

In the end, the success of the green transition may hinge on our ability to make it palpable, visible, and emotionally resonant for people across society. By embracing a new aesthetic of sustainability – one that celebrates the timeless over the transient, the enduring over the disposable – we can help bridge the gap between abstract goals and tangible reality. A move from “Made in China” to “Made in EU/USA” towards the next goal, “Made to Last”, is not just a change in sourcing, but a change in philosophy – one that will define the everlasting era to come. Those who find the right actors to collaborate with on this philosophy and gather a large enough coalition may succeed at defining the future aesthetics.

Key future questions

1. How can you make the sustainable transition more tangible and emotionally resonant for your customers and stakeholders?
2. What role can aesthetics play in signaling your commitment to sustainability and shaping the everlasting era?
3. How can you collaborate with upstream and downstream partners to lead the charge in making the sustainable transition visible and desirable?



Conclusion

MAKING THE INVISIBLE VISIBLE

NAVIGATING THE TRANSITION

A critical forward-looking perspective for all companies and organizations involved in the green transition is the need to fully grasp the scale and depth of this transformation. It goes far beyond simply improving materials or reducing emissions. While addressing these aspects is essential, the chapter on geopolitics illustrates that the energy transition is fundamentally reshaping power dynamics and ushering in an era of new business philosophies. Circular business models that optimize waste streams, advanced product traceability, carbon accounting, and capture are just a few examples of the emerging business environment.

This is where the concept of strategic drift becomes particularly relevant^[1]. As the transition accelerates, the volume and pace of changes that organizations must adapt to increase significantly. Consequently, current strategies often become progressively less effective at responding to external challenges.

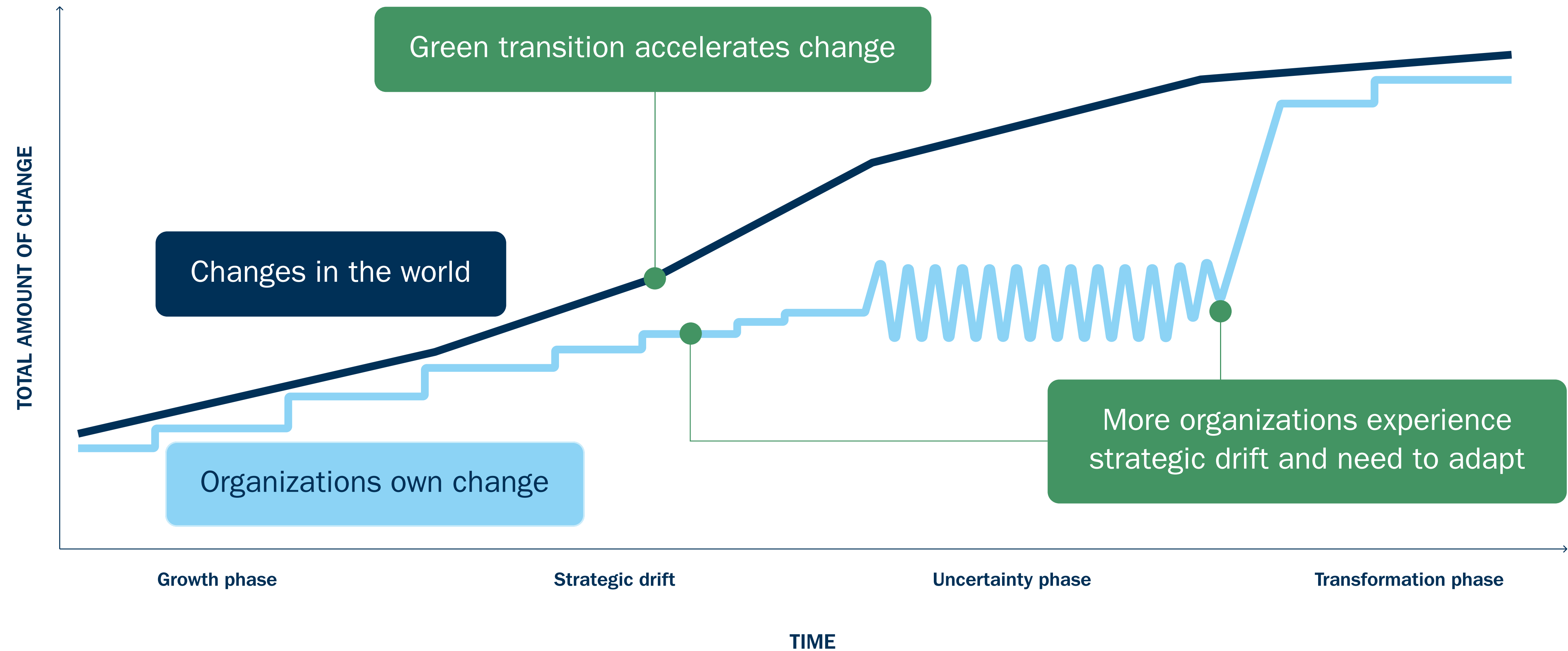
The green transition is one of the primary drivers of industrial transformation in the 21st century. The convergence of stricter environmental regulations, industrial policies, innovative technologies, and shifting consumer preferences is pushing many organizations toward a collective strategic drift. Recognizing which phase of change an organization is in is crucial for initiating transformational change. The organizations that succeed will be those that acknowledge the flux stage and boldly adopt new strategies aligned with 21st-century business philosophy.



^[1] Johnson, Scholes & Whittington. Exploring Corporate Strategy. 2005



GREEN TRANSITION ACCELERATES PACE OF CHANGE





KEY INSIGHTS FROM EVERY SHIFT

1. FROM CARBON REDUCTION TO SUSTAINABILITY EXPANSION

Sustainability scopes are expected to continue growing in the long term, our earth system depends on it. While carbon has been the primary focus, biodiversity, water but also social cohesion is likely to emerge as the next major areas of interest and innovation. The steel industry must recognize that the definition of sustainability is constantly expanding and adapt accordingly.

2. FROM GEOPOLITICS TO POLICY

Despite the uncertainty in the world and concerns about the future of globalization, maintaining a stable regulatory environment is crucial for the industry's success. Policymakers should prioritize long-term stability over short-term political wins and forget the importance of industrial sustainability transformation policy at home when the focus on geopolitics is high.

3. FROM CIRCULAR LEADER TO CIRCULAR ENABLER

Steel holds the distinction of being both the world's most recyclable and most recycled material, placing the industry at the forefront of the circular economy. To continue leading by example, steel companies must advance along the circularity value chain, surpassing basic recycling practices and investing in circular innovations. This approach will safeguard the positive demand for steel products in the face of competition from alternative materials.

4. FROM SHAMING PLAYERS TO CHANGING THE GAME

The green transition comes at a price, and as most investments, it carries high initial costs. The costs should be shared among stakeholders, with governments playing a vital role in ensuring long-term support. By internalizing externalities, guaranteeing demand, and supporting innovative ventures, we can overcome the green premium trap and accelerate the transition to a pragmatic, sustainable economy – shifting the game from one of guilt and sacrifice to one of aligned incentives and long-term prosperity.

5. FROM “MADE IN EU/USA” TO “MADE TO LAST”

To gather public interest, the green transition needs an aesthetic rebrand, shifting from "green" to "everlasting." The transition must be tangible and visible to the public. Industrial leaders, in collaboration with design and cultural leaders, should define the main features of this everlasting era. This new branding should go beyond traditional labels like "made in Europe" or "made in USA," and instead emphasize "made to last," highlighting the enduring nature of sustainable products and practices. The transformation must make the invisible visible.



ABOUT THIS REPORT

The research report was commissioned by Outokumpu and conducted by Kairos Future between June-September 2024, utilizing a blend of desk research, C-level interviews, AI, and data analysis. The report has focused mainly on the Western world.

We would like to thank all industry experts who took part in the interviews:

- STEPHAN MAY**, CEO, [Siemens Electrification and Automation Business unit](#)
- CLAUDIA ALFIERI**, CEO, [Padana Tubi](#)
- PETER FAABORG-ANDERSEN**, CCO, [Lemvigh-Müller](#)
- DANIEL KREBS**, CEO, [Stahl Krebs](#)
- SILVIO VANZO**, CPO, [Grundfos](#)
- PETER SPIRIG**, CEO, [V-ZUG](#)
- TOM ERIXON**, CEO, [Alfa Laval](#)
- ALEXANDER GULDEN**, COO/CTO, [Zwilling](#)



OLIVIER ROSTANG
Strategic Foresight Consultant
at [Kairos Future](#)

Outokumpu is the global leader in sustainable stainless steel. Our business is based on the circular economy: our products are made from 95% recycled materials, which we then turn into fully recyclable stainless steel. We are committed to the 1.5°C target to mitigate climate change, and with up to 75% lower carbon footprint than the industry average, we support our customers to reduce their emissions. Outokumpu Corporation employs approximately 8,500 professionals in close to 30 countries, with headquarters in Helsinki, Finland and shares listed in Nasdaq Helsinki. Read more: www.outokumpu.com

Kairos Future is a Swedish consultancy specializing in strategic intelligence, foresight, and scenario planning. Through trend analysis, innovation, strategy, and software support for AI-driven analytics, we help our clients understand and shape their future. Founded in 1993, Kairos Future is headquartered in Stockholm and has offices and partners around the world.
www.kairosfuture.com



Contact Outokumpu
media@outokumpu.com
+358 40 351 9840

Contact Kairos Future
info@kairosfuture.com
+46 8 545 225 00