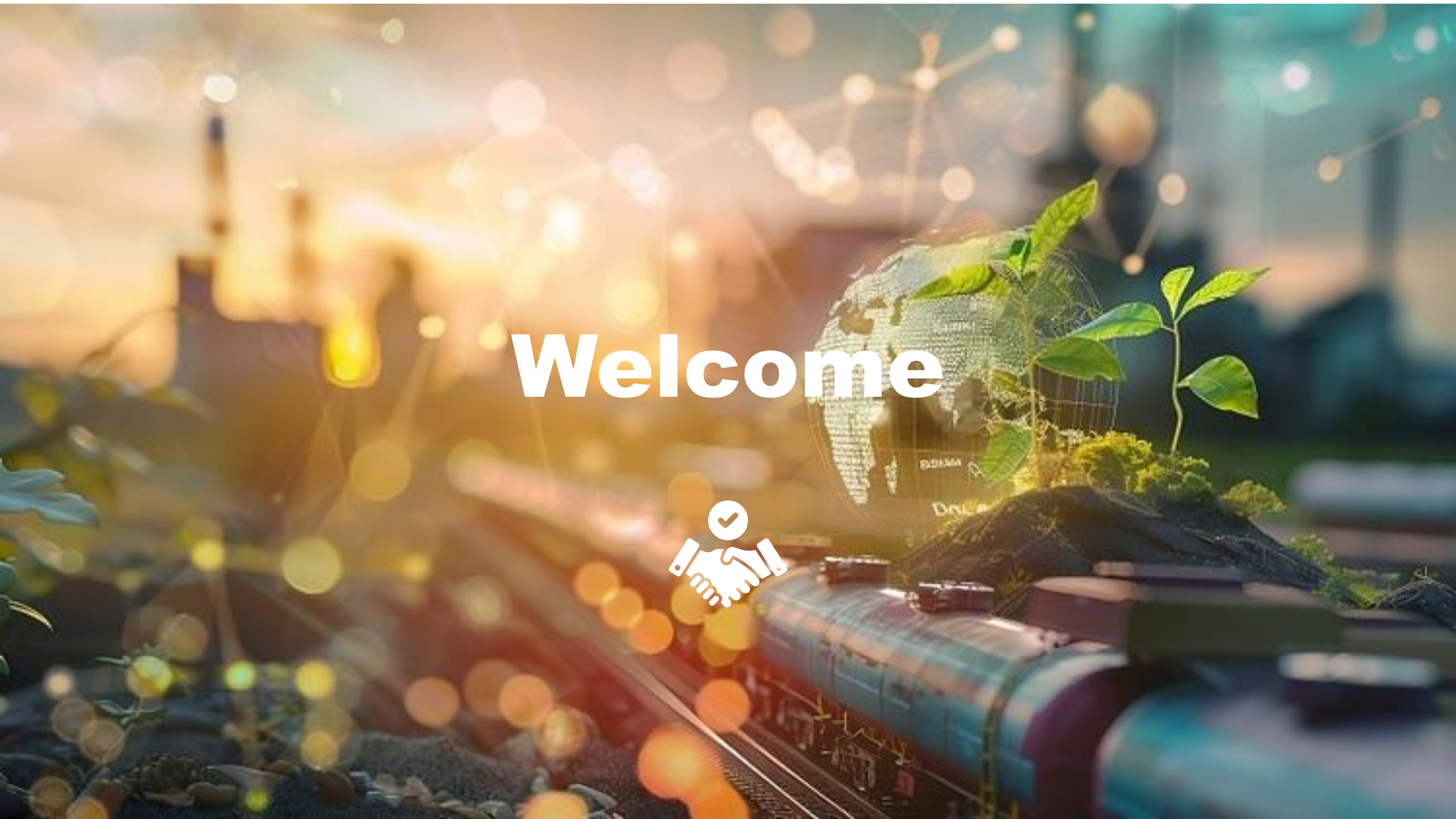
INTERNATIONAL UNION
OF RAILWAYS

How circularity can help railways in their journey to zero emission

5th UIC Zero Waste Railways Workshop

UIC HQ, 20 November 2024


Welcome

Agenda

Welcome and Introductions (15')	
Keynote Address (45') **Circular economy role in the net zero journey**	tbc
Coffee (15)	
Applying circular thinking in the rail sector (45') - **Introduction on Railsponsible** - **Presentation on Railsponsible whitepaper.**	Rose Stephani, Railsponsible
Interactive session	
Lunch (55')	
Suppliers point of view (10 min each + Q&A) • Thiotrack, the cement free sleepers • Wooden weather cabin by Strong by Form (+ DB?) • 100% recycled copper catenary system	D. Coppieters De Bonte Group D. Lyon, Strong by Form Carles Camprubi, La Farga
Infrastructure Managers Perspectives (10 min each + Q&A) • Modernized wooden sleepers for a low-carbon circular economy - Preserving natural resources • Recycling of scrap steel from rail grinding • Circular metrics reuse rate forecasting • Embedding Net Zero Design	Bénédicte Gourmandin, SNCF Réseau Mathijs Doesburg, ProRail Katy Beardsworth, Network Rail Chris Risoli, RSSB UK
Coffee (15)	
Operators Point of View • Waste to energy – HVO • Driving Toward a Beyond Zero Future: A Holistic Sustainable Approach	Jörg Schneider, DB Cargo Ilse van Eekeren, NS
Interactive session – discussions with speakers	

Rose Stephani

Project lead for the facilitation of Railsponsible, the sustainable rail initiative

H&Z Unternehmensberatung GmbH

RAILSPONSIBLE

Railsponsible:
The sustainable rail initiative

November 2024

Railsponsible was founded in 2015, with 6 founding members, who saw sustainable procurement as a key driver of sustainability in the rail sector

Railsponsible is the rail sector sustainability initiative **founded in 2015**, to help the rail sector understand what it could do to **drive sustainability** forward and take on the challenges that might seem overwhelming to one company.

It is a **member led initiative** committed to **limit climate change and reverse nature loss**.

The brainchild of its **founding members** NS, SCNF, Alstom, Bombardier, Knorr Bremse and DB, Railsponsible has **grown to 22 committed members.**

RAILSPONSIBLE

Railsponsible is a member led initiative, consisting of 22 companies in the railway value chain, driving sustainability in the rail sector

Member companies

Key deliverables 2024

- **Carbon in Tenders** Guidelines
- ESG **Risk Management Funnel mapping**, comparison and improvement
- Rail Sector **Double Materiality Analysis** Baseline Reference
- Compatible and sector specific **Product Carbon Footprint** (PCF) guidelines
- **ESG Audit and Self-Assessment** providers **minimum requirement** checklist

"Railsponsible enables us to tackle the great challenge of our time, climate change, through promoting sustainable procurement"

Stefan Braun, President Railsponsible, CPO ÖBB

RAILSPONSIBLE

Collaboration within Railsponsible drives sustainable improvements that individual member companies can benefit from

RAILSPONSIBLE

We currently have four larger working groups and two smaller task forces looking at sustainability challenges facing the Railway sector

Working Groups (10+ people per group)				Task Forces (4/5 people)	
Supply Chain Decarbonisation	**Supply Chain Due Diligence**	New **Circular Value Chains**	**Events and Communications**	New **Supplier Pain Points**	**Product Carbon Footprint**
Establish aligned Scope 3 commitments & methodology	Supply Chain Risk Management	To be defined	Promote and represent Railsponsible externally	Improve sustainability in the supply chain	Standardisation of rail sector carbon calculations
• Joint Scope 3 methodology • Carbon in Tenders	• Minimum audit requirements and audit sharing • Supply chain risk funnel	To be defined	• Preparation for Innotrans	• Questionnaire to understand supplier challenges	• Interoperable rail sector Product Carbon Footprint guidelines

RAILSPONSIBLE

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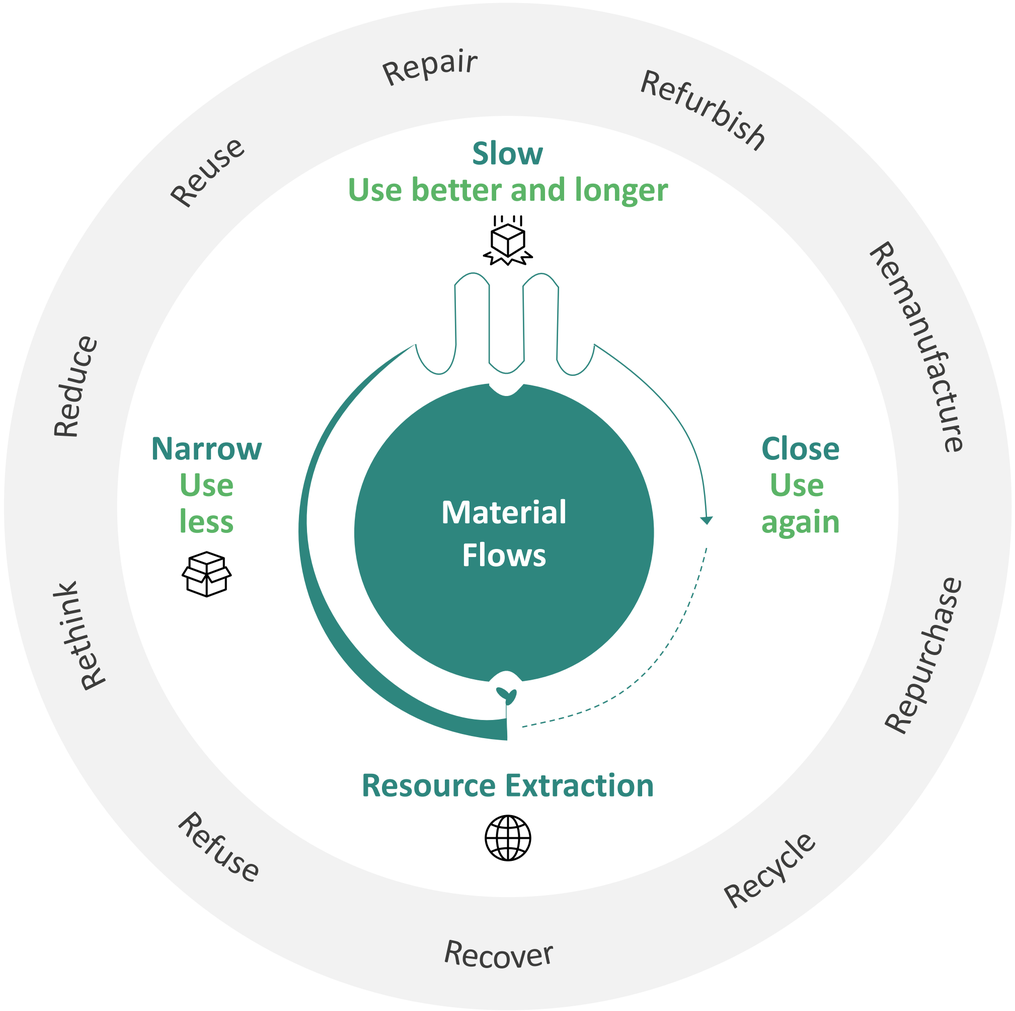
Circularity in the Rail Sector – Focus: Rolling Stock

Definition Circularity & business implications



Circular economy is an economic model aimed at eliminating waste and promoting the continual use of resources.

Unlike the traditional linear economy of "**take**, **make**, **dispose**," the circular economy focuses on designing products for **longevity**, **reuse**, and **recyclability**.

We recommend three steps to achieve circularity, **narrow**, **slow** and **close**.

Focus Rolling stock

Rolling stock is the lifeblood of the rail Industry, with an estimated 36 million tonnes of finished goods currently in circulation in Europe alone.

On average, procurement, leasing maintenance and service of rolling stock can account for 30-45% of an Operators capital budget annually.

Market Snapshot			
Rolling Stock type	Units EU	Unit weight (t)	Total weight (Mt)
Locomotives	24.800	150-250	5+
Light rail transit	20.800	17-50	1
Motorized passenger trains	34.100	100-800	15+
Unmotorized passenger cars	53.900	15-17	0,8
Freight cars	557.000	25-30	15+

Sources: H&Z-Analyse, Expertenbefragungen, Eurostat, Destatis, Europe's Rail, Office of Rail and Road, ERFA, UIC

Focus Rolling stock

Rolling stock is inherently complex but in its complexity lies substantial opportunity

1. Design:

Complexity and **lack of standardization** is a critical factor in managing railway fleets. Each usage segment (passenger, freight) includes numerous models from different manufacturers with versions customized for specific markets and energy sources (electric, battery etc.). This creates significant complexity in standardization, as even within the same model family, modules are not fully interchangeable. Estimates suggest that **operational costs could be reduced by 20-30% with more efficient designs that look circular principles into account.**

Product standardization is circularity's friend

Sources: H&Z-Analyse, Expertenbefragungen, Eurostat, Destatis, Europe's Rail, Office of Rail and Road, ERFA, UIC

Focus Rolling stock

Rolling stock is inherently complex but in its complexity lies substantial opportunity

2. Longevity:

Rolling stock is designed to last 30-35 years and requires significant maintenance investment. **By some calculations, around 50-60% of a train's total ownership cost comes from maintenance and overhauls.** Increasing modularity and ease of repair could reduce these costs, extend asset life, and cut down on waste.

Sources: H&Z-Analyse, Expertenbefragungen, Eurostat, Destatis, Europe's Rail, Office of Rail and Road, ERFA, UIC

Focus Rolling stock

Rolling stock is inherently complex but in its complexity lies substantial opportunity

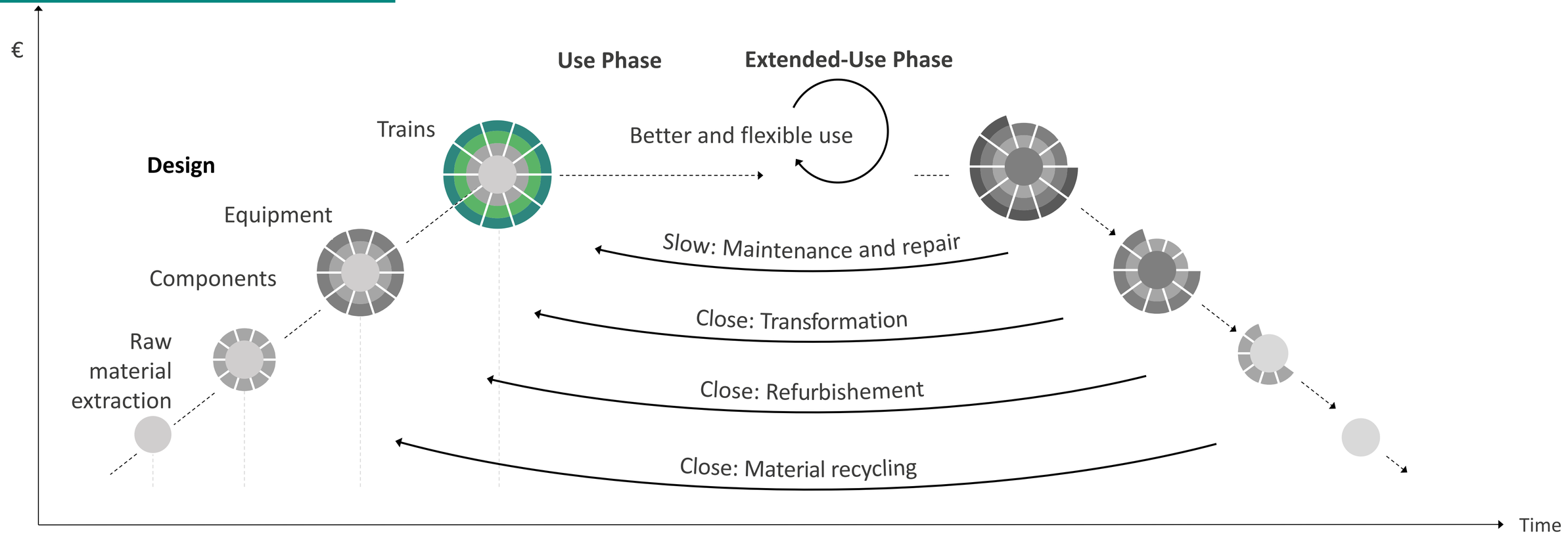
3. Use:

Any inefficiency in use, when the rolling stock is not rolling, requires additional stock to manage the load (passenger or freight). **The need for additional equipment is reduced by improving logistics and increasing run time.**

Keep your rolling stock rolling

Sources: H&Z-Analyse, Expertenbefragungen, Eurostat, Destatis, Europe's Rail, Office of Rail and Road, ERFA, UIC

Think in value



The value hill illustrates the business opportunities of circularity by **retaining value at its highest possible level** on the hill for as long as possible. When applying it to rolling stock we can say that we want to keep the rolling stock rolling.

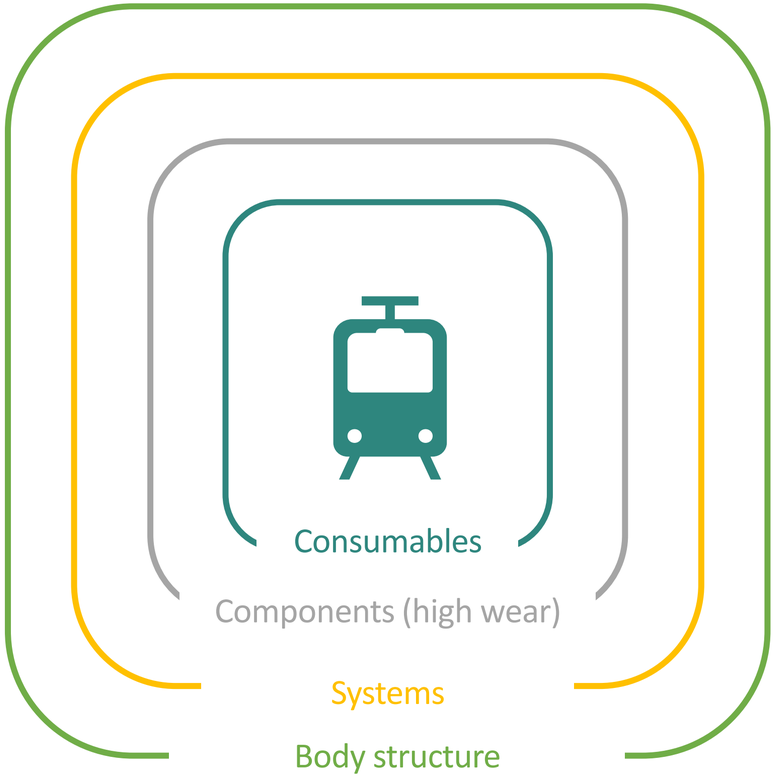
Think in layers

In “How Buildings Learn”, Stewart Brand explains a long-lasting product, like a train, consists of **different layers of products**, all having significantly **different lifespans.**

Designing with these lifespans in mind - **designing for disassembly and modularity** are therefore key business strategies to guarantee efficient maintenance, repair and upgrading. Modular design can **reduce production costs** by up to **30%.**

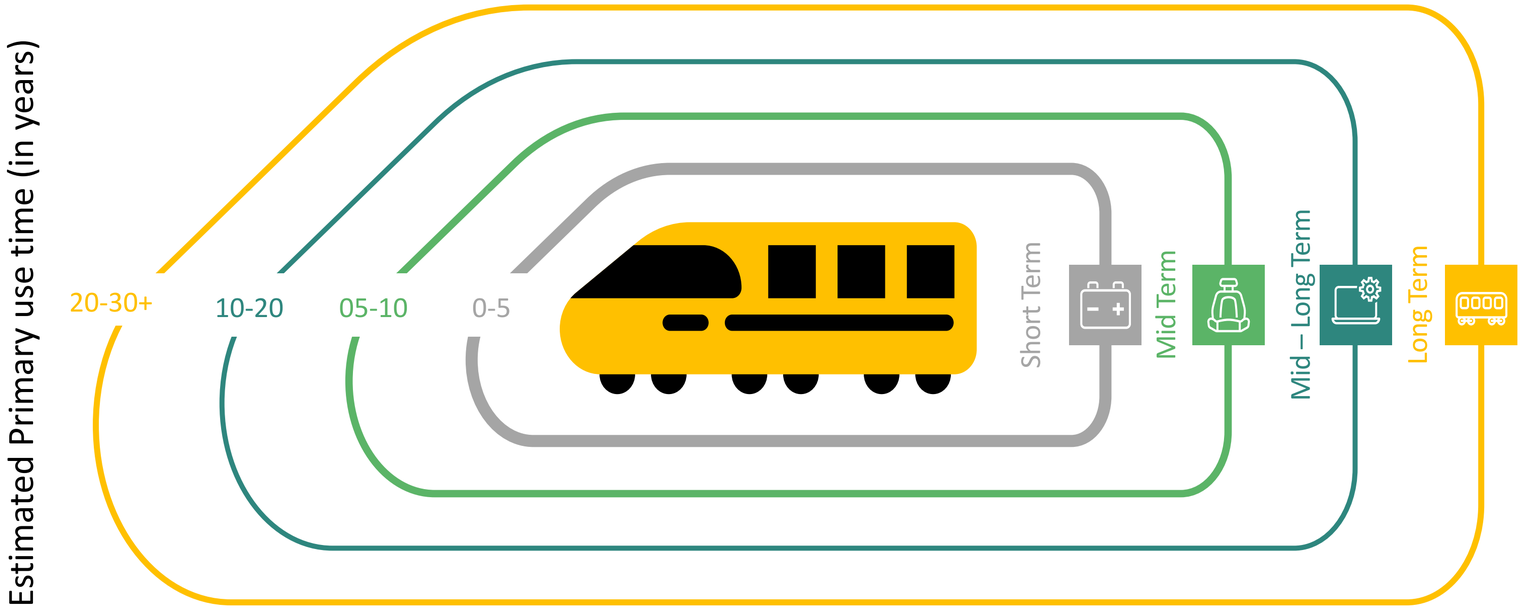
Modularity can also **reduce waste** and **extend the life span of the train**, keeping it in the highest point of the value hill.

Design for disassembly can prevent the composite parts of the train from falling down the value hill as the product is disassembled.



Source: Jeannot Schroeder, +ImpaKT Consulting, Ellen MacArthur Foundation

Focus on layers



Short Term	Mid Term	Mid-Long Term	Long Term
Lights, Filters, Sanitation, fluids	Components and parts with significant wear	HVAC, Electronics, Displays	Body Structure

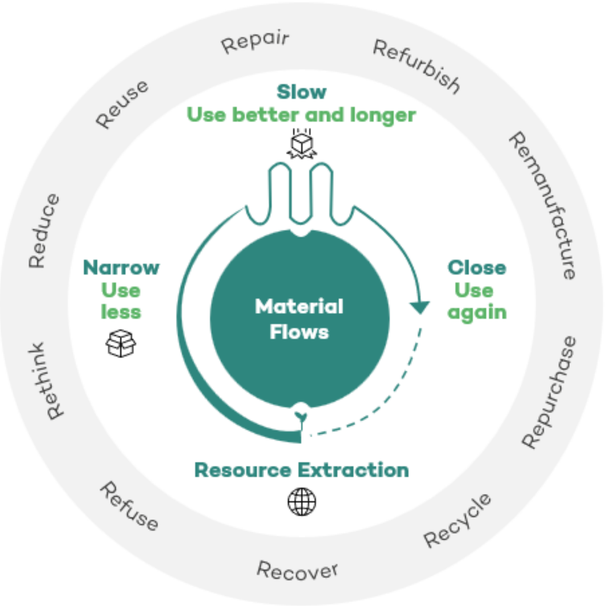
Thinking in layers allows us to see rolling stock and its complexity in a different light. Whilst there are huge variations in estimated primary use time, we have a tool to understand and **manage the complexity** of rolling stock and a way in to consider circular economy principles for different use times and to think better use.

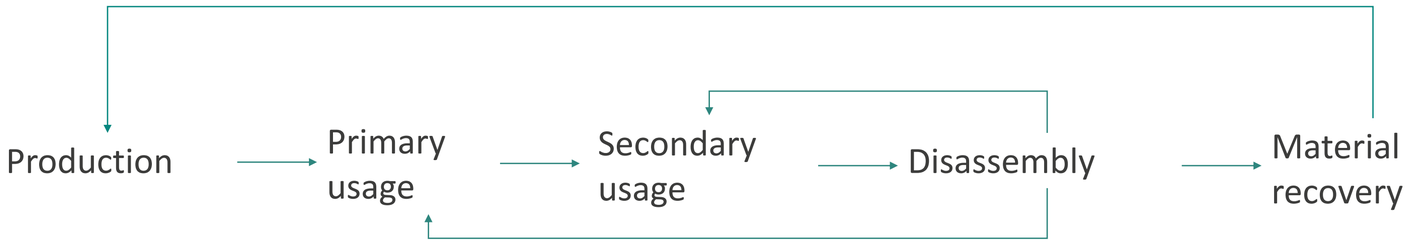
Think in use

Thinking in terms of usage is crucial because it **prioritizes keeping and reusing products and components over merely recovering materials at the end**.

Designing with multiple use phases in mind - where products are built to be maintained, reused, repurposed, or refurbished – keeping them at the highest point of the value hill for the longest time, **maximizes value while minimizing waste.**

The ultimate aim is to design for multiple use phases or lifecycles.





Primary usage: main function of the product

Secondary usage: function a product can fulfil after it has served the primary function

Focus on use

Upgrades

Upgrade components regularly to minimize the need for switching the entire train

Predictive Maintenance

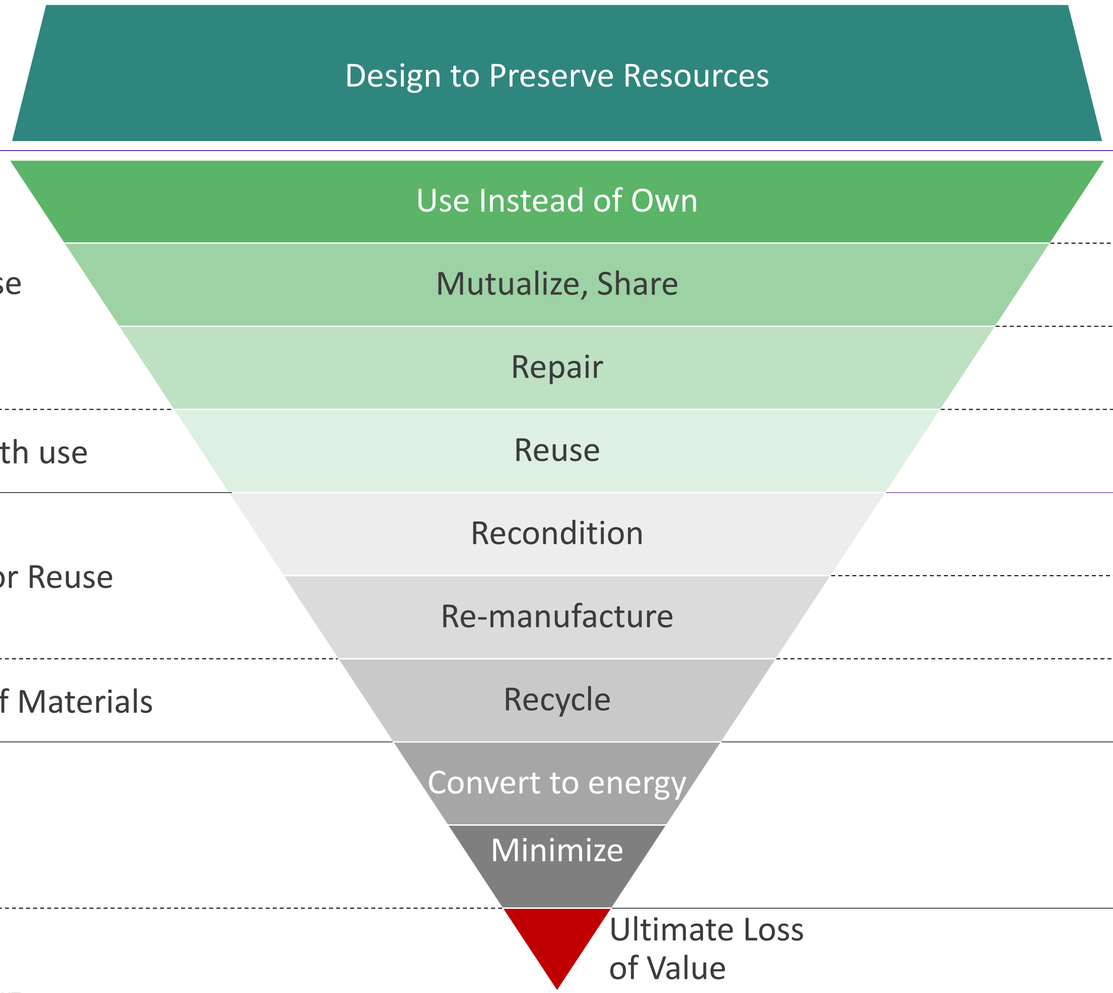
Reduce unplanned downtime and wear and tear - Estimates suggest this approach can reduce maintenance costs by up to 30% and decrease unplanned downtime by 50%.

Share

Incorporate shared use models to use the existing fleet efficiently and reduce the overall need for stock

Source: McKinsey, ERRAC

Think in design



1	Production	Design trains to use durable and sustainable materials, modular design for easy maintenance and upgrades.
2A	Better First Use	Encourage shared use models, such as public transportation services, train rentals, or ride-sharing
		Promote shared ownership and use of train facilities and assets among multiple users or organizations
		Implement efficient maintenance programs to repair train components regularly to extend service life
2B	Secondary / nth use	Reuse train components and parts in other trains or different applications to maximize their utility.
3A	Preparation for Reuse	Refurbish old trains to extend their lifespan by updating interiors, systems, and technologies
		Rebuild and update trains or train components to like-new condition, utilizing recovered materials
3B	Valorisation of Materials	Recycle materials from decommissioned trains, such as metal, glass, and plastics, for use in other products
4	Waste	Convert non-recyclable waste from trains into energy through safe and sustainable methods
		Minimize waste by optimizing all previous steps to reduce the need for disposal
		Consider as a last resort if all other reuse, recycling, or previous methods fail

Source: Jeannot Schroeder, +ImpaKT

Focus on design

Design for disassembly
A fundamental strategy for the economic success as it facilitates repair and maintenance, refurbishment, recycling and obsolescence.

Fulfil secondary usage requirements
Adapting products for secondary usage in the production saves energy and resources down the line.

Design for easy maintenance
Streamline the number of spare parts, design for easy access and rapid replacement.

Design for refurbishment
Design the product for replacement of worn parts and for upgrading over time

Design for interconnectivity
Make sure the components can interconnect with other products and can be swapped out easily.

Input Materials
Limit the raw material input by increasing the number of refurbished parts or increasing the recycle content.

Remember, the success of your circular business model starts with the product design

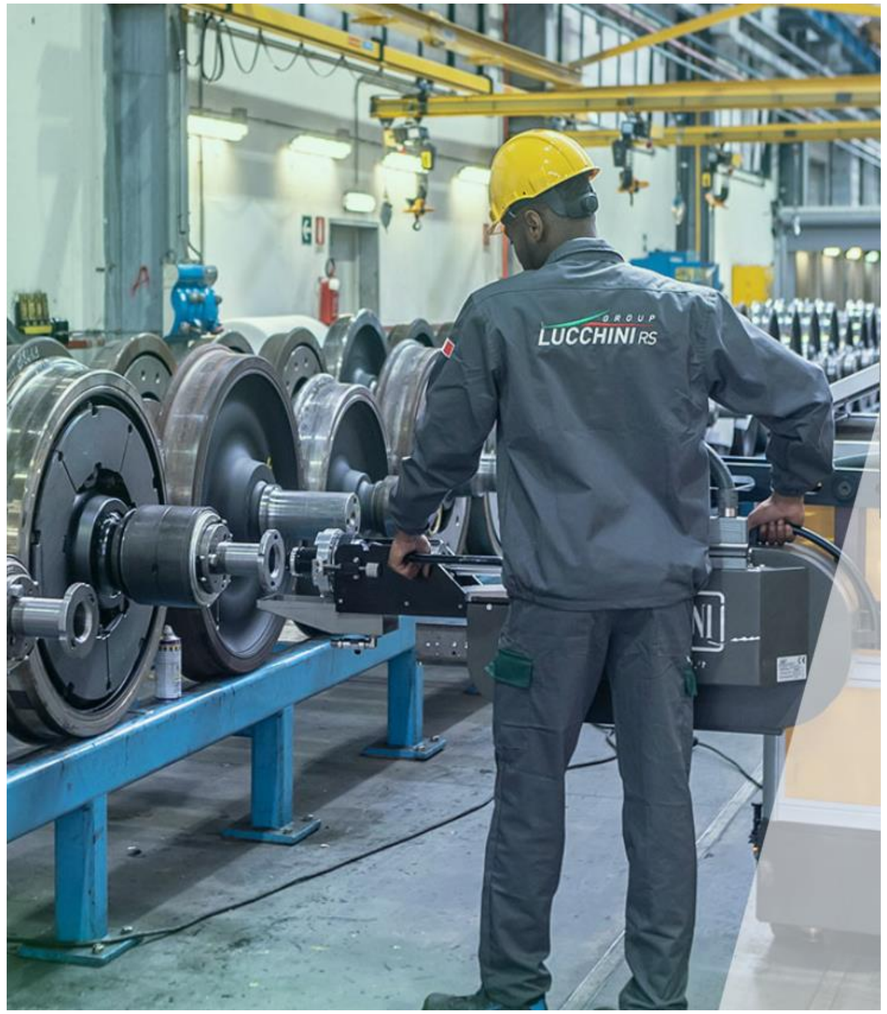
Railsponsible Supplier Award 2024: Innovation in Circular Economy

- Railsponsible's Annual Supplier Award highlights **best practices in sustainability** throughout the supply-chain
- This year's focus highlighted **Innovation in Circular Economy**
- Out of the many applications, **three entries stood out** for the innovation, scalability and circularity and have been included as our case studies for this paper
- This paper will serve as the foundation of **Railsponsible's new working group on Circular Economy in Rail** – if you are interested in learning more, please get in touch with us

Case study 1

Winner Railsponsible Supplier Award 2024

Lucchini RS is streamlining the return of scrap/end-of-life products to its plant in Italy to give them a second life. The project introduces a new role dedicated to coordinating the return of end-of-life railway components, improving circularity and reducing CO2 emissions. The initiative focuses on using high-quality recycled steel to minimize the need for virgin materials and lower the carbon footprint.



Case study 2

Runner-up Railsponsible Supplier Award 2024

Prysmian has validated the use of recycled polyethylene (LDPE) for signalling cable sheaths, making it the first cable supplier to do so. The inner sheath is made from 100% recycled PE, and the outer sheath from a 50% recycled mix. This innovation reuses plastic waste from households and industry, reducing landfill and energy consumption while promoting a circular economy.

Case study 3

Applicant Railsponsible Supplier Award 2024

Schijvens Corporate Fashion, a family business since 1863, focuses on sustainability by producing circular corporate fashion. They use 50% recycled textiles and 50% recycled polyester, eliminating the need for new raw materials. Their innovative process includes collecting and recycling old corporate clothing to create new fabrics. This initiative has significantly reduced water usage, CO_2 emissions, and energy consumption. Schijvens aims to produce fully sustainable collections by 2028 and currently, 78% of their collections are made from sustainable materials.

Future outlook and action plan

- In the circular world business models the **roles of companies within a supply chain change**
- Supply chains will become **Supply networks**. Implementing secondary use phases will turn buyers into sellers down the road
- Models liked renting components will thrive, **deepening the relationship between suppliers, manufacturers and operators**

We suggest the following action plan:

1. **Know what you have.** Implement detailed product passes and plan for a better use and later reuse of the resources
2. **Deepen relationships** with your suppliers and industry peers, in order to implement more profitable long term circular business strategies
3. **Build trust** in your partners and exchange circular product information in a standardized format

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Break time

See you back at 13.00

Denis Coppieters
CEO
ThioTrack

THIOTRACK

HIGH-STRENGTH SUSTAINABLE AND CIRCULAR SULPHUR CONCRETE SLEEPERS

November 2024

Denis Coppieters

Location : Oostende (Belgium)
Assets Manager : Infrabel
Installation : January 2014

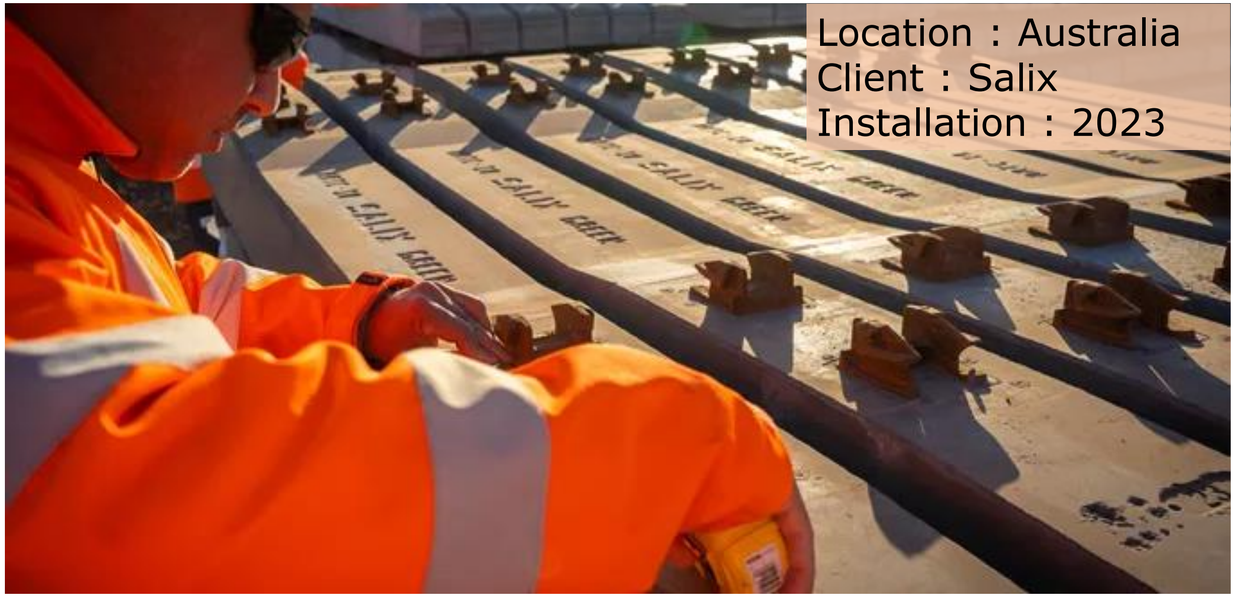
January 2024:
Removal of 10 sleepers after 10 years in track with successful laboratory test

Location : Zwolle (The Netherland)
Assets Manager : Prorail
Installation : July 2019

Location : St Ghislain (Belgium)
Assets Manager : Infrabel
Installation : October 2022

Location : Montellimar (France)
Assets Manager : SNCF
Installation : February 2020

Location : Australia
Client : Salix
Installation : 2023



Location : Lot (Belgium)
Assets Manager : Infrabel
Installation : May 2024

A 10-year Successful Program to a Sustainable Innovation

INFRABEL

2014
First test track installed

2019
Technical accreditation

Dec 2020
8-years contract for 200 000 sleepers

Feb 2022
Start Production in New Factory

Oct 2022
12 000 sleepers installed in track

May 2024
1 600 sleepers installed in track

LIJN

2014
Test track installed

ProRail

2019
Test track installed

Technical accreditation in final stage

SNCF

2020
Test track installed

Mar 2022
Technical accreditation

DB NETZE

Aug 2022
Prototypes Production

Mar 2023
EBA Trial Homologation

Others

Mar 2023
400 sleepers delivered to Australia

SALIX

Dec 2023
Prototypes Production

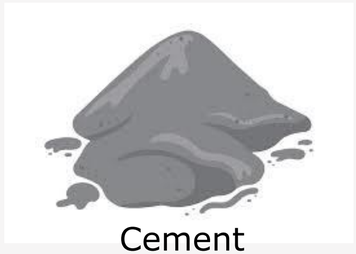
NetworkRail

Comparison of Cement vs. Sulphur Concrete

Cement Concrete


Sand


Aggregates


Cement

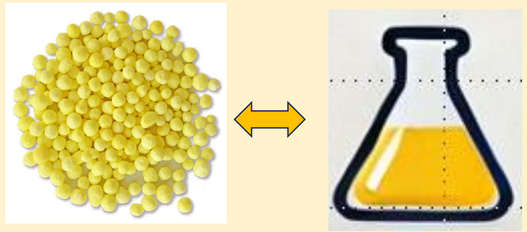

Water

- When mixed, a **chemical reaction** occurs between **cement** and **water**, leading to the hardening of the mixture.

Sulphur Concrete


Sand


Aggregates


Sulphur

- **Sulphur** melts at 114°C and transitions between solid and liquid states **without a chemical reaction**.
- Thiocrete is a type of concrete made from **sulfur** instead of cement and water.

Sulphur concrete’s physical process leads to quick solidifying and enables to reverse the complete production process

1. **Heating**
Raw matrials such as sand and gravel are heated to approx. 135 °C

2. **Mixing**
Liquid sulfur and fly ashes are added to the heated aggregates

3. **Cooling**
The heated mix is poured and cooled in a controlled setting

4. **Solidifying**
As soon as the cooling process is terminated, the product is stable and solid. There is no need to wait 28 days

5. **Re-cycling**
The process is a physical transition, allowing the process to be completely reversed through a heating process


DE
BONTE
GROUP
THIOMATERIALS

Technical Performance of THIOTRACK is Confirmed by 3 External Laboratories

1. TUM (Technische Universität München)
2. UCL-LEMSC (Mechanical Testing, Structures and Civil Engineering Laboratory)
3. Centre d'Essai Voie SNCF Réseau (Saint-Ouen)

Other tests were carried out at renowned research institutions such as SGS Intron, University of Ghent, PTG Eindhoven, University Duisburg Essen, etc.

Fig. Test setup for the examination with positive bending moment at the rail seat

Fig. Test setup for the examination with positive bending moment at the rail support

Fig. Resistance test under oblique loading

TECHNISCHE UNIVERSITÄT MÜNCHEN

PRÜFAMT FÜR VERKEHRSWEGEBAU
Prof. Dr.-Ing. S. Freudenstein

Bericht Nr. 4586 vom 02. März 2023
Report No. 4586 of 02 March 2023

FORSCHUNGSBERICHT
RESEARCH REPORT

Zulassungsprüfung an mit alternativen Bindemitteln hergestellten Spannbetonschwellen B70 gemäß DIN EN 13230-2:2016 und DIN EN 13481-2:2017

Approval test on pre-stressed concrete sleepers B70 manufactured with alternative binders according to DIN EN 13230-2:2016 and DIN EN 13481-2:2017

(Thio Materials bv, Waasmunster, Belgien)

Key Benefits of Sulfur Concrete

Significantly Less CO_2

Eliminates cement, significantly reducing CO_2 emissions.

(see next slide)

100% Circular

Fully recyclable: can be melted and reshaped into new sleepers

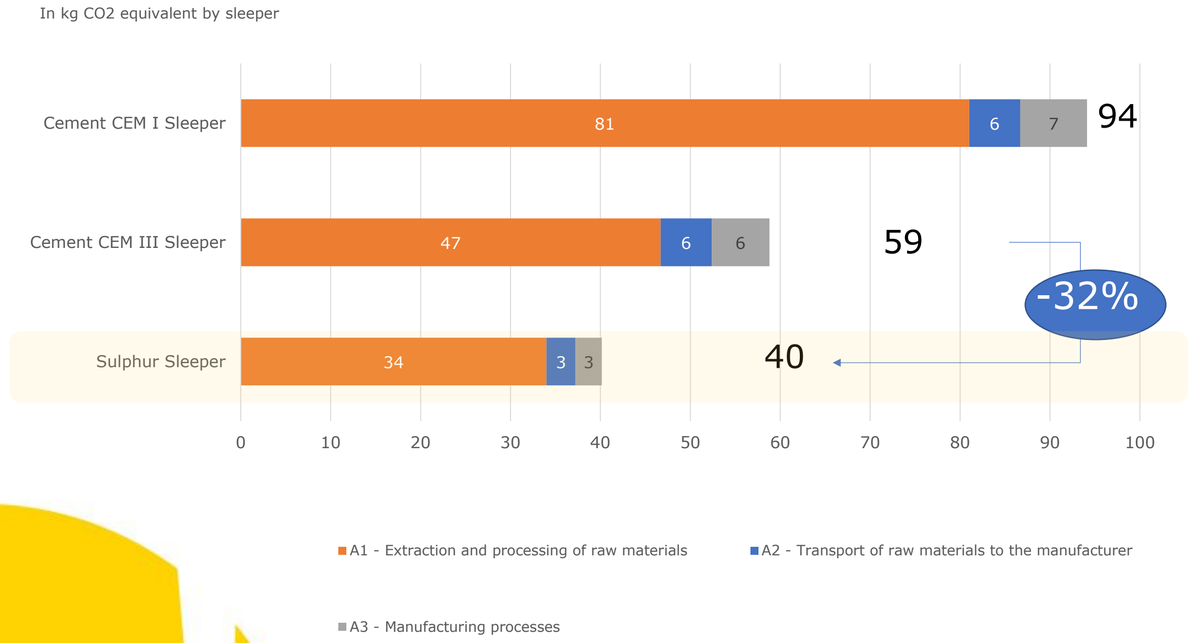
High Value Efficient

Endlessly reusable without degradation, providing long-term savings

Thiocrete sleepers are fully circular: after melting, the material can be reused indefinitely for new applications without any loss in quality or performance.

CO2 Reduction per Sleeper (NS90 – 285kg)

From A1 to A3



From A1 to D

Verified EDP for THIO NS90 : GWP = 32,3 kg CO2 eqv.

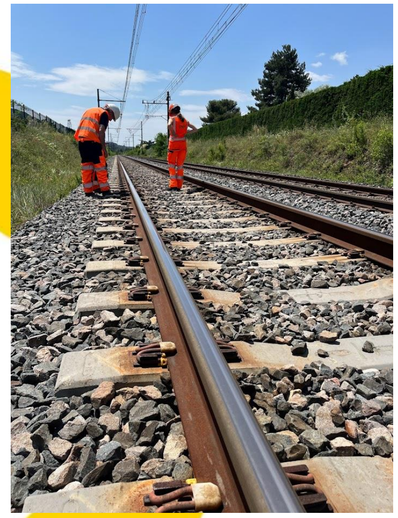
1.8 RESULTS

Environmental effects	Unit	A1	A2	A3	A4	A5	B1	B2	B3	C1	C2	C3	C4	D	Total
ADPE	Kg Sb	8.43E-4	7.27E-5	1.51E-5	3.32E-5	3.12E-5	0.00E+0	0.00E+0	0.00E+0	7.04E-7	4.95E-5	2.67E-6	1.41E-7	-3.56E-4	6.93E-4
ADPF	Kg Sb	2.14E-1	2.29E-2	2.30E-2	2.60E-2	1.20E-2	0.00E+0	0.00E+0	0.00E+0	3.00E-3	1.43E-2	9.78E-4	2.04E-4	-1.12E-1	2.05E-1
GWP	Kg CO2 Equiv.	3.27E+1	3.20E+0	2.93E+0	4.22E+0	1.89E+0	0.00E+0	0.00E+0	0.00E+0	4.54E-1	1.94E+0	2.74E+0	1.93E-2	-1.85E+1	3.16E+1
ODP	Kg CFC-11 Equiv.	1.78E-6	5.50E-7	4.79E-7	6.05E-7	1.93E-7	0.00E+0	0.00E+0	0.00E+0	7.86E-8	3.44E-7	6.67E-8	4.99E-9	-1.08E-6	3.02E-6
POCP	Kg Ethene Equiv.	3.60E-2	1.92E-3	1.85E-3	2.48E-3	1.77E-3	0.00E+0	0.00E+0	0.00E+0	4.62E-4	1.17E-3	8.21E-5	1.67E-5	-2.35E-2	2.23E-2
AP	Kg SO2 Equiv.	1.35E-1	1.55E-2	5.46E-3	3.02E-2	9.28E-3	0.00E+0	0.00E+0	0.00E+0	3.42E-3	8.52E-3	8.59E-4	1.10E-4	-7.48E-2	1.33E-1
EP	Kg PO43- Equiv.	1.83E-2	3.14E-3	7.79E-4	6.77E-3	1.70E-3	0.00E+0	0.00E+0	0.00E+0	7.78E-4	1.67E-3	1.55E-4	2.17E-5	-8.69E-3	2.46E-2
HTP	kg 1.4 DB	2.37E+1	1.26E+0	5.97E-1	1.03E+0	9.95E-1	0.00E+0	0.00E+0	0.00E+0	1.68E-1	8.16E-1	1.47E-1	7.01E-3	-8.72E+0	2.00E+1
FAETP	kg 1.4 DB	4.05E-1	3.61E-2	2.55E-2	2.56E-2	1.81E-2	0.00E+0	0.00E+0	0.00E+0	2.34E-3	2.38E-2	7.90E-3	5.47E-4	-1.48E-1	3.97E-1
MAETP	kg 1.4 DB	5.72E+2	1.29E+2	4.72E+1	8.10E+1	3.63E+1	0.00E+0	0.00E+0	0.00E+0	8.14E+0	8.57E+1	2.30E+1	9.52E-1	-1.88E+2	7.95E+2
TETP	kg 1.4 DB	1.77E-1	4.61E-3	1.12E-2	5.02E-3	6.30E-3	0.00E+0	0.00E+0	0.00E+0	2.77E-4	2.88E-3	4.40E-4	1.73E-5	1.29E-1	3.36E-1
AP	mol H+ eqv.	1.64E-1	2.08E-2	6.76E-3	4.22E-2	1.22E-2	0.00E+0	0.00E+0	0.00E+0	4.80E-3	1.13E-2	1.11E-3	1.45E-4	-9.17E-2	[illegible]
GWP-total	kg CO2 eqv.	3.40E+1	3.23E+0	3.00E+0	4.27E+0	1.93E+0	0.00E+0	0.00E+0	0.00E+0	4.59E-1	1.96E+0	2.75E+0	2.03E-2	-1[illegible]E+1	3.23E+1

Source for cement : 2021 07 29 CAT III LCA Dwarsliggers spoor.docx (milieudatabase.nl)

The circularity of Thio Material implies that, after a melting process, the same material can be re-used for new applications

- While cement-based concrete will be downgraded after its useful life (mainly as foundation material for road constructions), sulphur concrete elements are heated and re-melted to separate the raw materials and embedded components (cfr: steel, …).
- The sulphur concrete materials and all the integrated components can now be reused into identical or new concrete elements.
- Sulphur concrete has all the features for eternal reuse without degradation of quality nor performance and hence a perfect circular materials.



A new sulfur concrete sleeper contains the raw materials for the next concrete sleeper

Processus de recyclage - Béton de soufre - YouTube

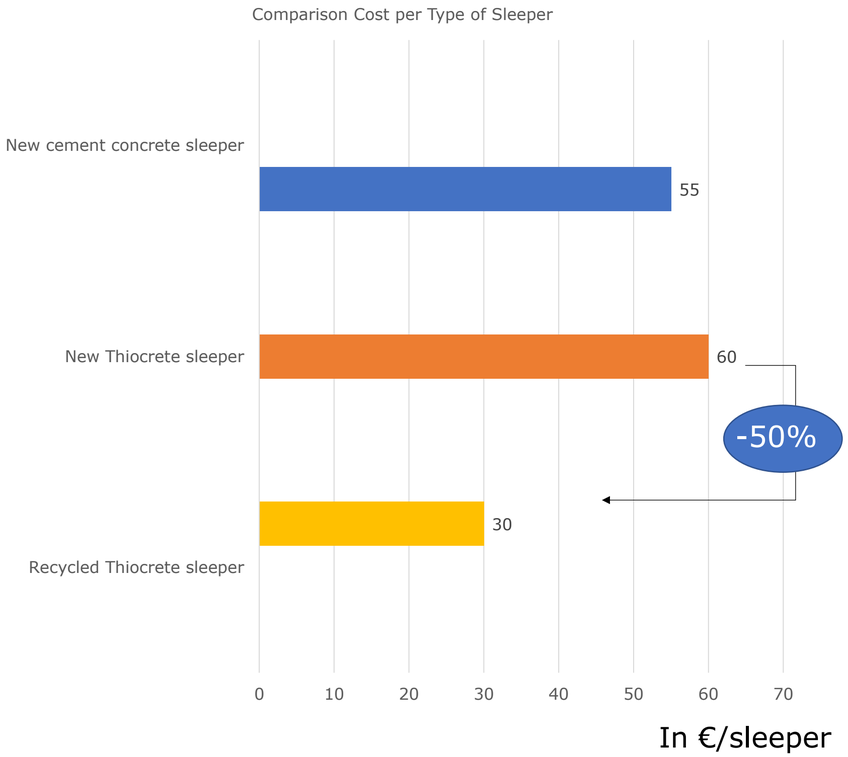
Left side : 4 years of experience of recycled sleeper on the line 800 000 Grivors – Grezan installed in track in 2020. Last inspection of June 2023

At any time, an “old” Thiocrete sleeper can be recycled into a “new” concrete sleeper at a ~50% cost of a new sleeper

Value of Circularity

A new Thiocrete sleeper contains the raw materials for the next concrete sleeper.

A recycled Thiocrete sleeper can be produced by re-using 100% of the raw materials of an “old” Thiocrete sleeper.



Note (1) excluding fastening systems (dowel or anchor) and excluding transportation and loading
(2) Excluding licensee fee to Thiomaterials
(3) assuming a 5€ overcost for sulfur concrete to cover 3€ for higher energy and 2€ in capex.

Appendix

Sources and Uses of Sulphur

Sources

- Sulfur is primarily derived from the **refining of fossil fuels**, such as crude oil and natural gas.
- It can also be extracted from natural deposits or mining sites.
- Additionally, sulfur can be recycled from waste streams generated in industrial processes.

Uses

- In **agriculture**, it is used as an essential nutrient in fertilizers to enhance soil fertility and stimulate plant growth.
- In the **chemical industry**, sulfur is crucial to produce sulfuric acid, as well as in food preservation, pharmaceutical production, rubber manufacturing, detergents, and wastewater treatment.

Supplemental testings were successfully performed (welding, leaching,…)

Tableau 4. Emission (ε_{64d}) du béton de soufre, calculée sur base des résulatats de l'essai de diffusion et de l'émission maximale selons le décret néerlandais de la qualité du sol.

code échantillon	M080312-1	M080312-2	M080313-2	*émission maximale*
charge	cendre volante I (mg/m²)	cendre volante CS (mg/m²)	limon (mg/m²)	*(mg/m²)*
Antimoine			0,26	*8,7*
Baryum			3,8	*1500*
Cadmium			0,048	*3,8*
Cuivre			1,9	*98*
Molybdène	< 0.32	0,75		*144*
Plomb			3,4	*400*
Sélénium	< 0.22	0,4		*4,8*
Vanadium				*320*
Zinc			7,4	*800*
Sulfates	100	260	890	*165000*

Source: Centre de recherche SGS Intron (NL)

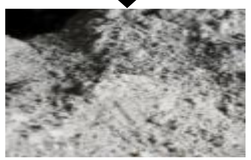
The production of sulphur concrete sleepers generates notably less CO2 compared to cement concrete

Low CO2 footprint

- Although the energy consumption is higher in the production process of sulphur concrete, Thio Material still has a significantly lower CO_2 footprint due to the **elimination of cement.**
- Cement production releases CO_2 in the atmosphere both:

  –**Directly**–when limestone ($CaCO_3$) is heated and converted into lime (CaO) and carbon dioxide (CO_2).
  –**Indirectly**–heating the kiln through the combustion of fuels such as coal, natural gas and oil.

CO2 emissions: cement vs. sulphur production



To produce cement, limestone needs to be heated up to 1,450 °C in order to separate CO_2 from lime.

After the heating process, limestone is converted into lime (CaO) and carbon dioxide (CO_2).

Crude oil is being processed and refined into more useful products such as petroleum, gas, fuel, etc.

Sulphur is being removed from crude oil through the process of desulphurization.

This process results in a large amount of hydrogen sulphide H_2S, which is subsequently converted in elemental sulphur.

Sulfur Concrete meets the technical performance of cement concrete

Robust mechanical characteristics: Thio Material resembles cement concrete due to a similar split of raw materials. More than 85% of sulphur concrete is composed of the same raw materials as cement concrete, indicating strong similar material characteristics.

Thio Material has a significantly **lower creep** than cement concrete. (creep measures the tendency of a solid material to move slowly or deform permanently under the influence of mechanical stress).

Regarding **electrical resistance** and **thermal conductivity**, Thio Material has significantly better characteristics than cement concrete.

It is also noted that Thio Material has an extremely low water absorption capacity. The quasi **non permeability** protects against the penetration of fluids.

Fire Resistance: Thio Material is practically **fireproof**, but melts at the surface. Sulphur concrete comply to EN ISO 9239-1 (A2fl and Bfl class)

Characteristic	Cement concrete	Thio Material	Assessment
Density	2,400 kg/m³	2,450 kg/m³	+
Compressive strength	± 35-150 MPa	± 60-80 MPa	≈
Flexural/tensile strength	± 8 MPa	± 12 MPa	+
Elastic modulus	± 30 GPa	± 30 GPa	≈
Creep	± 0.50 ‰	± 0.15 ‰	+
Coefficient of thermal expansion	± 1.25E$^{(-5)}$ 1/k	± 1.43E$^{(-5)}$ 1/k	≈
Thermal conductivity	± 2.4 W/mK	± 3.3 W/mK	+
Electrical resistance	±1-25 x 10^{12} µΩm	∞	+ +
Water absorption	± 3.5%	± 0.3%	+ +

Source: SGS Intron (NL) & Thio Materials

EDP for CEM III NS90 : GWP = 68,6 kg CO2 eqv.

From A1 to D

Nationale Milieu DATABASE

NS90 – CEM III

Tabel 6 Milieuprofiel NS90 – CEM III per stuk

Impact category	Eenheid	Totaal	A1	A2	A3	A4	A5	B	C1	C2	C3	C4	D
1 abiotic depletion, non fuel (AD)	kg Sb eq	2,18E-04	1,56E-04	1,62E-05	9,07E-06	1,62E-05	6,59E-06	0,00E+00	1,55E-07	1,62E-05	6,84E-07	2,38E-08	-3,27E-06
2 abiotic depletion, fuel (AD)	kg Sb eq	4,11E-01	2,66E-01	4,25E-02	4,61E-02	4,25E-02	1,65E-02	0,00E+00	3,18E-03	4,25E-02	3,92E-03	2,90E-04	-5,27E-02
4 global warming (GWP)	kg CO2 eq	6,86E+01	4,67E+01	5,68E+00	6,41E+00	5,68E+00	2,66E+00	0,00E+00	4,60E-01	5,68E+00	3,14E+00	5,33E-02	-7,87E+00
5 ozone layer depletion (ODP)	kg CFC-11 eq	6,23E-06	2,61E-06	1,06E-06	4,89E-07	1,06E-06	2,75E-07	0,00E+00	8,33E-08	1,06E-06	9,94E-08	7,02E-09	-5,17E-07
6 photochemical oxidation (POCP)	kg C2H4	3,32E-02	3,26E-02	3,37E-03	1,67E-03	3,37E-03	1,81E-03	0,00E+00	4,66E-04	3,37E-03	3,58E-04	2,76E-05	-1,38E-02
7 acidification (AP)	kg SO2 eq	2,49E-01	1,69E-01	2,46E-02	1,69E-02	2,46E-02	1,14E-02	0,00E+00	3,49E-03	2,46E-02	3,12E-03	1,52E-04	-2,92E-02
8 eutrophication (EP)	kg PO4--- eq	4,82E-02	2,97E-02	4,96E-03	3,58E-03	4,96E-03	2,25E-03	0,00E+00	7,85E-04	4,96E-03	7,06E-04	3,63E-05	-3,83E-03
9 human toxicity (HT)	kg 1,4-DB eq	2,88E+01	2,33E+01	2,33E+00	1,22E+00	2,33E+00	1,12E+00	0,00E+00	1,66E-01	2,33E+00	2,45E-01	1,00E-02	-4,17E+00
10 Ecotoxicity, fresh water (FAETP)	kg 1,4-DB eq	6,20E-01	3,19E-01	6,77E-02	2,70E-02	6,77E-02	1,93E-02	0,00E+00	2,31E-03	6,77E-02	1,45E-02	1,42E-03	3,32E-02
12 Ecotoxcity, marine water (MAETP)	kg 1,4-DB eq	1,79E+03	8,66E+02	2,41E+02	9,15E+01	2,41E+02	5,93E+01	0,00E+00	7,78E+00	2,41E+02	3,31E+01	1,95E+00	8,55E+00
14 Ecotoxicity, terrestric (TETP)	kg 1,4-DB eq	8,01E-01	4,23E-01	8,03E-03	4,09E-02	8,03E-03	1,50E-02	0,00E+00	2,74E-04	8,03E-03	1,61E-03	2,56E-05	2,96E-01
101. Energy, primary, renewable (MJ)	MJ	6,43E+01	7,36E+01	9,30E-01	7,09E+00	9,30E-01	2,56E+00	0,00E+00	3,89E-02	9,30E-01	4,74E-01	5,86E-03	-2,23E+01
102. Energy, primary, non-renewable (MJ)	MJ	8,74E+02	5,31E+02	9,43E+01	9,31E+01	9,43E+01	3,46E+01	0,00E+00	7,13E+00	9,43E+01	8,15E+00	6,47E-01	-8,44E+01
104. Water, fresh water use (m3)	m3	3,41E-01	6,32E-01	1,68E-02	4,82E-02	1,68E-02	2,31E-02	0,00E+00	9,22E-04	1,68E-02	6,47E-03	6,33E-04	-4,21E-01
106 Waste, hazardous (kg)	kg	1,28E-03	1,66E-03	5,64E-05	1,92E-04	5,64E-05	6,39E-05	0,00E+00	3,00E-06	5,64E-05	1,45E-05	4,19E-07	-8,19E-04
105 Waste, non hazardous (kg)	kg	2,83E+01	6,61E+00	5,40E+00	7,85E-01	5,40E+00	8,47E-01	0,00E+00	7,16E-03	5,40E+00	8,91E-01	3,49E+00	-5,02E-01
107 Waste, radioactive (kg)	kg	3,29E-03	1,14E-03	5,97E-04	2,26E-04	5,97E-04	1,43E-04	0,00E+00	4,67E-05	5,97E-04	3,51E-05	3,96E-06	-9,57E-05

EDP for CEM I NS90 : GWP = 105 kg CO2 eqv.

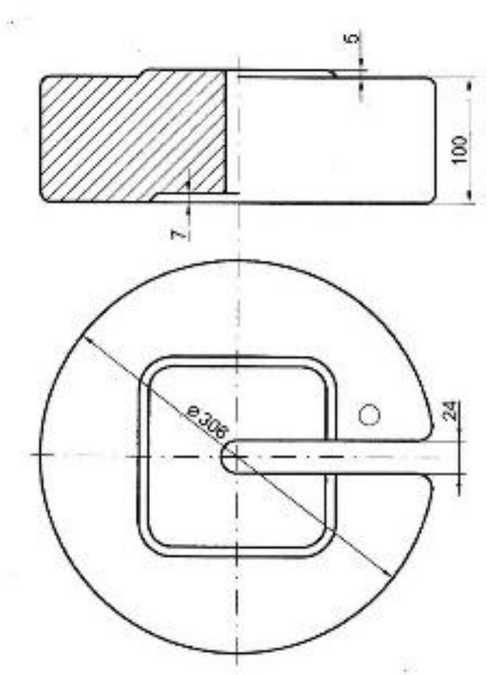
From A1 to D

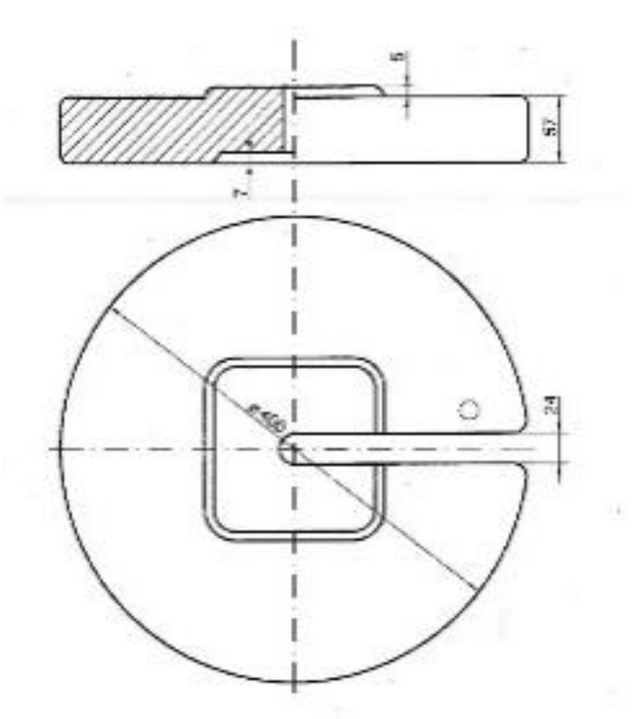
NS90 – CEM I

Tabel 5 Milieuprofiel NS90 – CEM I per stuk

Impact category	Eenheid	Totaal	A1	A2	A3	A4	A5	B	C1	C2	C3	C4	D
1 abiotic depletion, non fuel (AD)	kg Sb eq	4,18E-03	3,89E-03	1,62E-05	1,21E-04	1,62E-05	1,22E-04	0,00E+00	1,55E-07	1,62E-05	6,84E-07	2,38E-08	-3,27E-06
2 abiotic depletion, fuel (AD)	kg Sb eq	4,67E-01	3,19E-01	4,25E-02	4,76E-02	4,25E-02	1,81E-02	0,00E+00	3,18E-03	4,25E-02	3,92E-03	2,90E-04	-5,27E-02
4 global warming (GWP)	kg CO2 eq	1,05E+02	8,10E+01	5,68E+00	7,44E+00	5,68E+00	3,72E+00	0,00E+00	4,60E-01	5,68E+00	3,14E+00	5,33E-02	-7,87E+00
5 ozone layer depletion (ODP)	kg CFC-11 eq	6,26E-06	2,64E-06	1,06E-06	4,90E-07	1,06E-06	2,76E-07	0,00E+00	8,33E-08	1,06E-06	9,94E-08	7,02E-09	-5,17E-07
6 photochemical oxidation (POCP)	kg C2H4	3,75E-02	3,67E-02	3,37E-03	1,79E-03	3,37E-03	1,93E-03	0,00E+00	4,66E-04	3,37E-03	3,58E-04	2,76E-05	-1,38E-02
7 acidification (AP)	kg SO2 eq	2,79E-01	1,98E-01	2,46E-02	1,78E-02	2,46E-02	1,23E-02	0,00E+00	3,49E-03	2,46E-02	3,12E-03	1,52E-04	-2,92E-02
8 eutrophication (EP)	kg PO4--- eq	5,88E-02	3,98E-02	4,96E-03	3,88E-03	4,96E-03	2,56E-03	0,00E+00	7,85E-04	4,96E-03	7,06E-04	3,63E-05	-3,83E-03
9 human toxicity (HT)	kg 1,4-DB eq	2,94E+01	2,38E+01	2,33E+00	1,24E+00	2,33E+00	1,13E+00	0,00E+00	1,66E-01	2,33E+00	2,45E-01	1,00E-02	-4,17E+00
10 Ecotoxicity, fresh water (FAETP)	kg 1,4-DB eq	6,44E-01	3,42E-01	6,77E-02	2,77E-02	6,77E-02	2,00E-02	0,00E+00	2,31E-03	6,77E-02	1,45E-02	1,42E-03	3,32E-02
12 Ecotoxcity, marine water (MAETP)	kg 1,4-DB eq	2,11E+03	1,16E+03	2,41E+02	1,00E+02	2,41E+02	6,85E+01	0,00E+00	7,78E+00	2,41E+02	3,31E+01	1,95E+00	8,55E+00
14 Ecotoxicity, terrestric (TETP)	kg 1,4-DB eq	8,22E-01	4,43E-01	8,03E-03	4,15E-02	8,03E-03	1,56E-02	0,00E+00	2,74E-04	8,03E-03	1,61E-03	2,56E-05	2,96E-01
101. Energy, primary, renewable (MJ)	MJ	6,68E+01	7,60E+01	9,30E-01	7,16E+00	9,30E-01	2,63E+00	0,00E+00	3,89E-02	9,30E-01	4,74E-01	5,86E-03	-2,23E+01
102. Energy, primary, non-renewable (MJ)	MJ	9,44E+02	5,98E+02	9,43E+01	9,51E+01	9,43E+01	3,67E+01	0,00E+00	7,13E+00	9,43E+01	8,15E+00	6,47E-01	-8,44E+01
104. Water, fresh water use (m3)	m3	3,92E-01	6,80E-01	1,68E-02	4,97E-02	1,68E-02	2,45E-02	0,00E+00	9,22E-04	1,68E-02	6,47E-03	6,33E-04	-4,21E-01
106 Waste, hazardous (kg)	kg	1,96E-03	2,30E-03	5,64E-05	2,11E-04	5,64E-05	8,37E-05	0,00E+00	3,00E-06	5,64E-05	1,45E-05	4,19E-07	-8,19E-04
105 Waste, non hazardous (kg)	kg	2,86E+01	6,87E+00	5,40E+00	7,92E-01	5,40E+00	8,55E-01	0,00E+00	7,16E-03	5,40E+00	8,91E-01	3,49E+00	-5,02E-01
107 Waste, radioactive (kg)	kg	3,29E-03	1,14E-03	5,97E-04	2,26E-04	5,97E-04	1,43E-04	0,00E+00	4,67E-05	5,97E-04	3,51E-05	3,96E-06	-9,57E-05


DE BOHTE
THIOCRETE
INFRAREL





COUNTERWEIGHT – since 2004
BALLAST BLOCKS in THIOCRETE

- high compressive power
- very low absorption
- frost proof
- anti-corrosion and high resistance to caustic substances
- low maintenance cost
- environment-friendly; decreased CO 2 footprint and high recycling
- shape and dimensions can be adjusted to any specific order
- can be used as a cheap alternative for expensive cast-iron weights
- less attractive to steel thieves

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More info on:
Home - De Bonte Group
Sulphur concrete - Thiotube (thiomaterials.com)

Diego Lyon

VP of Business Development

Strong by Form

Strong by Form x DB Mindbox: Decarbonizing public infrastructure

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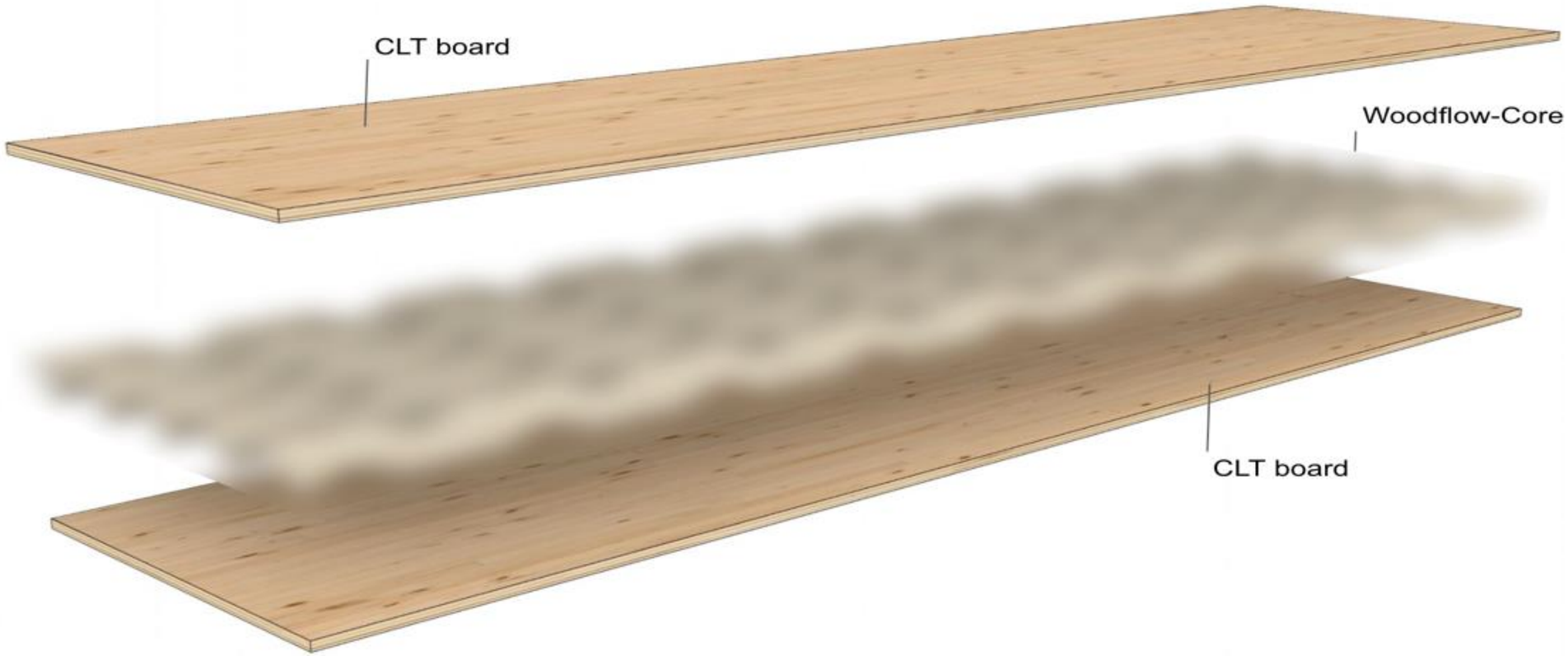
strong by form

WOODFLOW TECHNOLOGY

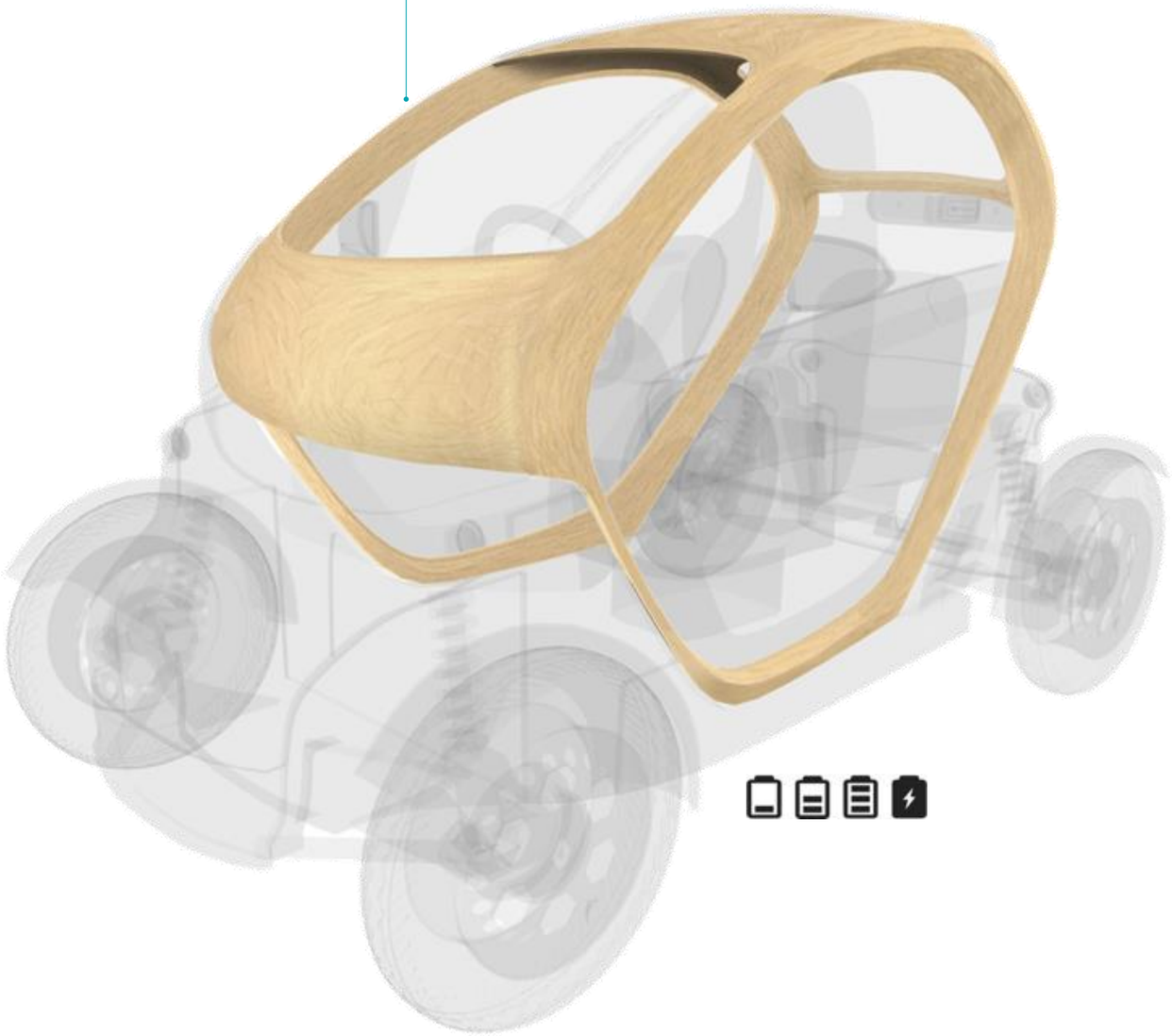
strong by form

WOODFLOW CORE – LONG-SPAN STRUCTURAL SLABS FOR HIGHRISE BUILDINGS

strong by form



Structural body parts

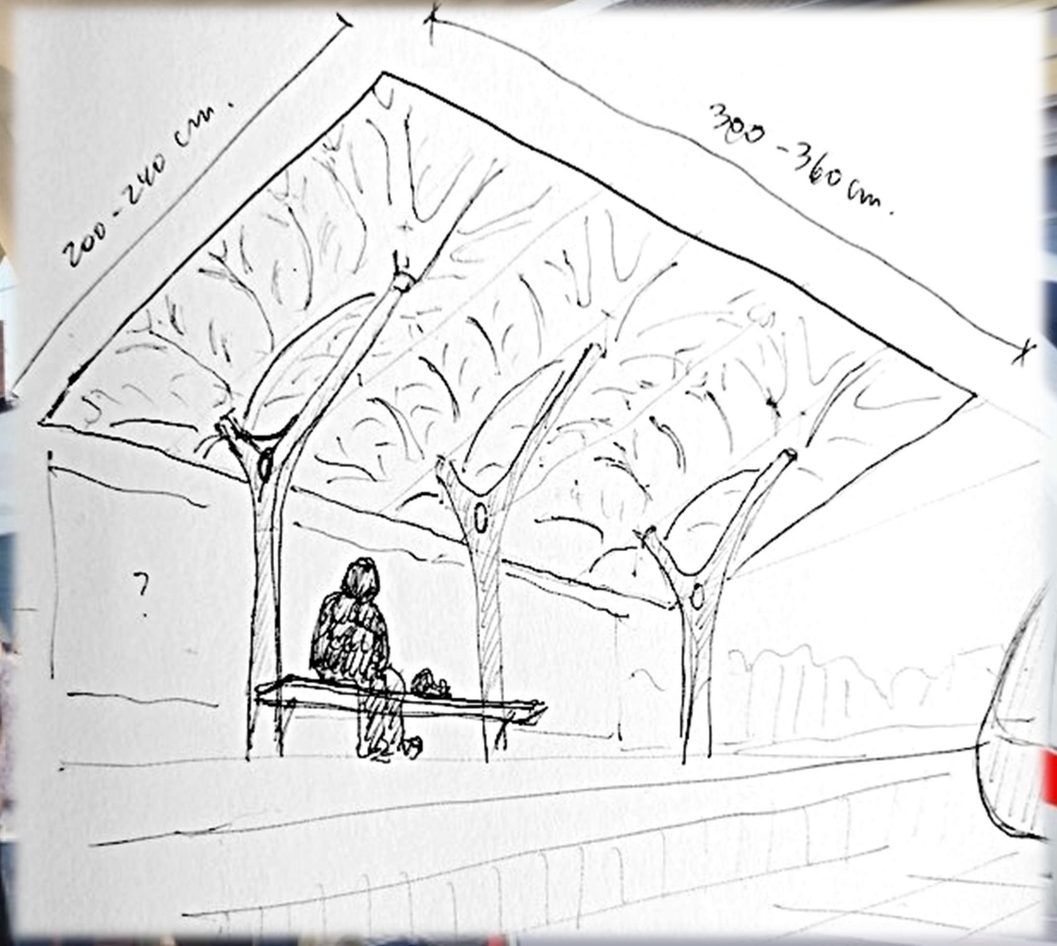


Pilot

Unique sustainable freeform cladding

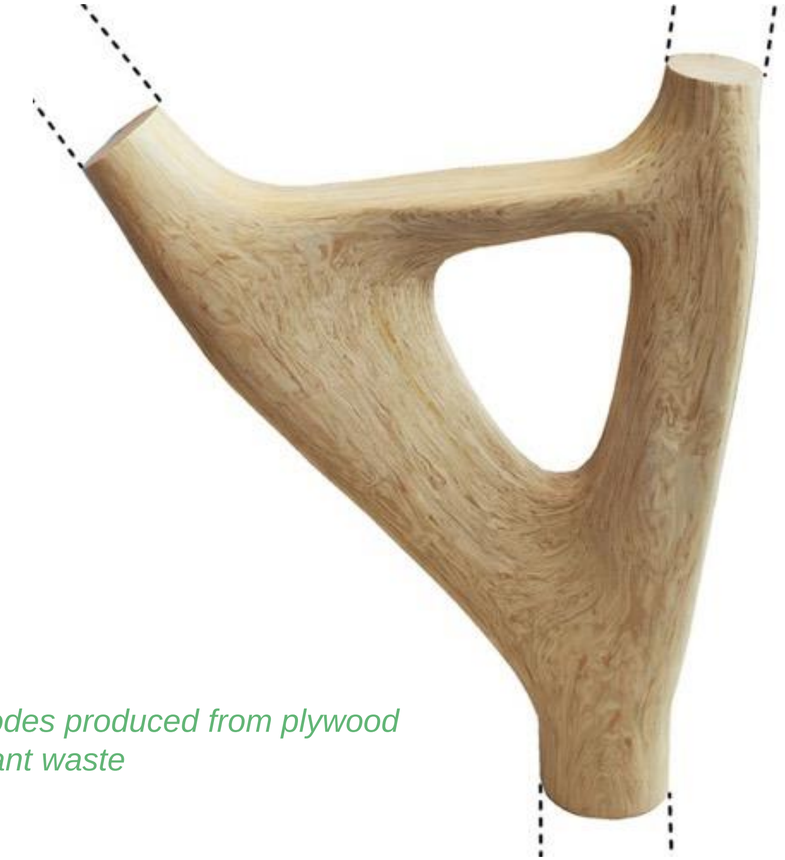
VISION

The POC that we proposed embodies a vision: High-tec, high-performance, nature-inspired solutions to reduce embodied carbon.



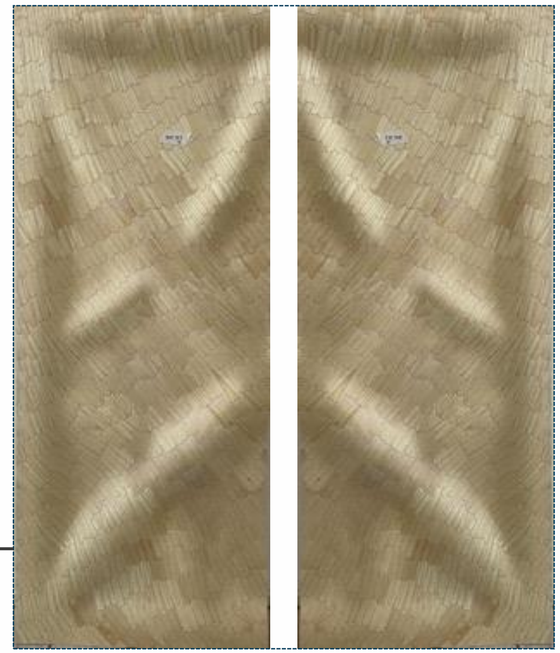
For this project, we combined two of our structural developments: the lightweight slab, and what we call Woodflow-nodes to build a bioinspired “Wartehäuschen”.

+



Nodes produced from plywood plant waste

PARTS DIAGRAM



ON-SITE TESTING

Diego Lyon
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strong by form

Carles Camprubi
Chief Circularity Officer
La Farga

La Farga

Innovative sustainable copper

THE WORLD'S FIRST CATENARY SYSTEM MADE FROM 100% RECYCLED COPPER

we are COPPER, we are INNOVATION, we are SUSTAINABILITY

www.lafarga.es

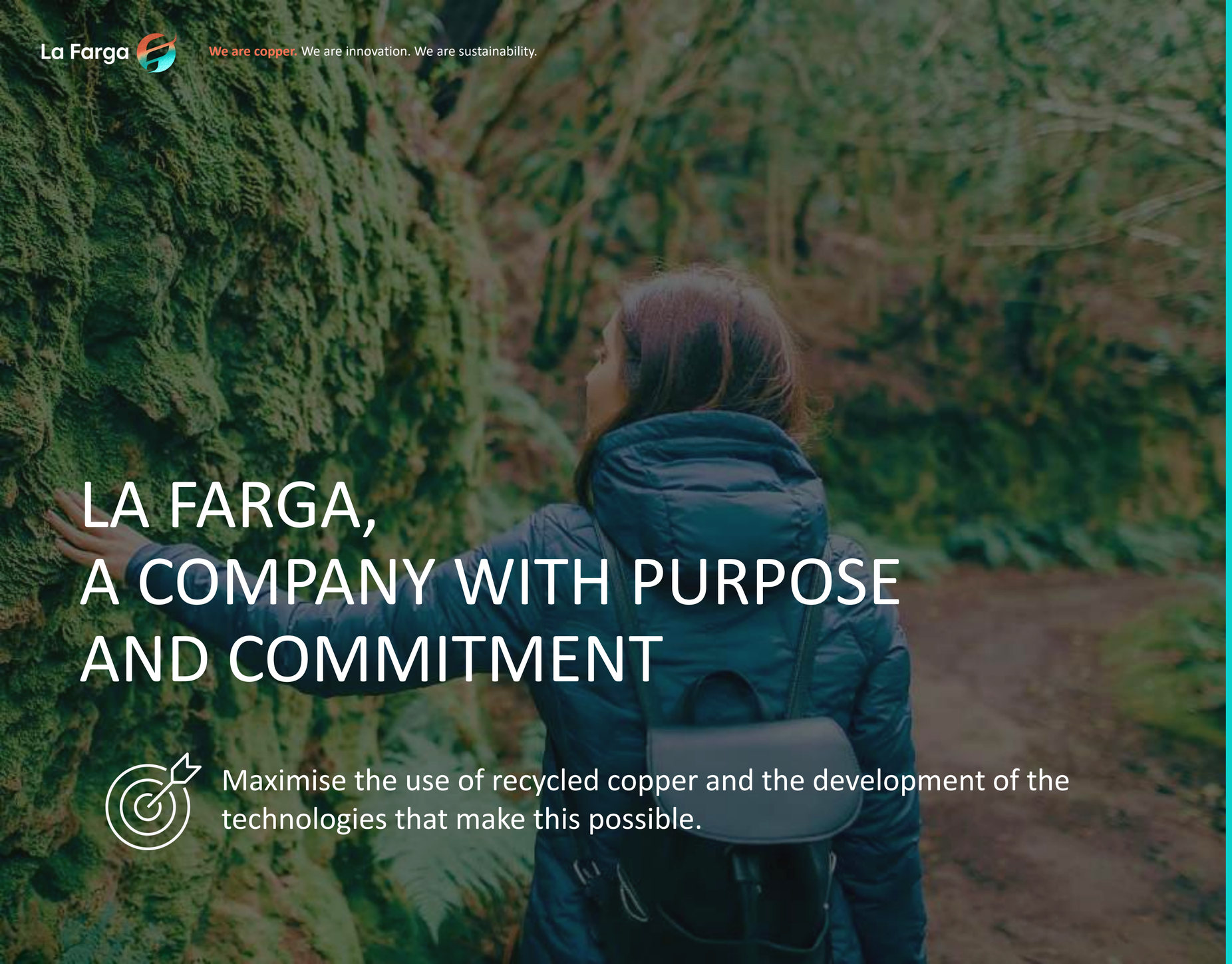
215 YEARS OFFERING CIRCULAR COPPER SOLUTIONS IN A SUSTAINABLE AND COMMITTED WAY

Family business that manufactures semi-finished copper products and its alloys.

World leader in technology and recycling process with **the first patent in 1986.**

Sustainability is the backbone of our corporate strategy.

We **generate long-term value.**



LA FARGA, A COMPANY WITH PURPOSE AND COMMITMENT

Maximise the use of recycled copper and the development of the technologies that make this possible.

OUR MISSION

Pioneers in offering sustainable copper solutions in society.

OUR VALUES

Innovation
Commitment
Open minded
Enthusiasm

LA FARGA’s CONTRIBUTION TO A NET ZERO ECONOMY

Company

Reduction of emissions, implementation of efficient processes and use of recycled copper as raw material.

2023	2030	2050
36%	55%	Net positive

** Emissions reduction by tons sold / Year of reference: 2019*

LA FARGA’s CONTRIBUTION TO A NET ZERO ECONOMY

Company

Reduction of emissions, implementation of efficient processes and use of recycled copper as raw material.

Products

necessary for the energy transition and with the lowest impact .

2023	2030	2050
36%	55%	Net positive

** Emissions reduction by tons sold / Year of reference: 2019*

COPPER
A KEY AGENT FOR THE CHALLENGES OF SUSTAINABLE DEVELOPMENT

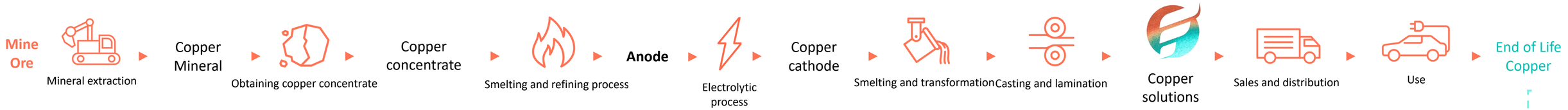
Cu

Copper is infinitely recyclable without losing its natural properties.

30 M Tn

Every year 30M tons of copper are produced in the world and only 9M tons are recycled.

Standard process based on mined copper



Environmental impact of the direct mine process

La Farga's process based on scrap as raw material

Reduction of the environmental impact through the direct use of scrap with the innovative technology patented by La Farga

Environmental impact of the direct scrap process

Genius by La Farga

100% RECYCLED AND 100% RECYCLABLE COPPER WITH THE LOWEST CARBON FOOTPRINT ON THE MARKET

EPD®

EPD complies with the standards ISO 14025 and EN 15804.

92%

Reduction in CO_2 emissions

99%

Reduction of water consumption

89%

Less depletion of fossil resources

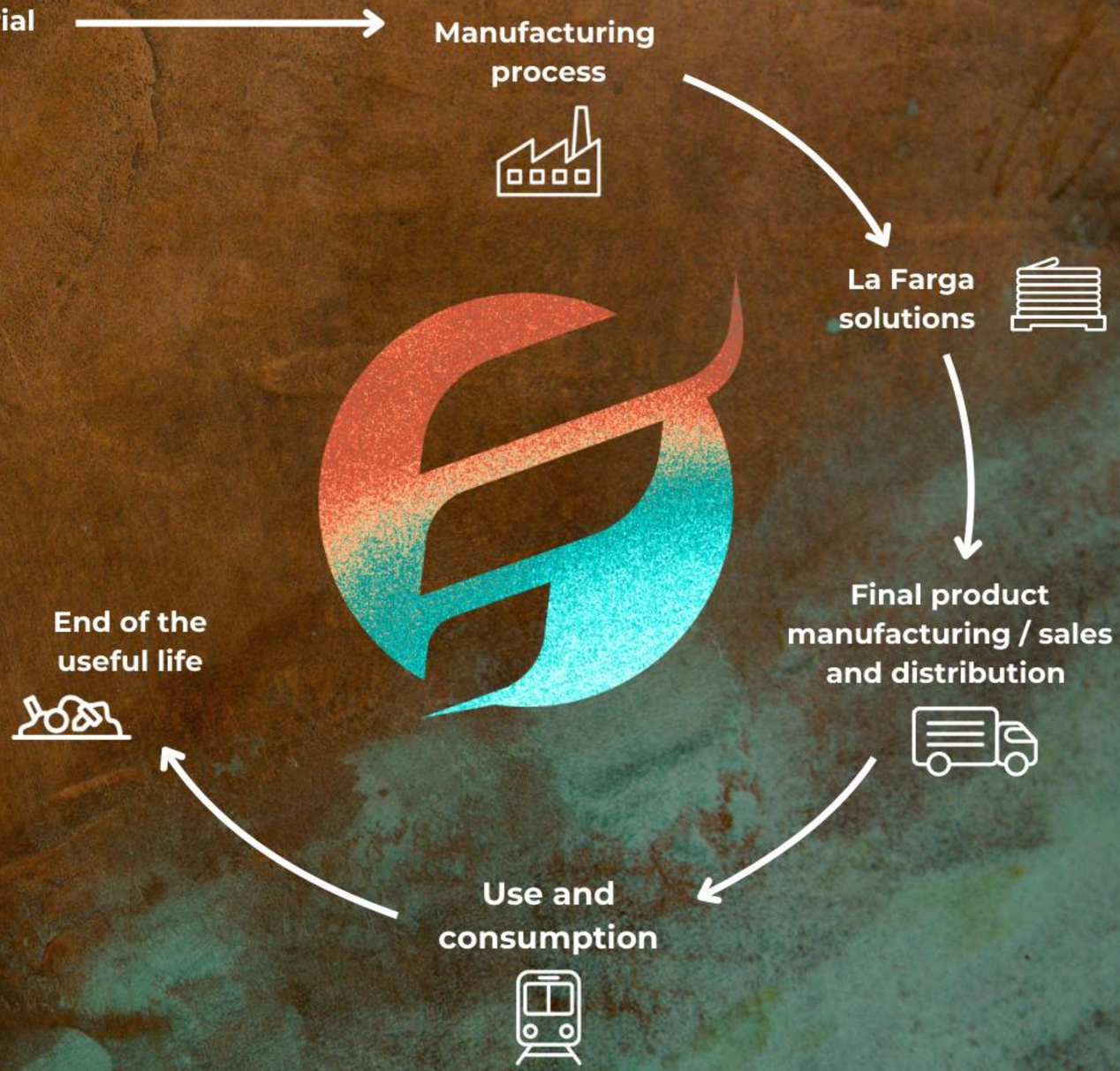
99%

Reducing SO_2 emissions

*Data corresponding to the EPD of GENIUS wire rod vs the average of the official data calculated by the ICA

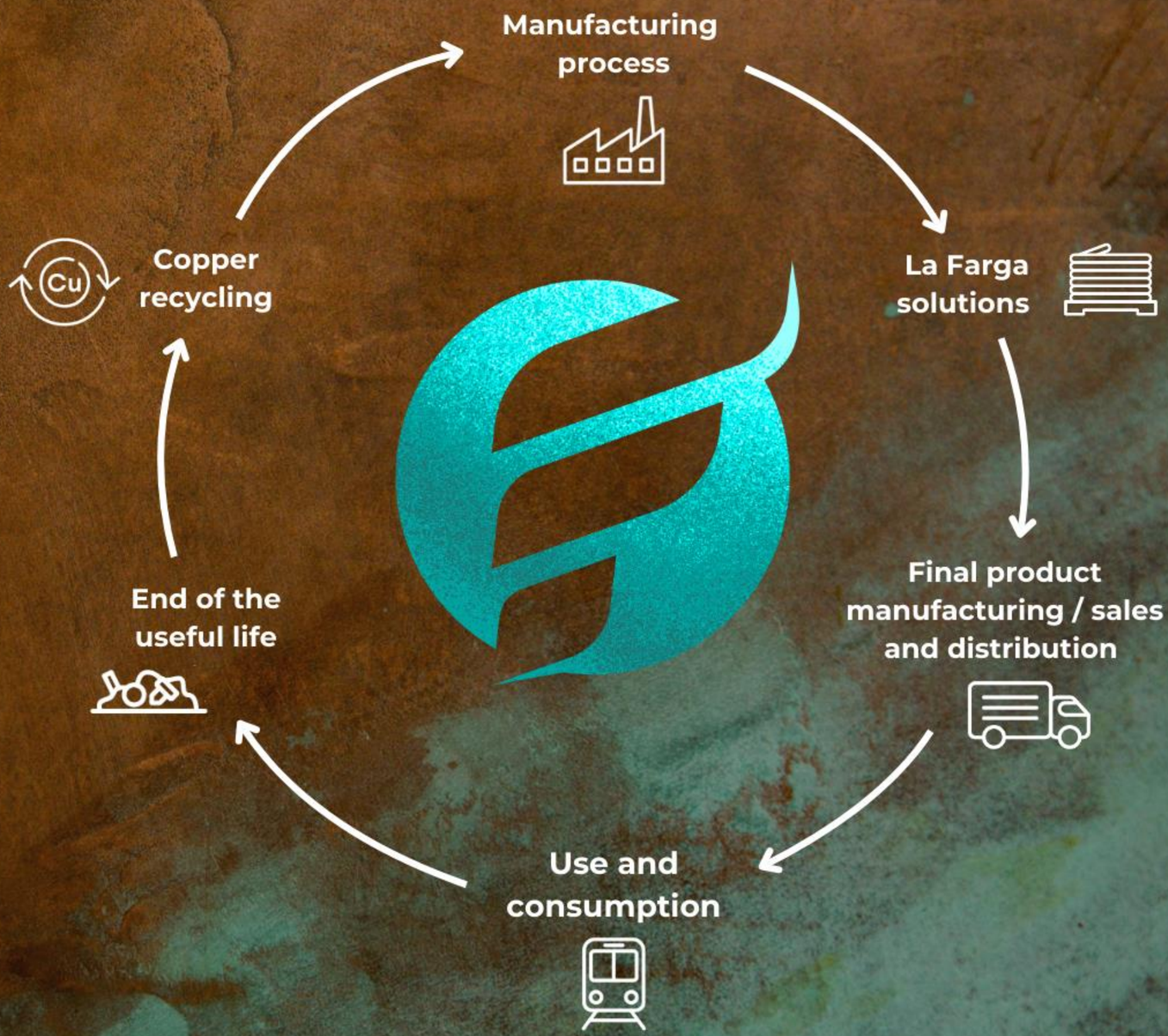
We are the first company in the sector to offer a 100% recycled copper with the lowest carbon footprint, certified by an Environmental Product Declaration (EPD).

FROM LINEAR...


Raw Material
Cu
Manufacturing process
La Farga solutions
Final product manufacturing / sales and distribution
Use and consumption
End of the useful life

FROM LINEAR...

TO CIRCULAR !



CIRCULARITY REQUIRES COLLABORATION

ProRail

Leads the implementation of the project in the Dutch railway system.

RAILTECH BV
Railinfra Solutions

Provides technical services to guarantee the catenary system's reliability.

Strukton
Rail

Manages the catenary system installation.

La Farga
Innovative
sustainable
copper

Manufactures and supplies Genius contact wire.

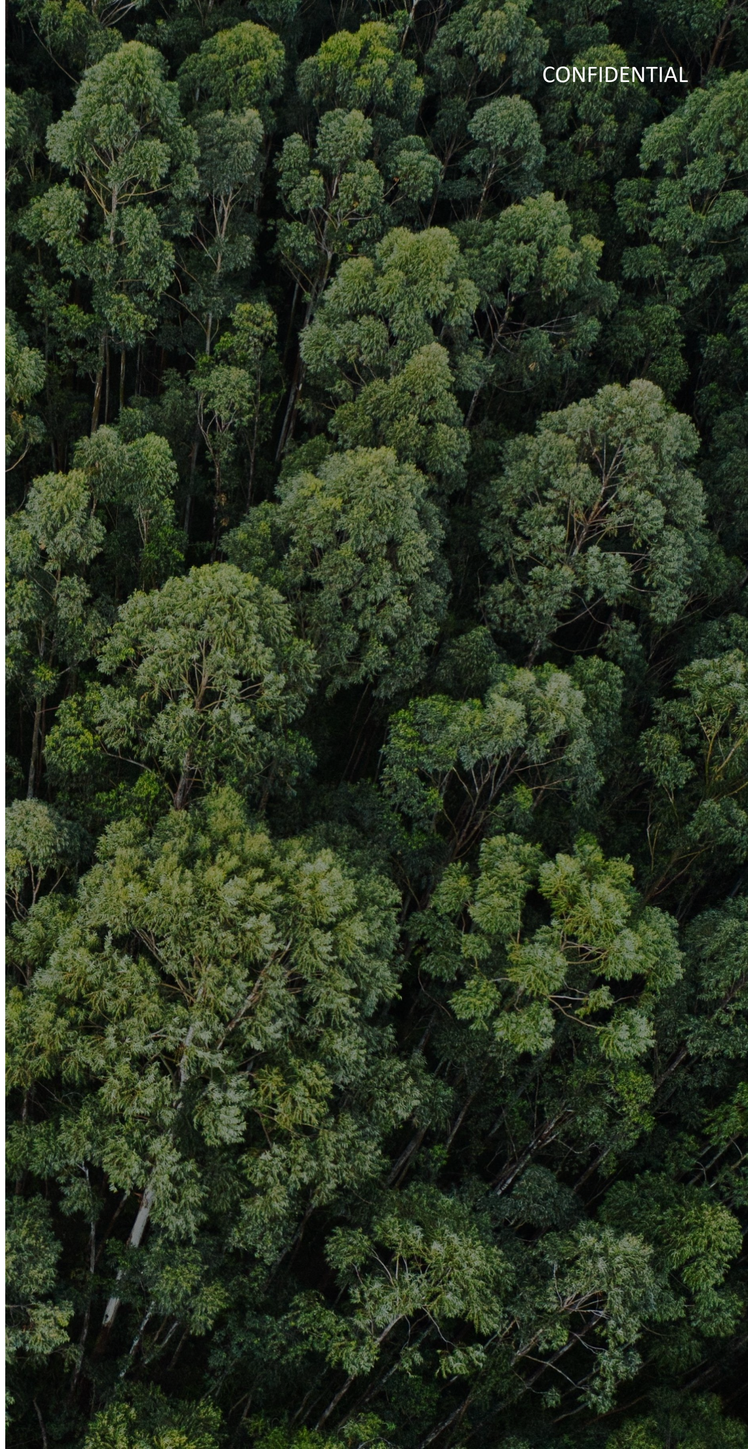
La Farga **We are copper.** We are innovation. We are sustainability.

THE PROJECT

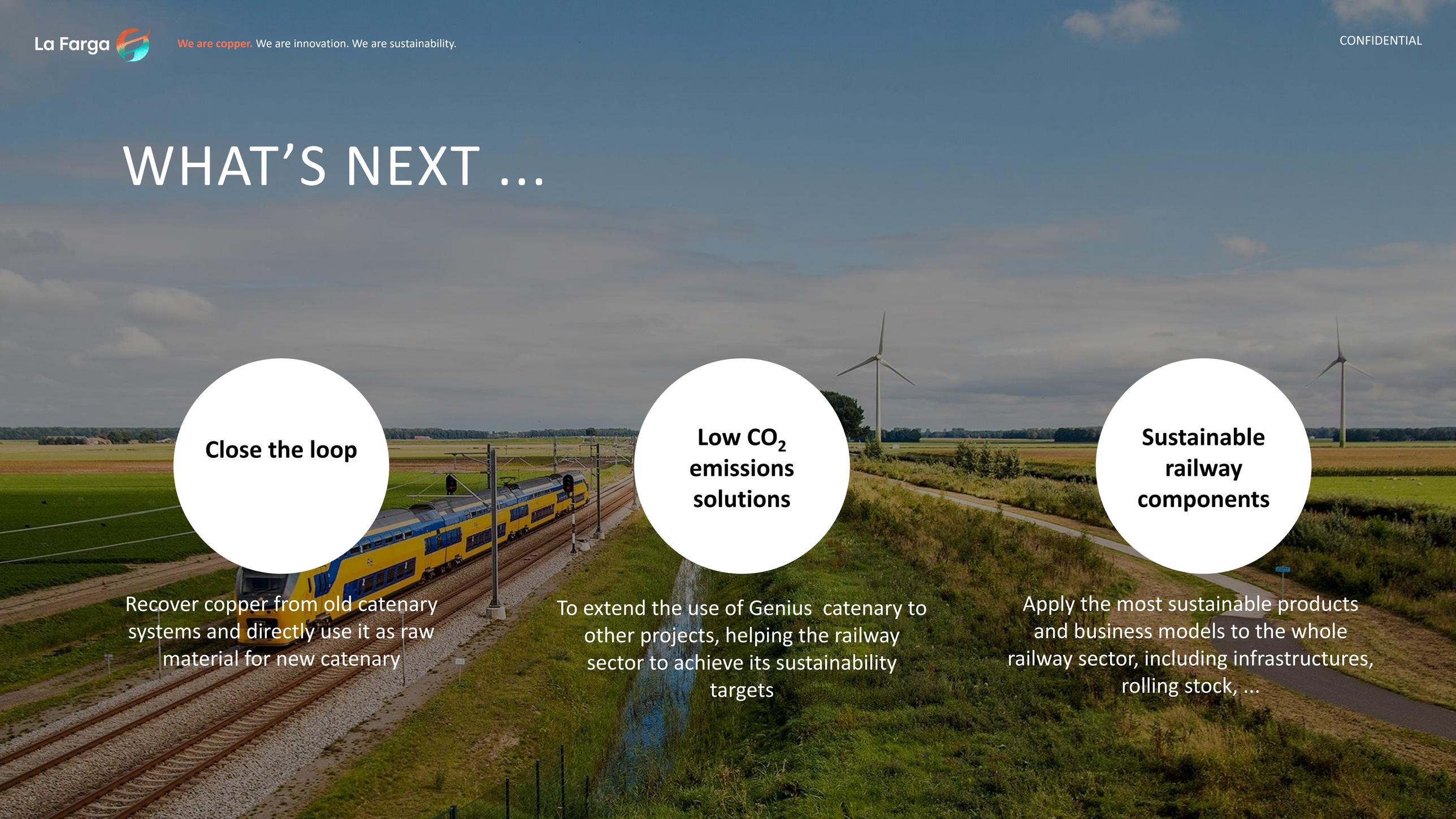
The world's first contact wire made from 100% recycled copper.

Genius by La Farga

OUR CONTRIBUTION TO ACHIEVING THE NET ZERO EMISSIONS



WHAT'S NEXT ...



Close the loop

Recover copper from old catenary systems and directly use it as raw material for new catenary

Low CO_2 emissions solutions

To extend the use of Genius catenary to other projects, helping the railway sector to achieve its sustainability targets

Sustainable railway components

Apply the most sustainable products and business models to the whole railway sector, including infrastructures, rolling stock, ...

La Farga Innovative sustainable copper

Thank you for your time

Carles Camprubí

carles.camprubi@lafarga.es

LA FARGA yourcoppersolutions, S.A.

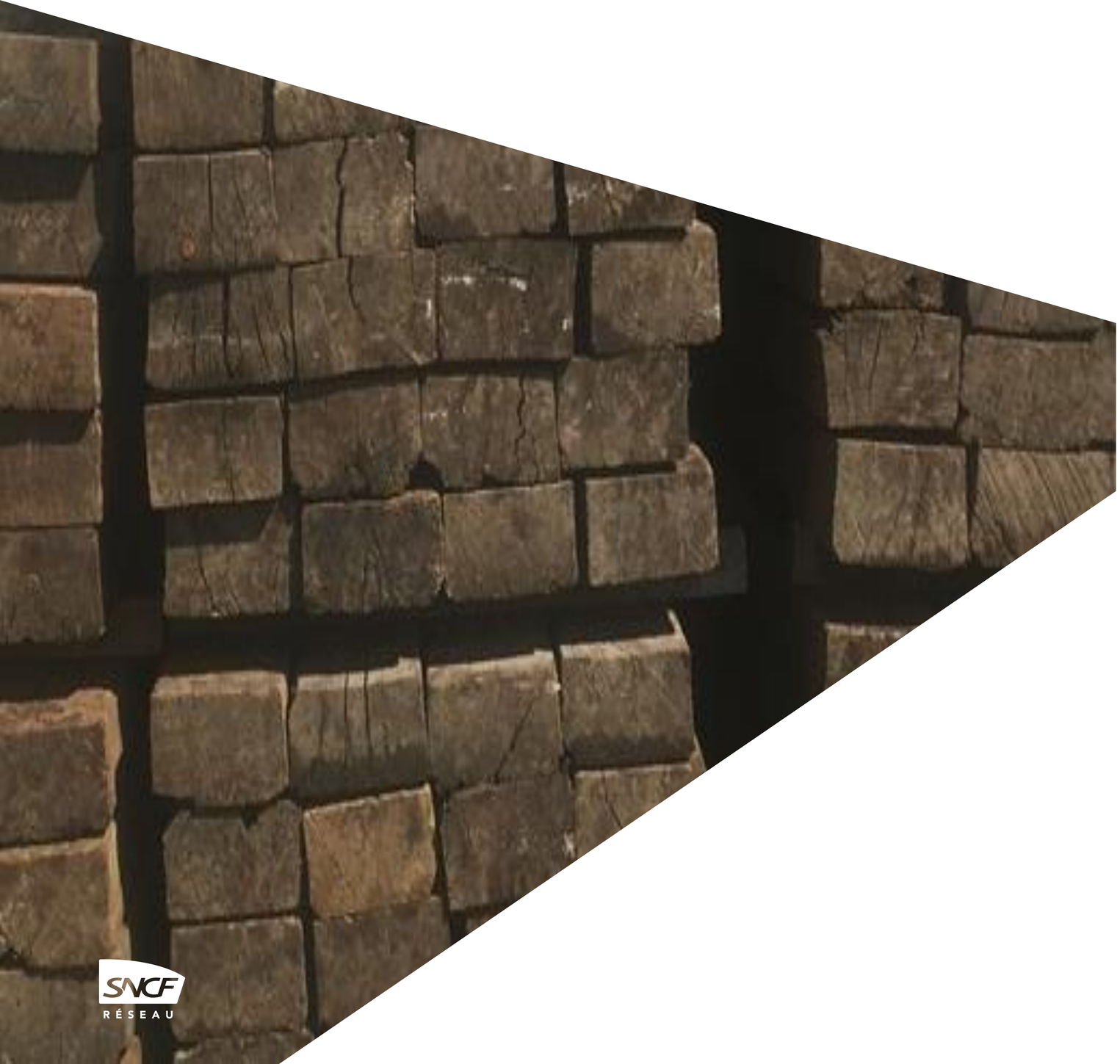
Colònia Lacambra S/N

08508 / Les Masies de Voltregà (Barcelona) / Spain

lafarga@lafarga.es / www.lafarga.es / Follow us

Thomas Pegalajar
Advocacy Officer
SNCF Réseau

Bénédicte Gourmandin
Circular economy specialist
SNCF Réseau



Modernized wooden sleepers for a low-carbon circular economy

Preserving natural resources to contribute to European net 0 emission

Novembre 20, 2024

Sleepers’ situation on the French railway network

Key figures

2M

sleepers installed every year

sleepers installed every year (mostly concrete)

500K

Wooden sleepers

Made from oak and exotic wood

400K

Wooden sleepers treated in our own factory

Only french oak PEFC qualified

Creosote raises concerns and is authorized by European legislation until 2029 for only two uses: sleepers and poles

SNCF Réseau has made a long-term commitment to conserving the only bio-sourced railway product: wooden sleepers.

Transitioning from creosote to copper-oil treatment

Key figures

10M€

Investment to modernise the site and chose a new product

6 million for the research and development program, 4 million for modernization

36

Alternative surveyed

6

Chemical products tested

What impact does the project have on SUSTAINABLE DEVELOPMENT GOALS ?

Non cancerogenic product

Odorless product

Improved quality of life at work

Europe's largest copper-oil impregnation site

Maintaining local jobs

Contributing to regional development

Eco-design with a view to re-use of the treated sleepers

Local commitment to the French oak sector

Low CO2 emissions by using wood

Non fossil oil-based solution

Promotion of eco-forestry (100 % PEFC oak)

No impact for the environment thanks to copper treatment

Engage the entire wood industry

Low CO2 emissions by using wood

To contribute to European net 0 emission

Wood : 40 - 44 tCO2 eq/Km

Concrete : 70 - 75 tCO2 eq/Km

Composite : 50 - 83 tCO2 eq/Km

Circularity in new process

Applied to the wooden sleeper system

A life cycle commitment

Eco-design with a view to re-use of the treated sleepers

New possibilities in the end-of-life valorization

The keys to success for SNCF Réseau

Develop an integrated engineering approach

Think circular

Respect employees' concerns and building on collective efforts

Anticipate regulatory changes

Involve the entire industry (from forestry operators to impregnators)

Defend and promote the intrinsic environmental value of wood

THANK YOU

Katy Beardsworth

Circular Economy Strategy Manager

Network Rail

Circular metrics – reuse rate forecasting

Katy Beardsworth – Circular Economy Strategy Manager
Network Rail

Simpler.
Better.
Greener.

UIC Zero Waste Workshop

Simpler.
Better.
Greener.

To be discussed

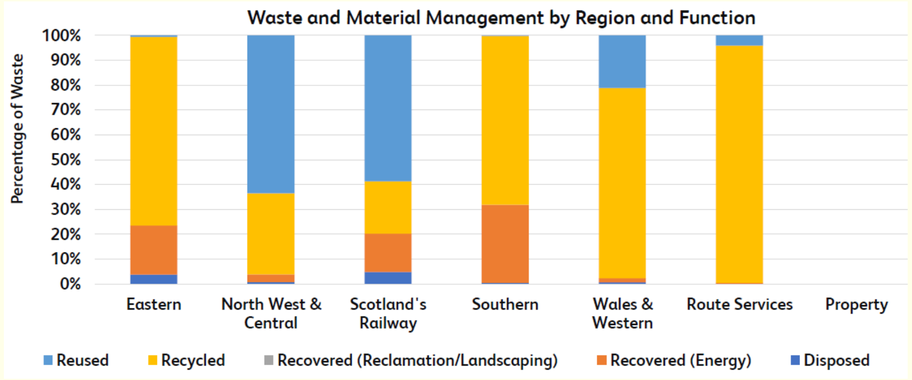
- What circular economy metrics to Network Rail have in place
- How are we measuring and reporting on these
- What is a Tier 2 measure
- How are we forecasting our reuse
- Next steps

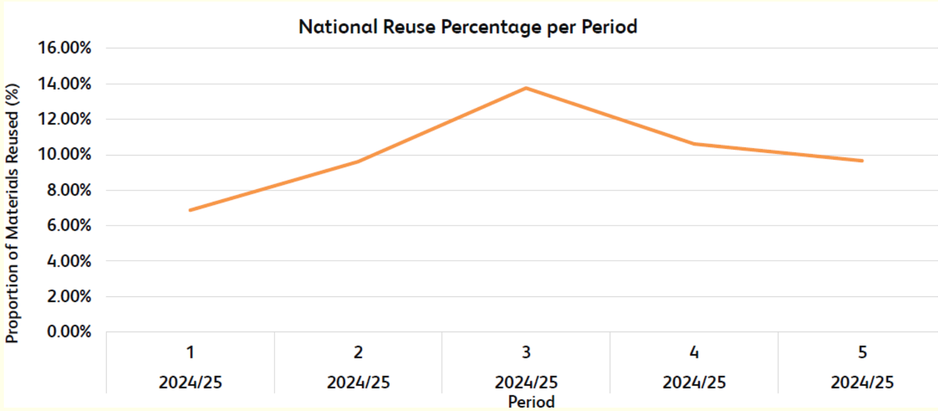
Agreed Metric	Area covered	Reporting
% of non-hazardous waste re-used, recycled, recovered, landfilled	Operations	Periodic (from April 2024)
Reuse: further break down of track materials (track, ballast, sleepers)	Operations	Periodic (from April 2024)
No of standards adapted with circularity embedded	Design	Quarterly (April-June 2024 first report)
£ savings from material reuse via Surplus App (pending app update)	Procurement	Periodic (from April 2024 or when SurPlus updates are made)
% of virgin and non-virgin materials used in *key priority products	Operations (year 1); design / procurement (Year 2)	Annually (April 2024 – March 2025 first report)
Proportion of procurement contracts incorporating sustainability criteria	Procurement	Quarterly (April-June 2024 first report)
Use of critical raw materials in key priority products	Design (year 2)	Annually (April 2025 – March 2026 first report)

Simpler.
Better.
Greener.

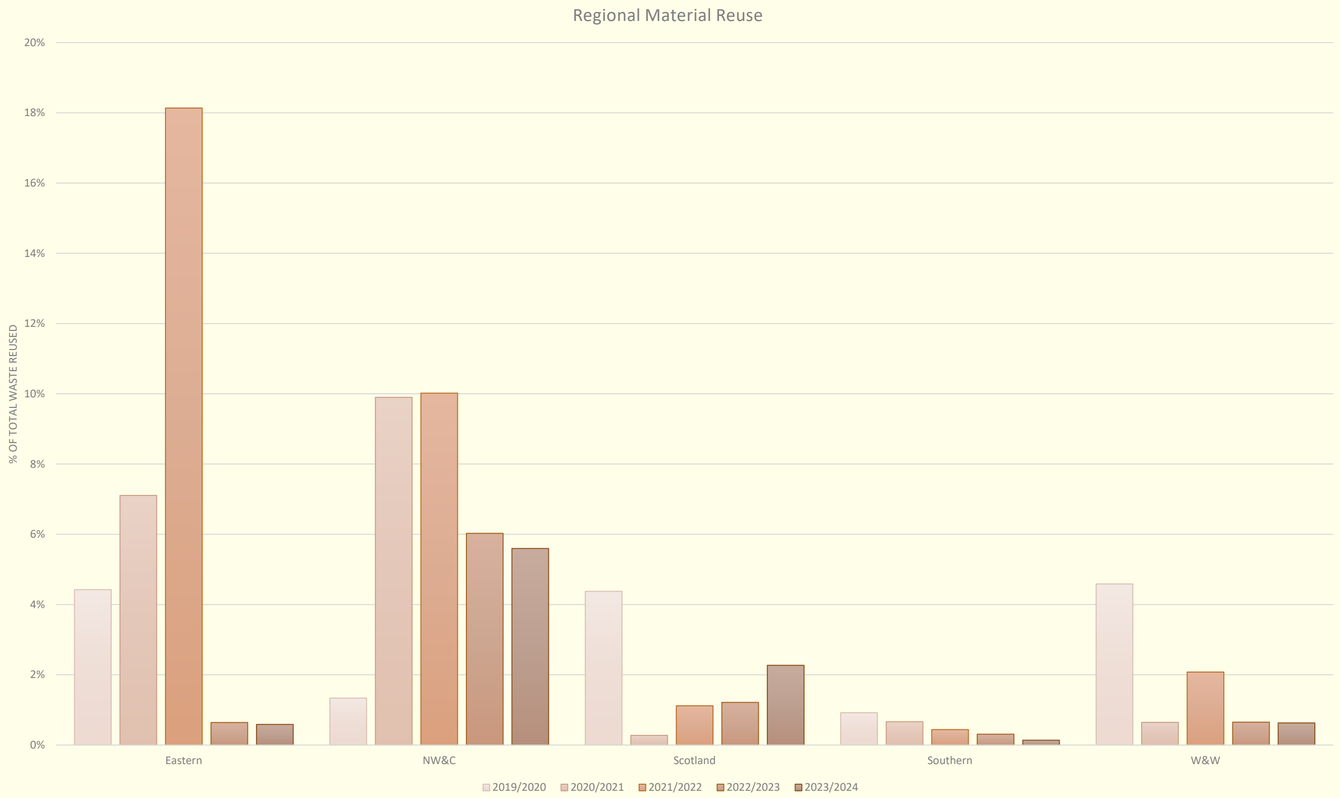
Measuring and reporting

- Multiple reports in place
  - Periodic (every 4 weeks)
  - Quarterly
  - Annually
- Scorecard measure – Route to Net Zero
  - Waste from offices and depots converted to CO2
- Greater scrutiny from regulator (Office of Rail and Road, ORR)
  - Request to create a Tier 2 metric
    - Originally needed to cover ‘design, procurement and operations’
    - Compromised on ‘material reuse’ as a proxy for circularity





Forecasting our reuse



- Previous rates vary due to differences in works and materials used
- Research project:
  - Previous reuse
  - Works happening / materials being reused
  - Future work planned
  - Research into reuse potential
  - Ambitious targets set

Next steps

- Agreement of reuse rates
- Workstreams to improve reuse
- Lowering of carbon emissions in Route to Net Zero

Mathijs Doesburg

Manager national rail maintenance programme (grinding & milling)

ProRail

Grinding residue
120 ton dust / year

- **No contract requirement**
- **Waste disposal = linear economy**

Team up

- **Starting all for one at own costs**
- **Searching for steel producer**


Input 120 ton in sinter plant / year


NDI
1-3
-7.9
4-6
-4.4
9-11
-3.0
13-15
-6.5
17-19
-1.9
21-23
1.0
25-27
7.0
29-31
-0.4
33-35
99.8
93.2
2-4
-8.0
-7.9
94.9
90.4
6-8
-4.5
-4.4
80.2
85.1
10-12
-3.0
-2.9
100.2
101.7
14-16
-6.5
-6.4
90.9
89.3
18-20
-2.0
-2.0
82.2
87.4
22-24
0.9
79.5
92.7
26-28
89.2
7.1

Benefits

- ✓ No waste disposal
- ✓ Less mining (185 ton CO_2 reduction / year)
- ✓ Relation ProRail & contractor Speno / BAM
- ✓ Break-even in EUR

Outlook

- ✓ Scaling Europe
- ✓ Specification in future contracts

Christian Risoli

Net Zero Emissions Specialist

RSSB

Embedding Net Zero Design

UIC November 2024

Chris Risoli, Net Zero Emissions Specialist,
British Rail Safety Standards Board (RSSB)

RSSB: independent voice at the centre of Great Britain's rail

KNOWLEDGE AND TOOLS

EXPERT ADVICE AND GUIDANCE

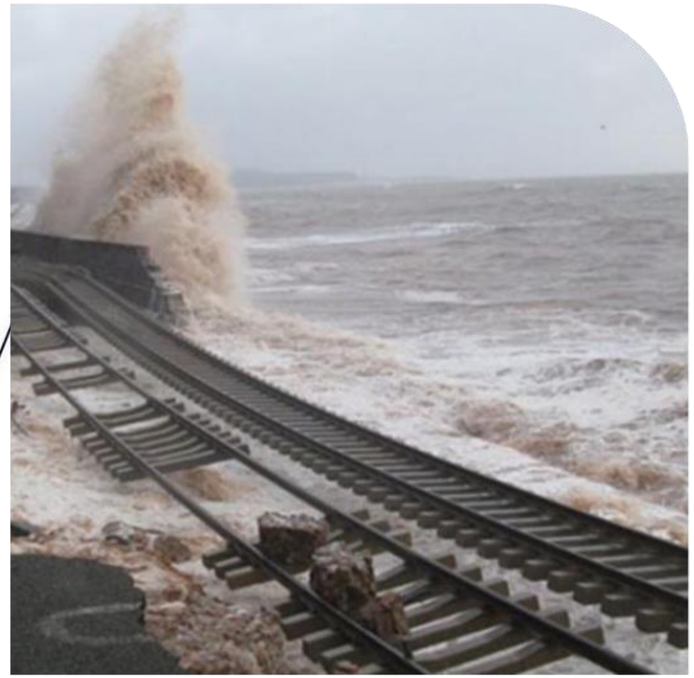
COMMUNITIES AND NETWORKING

FUNDING AND RESOURCES

PRODUCTS AND SERVICES

INDUSTRY STRATEGIES

How Climate Change is impacting GB Rail

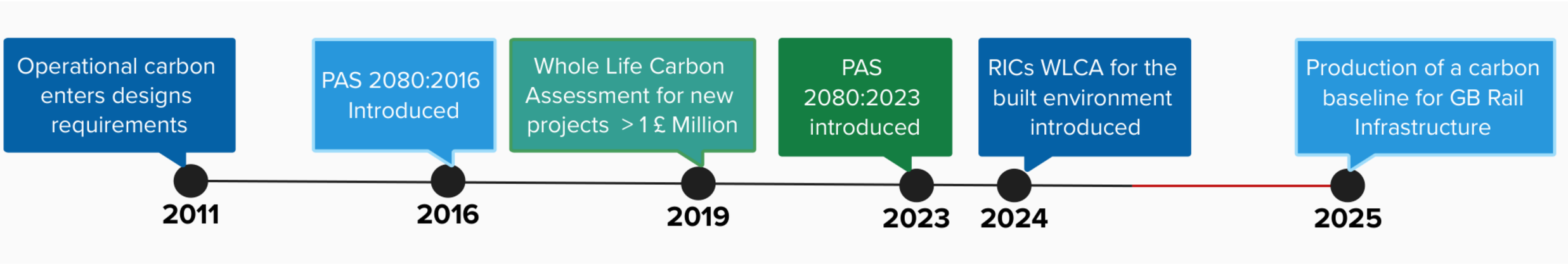


Stom and floods Dawlish, 2014

Buckled Rails in Glasgow, 2018

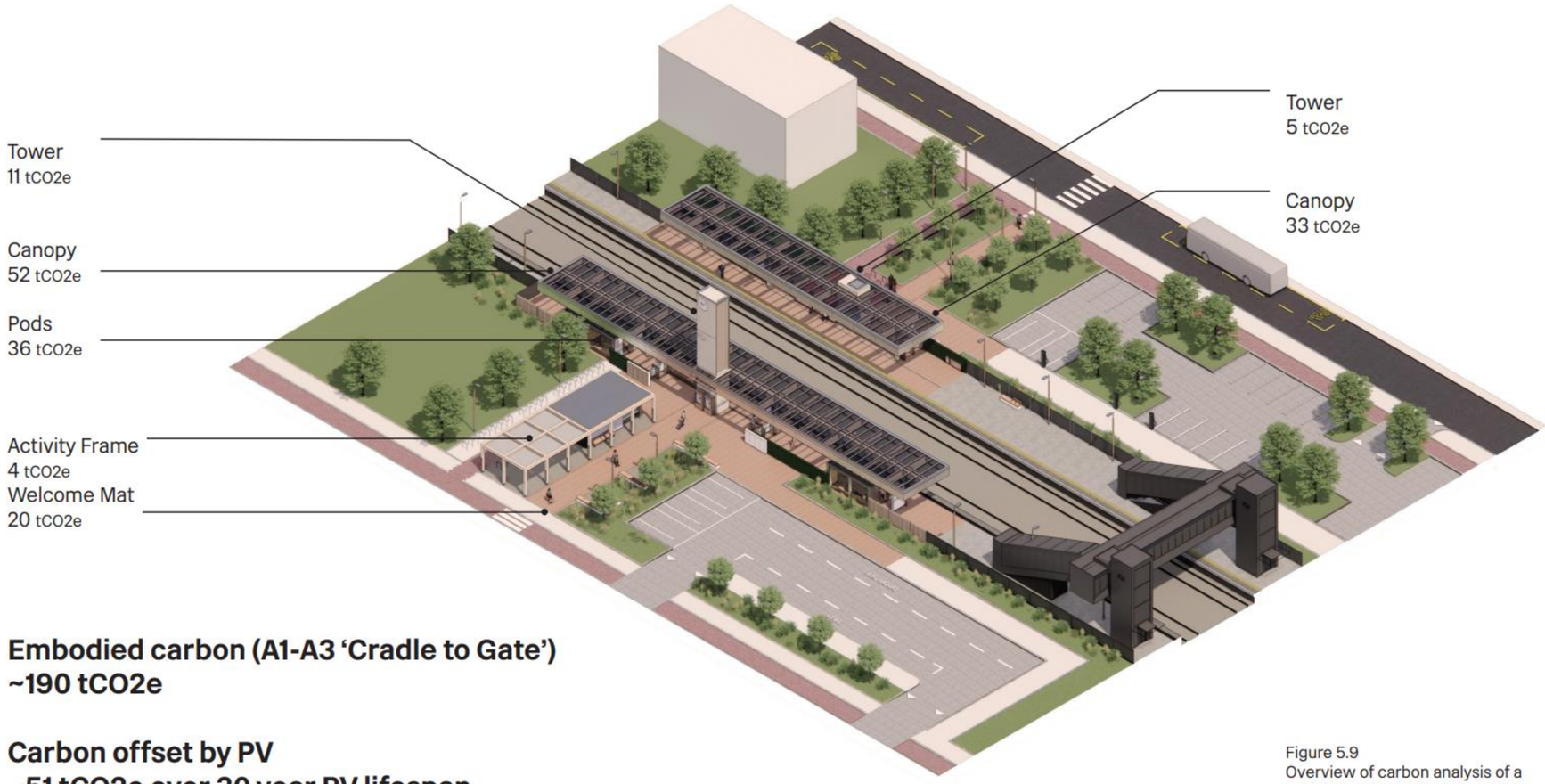
Landslip in Leeds, 2023

Quick history of GB Rail infrastructure carbon assessment



Circular economy driving CO2e in design

Example: Small & medium station designs



Embodied carbon (A1-A3 'Cradle to Gate')
~190 tCO2e

Carbon offset by PV
~51 tCO2e over 30 year PV lifespan

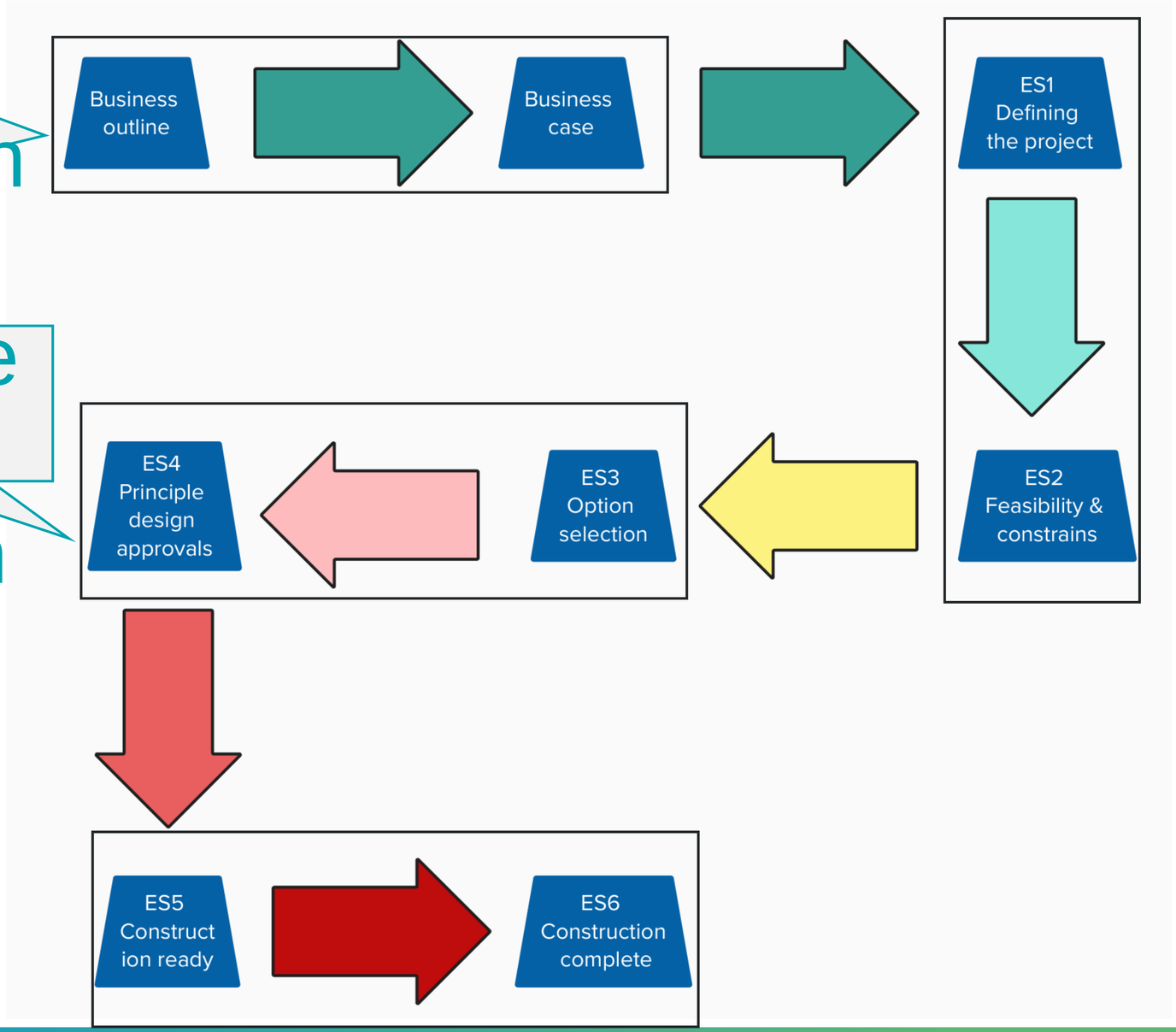
Figure 5.9
Overview of carbon analysis of a typical category D station

Source NR_GN_CIV_200_02

The importance of benchmarks

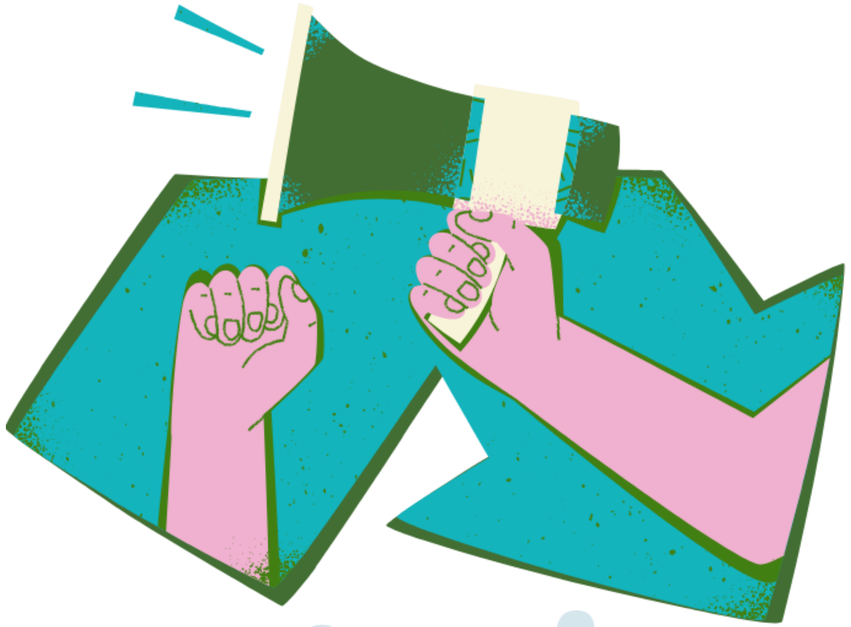
Can we reuse existing assets?

How can I optimise my solution?



Can we use recycled material?

Challenging existing practices



HOW DO WE GET THE WORD OUT?

The opportunity to reuse and retrofit machinery

Example: HS2 retrofitting

Reducing emissions in construction: Non-road mobile machinery retrofit - HS2 Learning Legacy

RAIL SAFETY AND STANDARDS BOARD

RAIL SAFETY AND STANDARDS BOARD

Thank you

Get in touch at:
Chris.Risoli@RSSB.CO.UK

Break time

Jörg Schneider
Head of Climate Protection and Energy
DB Cargo AG

DB Cargo

Use of renewable fuels at DB Cargo

5th Zero Waste Railways workshop

20. November 2024 | 5th Zero Waste Railways workshop | Paris

Management Summary

CO_2 emissions lead to global temperature rise and climate change – Therefore Sustainability is part of Deutsche Bahn strategy “Strong Rail”

To contribute towards climate neutrality at DB in 2040 we have three main fields of activities – One of them is the Transition from fossil diesel to climate-neutral operation

HVO saves up to 90% CO_2 compared to fossil diesel - All results on Engine bench tests and operational testing with HVO were consistently positive

Green transformation | Sustainability is part of Deutsche Bahn strategy “Strong Rail”

Green transformation

We take responsibility for our planet, greening not only our products and services, but also the way we work.

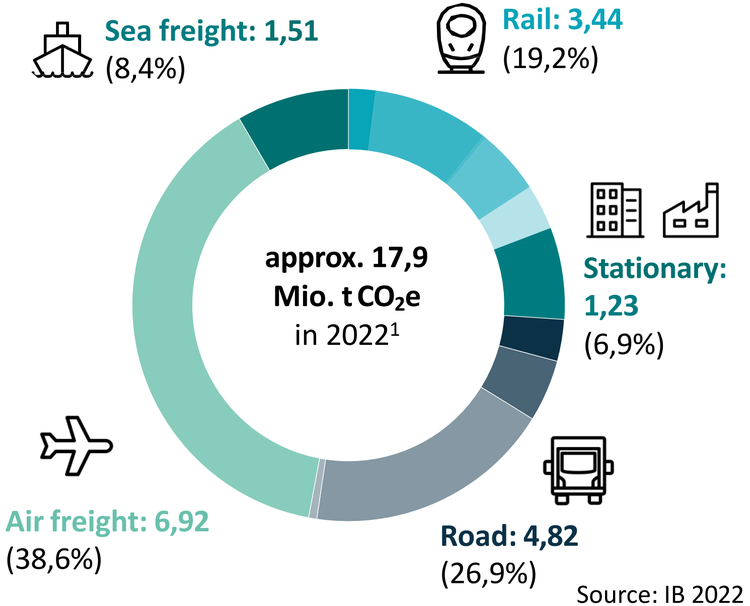
Green transformation | Three main fields of activities and two packages of measures contribute towards climate neutrality at DB in 2040

Our mission:

Climate Neutrality until 2040

Today:

CO_2e-emissions Deutsche Bahn AG (2022)[1]



Source: IB 2022

Three main fields of activities to reach climate neutrality:

- Green Power Transformation
- Diesel Exit
- Renewable Heat

New: Two DB group programs

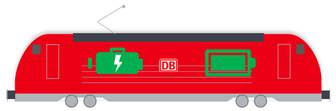
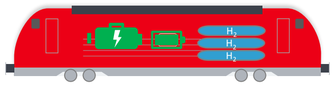
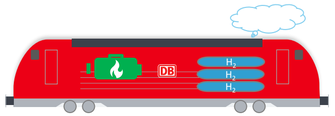
- Diesel Exit
- Renewable Heat

- **Climate neutrality by 2040** requires **100% green power** and innovative, sustainable solutions for **Diesel Exit** as well as **green heating supply**
- **Measures** on Greening Power, Diesel Exit and Renewable Heat are planned for **medium term**
- **Beginning in 2022**, DB develops and implements **specific projects and measures**

(1) 2021: 18,5 Mio. t CO_2, 2020: 16 Mio. t CO_2 due to the CoVid-Pandemic, 2019: 20 Mio. t CO_2

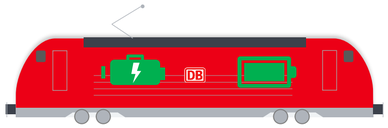
Technology assessment | In principle, there are four alternatives to diesel. There is not "THE ONE" technology.

DB Cargo

		Electric motor		Internal combustion engine	
		Battery	**Fuel cell**	**Alternative, C-based fuels (HVO, e-diesel)**	**C-free fuels (hydrogen, ammonia)**
	Relevant drive types				
	Emission-free operation possible?	✓	✓	✗	(✓)
Maturity	Technology maturity level (drive technology)	**Medium**	**Low**	**Very high**	**Low**
Use case	Long emission-free sections possible?	✗	✓	✓	✓
Use case	Heavy goods traffic possible?	✗	✗	✓	✓
Costs	Vehicle expense	**high**	**Very high**	**None**	**High**
Costs	Infrastructure expense	**high**	**Very high**	**Low**	**Very high**
Costs	Availability of energy sources	**Very high**	**Low**	**HVO: high** **e-diesel: very low**	**Green hydrogen: low** **Green ammonia: low**
	Assessment DB				
	New vehicle	✓	(✓)	✗	✓
	Existing vehicle	✗	✗	✓	✓

Technology assessment | The greatest need for action from a development perspective is heavy goods traffic.

Battery



Suitable for overhead line-free sections < 100 km (200 km in perspective)
Suitable solution for **regional rail services on >90% of routes**

Fuel cell

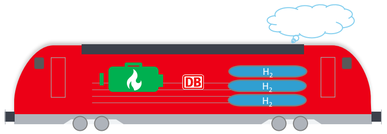
Higher TCO than battery, **niche technology** for a few routes in regional rail transport,
Not suitable for heavy-duty use due to high space requirements and poor dynamic performancesuitable for heavy-duty use

Alternative, C-based fuels (HVO, e-diesel)

Bridging technology for existing vehicles without existing conversion option in heavy goods, construction site and shunting traffic currently without alternative (high energy density and performance)

Today focus

C-free fuels (hydrogen, ammonia)



Prospective replacement or conversion option for heavy-duty, construction site and shunting traffic, currently not available on the market, **development work required**

HVO | The use of Hydrotreated vegetable oils (HVO) saves up to 90% CO_2 compared to fossil diesel

Main advantages and properties of HVO

Production

- Only **biological residues and waste materials** are used as raw materials
- HVO is furthermore **palm oil-free**

Compatibility

- **"Drop-In" fuel** - Engine compatibility proven through several tests
- Several engine **manufacturers approved** the use of HVO

Costs

- Approx**.+20 ct/l additional costs** compared to fossil diesel
- Migration of refueling **infrastructure** comparatively **simple and inexpensive**

Availability

- **Short-/middle-term switch** from fossil diesel to HVO possible
- **Short-term Availability** of several million liters/year

HVO | All results on Engine bench tests and operational testing with HVO were consistently positive

Engine Bench tests

- Extensive engine test bench trials carried out in 2021-23 on over **15 DB Cargo engines**
- **Certified** comparative **measurements** (including performance behavior, fuel consumption and greenhouse gas emissions) between HVO fuel and fossil diesel
- **All engines** analyzed work **smoothly** with the **HVO fuel**

Operational Testing

- **Extensive** operational **testing** carried out on various diesel-powered DB Cargo series
- **Diesel locomotives** are HVO-compatible **without restriction**. Release of DB Cargo's entire diesel locomotive fleet (>1,300 locomotives)
- Rededication of **20 filling stations** with a volume **of over 10 million liters** per year

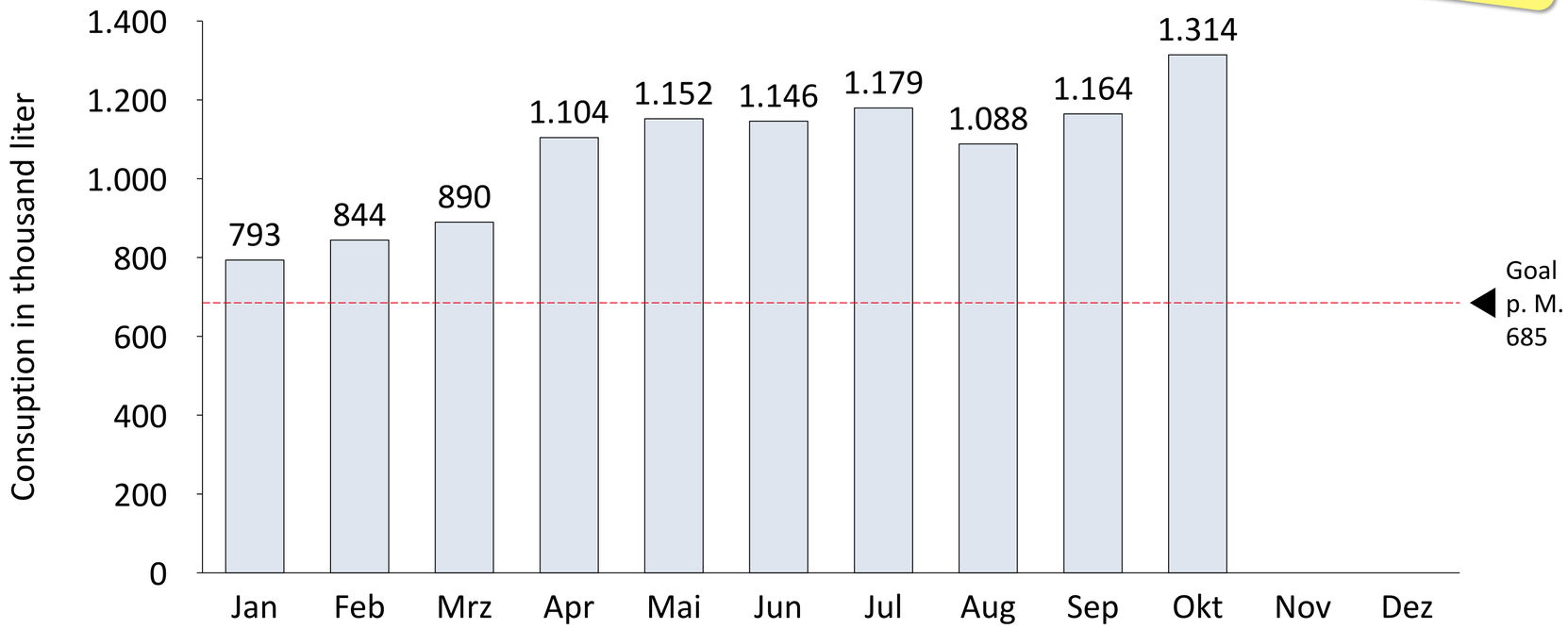
HVO | With over 10.7 million liters of HVO, the annual target has already been reached

HVO consumption volumes since January 2024

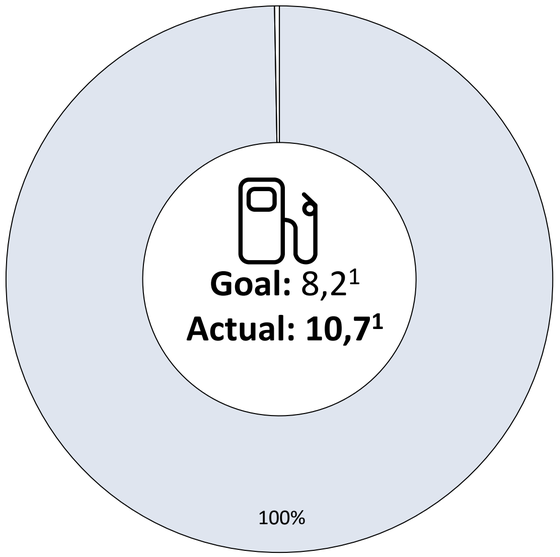
Date 14.11.2024

New Goal 2024:
12,8 Mio. liter HVO

Consumption HVO 2024



Total consumption HVO
(Year 2024)



[1] in million liters

Actual consumption

Frankfurt, Kassel, Würzburg, Bremerhaven, Seelze, München, Gremberg, Nürnberg, Braunschweig, Brake (Unterweser), Braunschweig Hgbf, Halle, Kornwestheim Rbf, Magdeb.-Rothensee

HVO | A success story for DB Cargo!

Highlights HVO 2023/24

Operations

Germany

Netherlands

Belgium

Italia

UK

Press events

München

Bremen

Mainz

Newspapers

Media campaign

White Paper

Webinar

Ad campaign

Neste Testimonial

UIC Award

UIC Sustainability Impact Award: DB Cargo was honored for testing and using the synthetic fuel HVO100

Speaker

Jörg Schneider
DB Cargo
Head of Climate Protection and Energy
joerg.j.schneider@deutschebahn.com

Mainz

Ilse de Vos - Van Eekeren,
Program Manager Circular Business
Nederlandse Spoorwegen

Driving Toward a Beyond Zero Future: “A Holistic Sustainable Approach"

UIC Zero Waste Workshop

20-11-2024

Ilse de Vos van Eekeren
Dutch Railways

Sustainable & future proof

Project:

Renovation of tracks and switches & construction of a depot in XXXX for:

- Safe, reliable, and optimal performance of train(wheel)s
- Extending the Lifespan of Train Wheels
- Saving costs, resources and energy

Holistic sustainable approach:

Fossil-free + Circular + Green

- Presentation content under embargo until further notice

- Contact Ilse de Vos (ilse.devosvaneekeren@ns.nl) for more information

"Driving Toward a Beyond Zero Future”

Questions?

Ilse de Vos van Eekeren
Dutch Railways (NS)

Sara Walton

Sector Lead for Net Zero & Circularity,

British Standard Institute

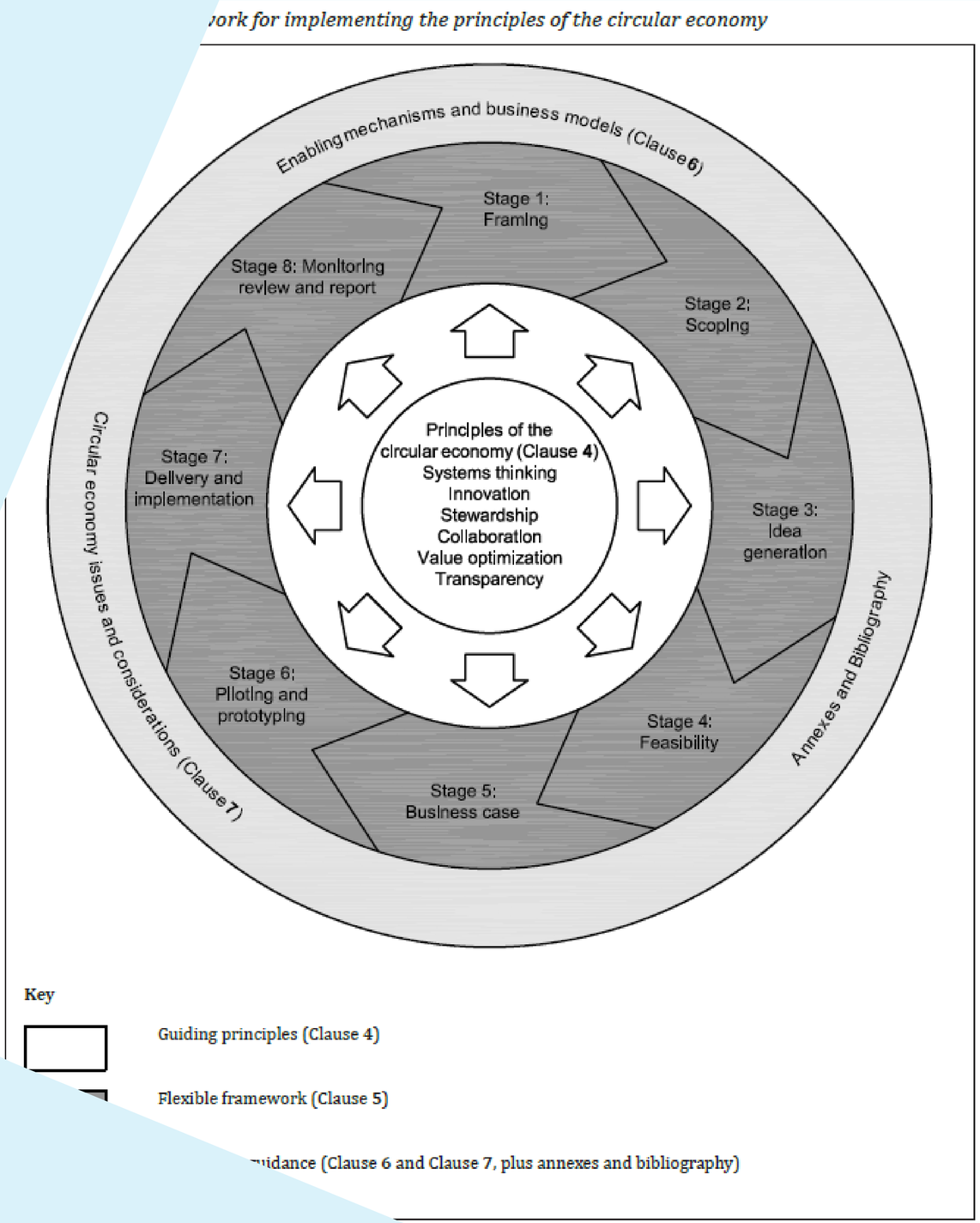
How do you monitor external drivers for circularity?

(e.g. standards, regulation, customers, etc)

BSI Knowledge – Sara Walton

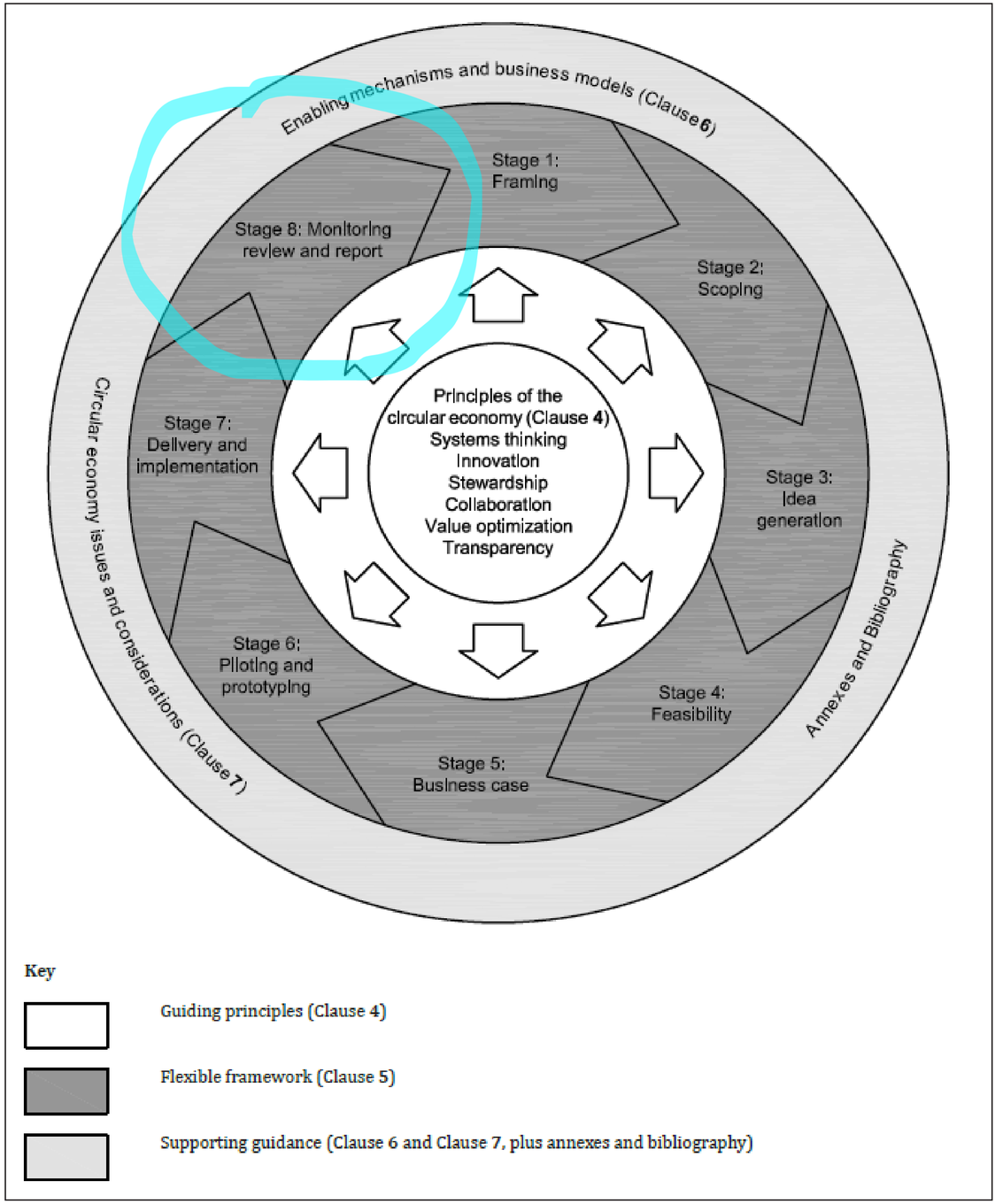
20 November 2024

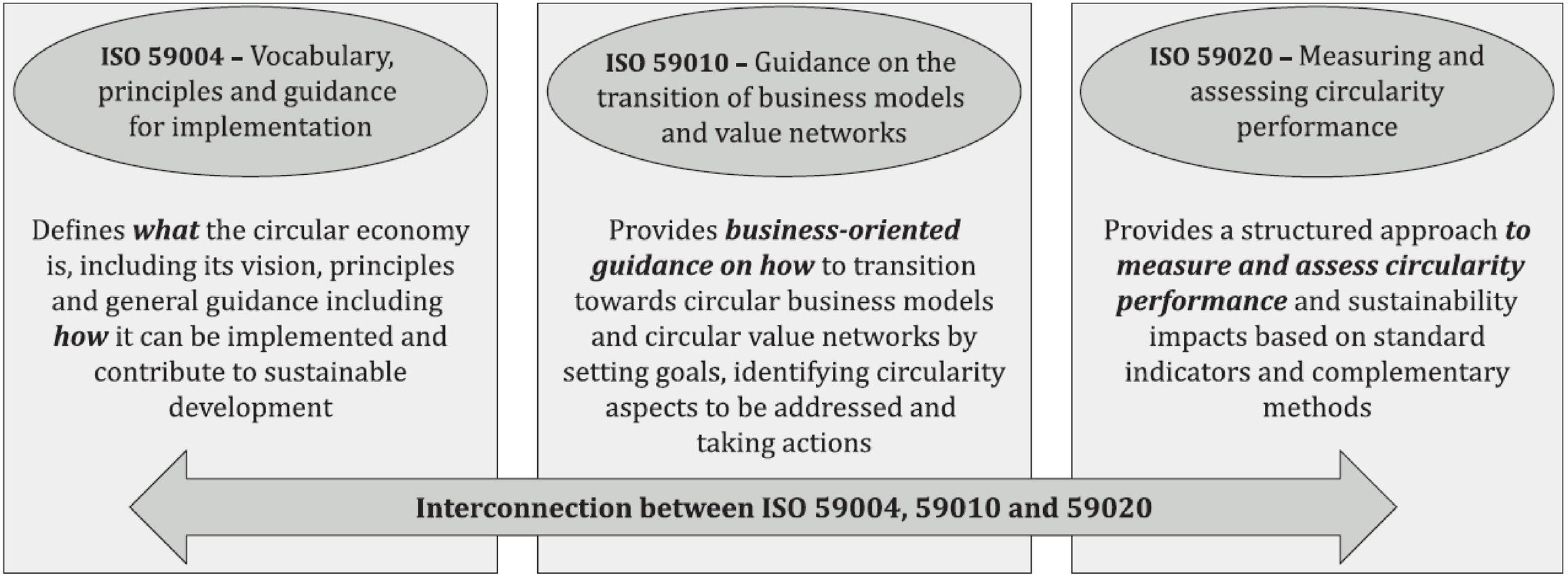
Circular principles



Source: *BS 8001 Framework for implementing the principles of the circular economy in organizations - guide*

Figure 1 — *Overview of the framework for implementing the principles of the circular economy*




ISO 59004 – Vocabulary, principles and guidance for implementation
Defines ***what*** the circular economy is, including its vision, principles and general guidance including ***how*** it can be implemented and contribute to sustainable development
ISO 59010 – Guidance on the transition of business models and value networks
Provides ***business-oriented guidance on how*** to transition towards circular business models and circular value networks by setting goals, identifying circularity aspects to be addressed and taking actions
ISO 59020 – Measuring and assessing circularity performance
Provides a structured approach ***to measure and assess circularity performance*** and sustainability impacts based on standard indicators and complementary methods
Interconnection between ISO 59004, 59010 and 59020

Boundary setting and monitoring circularity

Source: ***ISO 59020: 2024 — Circular economy — Measuring and assessing circularity performance***

Boundary setting

Circularity measurement and data acquisition

Circularity assessment and reporting

5 Framework for measuring and assessing circularity performance

5.1 Framework introduction

The framework for measuring and assessing circularity performance consists of several interrelated stages which can be repeated as required. The framework is illustrated in Figure 3.

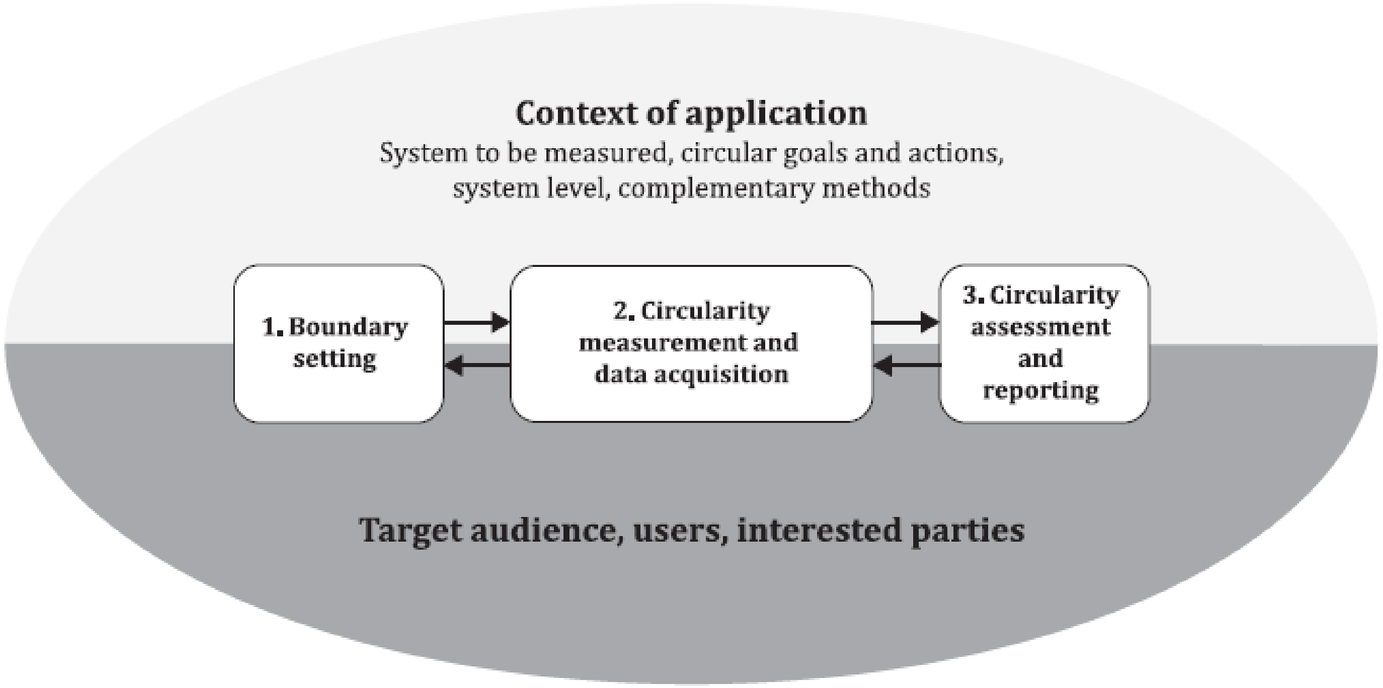


Figure 3 — Framework for measuring and assessing circularity

What is a standard and how can they be used?

- Standards are **voluntary.**
- An agreed way of doing something.
- Standards could be about making a product, managing a process, or delivering a service.
- They are open, consensus-based documents.
- Standards represent the distilled wisdom of what ‘good’ looks like.

Improve productivity

Increase efficiency

Build trust

Reduce costs

Accelerate innovation

Agreed good practice

Ensure interoperability

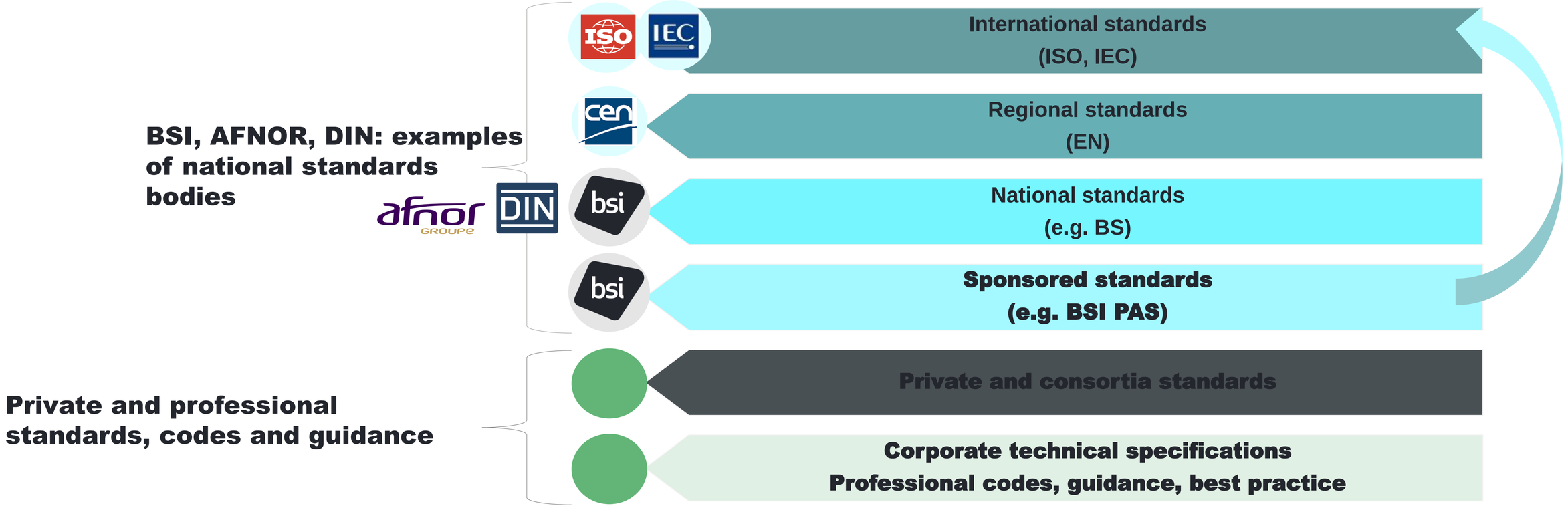
Embed sustainability

Fine tune performance

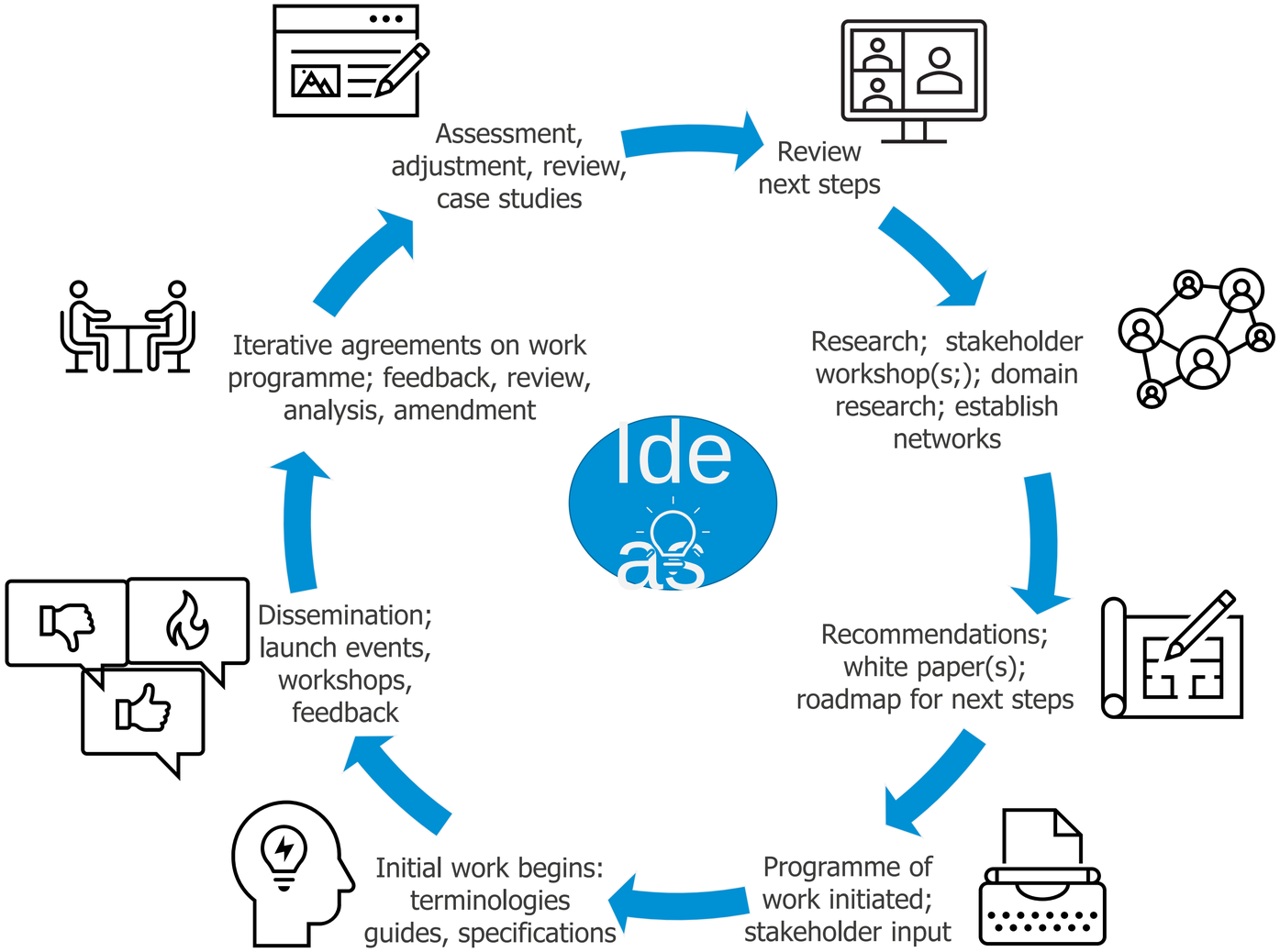
Standards are part of a global system

There are various routes to develop standards:

- Starting from private and professional standards, codes and guidance
- Through national standards bodies
- Through European and International standards



Cycle of development for new areas of work



Close - & Thanks!

Contact for further information:

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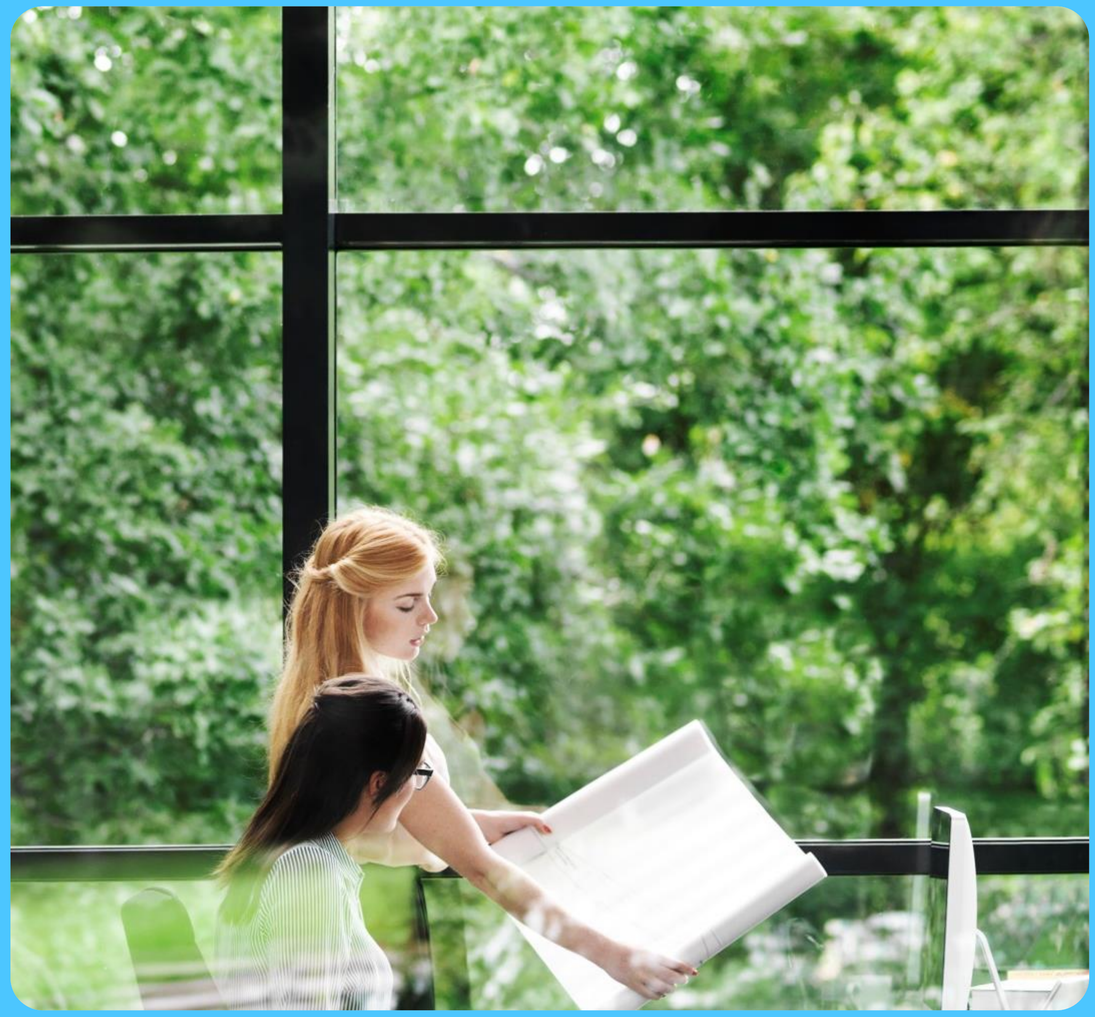

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