



Sustainable Refractory Production

Transforming the Industry Towards a Greener Future

Thomas Prietl

Head of Global R&D and Innovation at RHI Magnesita
ISR24, Chengdu
October 2024



Content

- 1 RHI Magnesita at a glance
- 2 RHI Magnesita decarbonization pathway
- 3 Driving forces to reduce our CO2 footprint
- 4 CCU – Mineralization and Recycling as major drivers to reduce our carbon footprint
- 5 Mireco focusing on circular business models
- 6 CO₂ transparency of our products

The global leader in refractories

There for you, wherever you need us

Digital Solutions



Systems & Machinery



21,000
Employees³



€ 3.6bn
2023
revenue



€ 83m

Investment in R&D and Technical Excellence & Solutions including low-CO₂ emission products



+1,700
Active
patents



2.2%
R&D and Technical Marketing expenditure as % of sales¹



20%
Revenue from new products² as % of total revenue



47
Main production sites (incl. raw material sites)



+100
Countries shipped to worldwide



5
1 R&D hub and 4 centres

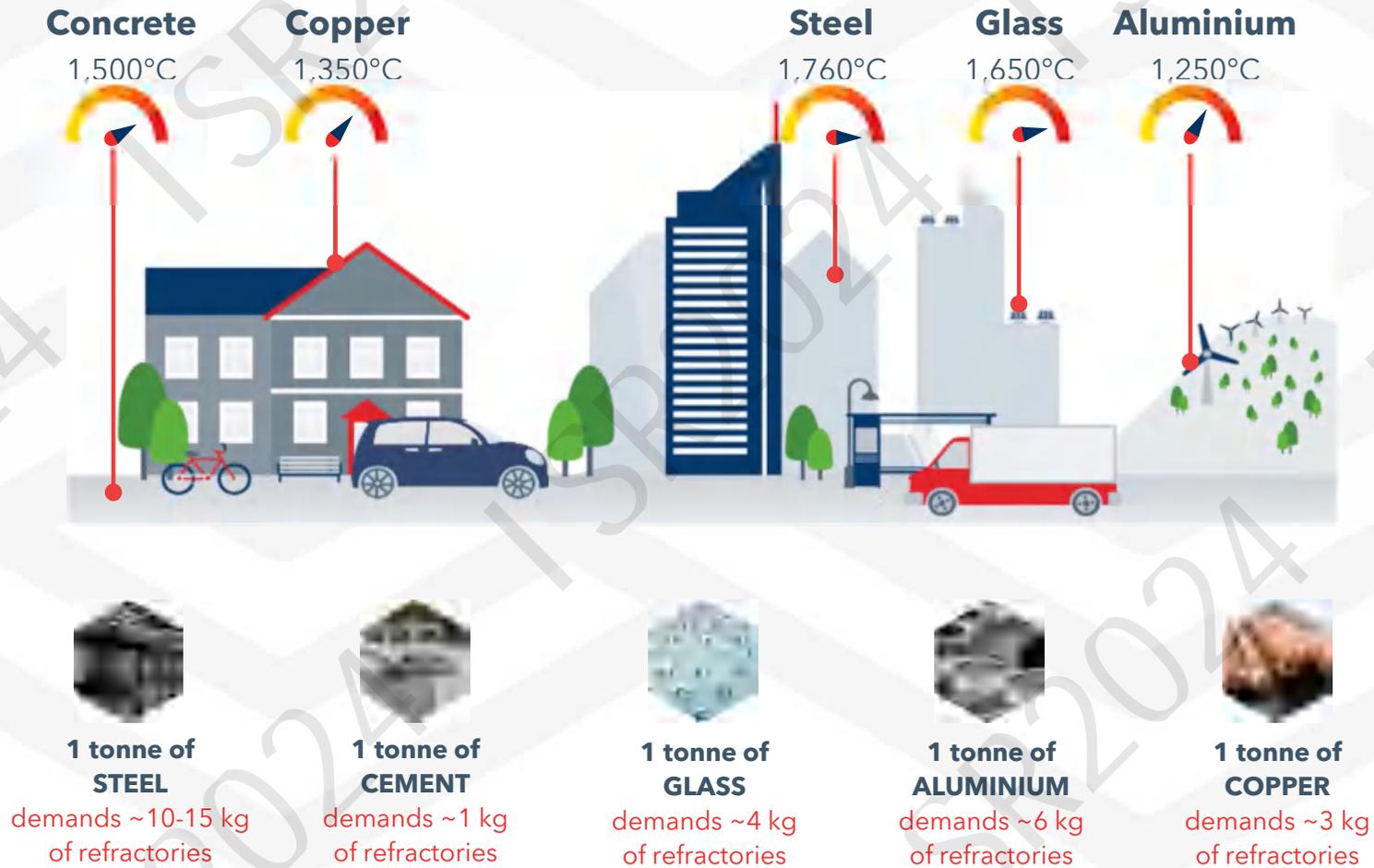


+480
Experts¹ across 90 countries to consult, develop and deliver innovative solutions directly to our customers



1) R&D, Product Management and Technical Excellence & Solutions
2) Defined as products and brands less than 5 years old
3) 16,000 direct employment, 5,000 contingent workforce

Refractories: the building blocks of modern life



Our 2025 sustainability targets



Safety

Strong safety culture with goal of zero accidents



CO₂ emissions

Reduce by 15% per tonne¹



Energy

Reduce by 5% per tonne



Recycling

Increase use of secondary raw materials to 15%.



NO_x and SO_x emissions

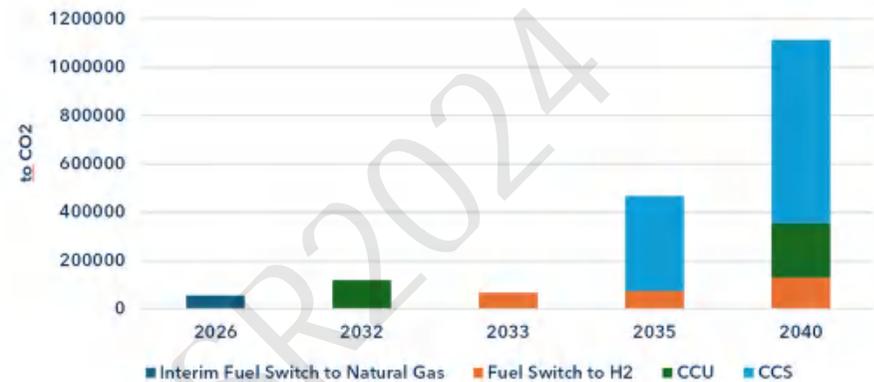
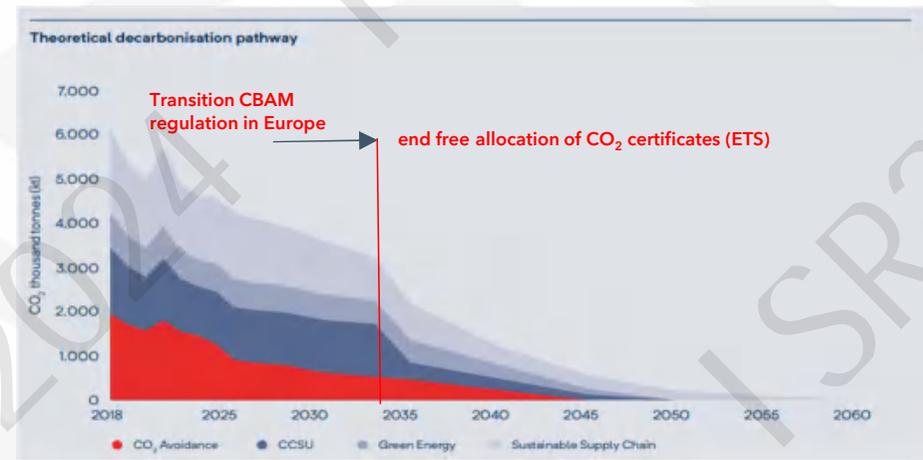
Reduce by 30%² (achieved in China already)



Diversity

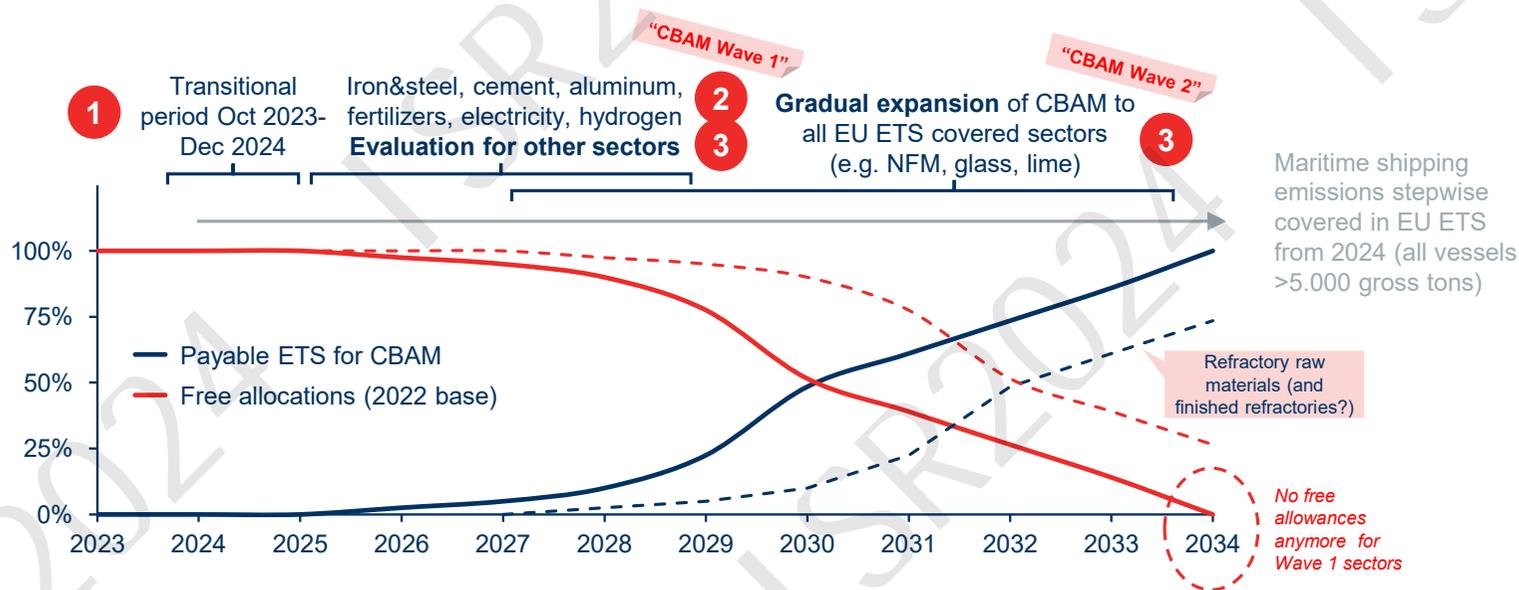
Increase women on our Board and in senior leadership to 33%

RHIM's Decarbonization Pathway



Note: Targets are compared to 2018 baseline; Includes Scope 1, 2 and 3 (e.g. own sites, customers and suppliers)

CBAM is introduced in two waves with many details being still unclear despite the quite near-term implementation



1,2,3
EU ETS and CBAM are “combined policies”
 One without the other doesn't make sense. Both are completely connected and complementary.

3
All EU ETS sectors covered (incl. finished refractories)
 Full implementation will take a while, or maybe won't come at all due to bureaucratic barriers

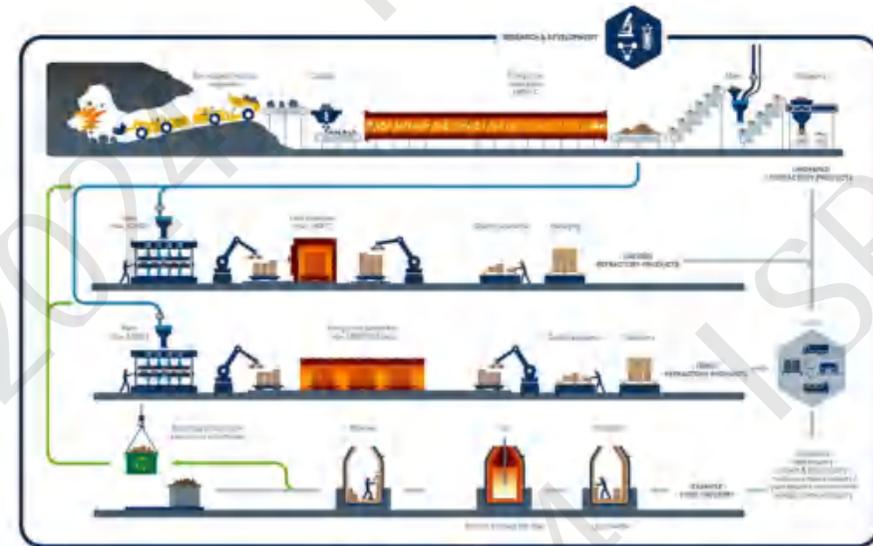
2,3
CBAM is implemented, other sectors evaluated

- Almost all RHIM key end-use industries covered
- Refractory raw materials likely to be covered early (2027-2028?) in the CBAM expansion phase
- Finished refractories still unclear (likely little later)

CO2 emissions classification according Greenhouse Gas Protocol

Scope 1, 2 and 3

Magnesia Production (Similar for Dolomite)



- **Scope 1 Emissions:** covers emissions from sources that an organization owns or controls directly – for example CO2 direct out of our plants (magnesite, rotary kiln, tunnel kiln, fork-lifts, etc.)
- **Scope 2 Emissions:** are emissions that a company causes. For example, the emissions caused when generating the electricity that we use in our buildings and facilities, for example.
- **Scope 3 Emissions:** encompasses emissions that are not produced by the company itself and are not the result of activities from assets owned or controlled by them, but by those that it's indirectly responsible for up and down its value chain. Scope 3 emissions include all sources not within the scope 1 and 2 boundaries.

Priorities of the Decarbonization Roadmap

We have a unique opportunity via our backward integration

Priorities

What we already committed to publicly

To achieve this, a set of internal targets were set (e.g., recycling rate, CO₂ savings till 2025)

- To **lead** the refractory industry by decarbonizing our operations as fast as sustainably possible
- To offer our customers enabling technologies with **full carbon footprint transparency**
- Commitment: 15% CO₂ reduction by 2025 relative to 2018; **target met rebased for invests and divests** (see chart bottom left)
- RHIM has **not committed** to Net Zero and Science-based targets

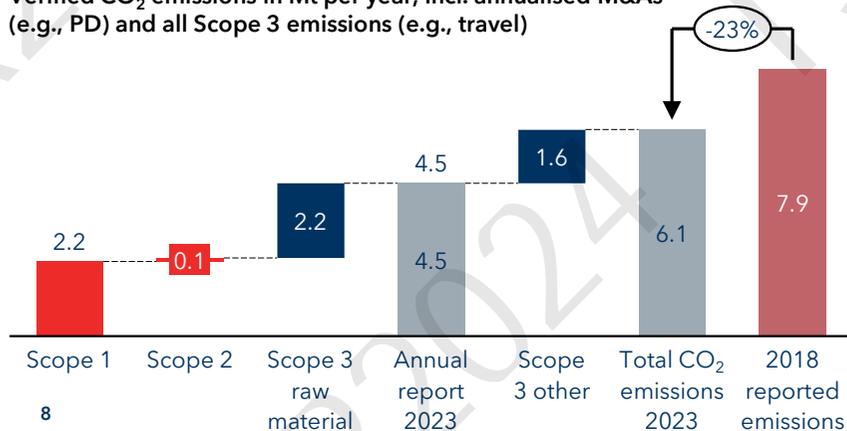
Non exhaustive list, for complete list see official Sustainability slide deck

Opportunity

RHIM

- RHIM is **uniquely backward integrated** on multiple continents

Verified CO₂ emissions in Mt per year, incl. annualised M&As (e.g., PD) and all Scope 3 emissions (e.g., travel)



Refractory Industry

- **Refractories** account for ~0.1% of global carbon emissions
- Refractory **raw materials are the biggest emission driver**
- Most refractory suppliers depend on **raw materials from China**, or other regions, effectively outsourcing their emissions



Relevant CO₂ frameworks

varying by region and subject to ongoing changes

- CO₂ price in place with ETS (currently ~67 EUR/t)
- Free allocation expires within 2034-39
- Planned carbon border adjustment mechanism (CBAM)
- Subsidy scheme in place with Green Deal
- ETS crediting only for options defined as "green"

EU

China

- CO₂ price (currently ~10 USD/t)
- Target Carbon Neutral before 2060
- Strong focus on expanding renewable energy

USA

- CO₂ price: only in some states (RGGI)
- Significant subsidy scheme in place with 45Q (Carbon Capture Credits)
- CCS projects and pipelines further supported by EOR

Brazil

- No CO₂ price
- Sectoral decarbonization plans were developed but so far not included in policy

Turkey

- No CO₂ price
- Low priority for CCUS

India

- No CO₂ price
- Target Net-Zero by 2070
- Focus on expanding renewable energy

RGGI..Regional Greenhouse Gas Initiative - Pennsylvania - for fossil-fueled power plants 25 megawatts (MW) and larger
CCUS..Carbon Capture and Utilization/Storage; EOR..Enhanced Oil Refining (CO₂ used to increase oil reservoir output)

Our main options to reduce our carbon footprint

Low CO₂ refractory to achieve our 2050 targets



50% of the ore is being released as carbon dioxide (CO₂) when the raw material is processed into oxide

$$\text{MgCO}_3 = \text{MgO} + \text{CO}_2\uparrow$$

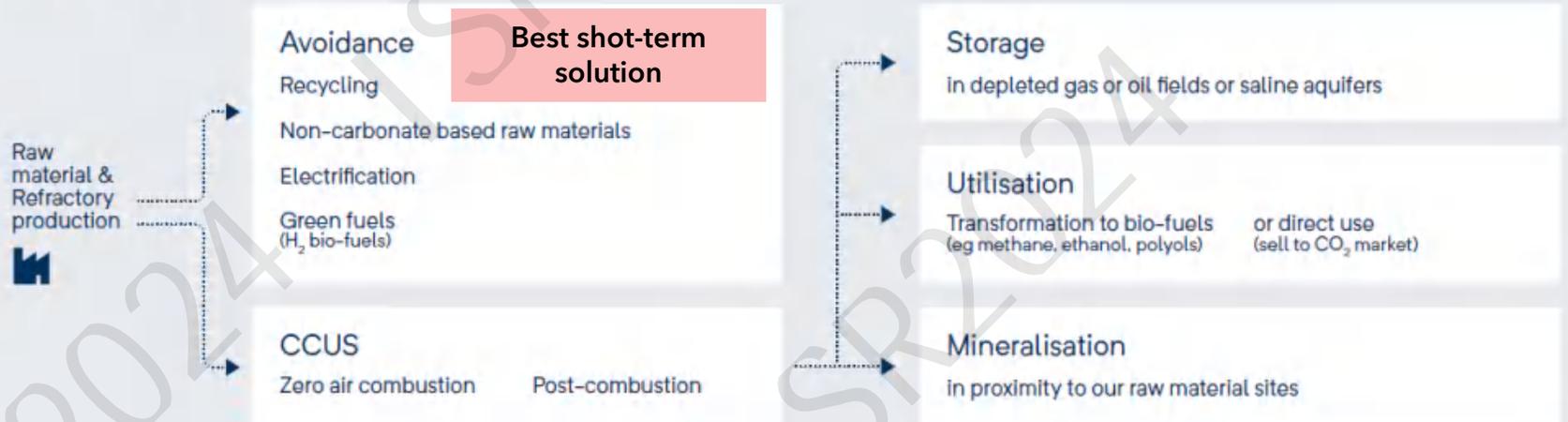
$$(\text{Ca, Mg})\text{CO}_3 = \text{MgO} + \text{CaO} + \text{CO}_2\uparrow$$

Carbon Emissions per Scope¹



- Scope 1 of which geogenic emissions
- Scope 1 of which fuel-based emissions
- Scope 2 electricity
- Scope 3 emissions only Raw Material

Understanding our reduction measures

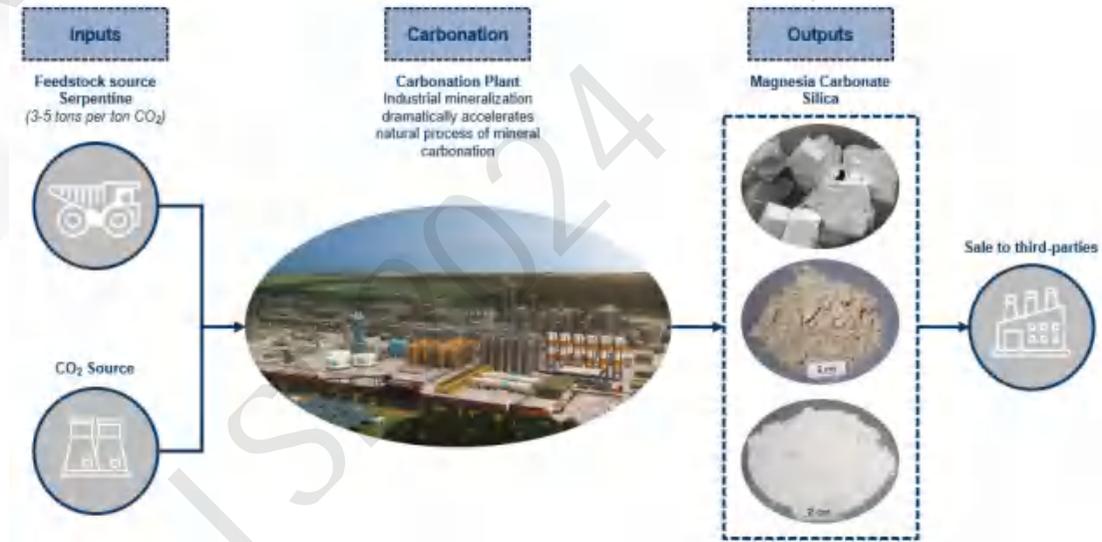




Carbon Capture and Utilization

Goal: Become carbon neutral by 2050 and reach a new industry standard

- Vision: Transform CO₂ into **valuable industrial minerals**.
- Capture unavoidable (geogenic) CO₂ emitted during raw material processing.
- **New business opportunity** to generate minerals with a low carbon footprint.
- The only carbon capture option for RHIM plants with infrastructure limitations and an **option to generate revenue**.



Key Developments

2028 first commercial pilot plant in Europe



**Pilot Plant
2016 - now**

University of Newcastle

~10-20 tonnes of CO₂/year

Validate global customers
through pilot
studies and materials
development



**'Myrtle'
Under construction**

Orica's Kooragang Island
manufacturing plant, Australia

~1.000 tonnes of CO₂/year

Test customer scenarios &
trial output materials



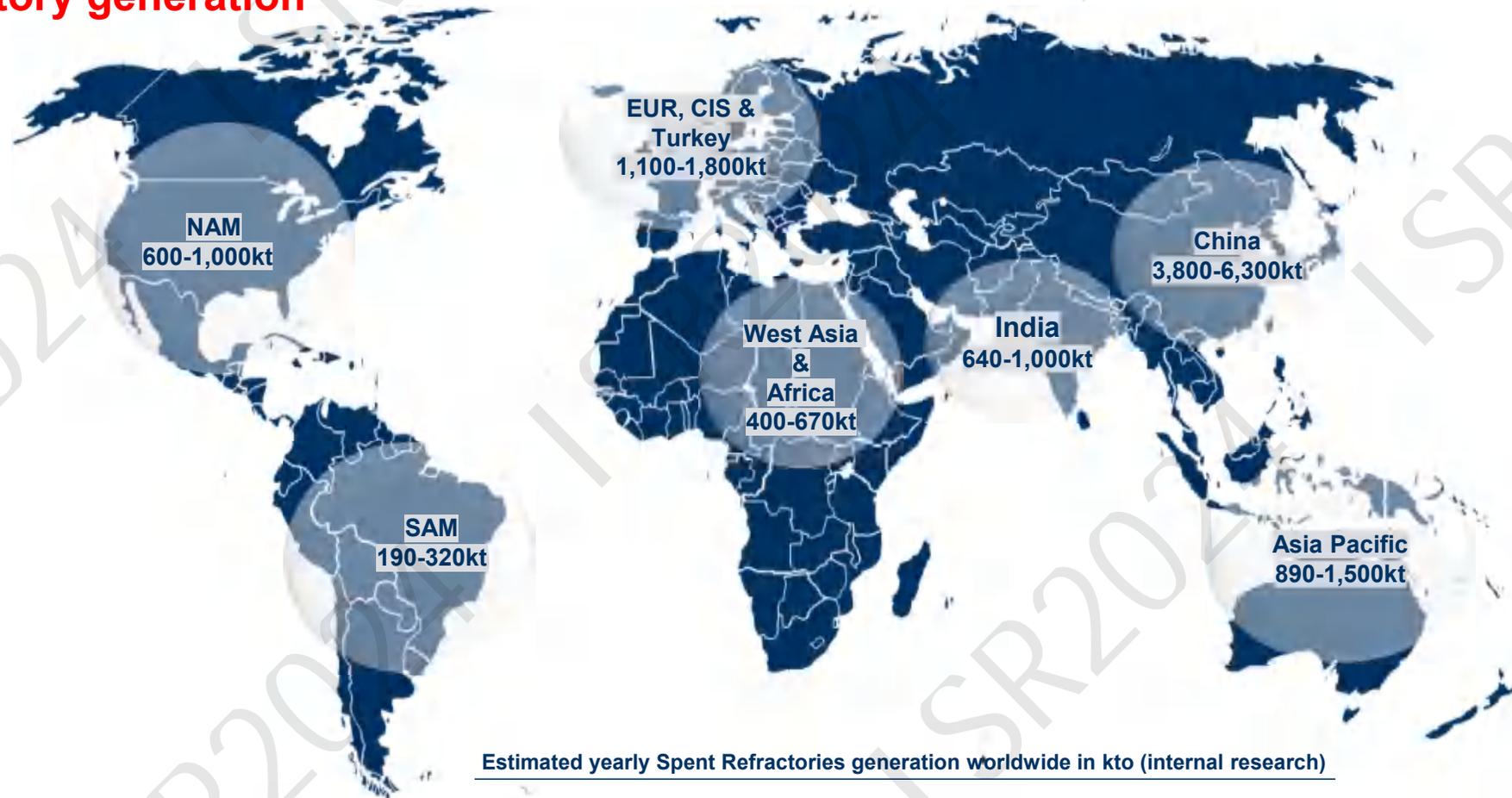
**First Commercial Pilot Plant
2028+**

RHI Magnesita, Austria, Hochfilzen

~ 50.000 tonnes of CO₂/year

RECYCLING - The circular economy of refractories is being developed

New technologies and innovations are needed to capture the value of all spent refractory generation



RHI Magnesita Recycling Journey

Focus on our recycling pillars brought significant increase in recycling usage in the company



Recycling Rate evolution



- **Data** intelligence
- Strengthening of **sourcing** capabilities
- **Benchmarking** across the regions
- Creation of recycling **portfolios**

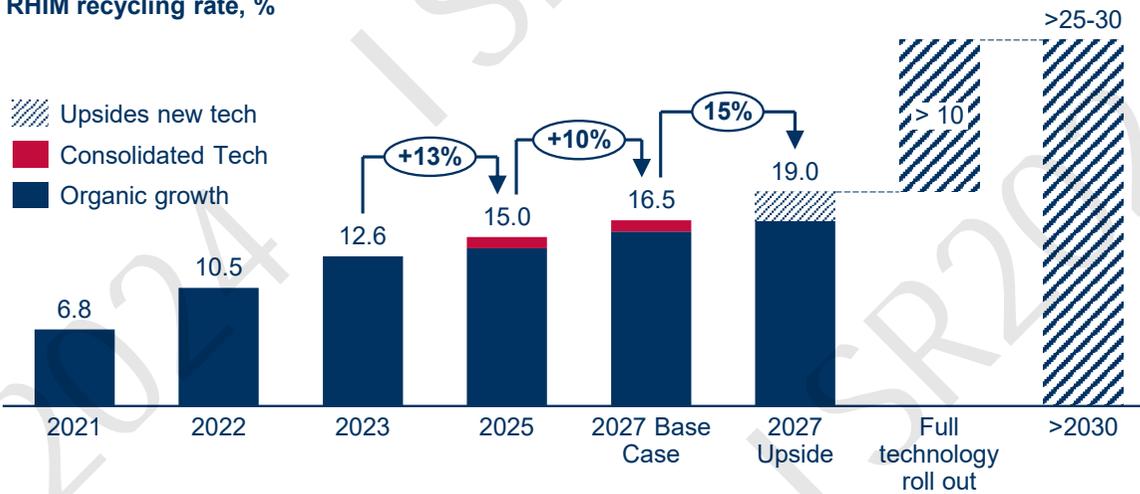
- **Sales** recycling initiatives
- **Partnerships & Cooperations** - JV with Horn&Co

- **Technology** for processing and usage of recycling
- **Industrial symbiosis** - Further ecosystem building for recycling

Recycling rate impact by the technology roadmap

Innovation in processing techniques to improve CRM quality and recovery is key for growth

RHIM recycling rate, %



CO2 emission savings expected to come from the technology projects benefits

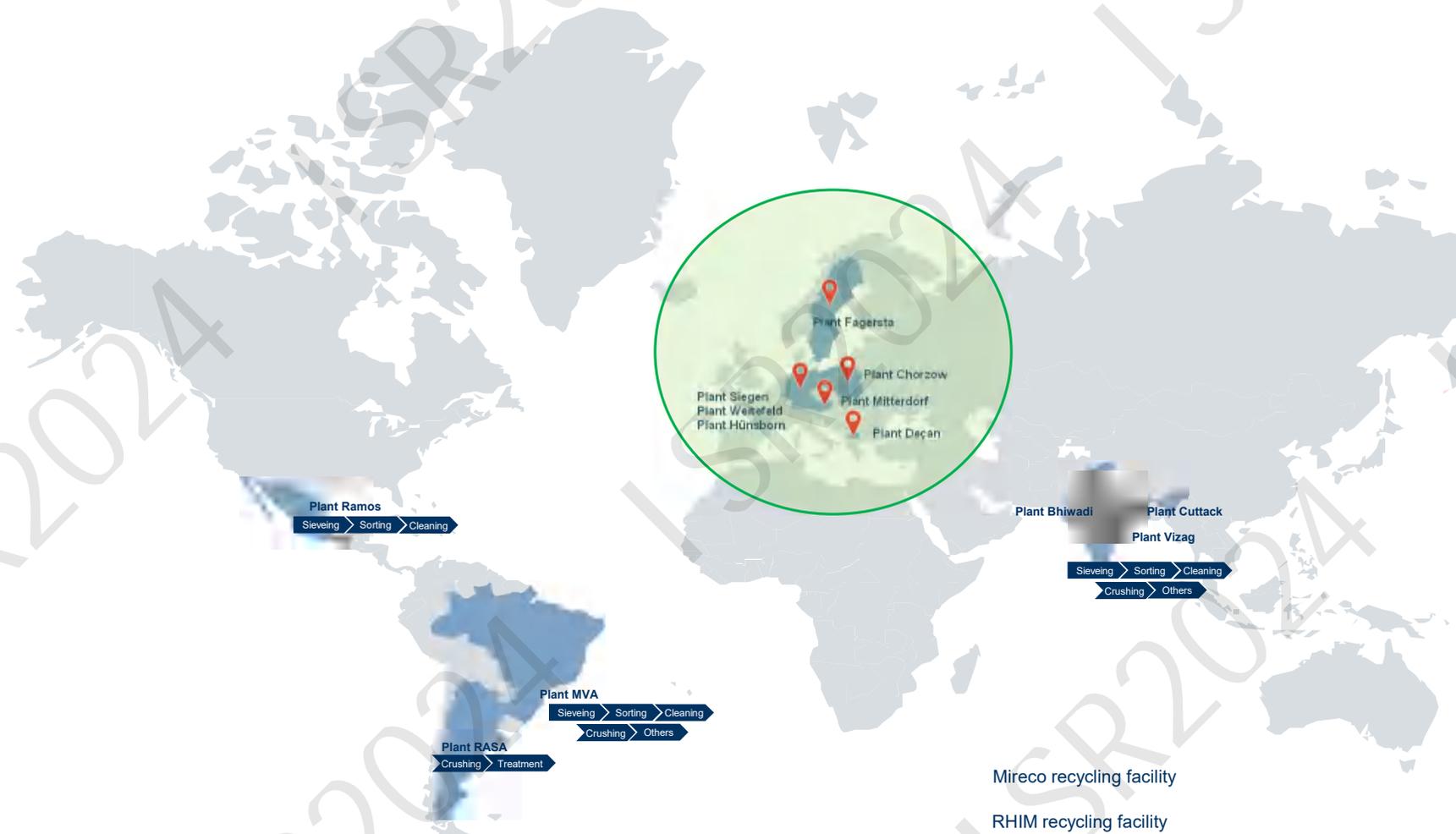


Each 1 ton of external recycling consumption, saves 1.80 tons of CO2 emissions

CO2 savings emission (kty):



Recycling plants all over the world



More than 100 years of innovation

MIRECO is the result of RHI Magnesita and Horn & Co. Group joining forces. With our combined expertise, leadership and over 100 years of refractory history, we are able to tackle major challenges of our society and industry such as climate change and resource conservation.

For us, recycling is part of our DNA !!!

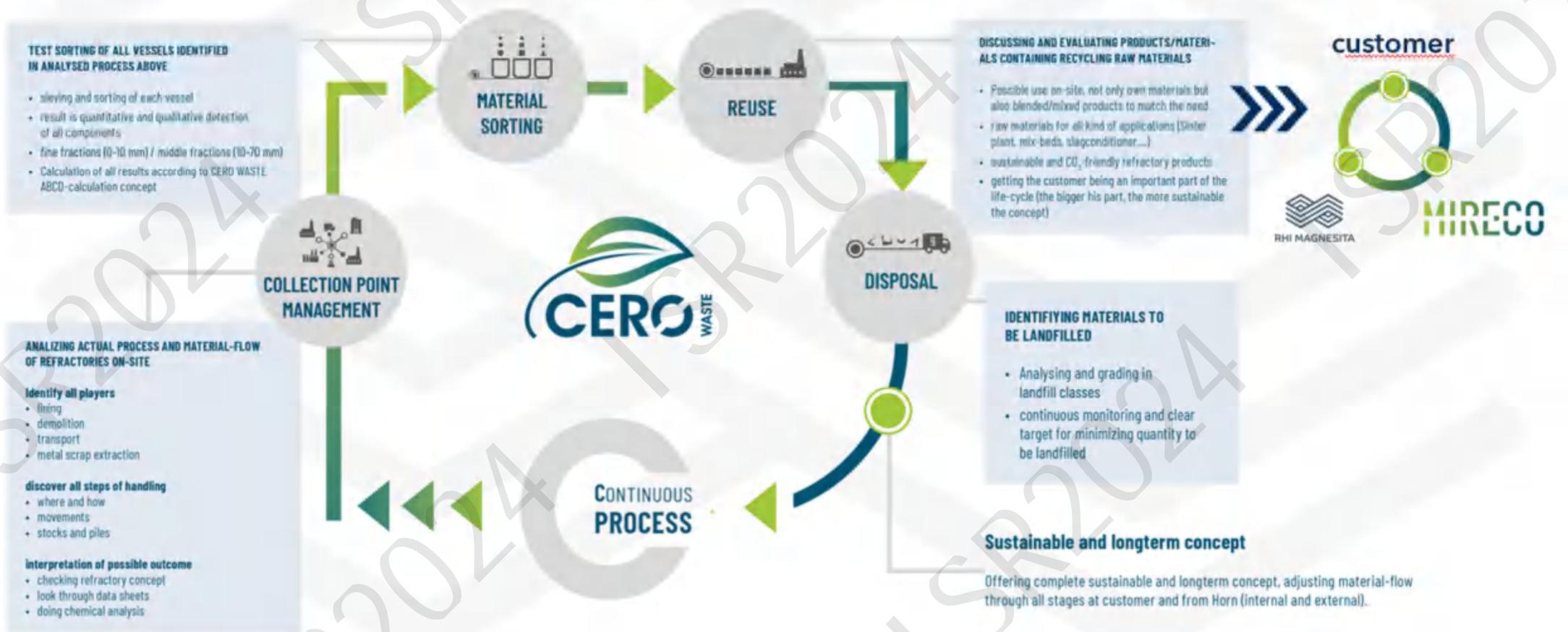


Europeans leading refractory recycling platform

Together with and for our customers we design circular solutions that provide high quality and performance, while saving CO₂ emissions. Join our mission of strengthening the circular economy in European refractories and contribute to transforming the industry.

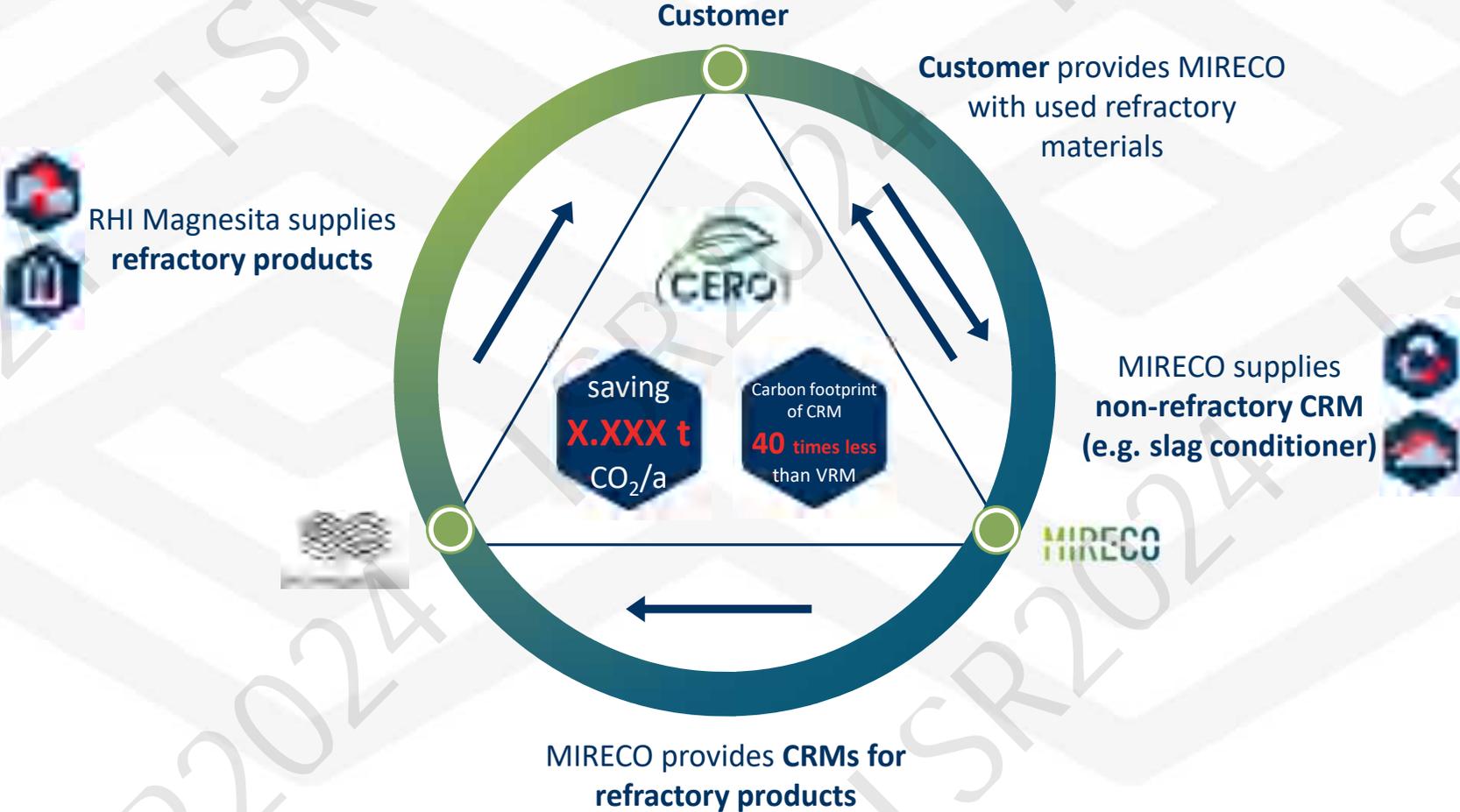
MIRECO – The key force in closing the cycle

CERO-Waste Concept as answer to "green steel", circularity and Carbon footprint



Circular Refractory Framework (CRF) - Triangle

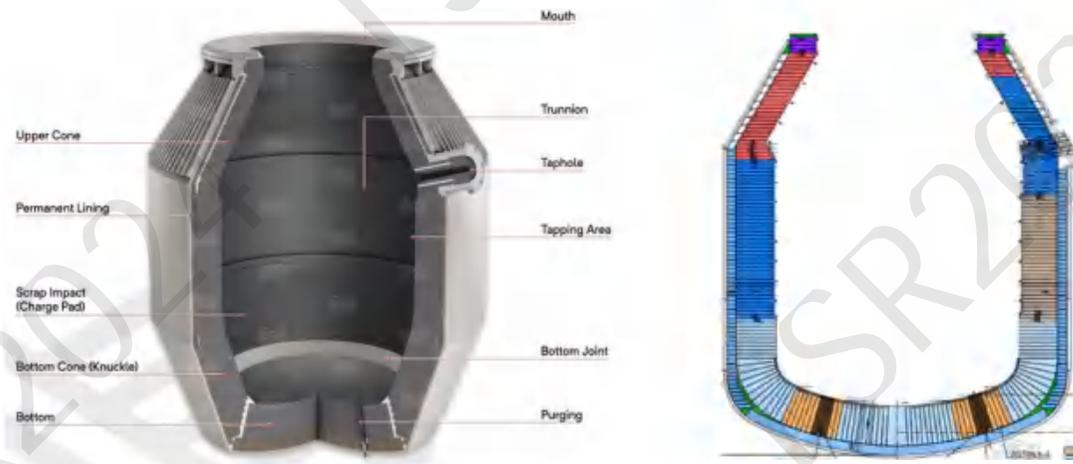
Customer x RHIM x MIRECO



The challenges of refractory recycling

General motivation

Lining concepts of industrial aggregates are complex and contain different products (> 200 tons). After the life-cycle of the lining ends the material is removed and mixing of different qualities can hardly be avoided.



Blast oxygen furnace: Different colors indicate different products



Material break-out after lining life cycle



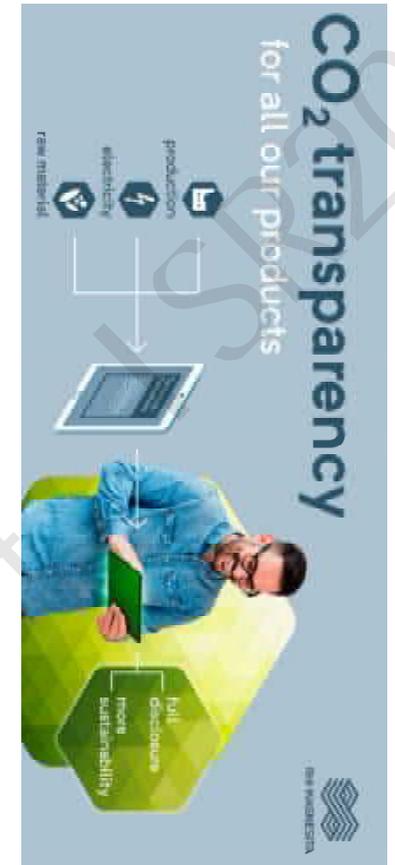
Spent refractories partly undergo changes in phase composition and chemistry during the customer application. Contaminated surfaces and the coarse ceramic microstructure make the challenge even bigger.

The recycling process involves activities from sourcing, sorting, processing materials, and selling recycled products

But technology for processing has not evolved so much



RHIM Product Carbon Footprint (PCF) CO2 transparency (video)





CO₂ transparency

We show the results of this efforts on our datasheets

For the same product group, RHI Magnesita can offer products with **lower** PCFs!

ANCARBON C F3E14				
General information				
Classification	Magnesia-cation product type M20010 (EU) 10013			
Basic raw (starting) components	Fused magnesite, SiO ₂ (SiO ₂)			
Working type	Cast-in-place			
Basic Application(s)	Concrete (CC), Reinforced concrete			
Additional Information	Company			
Environmental indicators				
Product Carbon Footprint	2,987	[t CO ₂ e/t prod.]	ISO 14067	
The Carbon Footprint of the Product (CFP) has been calculated following the principles of ISO 14067.				
Chemical analysis				
MgO	Al ₂ O ₃	Fe ₂ O ₃	CaO	SiO ₂
97.1%	0.9%	0.8%	0.2%	0.7%
Determination of loss on sintering (1025 °C / 1917 °F) acc. to ISO 12617				
L	14.0%			
Physical properties				
Bulk Density	3.00	[g/cm ³]	ISO 9117	
Bulk Density, calc. acc. (1000 °C / 1832 °F)	2.94	[g/cm ³]	ISO 9117	
Apparent Porosity	4.6	[%vol]	ISO 9117	
Apparent Porosity, calc. acc. (1000 °C / 1832 °F)	10.0	[%vol]	ISO 9117	
Open Porosity, Strength	20.0	[%vol]	ISO 10681	
Open Porosity, Strength, calc. acc. (1000 °C / 1832 °F)	20.0	[%vol]	ISO 10681	
Thermal Expansion	0.00	[1/1]	EN 990-10	
1000 °C / 1832 °F	1.90	[1/1]	EN 990-10	
1800 °C / 3272 °F	1.70	[1/1]	EN 990-10	
Thermal Conductivity (300 °C / 572 °F)	0.50	[W/mK]	EN 501-2	

ANCARBON C F8E14-EU				
General information				
Classification	Magnesia-cation product type M20010 (EU) 10013			
Basic raw (starting) components	Fused magnesite, SiO ₂ (SiO ₂)			
Working type	Cast-in-place			
Basic Application(s)	Concrete (CC), Reinforced concrete			
Additional Information	Company			
Environmental indicators				
Product Carbon Footprint	1,842	[t CO ₂ e/t prod.]	ISO 14067	
The Carbon Footprint of the Product (CFP) has been calculated following the principles of ISO 14067.				
Chemical analysis				
MgO	Al ₂ O ₃	Fe ₂ O ₃	CaO	SiO ₂
95.9%	0.9%	0.8%	0.7%	1.0%
Determination of loss on sintering (1025 °C / 1917 °F) acc. to ISO 12617				
L	14.0%			
Physical properties				
Bulk Density	3.00	[g/cm ³]	ISO 9117	
Bulk Density, calc. acc. (1000 °C / 1832 °F)	2.94	[g/cm ³]	ISO 9117	
Apparent Porosity	5.5	[%vol]	ISO 9117	
Apparent Porosity, calc. acc. (1000 °C / 1832 °F)	11.0	[%vol]	ISO 9117	
Open Porosity, Strength	20.0	[%vol]	ISO 10681	
Open Porosity, Strength, calc. acc. (1000 °C / 1832 °F)	20.0	[%vol]	ISO 10681	
Thermal Expansion	0.00	[1/1]	EN 990-10	
1000 °C / 1832 °F	1.20	[1/1]	EN 990-10	
1800 °C / 3272 °F	1.10	[1/1]	EN 990-10	
Thermal Conductivity (300 °C / 572 °F)	0.50	[W/mK]	EN 501-2	

Environmental indicators			
Product Carbon Footprint	2,987	[t CO ₂ e/t prod.]	ISO 14067
The Carbon Footprint of the Product (CFP) has been calculated following the principles of ISO 14067.			

Environmental indicators			
Product Carbon Footprint	1,842	[t CO ₂ e/t prod.]	ISO 14067
The Carbon Footprint of the Product (CFP) has been calculated following the principles of ISO 14067.			



“The future is created by what you do today, not tomorrow”



Let's go
GREEN together,
step by step

Thank You – any Questions?



“The future is created by what you do today,
not tomorrow”

Get in touch

Dr. Thomas Prietl
Head of Global R&D and Innovation
Magnesitstrasse 2
8700 Leoben Austria
Phone: +43 50213 5301
E-mail: thomas.prietl@rhimagnesita.com
rhimagnesita.com

Important notice:

These materials do not constitute or form part, or all, of any offer of invitation to sell or issue, or any solicitation of any offer to purchase or subscribe for, any securities in any jurisdiction in which such solicitation, offer or sale would be unlawful, nor shall part, or all, of these materials form the basis of, or be relied on in connection with, any contract or investment decision in relation to any securities.

These materials contain forward-looking statements based on the currently held beliefs and assumptions of the management of RHI Magnesita N.V. or its affiliated companies, which are expressed in good faith and, in their opinion, reasonable. These statements may be identified by words such as “expectation” or “target” and similar expressions, or by their context. Forward-looking statements involve known and unknown risks, uncertainties and other factors, which may cause the actual results, financial condition, performance, or achievements of RHI Magnesita N.V. or its affiliated companies to differ materially from the results, financial condition, performance or achievements express or implied by such forward-looking statements. Given these risks, uncertainties and other factors, recipients of this document are cautioned not to place undue reliance on these forward-looking statements. RHI Magnesita N.V. or its affiliated companies disclaims any obligation to update these forward-looking statements to reflect future events or developments.