LCA studies to support a waste treatment company in the context of the circular economy

by

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A path of environmental sustainability

Life Cycle Assessment (LCA) has gained wide acceptance as a tool to support waste treatment companies to:

- *understand the* ***overall impacts*** *and the* ***relative hotspots*** *both* ***on-site*** *and* ***across the value chain***
- *promote* ***compatibility*** *between* ***productivity*** *and* ***environmental impacts***
- *improve their role in the* ***circular economy*** *and in the* ***conservation of natural resources***

THE EXAMPLE OF RMB S.p.A.

Multi-functional **platform** in Brescia (Lombardy Region, Italy) for **treating** and **recovering special hazardous and non-hazardous waste**

LCAs ON REPRESENTATIVE PRODUCTS from TREATED WASTE

- *hotspots identification across the production*
- *definition of strategies for impacts reduction*
- *communication of the impact profile to the final users*

ORGANIZATIONAL CARBON FOOTPRINT

quantification of direct and indirect GreenHouse Gases (GHG) emissions of the company, aiming at defining a reduction plan

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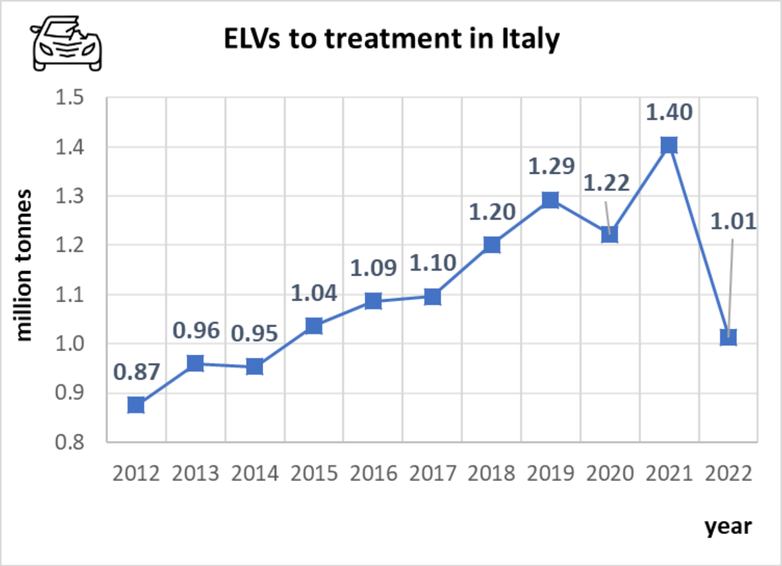
Italian management system of End-of-Life Vehicles (ELVs): numbers

- **2012-2022**: progressive growth **(+16%) in the mass** of **ELVs to treatment** in **Italy**
- Currently, in Europe, **Italy** is the **second country** after France for **ELVs treated mass**
- In **2022**, the **reuse/recycling rate** of **ELVs** in **Italy** reached **86%** of the average vehicle weight



RECOVERY SYSTEM IN ITALY - 2022

CAR WRECKERS (1,542 companies)

SHREDDING PLANTS (26 facilities)

1.0 million tonnes

depollution dismantling compaction

shredding and sorting (**R4 recovery operation**)

The waste is sorted into

- **Ferrous metals**
- **Non-ferrous metals**
- **Other residues (mainly plastics and rubbers)**

Recycling in metals industry

Energy recovery or disposal

1. Eurostat (2025). *End-of-life vehicle statistics* (here)
2. ISPRA (2024). *Italian report on special waste. Edition 2024* (here in Italian)

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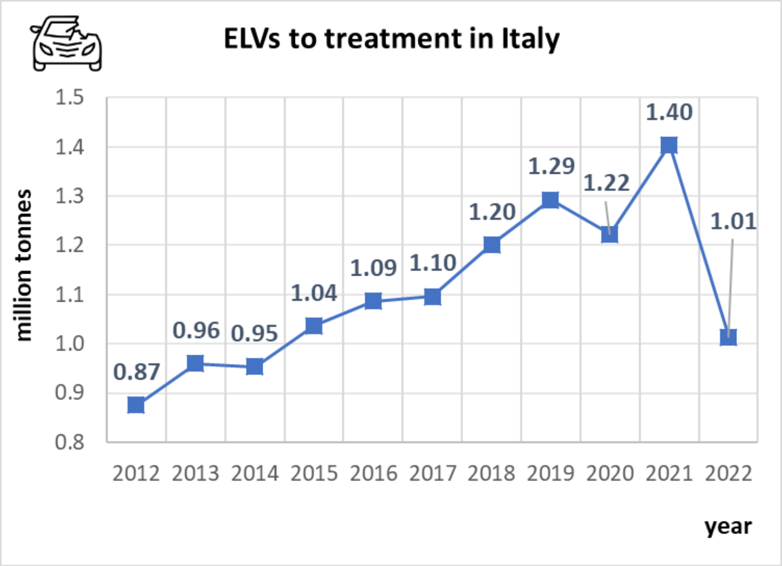

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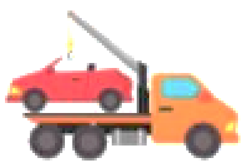

RMB

First plant in Italy for treated mass of ELV$_S$ (163,188 tonnes)

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ELVs recovery treatment: the case of RMB

INCOMING WASTE

ELVs components (mainly car hulks and engines) from car wreckers

OUTGOING MATERIALS

FERRO PROLER	*Fraction of ferrous metals (single pieces: 5-150 mm*)*		**65%**
ALLUMINIO RESAL	*Aluminium alloy EN AB-46000**		**7.1%**
HEAVY MIXED METALS	*Fraction refined in RMB facility → separation of single metals*		**1.4%**
CAR FLUFF	*Mainly plastics and rubbers. High calorific value → energy recovery or disposal*		**26%**

* Secondary raw products, ceasing to be waste. They fulfill criteria of the 333/2011/EC Regulation

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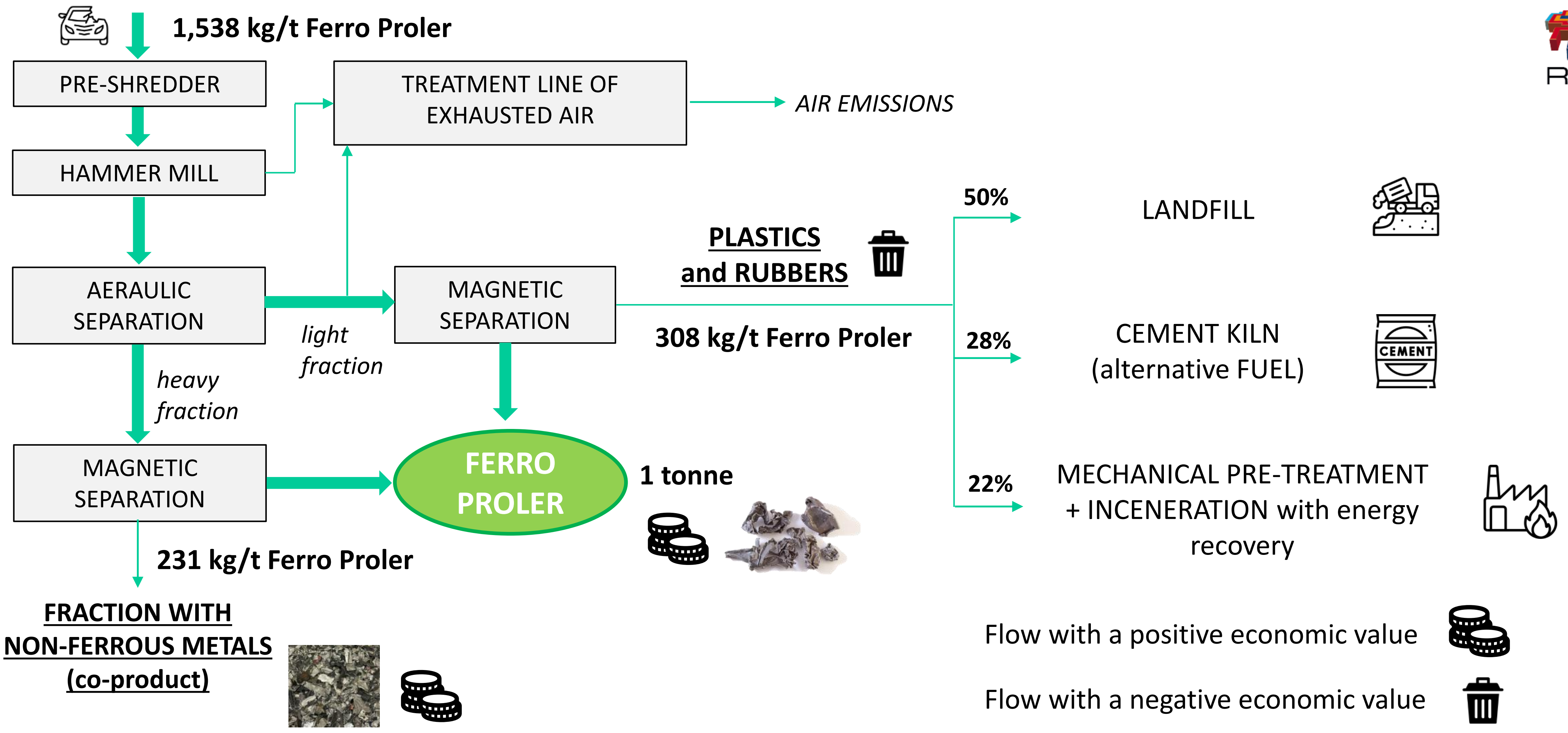
The first LCA focused on a product recovered from ELVs
→ previous LCAs focused on the ELVs waste

1. *Identification of the **main hotspots** of the production process both **at RMB** and **across the value chain***
2. *Useful for **RMB** and for **steel mills** that use Ferro Proler **to evaluate the performance of their final iron products***

* Secondary raw product, ceasing to be waste. It fulfills criteria of the 333/2011/EC Regulation

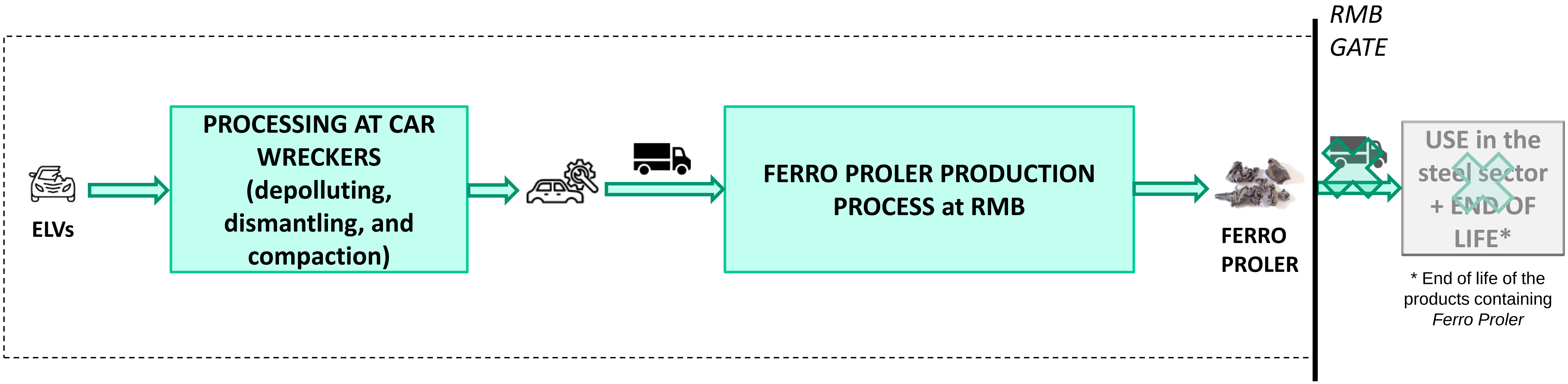
The production of Ferro Proler at RMB



LCA study setup

SYSTEM BOUNDARY: <u>partial LCA</u>, from cradle to the gate of RMB

DECLARED UNIT (DU): 1 tonne of Ferro Proler



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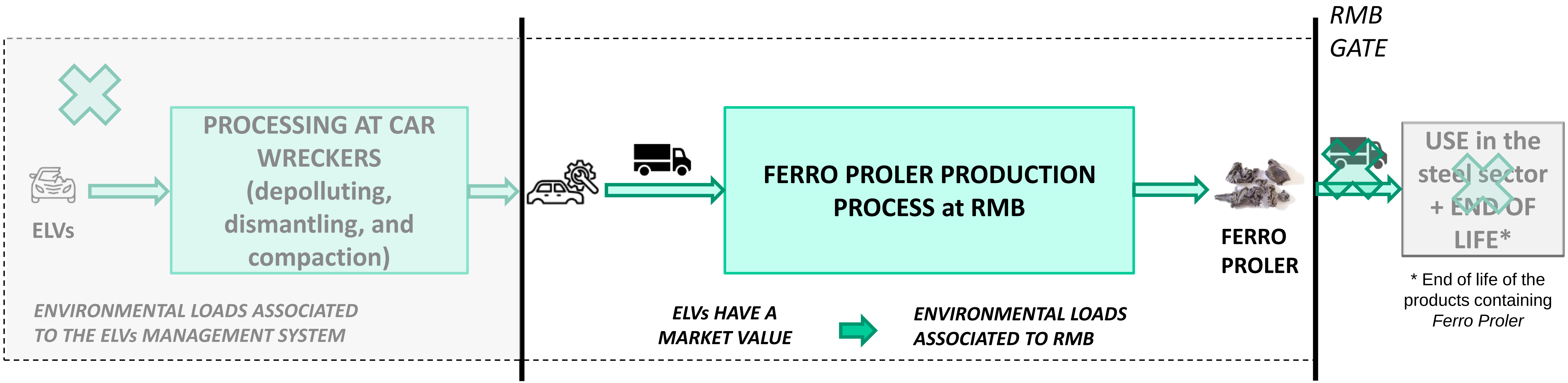
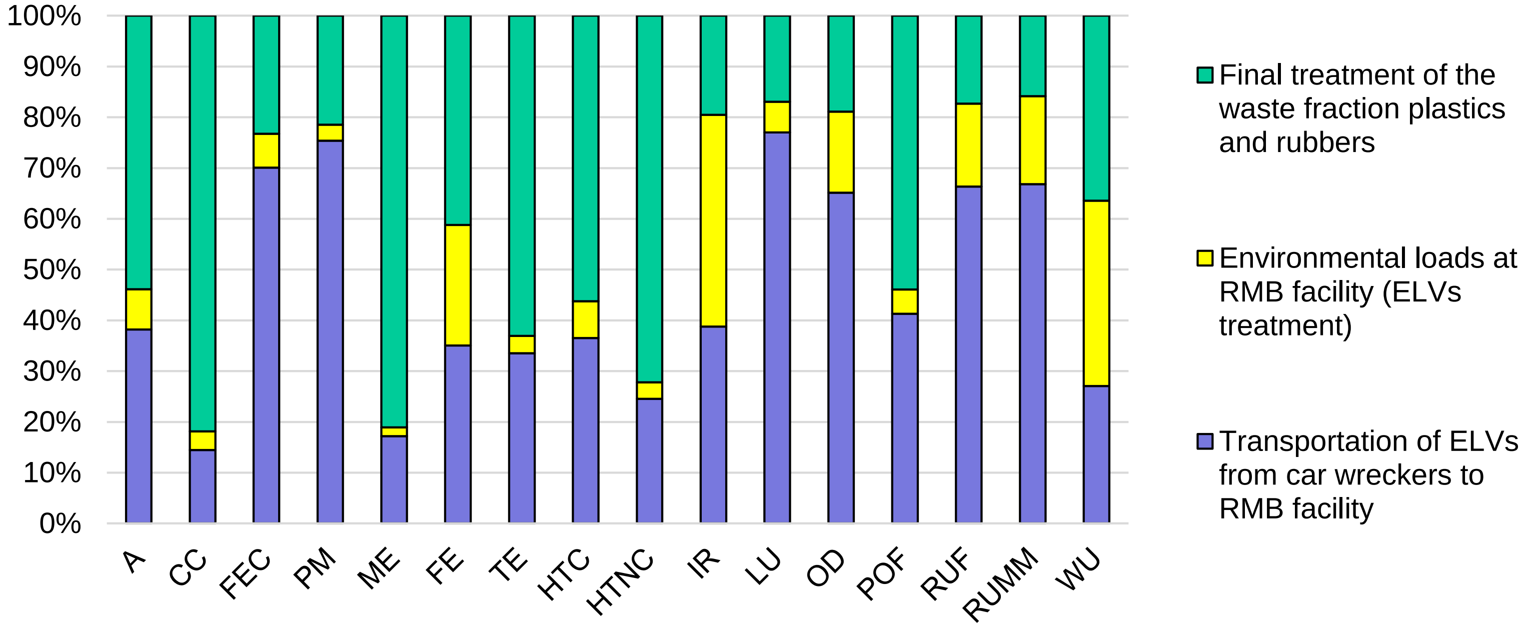


- ***Ferro Proler*** is produced **from a waste** (ELVs) → the **environmental load** of its production should be **partitioned between RMB** system and the **system that generated the ELVs**
- Guidelines of the **International EPD® System** ("polluter pays principle") → the **system boundary starts** when **ELVs gain a market value** (gate of the car wrecker)

Results: LCA of Ferro Proler production



- **Most important environmental loads** associated to **stages performed outside RMB facility** (transportation of ELVs from car wreckers and final treatment of plastics and rubbers) except for IR
- **Treatment of the plastics and rubbers** → impact mainly associated to **air emissions of their combustion** in the **cement kiln** and in the **incineration plant** (fossil CO_2, NO_X, Cd, and Hg)
- Transportation **car wreckers - RMB**: **road transportation** (average distance of **445 km**)

IMPACTS per 1 tonne of Ferro Proler (DECLARED UNIT)

A	5.0×10^{-1}	mol H^+ eq.
CC	$3.1E \times 10^{2}$	kg CO_2 eq.
FEC	4.6×10^{2}	CTUe
PM	6.7×10^{-6}	disease incidence
ME	4.2×10^{-1}	kg N eq.
FE	9.3×10^{-3}	kg P eq.
TE	2.3	mol N eq.
HT_C	6.5×10^{-8}	CTUh
HT_{NC}	2.1×10^{-6}	CTUh
IR	2.2	kBq U-235 eq.
LU	8.8×10^{2}	Pt
OD	1.5×10^{-6}	kg CFC11 eq.
POF	7.1×10^{-1}	kg NMVOC eq.
RUF	1.0×10^{3}	MJ
RUMM	1.8×10^{-4}	kg Sb eq.
WU	1.2×10^{1}	m^3 deprived

IMPACT CATEGORIES (Environmental Footprint impact assessment method, version 3.1)

A=acidification; CC=climate change; FEC=freshwater ecotoxicity; PM=particulate matter; ME=marine eutrophication; FE=freshwater eutrophication; TE=terrestrial eutrophication; HT_C=human toxicity cancer; HT_{NC}=human toxicity non-cancer; IR=ionising radiation; LU=land use; OD=ozone depletion; POF=photochemical ozone formation; RUF=resources use, fossils; RUMM=resources use, minerals and metals; WU=water use

Impact improvement: management of plastics and rubbers

- Identification of a more sustainable treatment for plastics and rubbers (material recovery in place of energy recovery) → development of new technologies at the commercial scale

- Pilot-scale processes in the existing literature:

i) Conversion into **aggregates** for **asphalt** or **concrete** used in **non-structural applications** [Rao et al., 2024]

ii) Separation into **individual plastic polymers** by **sinking flotation** [Quelal et al., 2022]

- RMB S.p.A. is testing a new treatment for the plastics and rubbers dedicated to the **production of a Secondary Reducing Agent (SRA) → substitution of coke** in **electric-arc furnace steel mills**

Compliant with the Italian Standard UNI 10667-17:2021 *Plastic raw-secondary materials - Blends of heterogeneous plastics from industrial residue and/or from post-consumer materials, to be used in metallurgical and steel processes - Requirements and test methods*

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PRODUCTION FROM PLASTICS AND RUBBERS

1° step - __SEPARATION OF BOTH THE RESIDUAL METALLIC FRACTIONS AND THE HEAVY MINERAL FRACTION__ → sieving, size reduction, and separation steps

2° step - __REDUCTION OF MOISTURE, SIZE, AND VOLUME OF THE MATERIAL__ → use of densifiers and granulators

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Organizational Carbon Footprint analysis - methodology

COMPANY

Multi-functional platform for treating and recovering special hazardous and non-hazardous waste

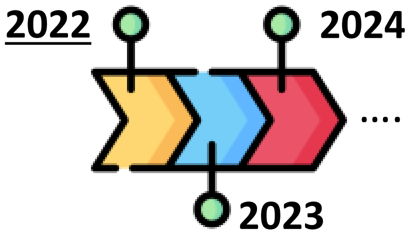
REFERENCE STANDARD


ISO 14064-1:2018

Greenhouse gases

Part 1: Specification with guidance at the organization level for quantification and reporting of greenhouse gas emissions and removals

TEMPORAL BOUNDARIES



The **year 2022** was assumed as **base year** (first year with standard operativity after the COVID pandemic)

INCLUDED GHG EMISSIONS

CATEGORY 1: direct emissions

STATIONARY COMBUSTION

MOBILE COMBUSTION

LEAKS OF REFRIGERANT GASES

CATEGORY 2: indirect emissions from imported energy

CONSUMPTION OF ELECTRICAL ENERGY FROM THE ITALIAN GRID

INCLUDED GHGs

CO_2, CH_4, N_2O, HFCs*, and HFOs*

* From refrigerant gases

GWP_{100} reference DOCUMENT

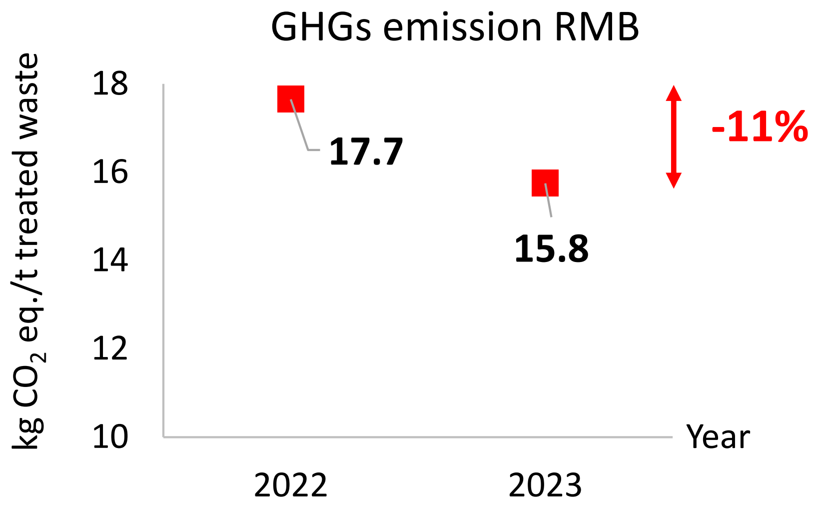
Sixth IPCC report

EMISSION FACTORS

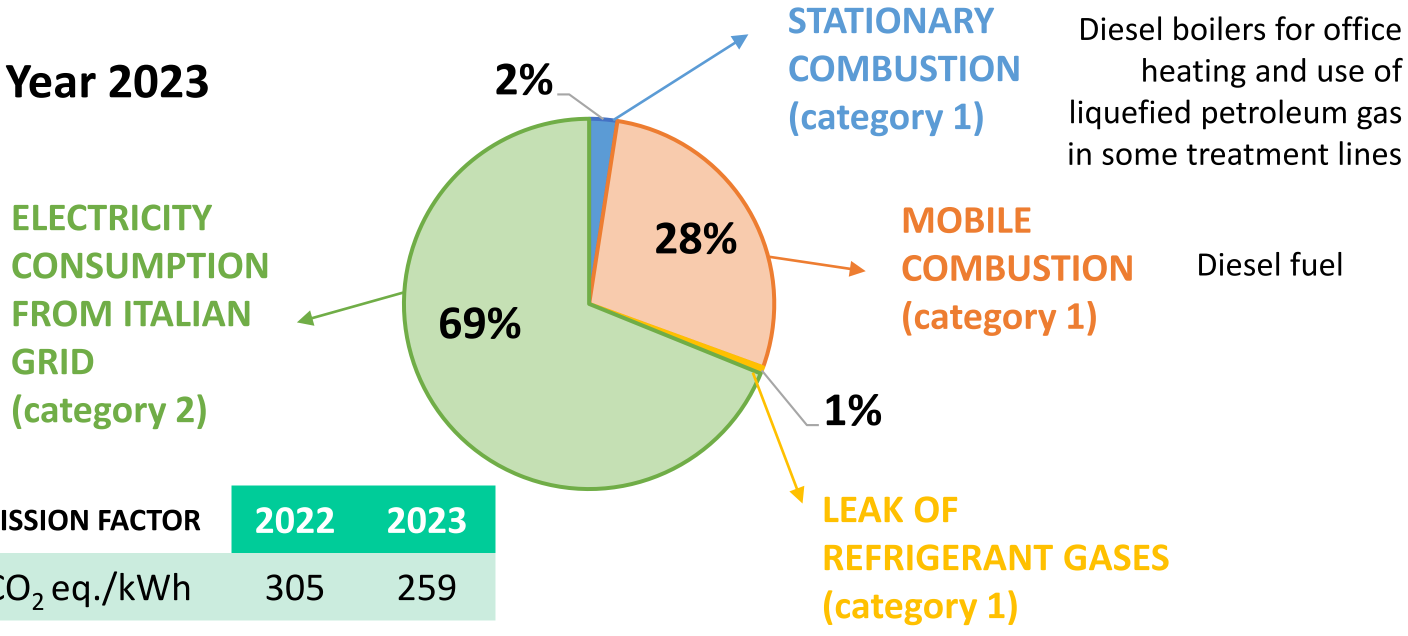
Specific for the Italian context. Provided by ISPRA (the Italian Superior Institute for the Protection and the Research on the Environment)

Organizational Carbon Footprint analysis - results

LOCATION-BASED APPROACH



Year 2023



EMISSION FACTOR	2022	2023
g CO_2 eq./kWh	305	259

- **Reduction of GHG emissions** in one year thanks to:
  - **reduction** of the GHG **emission factor** for the **electricity** consumption **from the grid** (external factor)
  - progressive **installation** of **photovoltaic panels** on-site (up to 4.4 MW)
  - **raising awareness** among **personnel** on the topic
- Most of the **emission** is due to **the electricity from the grid** → **prevention measures** should be implemented

Conclusions

LCA helps waste management companies to become more conscious of their environmental impacts and to define a plan for improving their performance from both a product and an organization perspective

PRODUCT LCA ON *FERRO PROLER:*

i. ***main impact contributions*** *from* ***stages performed outside RMB facility***

ii. ***optimization of the logistic*** *and* ***implementation of new recycling treatments*** *for* ***plastics and rubbers*** *(main scrap of the process)*

ORGANIZATIONAL CARBON FOOTPRINT (GHG EMISSIONS OF CATEGORY 1 AND CATEGORY 2):

i. ***electricity consumption*** *plays a* ***crucial role*** *in the GHG emissions*

ii. ***reducing*** *of* ***electricity consumption*** *at the source and promoting the* ***purchase of certified renewable energy*** *should be prioritized*

New LCAs will soon be conducted for other key products of the company using a similar modeling approach

Questions?

Contact: lucia.rigamonti@polimi.it

Assessment on WAste
and REsources

Reference blog of the AWARE research group: https://www.aware.polimi.it/