DECARBONIZATION THROUGH INDUSTRIAL SYMBIOSIS: THE USE OF RECYCLED CARBON RAW MATERIALS IN THE STEELMAKING

ESTEP

Linz, October 2024

I.BLU Gruppo IREN

FERALPI GROUP

tenova

voestalpine ONE STEP AHEAD.

K1 MET metallurgical competence center

CHALLENGES AND OPPORTUNITIES OF THE STEELMAKING INDUSTRY

The metallurgical sector is a *hard-to-abate* industry facing enormous challenges in the intent to cut down CO_2 emissions in accordance with the Green Deal.

While new technologies for climate change mitigation, involving for example the use of hydrogen and CCUS, are still in the development phase and need to be perfected, one readily available solution is the use of recycled polymeric carbon-carriers used as reducing/foaming agents in substitution of coal.

Besides contributing to decarbonization, using plastic recyclates in the iron and steelmaking process, is also a virtuous example of industrial symbiosis that can at the same time boost plastic recycling and the circular economy.

DECARBONIZATION OF THE STEELMAKING THROUGH THE USE OF PLASTIC RECYCLATES

Through the know-how and experience developed thanks to the collaboration of plastic recyclers, technology providers, competence centers, and iron/steel producers, the use of reducing/foaming agents deriving from the recycling of mixed plastic waste in substitution of virgin fossil resources has become a consolidated best practice in Europe, both in EAF and BF processes.

The use of recycled polymers in substitution of coal in the steelmaking leads to significant CO_2 emission savings as well as the preservation of natural resources and, therefore, of carbon storages in the ground. Thanks to the recycling of mixed plastic waste, it also helps achieve the European recycling targets for plastic packaging waste.

A CONSOLIDATED BEST PRACTICE IN THE STEELMAKING INDUSTRY

Onlyplastic Project: BLUAIR® in EAF

Pioneer experience in use of recycled polymers in BF

FERALPI Group is a European manufacturer of reinforcing steel in bars and coils, wire rod, electro welded mesh and special Steel, with a production capacity of about 2,4 Mt/year and about 1900 employees.

EAF STEEL PRODUCER
Feralpi is the first EAF steelwork to substitute 100% of the injected coal with polymeric secondary reducing agents within the Onlyplastic project thanks to installation of new storage and injection facilities.

Tenova is the technology provider that designed a highly-performing EAF injection systems tailored for recycled polymers.

TECHNOLOGY PROVIDER
Tenova SpA is a worldwide supplier of advanced technologies, products and services for metal and mining industries, providing innovative and integrated solutions for complete process areas, like the KT® injection systems.

I.BLU is one of the main plastic recyclers in Europe, focusing on plastic packaging waste and producing BLUAIR®, largely used in Europe both in EAFs and BFs across Europe.

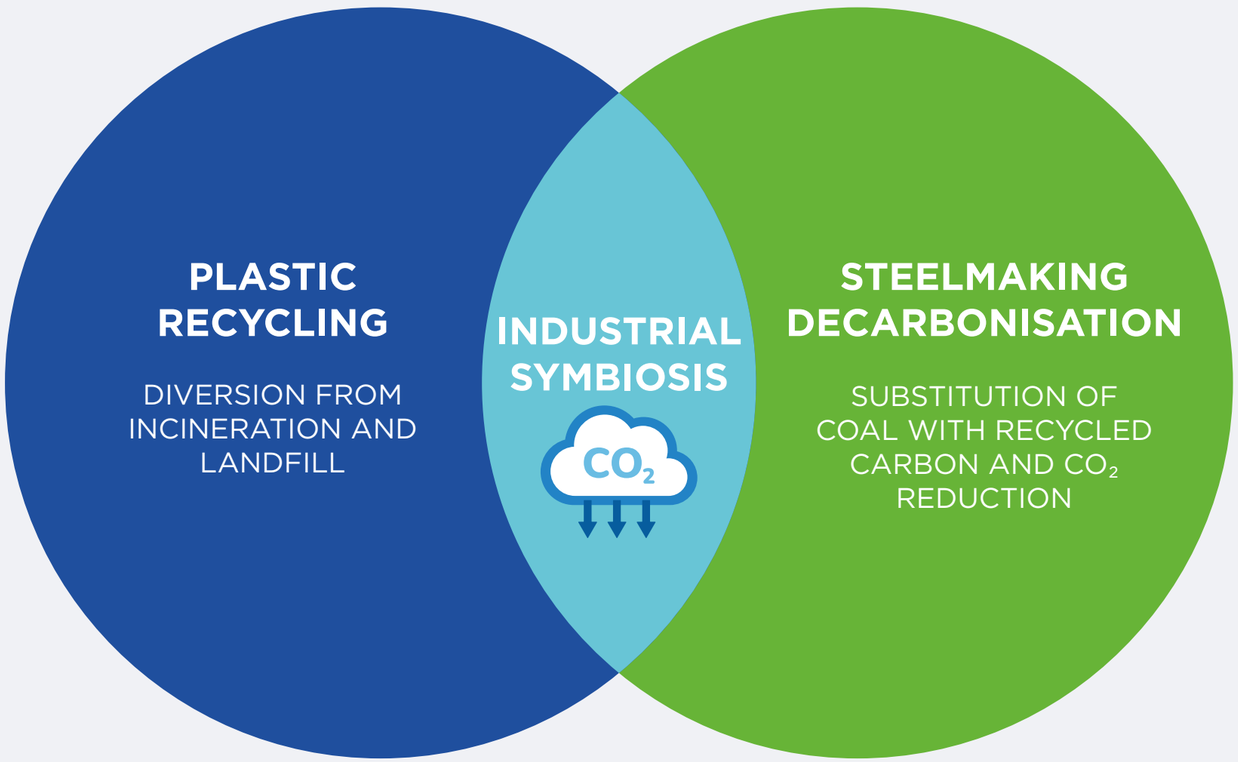
PLASTIC RECYCLER
I.Blu supplies steelworks across Europe with BLUAIR®, an EoW product deriving from the recycling of hard-to-recycle plastics, to be used in the steelmaking in substitution of traditional reducing and foaming agents (e.g. coal).

voestalpine is a globally leading steel and technology group based in Linz/Austria, acting as the main European Blast Furnace to uptake the injection of recycled polymers as alternative reducing agent.

BF/BOF STEEL PRODUCER
voestalpine is using recycled carbon raw materials from polymers as alternative reducing agents in the Blast Furnace since 2006. The efficient use of resources and acting sustainable are core values at voestalpine.

K1-MET is a metallurgical competence centre, highly experienced in research about the use and reactivity of alternative reducing agents for ironmaking (e.g. from waste plastics).

METALLURGICAL COMPETENCE CENTRE
Expert in sustainable and digitalized metallurgy for a climate neutral and resource efficient planet, providing support to the steel industry.



INDUSTRIAL SYMBIOSIS: BEYOND THE MARKET MISMATCH

The demand for coal, which significantly exceeds its availability in the EU, can be compensated by the uptake of recycled carbon-bearing materials deriving from plastic waste streams that are *hard-to-recycle* for traditional plastic applications.

I.BLU BLUAIR®

BLUAIR® is a reducing/foaming agent developed by I.Blu, to be used in blast furnaces (BF) and electric arc furnaces (EAF) in substitution of coal. It's a **circular raw material** deriving from the recycling of plastic packaging waste and intended for the technical functions foreseen by the standard UNI 10667-17:2021:

a) as a reducing and/or foaming agent;
b) as a protective agent for the elements to be preserved during the melting process;
c) as a vector of reagents in oxide reduction reactions;
d) for the production of mixtures typically employed for the intake of carbon and hydrogen in the process (e.g., coke).

Politecnico di Torino

Dipartimento di Ingegneria dell'Ambiente, del Territorio e delle Infrastrutture

Evaluation of the environmental benefits deriving from the use of BLUAIR product in steel production according to the UNI 10667-17:2021 standard, also considering the national established recycling targets

Report Phase II

Prof.ssa Mariachiara Zanetti
Prof.ssa Barbara Ruffino
Prof.ssa Deborah Panepinto

18th october 2022

NO NEGATIVE IMPACTS ON INDUSTRIAL EMISSIONS

A study by the Polytechnic University of Torino (2022) investigated the environmental benefits deriving from the use of BLUAIR® in three Italian EAF steelworks.

With regard to industrial emissions, the report showed that:

- overall, the injection of BLUAIR® does not negatively impacts the quality of the emissions and ensures **full compliance with the threshold values** established by the environmental permits and monitoring regimes of each steelwork;
- the emission points measurements during the injection of BLUAIR® were **similar or beneficial compared to the standard practice (only coal)**, including the monitoring of PAHs, PCBs, PCDD/PCDF, dusts, NOx, and heavy metals.

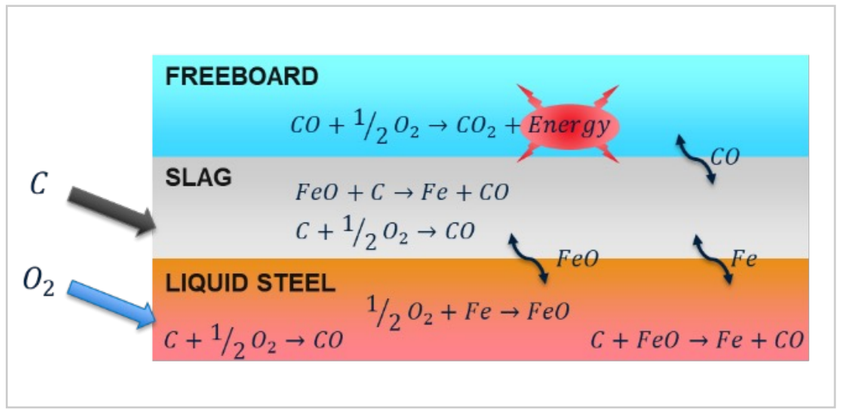
ONLYPLASTIC PROJECT

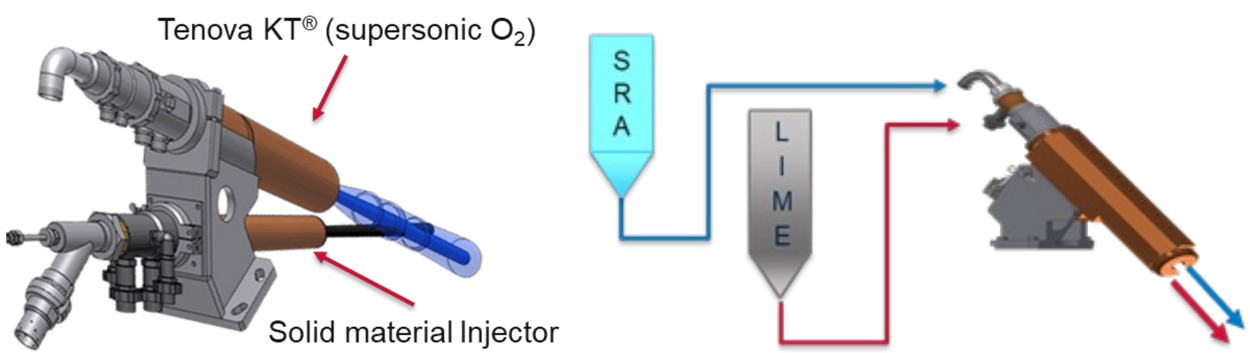
PROJECT NUMBER: RFCS 899415
PROJECT ACRONYM: ONLYPLASTIC
PROJECT TITLE: EAF WORKING WITH POLYMERS DERIVED FROM PLASTIC RESIDUE IN SUBSTITUTION OF FOSSIL FUEL

The project aimed at the substitution of virgin coal in the Feralpi EAF steelwork with the recycled polymer product (BLUAIR®). The next slides summarize the results obtained in terms of:

- development and testing of the KT® injection system by Tenova;
- experience of Feralpi regarding the industrial tests carried out in the EAF;
- LCA study regarding the production of BLUAIR® and its use in EAF.

The research leading to these results has received funding from the European Union's Research Fund for Coal and Steel research program under grant agreement number 899415





TENOVA: KT®INJECTION SYSTEM

The injection system is the key element to ensure EAF performances through proper slag foaming

Solution #1 - Tenova KT® TWIN SRA

- State-of-the art technology for EAF adapted to SRA injection
- Compact solution with high injection efficiency
- Suggested for revamping (minimal EAF modifications)

Solution #2 - New Tenova KT® MULTI

- SRA and lime injection **in the same device**
- Enables advanced process control solutions
- Simplify installation in complex layouts
- Less opening in EAF walls

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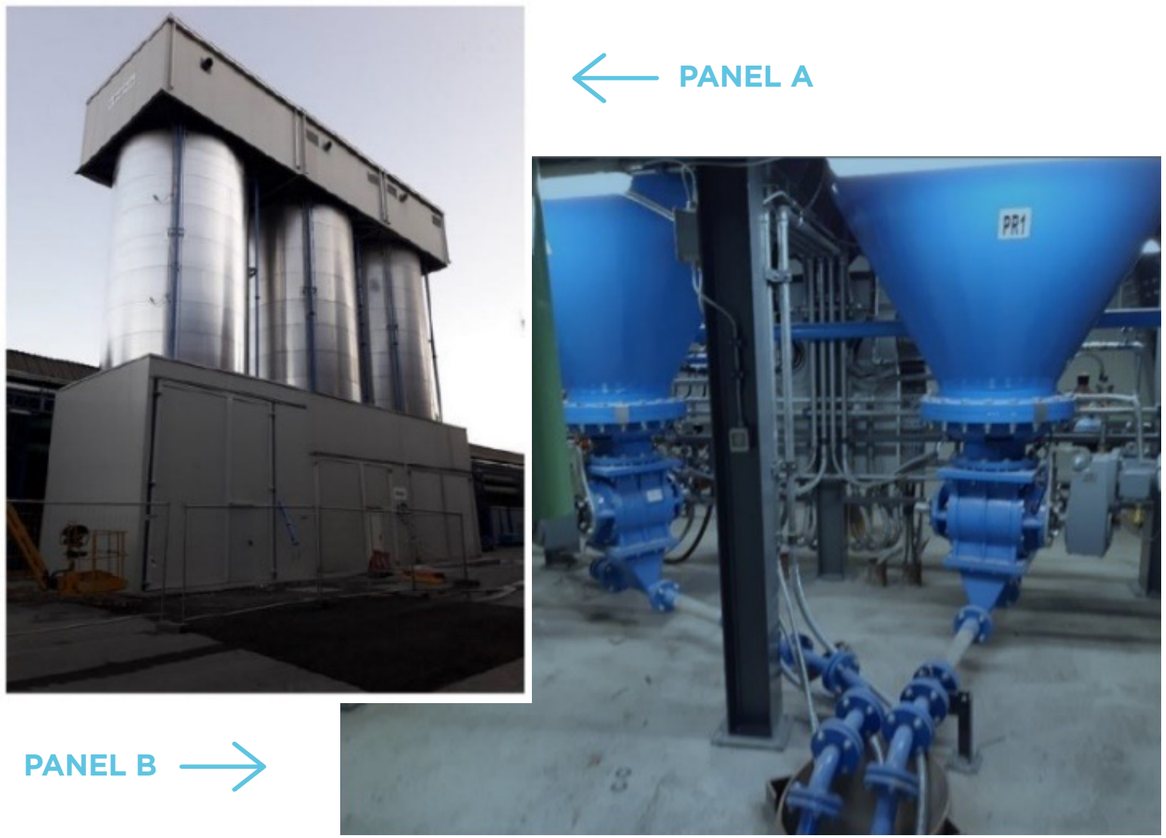

Feralpi Lonato SRA material handling system.
Panel A: silos for storage. Panel B: detail of the propulsors and transport lines.

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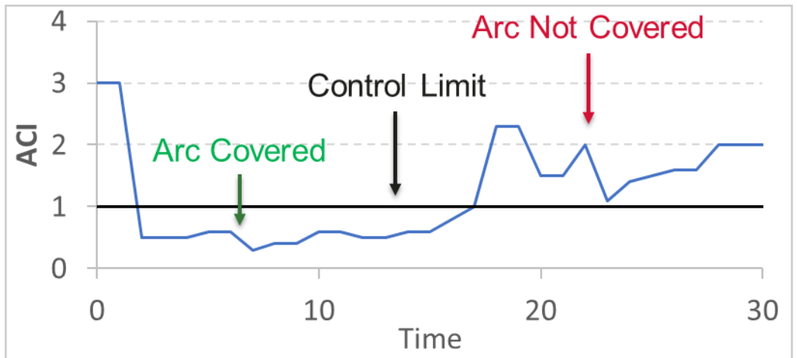
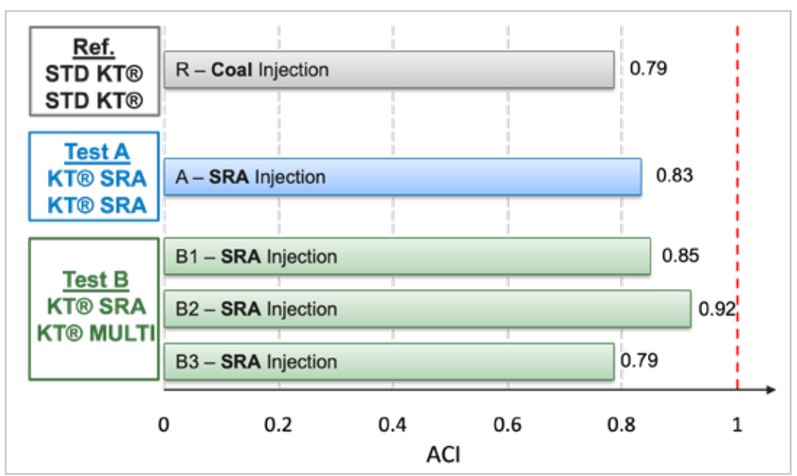
FERALPI: EAF EXPERIENCE

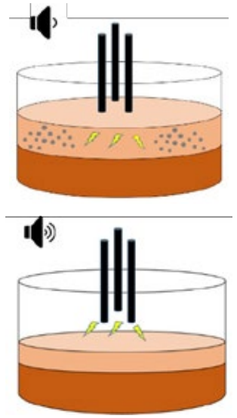
SRA usage required to adapt the material storage and handling systems to avoid clogging and corrosion phenomena. The system is designed to supply two different injection points at the same time, and it is characterized by

- 2x storage tanks with automatic charging
- 2x propulsion systems and transportation lines
- pressures and flow meters, plus regulation valves
- dedicated software for monitoring and control of the injection parameters.

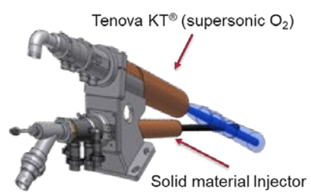




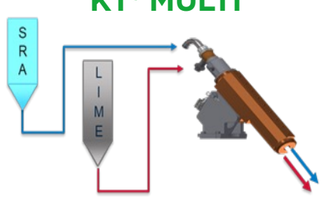
Main results of the tests performed at Feralpi Lonato. Data are normalized with respect to the "Reference" scenario.



KT® SRA



KT® MULTI



FERALPI: EAF EXPERIENCE

Process stability: Acoustic Index (ACI)

Correlation between the noise produced by the electric arc with the foaming slag level inside the EAF

- ACI <= 1 → Covered arc, good EAF performances
- ACI > 1 → Arc not covered, poor EAF performances

- Coal substituted with SRA in 2 injection points
- All trials with SRA (**A** and **B**) show an acceptable ACI index: no significant variations with respect to the standard coal practice **(Ref)**
- Trials **A** and **B** confirm the Injection efficiency of both Tenova KT® solutions

- Good slag foaming
- No solid material entrainment into fume system

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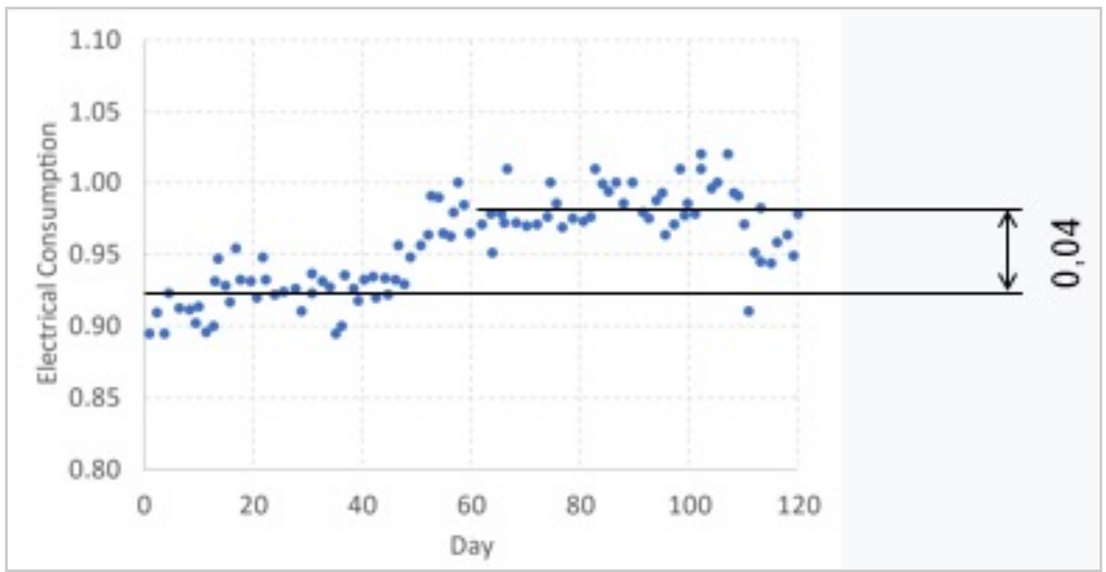

Daily average of electrical consumption with BLUAIR® SRA (Test A) for 120 production days.
Data are normalized with respect to the "Reference" scenario.

FERALPI: EAF EXPERIENCE

- No significant variations on:
  - ▷ Final product quality
  - ▷ Electric consumption
  - ▷ Off-gas temperature (before quenching tower)
- Slag composition variations below 10%: to BLUAIR® usage has no detrimental effect on the EAF process
- **No increases of hazardous molecules into off-gases**
  - ▷ Significant decrease of Dioxins and Furans

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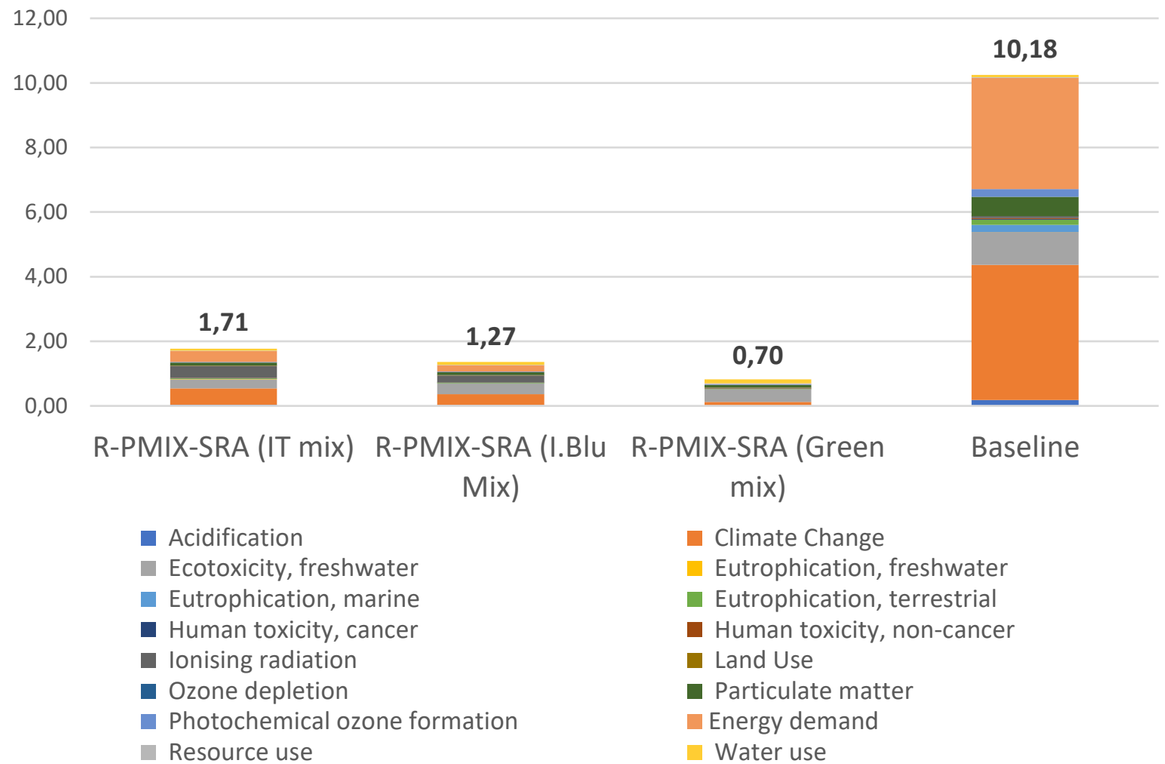

Single-score analysis comparing the impacts related to the innovative scenario (production of BLUAIR®) with the baseline scenario (incineration of mixed plastics and supply of coal).

LCA: BLUAIR® PRODUCTION

An LCA study was performed by Rina CSM within the OnlyPlastic project, which confirmed that the use of recycled carbon raw materials, in this case BLUAIR®, in EAF steelmaking is beneficial in most environmental impact categories.

The first part of the study compares the environmental performance of the innovative scenario (BLUAIR® production with different electricity sources) with the baseline scenario (plastic waste disposal of hard-to-recycle plastic packaging waste and coal use). It evaluates various impact categories such as acidification, climate change, ecotoxicity, eutrophication, human toxicity, ionizing radiation, land use, ozone depletion, particulate matter emissions, photochemical ozone formation, resource use (fossils and minerals), and water use.

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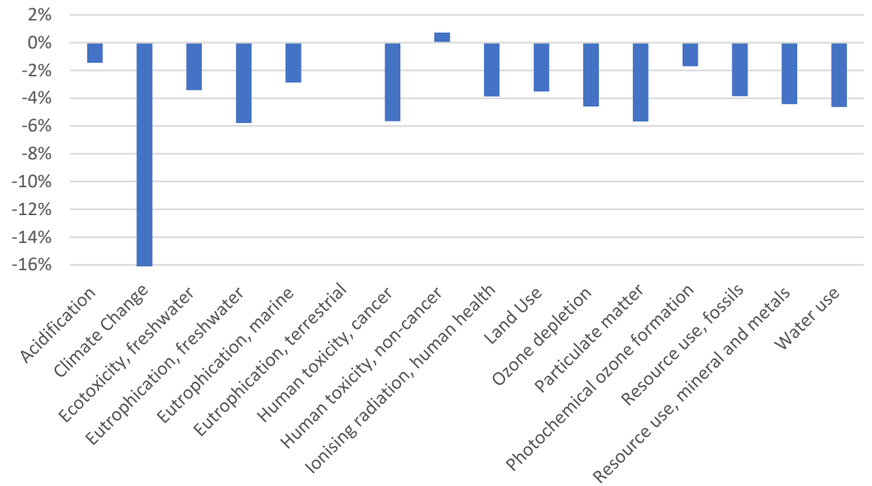


Figure 1: Reduction of environmental impacts due to the substitution of coal.

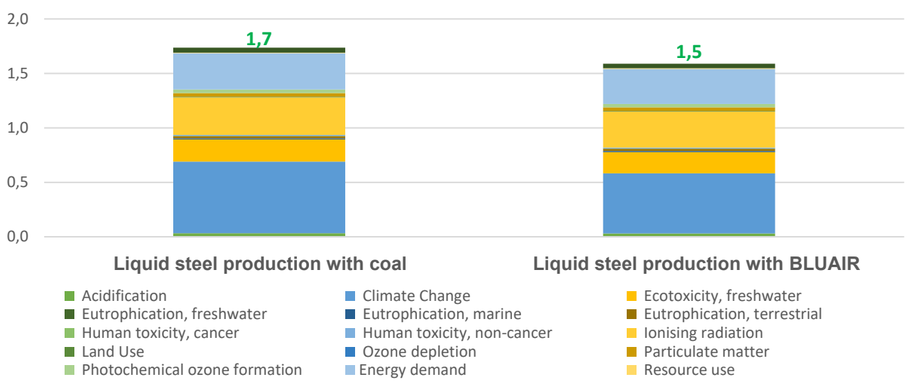


Figure 2. Single-score analysis comparing baseline and innovative scenario in EAF.

The research leading to these results has received funding from the European Union's Research Fund for Coal and Steel research program under grant agreement number 899415

LCA: BLUAIR® IN EAF

The second part of the study compares the environmental performance of liquid steel manufacturing with coal and with BLUAIR®, produced by I.BLU, as its replacement.

An average reduction of 4 % was found when BLUAIR® is used as carbonaceous material, in particular a 16 % reduction in climate change and 6 % reduction in human toxicity (cancer) were found. Figure 1 shows the reduction in environmental impact for all categories when BLUAIR® is used in the furnace as replacement for coal.

The single score analysis, Figure 2, obtained through normalization and weighting process, represents an overall result. It is possible to highlight that the use of coal in EAF has an overall impact that is higher with respect to the BLUAIR, mainly due higher environmental impacts in climate change and energy demand (resource use, fossils) category when coal is used as carbonaceous material.

LCA: BLUAIR® IN EAF

[...]

3.4. Interpretation of Results

This work provides a comprehensive life cycle assessment (LCA) study focusing on the environmental impact of producing steel with a conventional carbon source and an innovative one produced from waste plastic. The study compares the environmental performance of liquid steel manufacturing with coal and with BLUAIR®, produced by I.BLU, as its replacement.

The study evaluates various impact categories such as acidification, climate change, ecotoxicity, eutrophication, human toxicity, ionizing radiation, land use, ozone depletion, particulate matter emissions, photochemical ozone formation, resource use (fossils and minerals), and water use.

The results indicate that the implementation of BLUAIR® in steel manufacturing generally performs better than the conventional scenario, with lower environmental impacts. A single score analysis shows lower overall impact of BLUAIR implementation when compared with coal. Hotspot analysis shows that the electricity production phase is the primary contributor to most impacts, while BLUAIR production phase has negligible impacts in all categories.

Overall, the LCA study demonstrates the positive environmental impact of using BLUAIR as replacement of coal in steel industry. The findings can guide decision-making and promote more sustainable practices in the steel manufacturing field.

[...]

The research leading to these results has received funding from the European Union's Research Fund for Coal and Steel research program under grant agreement number 899415

voestalpine

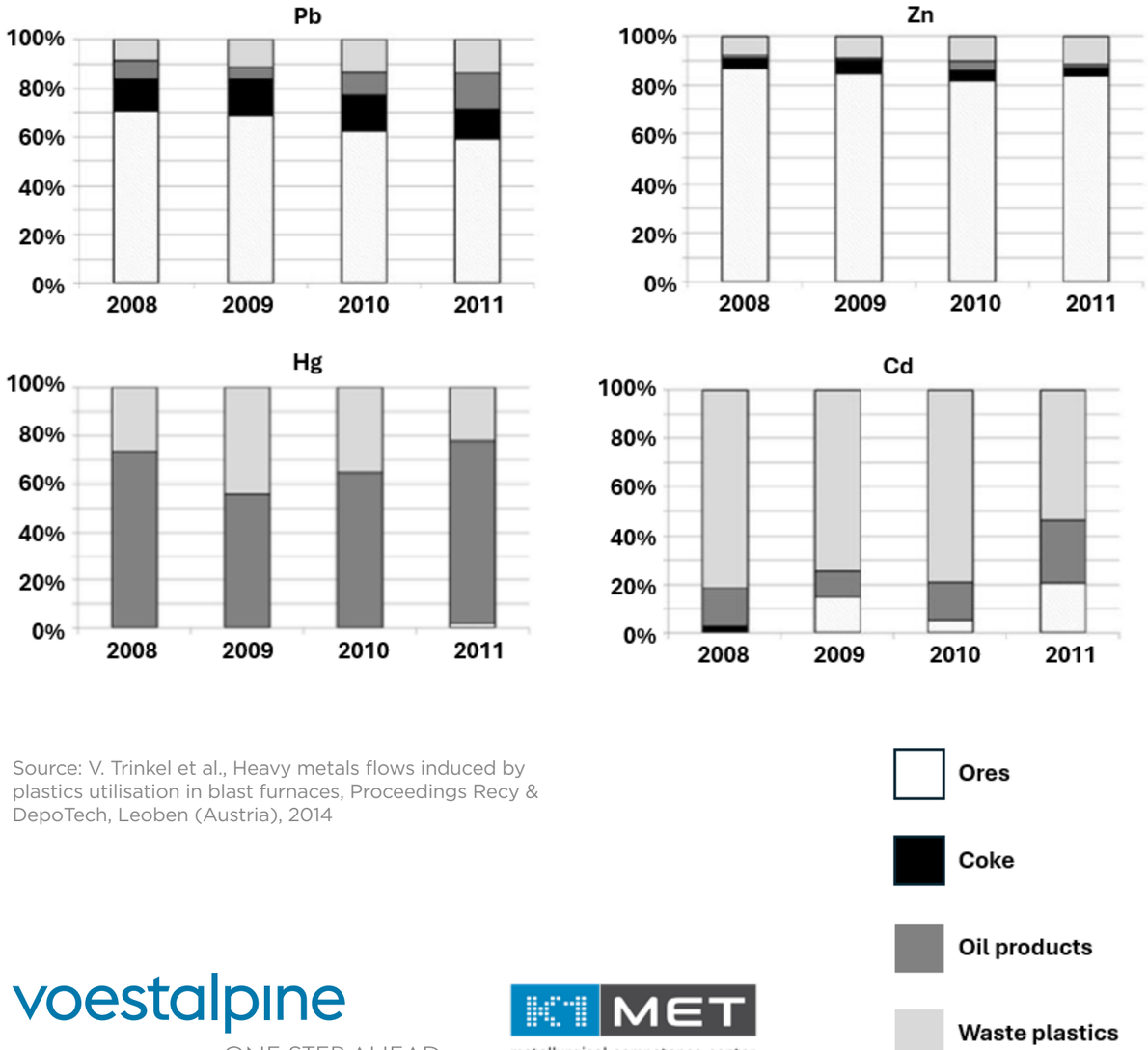
ONE STEP AHEAD.

RECYCLED CARBON IN BF

voestalpine's integrated steel production sites in Linz is among one of the most environmentally friendly plants of its kind in Europe, sustainability and the responsible use of resources are a driving force in our production process.

The introduction of recycled polymers injection in BF started in 2006, an established and proven environmental sound process.

The collaboration with I.Blu started in 2013 and has been ongoing ever since. It enabled the development and refinement of the recycled polymers quality in terms of physical-chemical requirements, as well as their optimal utilization and functioning in the BF/BOF steelmaking process.

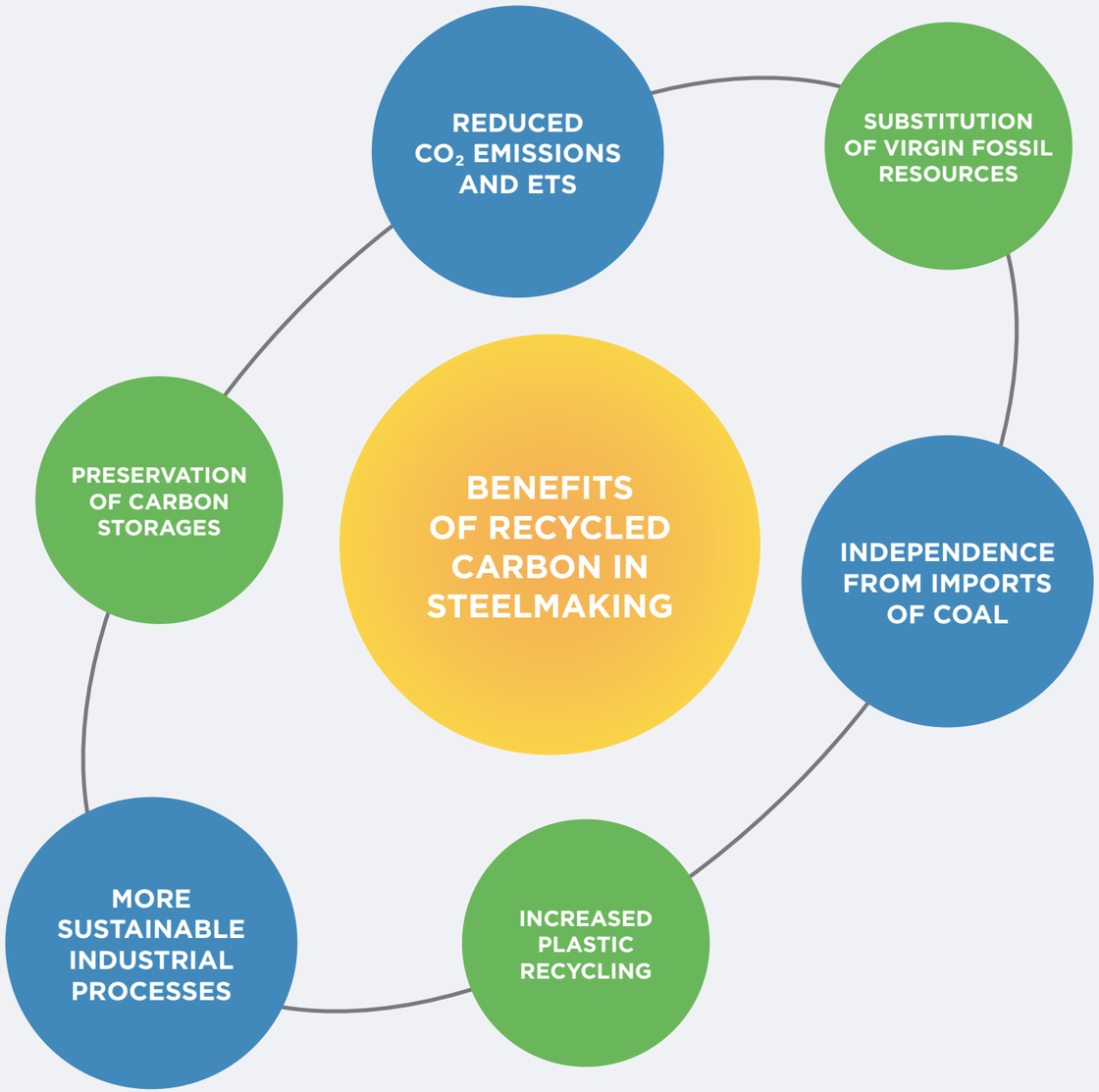


Source: V. Trinkel et al., Heavy metals flows induced by plastics utilisation in blast furnaces, Proceedings Recy & DepoTech, Leoben (Austria), 2014

BENEFITS IN BF

- Heavy metal input into the BF is changed when using waste plastic as alternative reducing agent;
- Highest Cadmium (Cd) input originates from waste plastic with smaller shares for Mercury (Hg), Lead (Pb), and Zinc (Zn);
- BF gas cleaning removes Cd, Hg, and Pb;

- **Waste plastic use in BF to partially substitute pulverized coal is an environmentally sound solution;**
- **No negative impact on hot metal quality are known;**



RECYCLED CARBON AND DECARBONIZATION

Incentivizing the use of recycled carbon would be at the core of a sustainable economic model, where:

1. CO_2 emissions and ETS costs are reduced;
2. Plastic recycling is increased, preventing the emissions linked to incineration of plastics;
3. Carbon storages and virgin resources are preserved;
4. Europe becomes more independent from the import of virgin fossil resources;
5. A more beneficial industrial model is developed from an environmental and economic point of view.

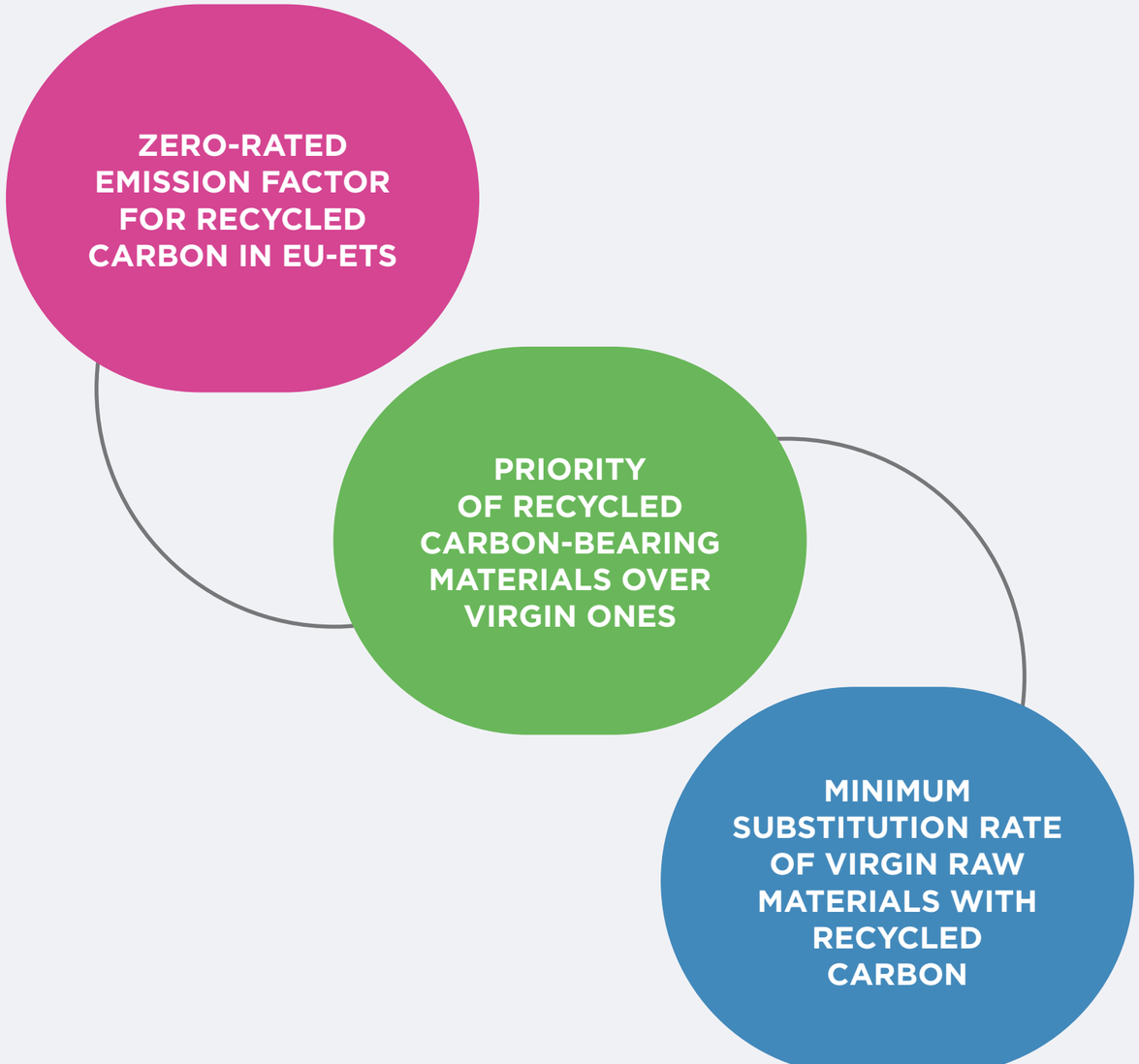
NEED FOR JOINT ACTION IN THE EU

The future revisions/implementations in the ETS legislative framework repesent a great opportunity for the industry to initiate a dialogue with the European Institutions, involving stakeholders operating throughout the whole value chain.

More specifically, appropriate mechanisms should be introduced to incentivize the substitution of virgin fossil resources with the recycled carbon contained in secondary raw materials, such as:

1. **establishing a ZERO EMISSION FACTOR for the recycled carbon** containded in plastic secondary raw materials in the EU-ETS system, or in alternative a reduced carbon permit price (similarly to what has been done for liquid and gaseous fuels).

2. establishing a hierarchy to prioritize the use of secondary raw materials containing recycled carbon over virgin fossil ones, while also introducing a minimum rate of recycled carbon-based raw materials to be used in in substitution of virgin fossil resources.



THANK YOU FOR YOUR ATTENTION!

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