The role of slags and other by-products within circular economy in the steel industry

5.–6. MARCH 2025

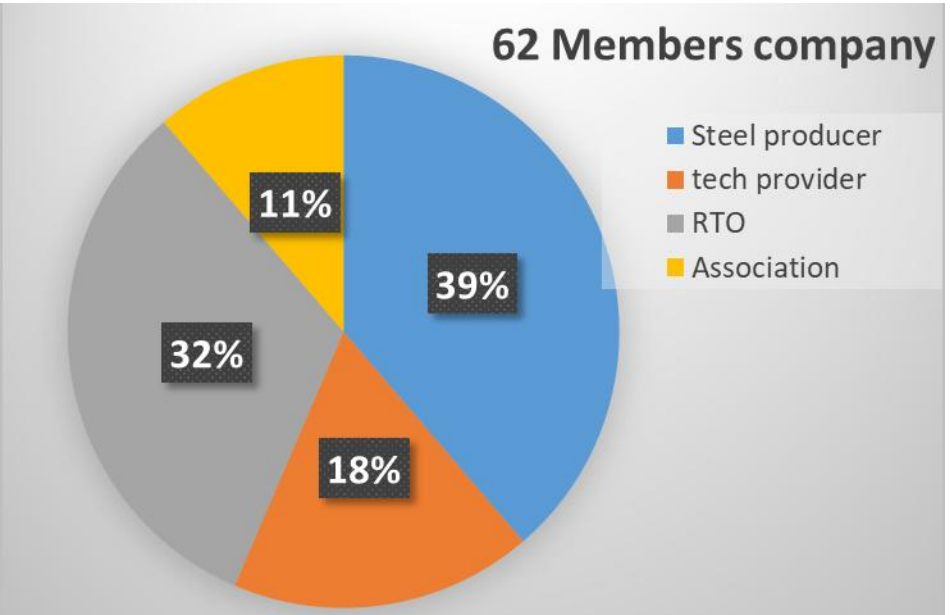
ESTEP Focus Group Circular Economy & FEhS-Institute

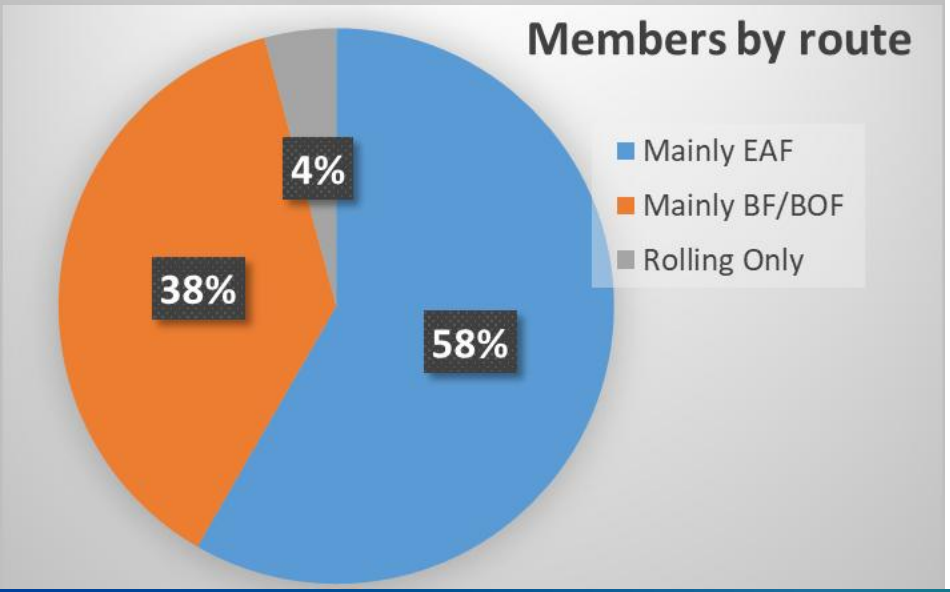
- Focus Group Circular Economy
- Enrico Malfa
R&D Director, Tenova
ESTEP FG CE Chairman

ESTEP
European Steel Technology Platform

INSTITUT FÜR BAUSTOFF FORSCHUNG
FEhS

ESTEP Focus Group Circular Ecomony





ESTEP
European Steel Technology Platform

Circular Economy

Circular economy & sustainability

Training	**Competence sharing**
Design	**Implementation by projects**
Innovation / Uptake	**Dissemination**

Contributions to CSP SRIA - CDA & SCU-PI

chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.estep.eu/assets/Publications/2024-CSP-SRIA-v2.pdf

Main topics and actions 2022-2025

Most important topics for FG CE 2021/22 Survey

1. Please give the two most important topics that you think FG CE should be working on within the next 2 years? (Max 2 answers) (Mehrfachauswahl) *

Metal and/or mineral recovery from filter dusts	28%
Scrap yard management	36%
Secondary carbon carriers	44%
Slag processing and utilization	44%
Digital tools	44%

Preferred action for the ESTEP tasks

3. Secondary carbon carriers (Einzelne Wahl) *

Workshop	29%
Position paper (or state-of-the-art journal paper)	38%
EU project proposal	33%

4. Slag processing and utilization (Einzelne Wahl) *

Workshop	29%
Position paper (or state-of-the-art journal paper)	25%
EU project proposal	46%

2025

5. Digital tools (Einzelne Wahl) *

Workshop	38%
Position paper (or state-of-the-art journal paper)	21%
EU project proposal	42%

Task with FG SF

2024/5

Some details about the topics

1) Pyrometallurgical or leaching processes

2) Metal scrap tracking and handling by neural networks/ industrial application, characterization/ sorting/ cleaning

3) Waste plastic, carbon fiber-reinforced polymers, automotive shredder residues, bio-based residues (food/ agricultural/ wood), use as granulate in BF/ EAF, as gasified alternative reducing agent, material processing (carbonization, drying, torrefaction) to be integrated in existing steel plants

4) Dry slag granulation, DR-EAF slag for cement, LF slag in lime value chain, slags from low-grade ore processing (smelter)

5) Dynamic environmental impact analysis, simulation and optimization of by-product pre-treatment evaluation (e.g., slag reuse), digital tracking of secondary raw materials (scrap, metallic residues…), new management systems for circularity performance

Needs for R&D activities to increase the Circular Economy within the iron and steelmaking sector

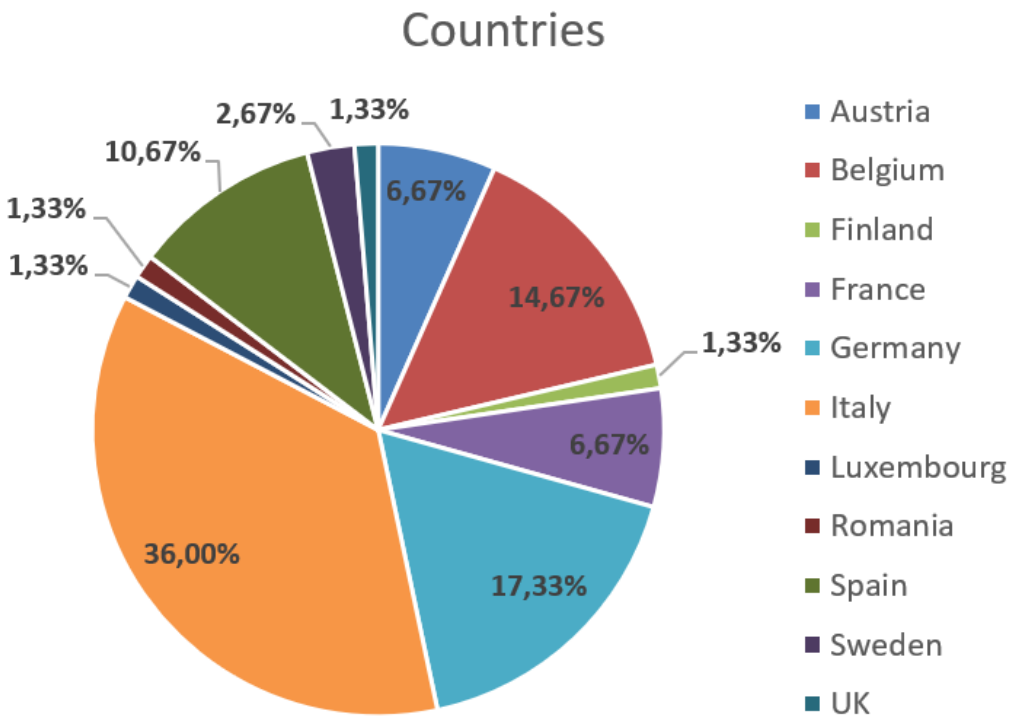
Initiative launched by the Focus Group “Circular Economy” of the European Steel Technology Platform

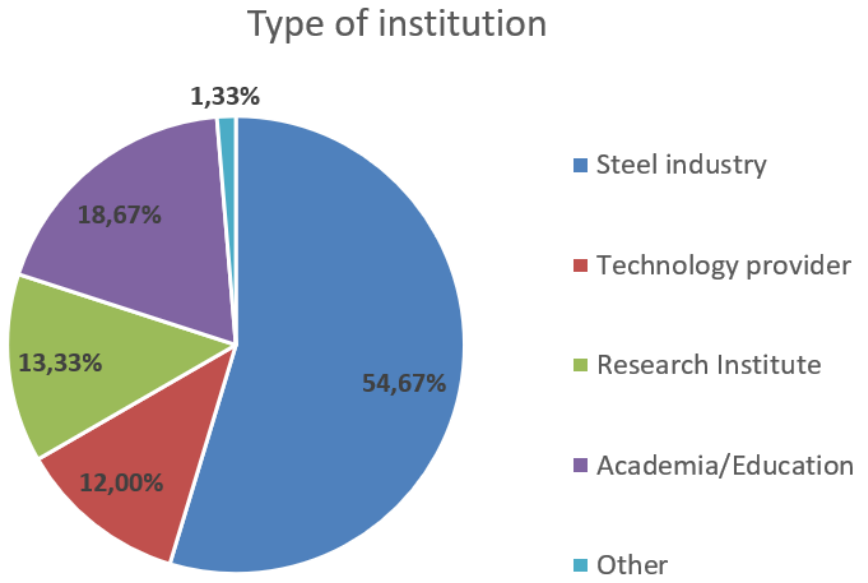
https://www.surveymonkey.com/r/BRC8WXY

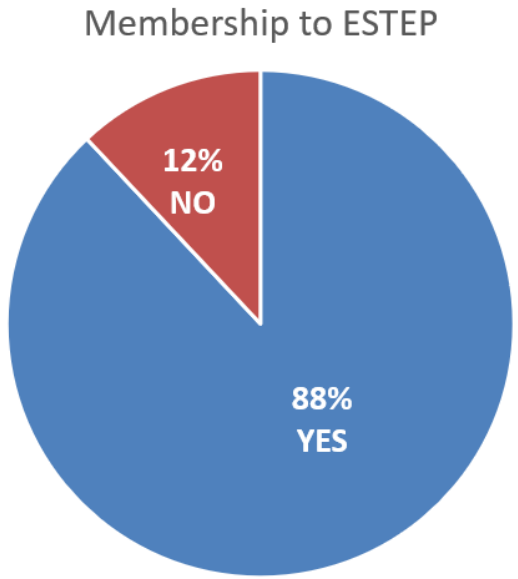
ESTEP Home Page : https://www.estep.eu/

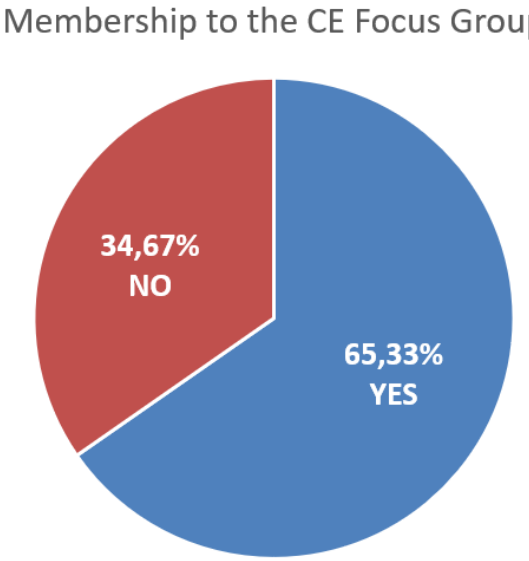
Preliminary outcomes from the survey: statistics on respondents

of answers gathered so far: **75**

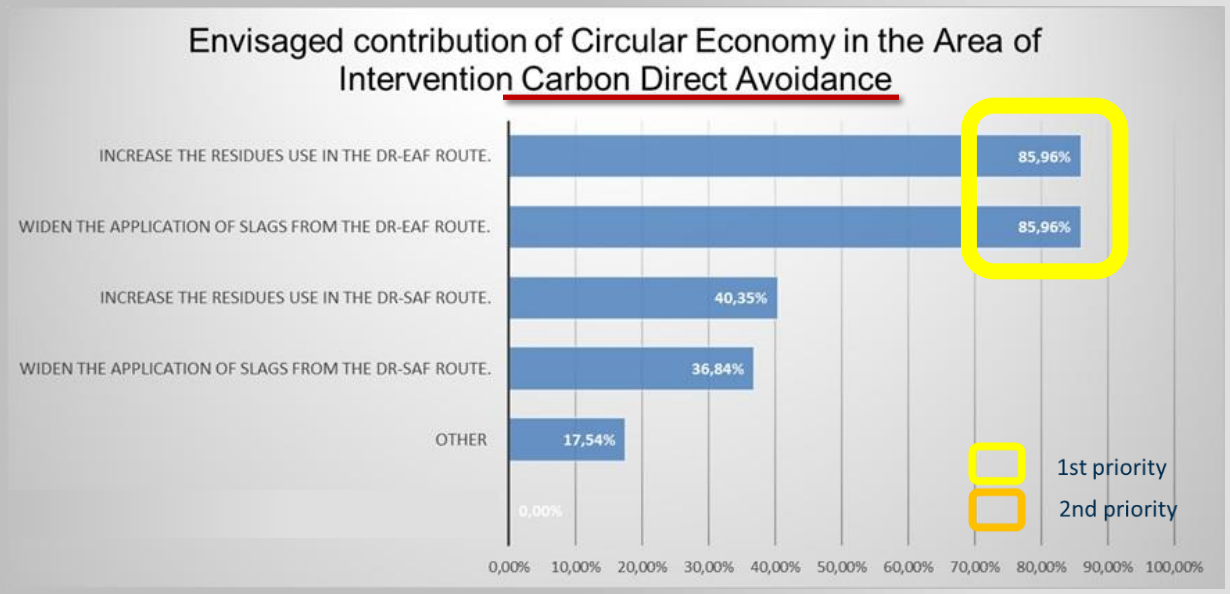


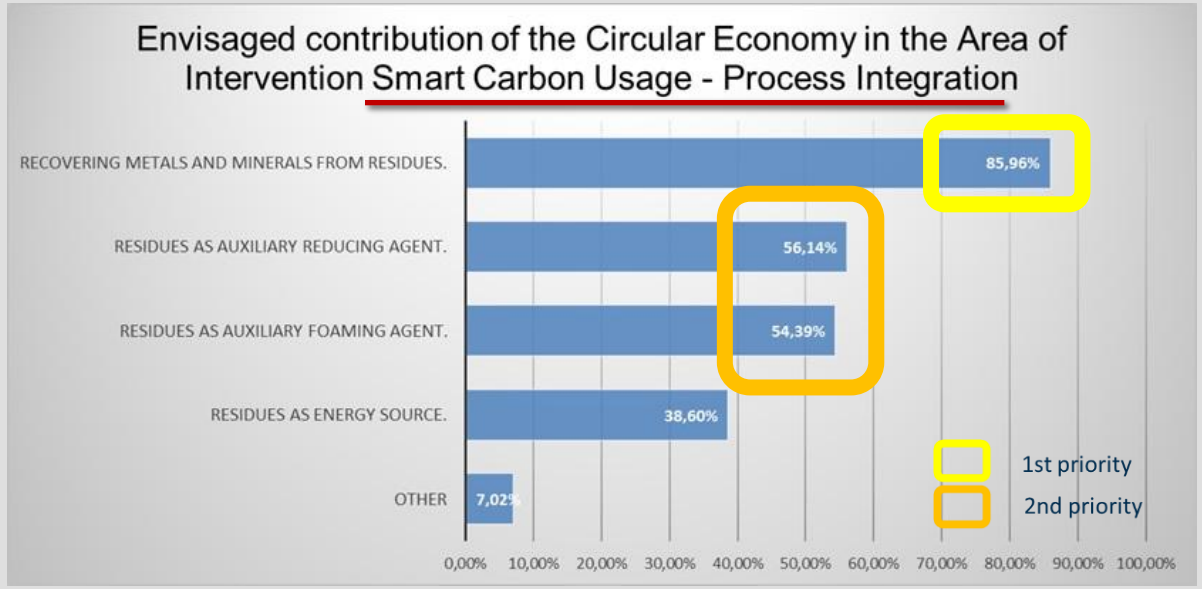






Envisaged contributions to CDA and SCU-PI





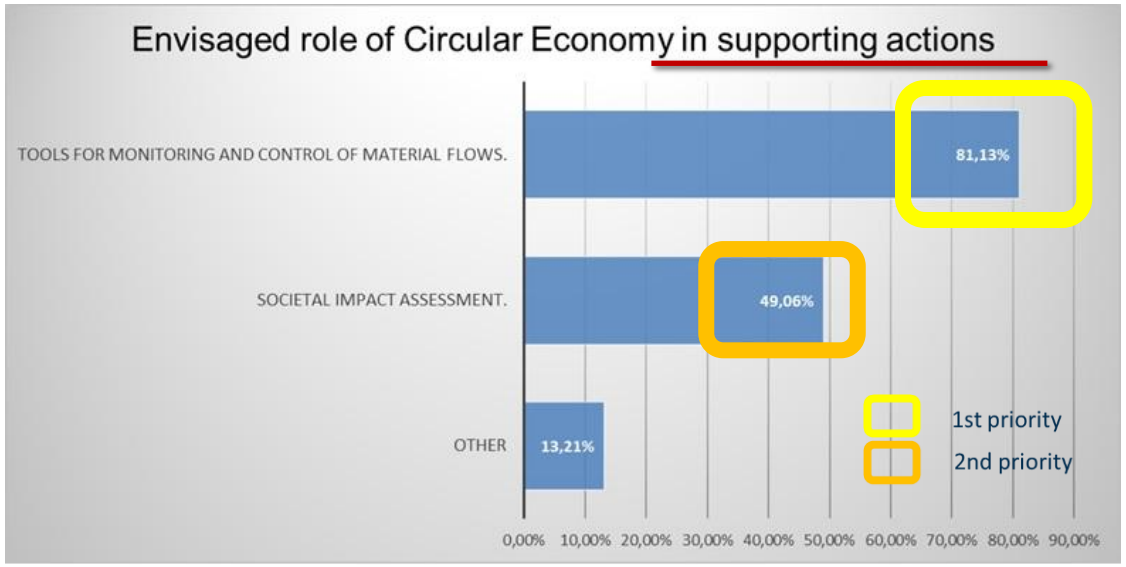
Other sugested contributions (selection):

- Widen the reuse of old existing slags from **BF-BOF route**
- Recycling of DRP dust and sludge and DRI fines in conventional BF/BOF route during the transition phase, e.g. cold bonded agglomerates into BF, increased rate of byproducts in sinter mixes
- Use of **low-value iron carriers** (DRI from low-grade ore, iron fractions from by-products, post-consumer scrap,…) for low-C melting processes
- **Circular economy applied to energy**
- Increase low-CO_2 recycling of residues from EAF-route including sector-coupling potential
- Heat-recovery from slag treatment

Other suggested contributions (selection):

- Assess the possibility to **use an existing coking plant infrastructure for the processing of bio-based secondary carbon carriers** (pyrolysis process to produce biochar and a H_2-rich syngas)
- Removal of **nonferrous metals** from steel mill external by-products (active material/black mass from Lithium-Ion Batteries for a reuse as alloying additive) e.g., by bioleaching (bio-hydrometallurgical approach)

Envisaged contributions to supporting actions



Other suggested contributions (selection):

- Enable a **legislative framework** which helps circular Economy
- Unification of regulatory aspects concerning the recovery and re-use of residues and by-products.
- Improve the European competitiveness also in terms of business and economic aspect through **synergies between industries** and civil sector.
- Bigger waste generation of the steel value chain is indeed in **mining.** Although the iron ore comes mainly from outside Europe, mining investors and external stakeholders will start considering the full circularity of the value chain and not only of steel production processes.
- Support Academia and education organizations in development of **new educational paths** for future professionals

Other envisaged roles of Circular Economy in improving performance of processes (selection):

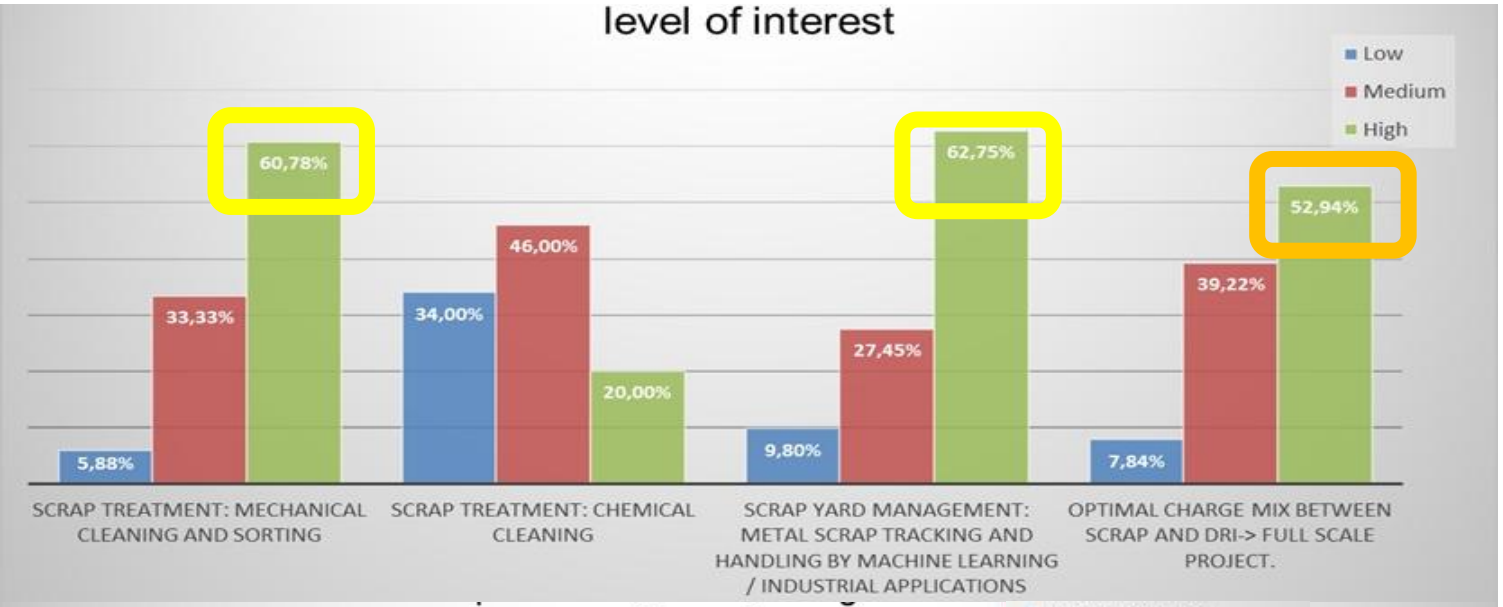
Innovative revenue opportunities and strengthening partnerships across the supply chain:

- New collaborations and business models by turning waste streams into valuable resources by opening Closed-loop solutions that deliver circularity to regional economies**.**
- Steel making Service - a material recovery service to other industries (Construction, Automotive etc).
- To benchmark the initiatives taken by other stakeholders

Circularity of water

- Sustainable water treatment and recirculation of water resources
- Recovery and reuse of waste oils from rolling mills
- Recovery and reuse of steel cycle residues from wastewater treatment such as sludge from gas washing
- Water recycling for new H_2-based DR-EAF/SAF-route (e.g. in combination with FG LC & EE for energy and media) including sector-coupling potential

Scrap treatment and management



Topic priorities:

1. Yard management
2. Mechanical cleaning and sorting

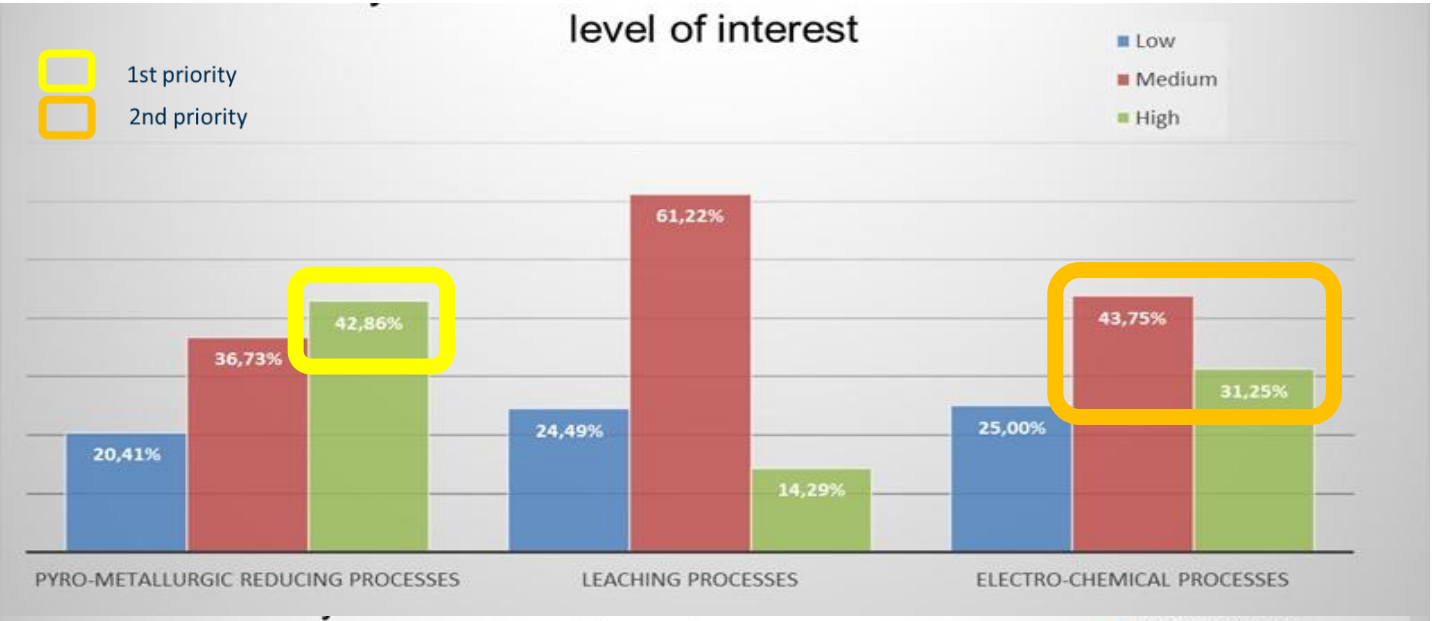
3. Charge mix scarp/DRI

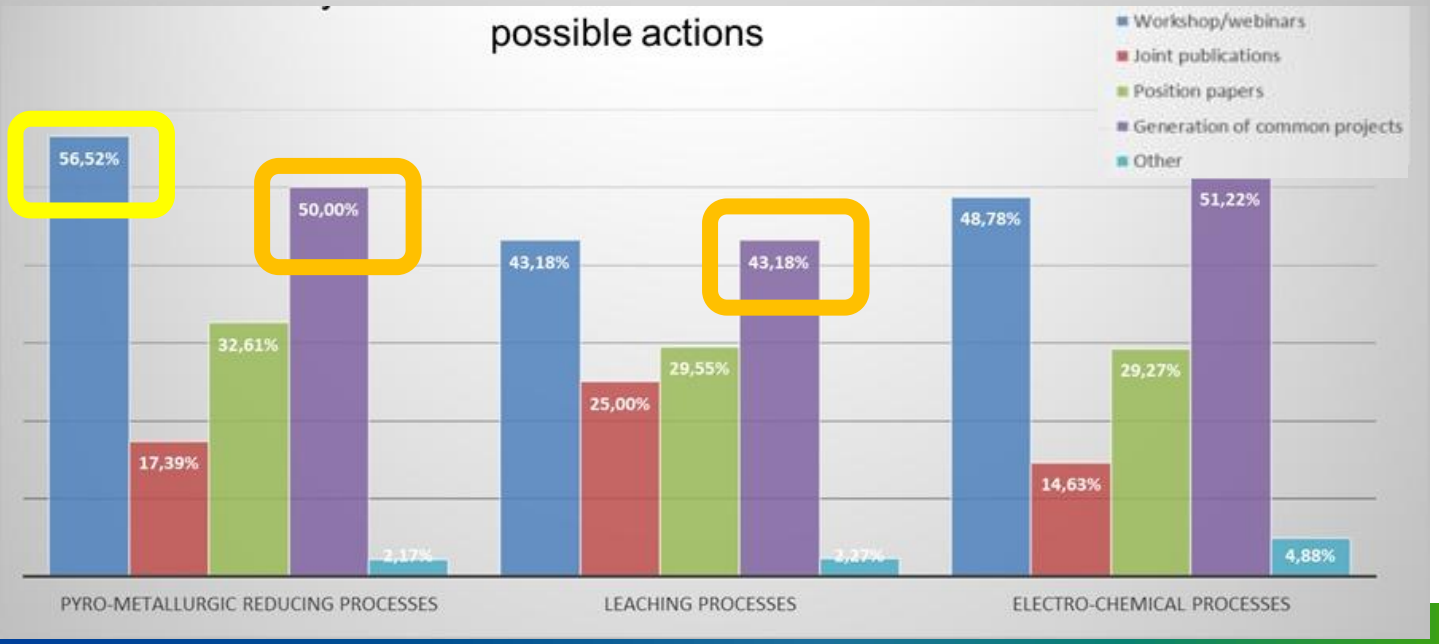
Actions

1. Generation of common projects

2. Workshops

Recovery of Zinc and mineral fraction from filter dust





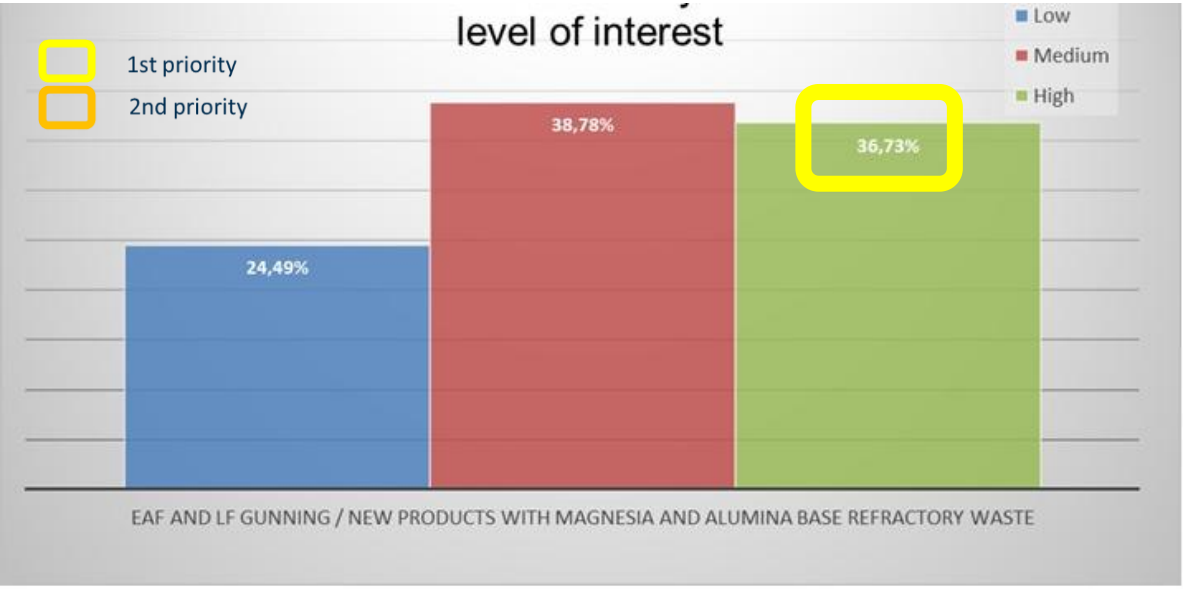
Topic priorities:

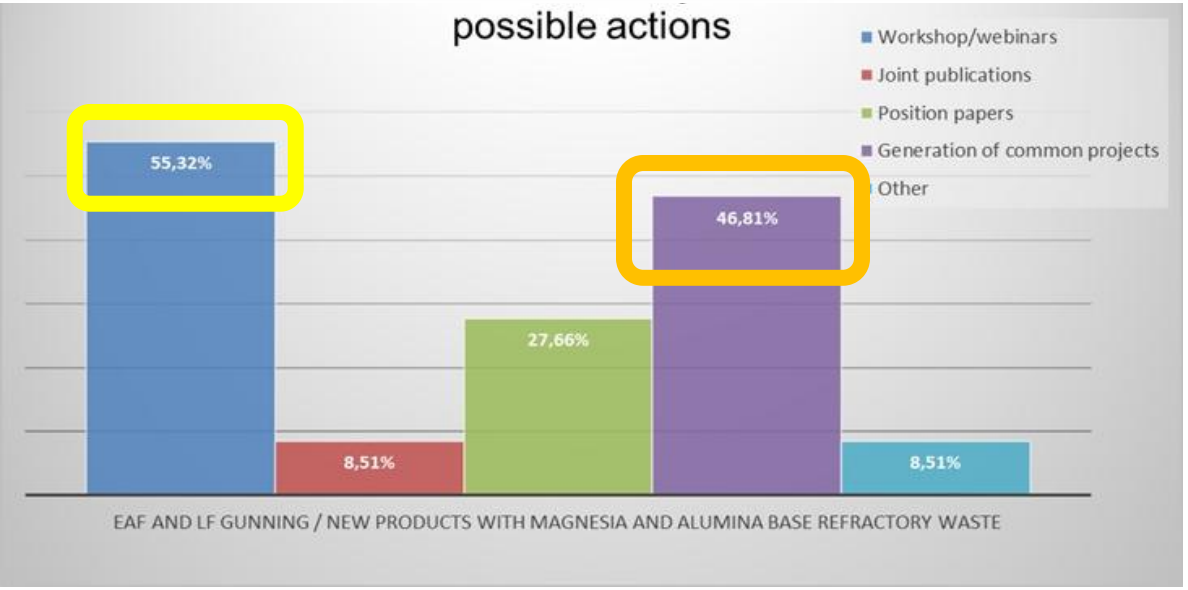
1. Pyro-metallurgical
2. *Electro-chemical*

Action

1. Workshops
2. *Generation of common projects*

Reuse of refractory waste





Topic priorities:

1. New products from waste

Action

1. Workshops
2. Generation of common projects

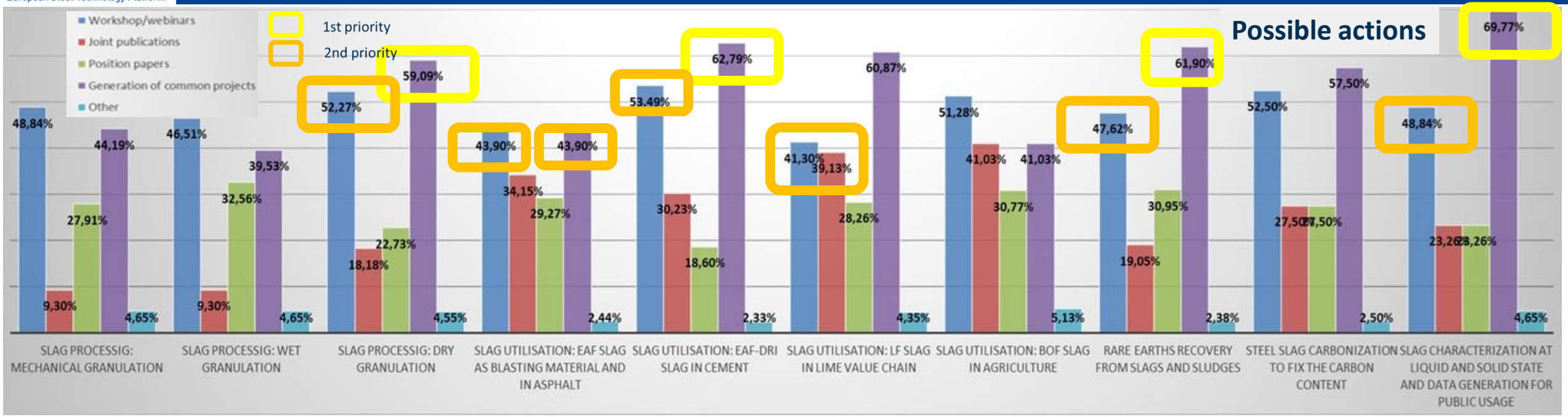
Slag processing and utilisation /1

Topic priorities:

1. EAF/DRI slag in cement
2. LF in lime
3. Slag characterization (liquid and solid)
4. EAF as blasting and asphalt

5. *Dry granulation*
6. *Rare earths recovery from slag and sludge*

Slag processing and utilisation /2



Action

1. Generation of common projects

2. *Workshops*

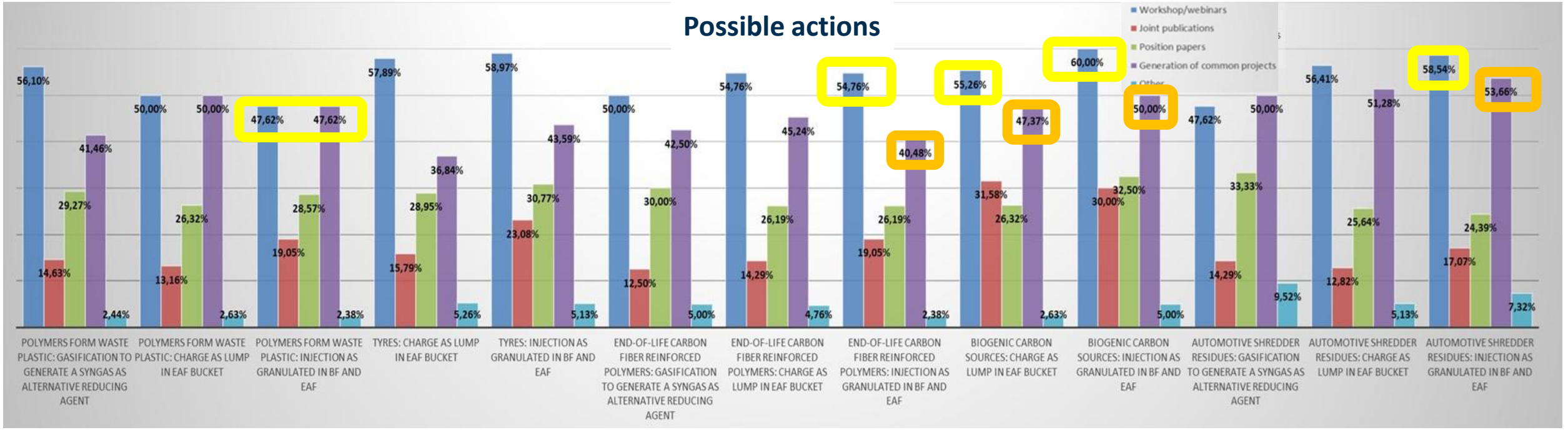
Alternative non-fossil Carbon sources

Topic priorities:

1. Biogenic material injection in EAF and BF
2. Polymers injection in EAF and BF

3. *Biogenic lump in EAF baket*
4. *ASR injection in EAF*
5. *EoL carbon fiber injection in BF & EAF*

Alternative non-fossil Carbon sources

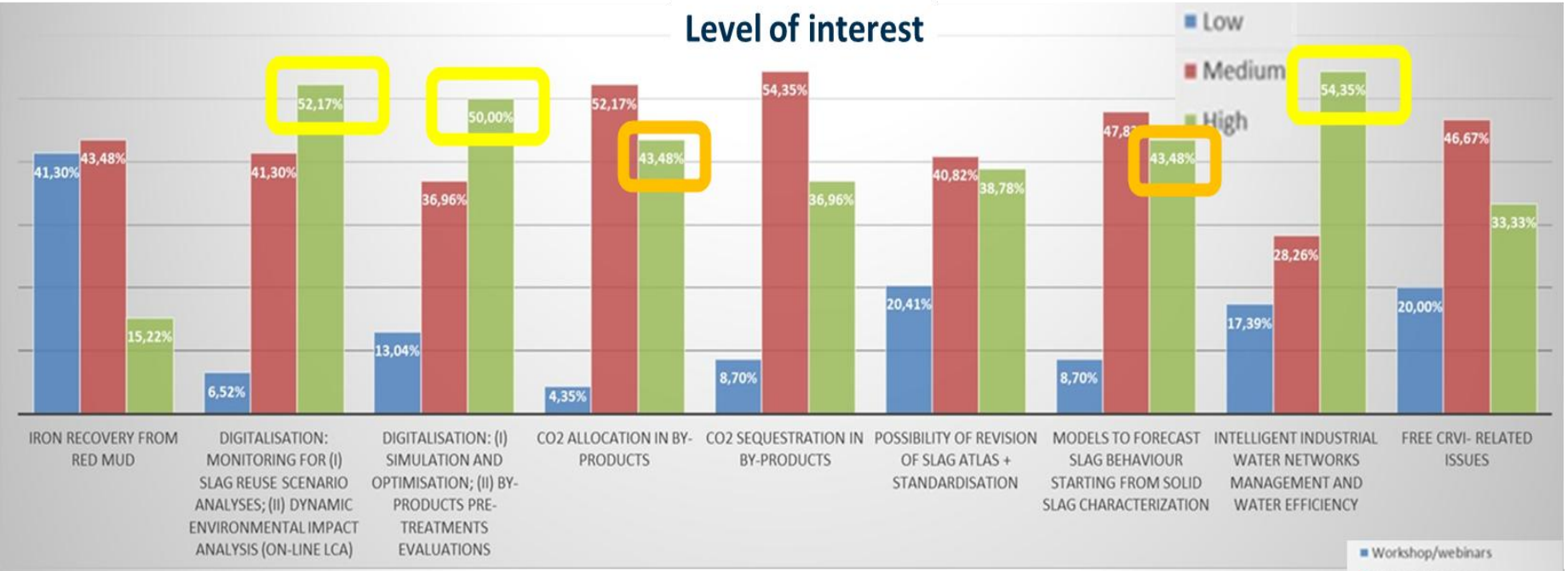


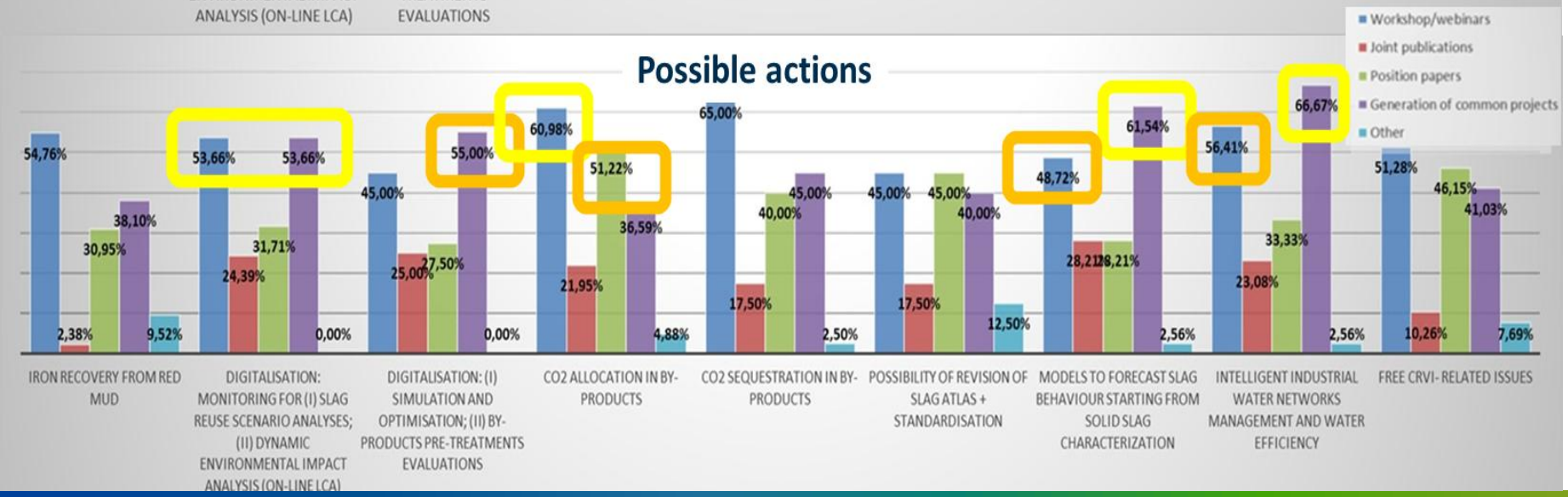
Action

1. Workshops

2. *Generation of common projects*

Other topics





Topic priorities:

1. Water managment
2. Digitalisation

3. *CO_2 allocation in product*
4. *Forecast slag behavours*

Action

1. Generation of common projects

2. *Workshops*

Other suggestions

Standardization

- **Standardizing by-product definitions**, consistent testing protocols, and digitalized traceability. Possible actions include workshops/webinars, position papers, and joint projects that can foster practical progress.
- A **joint position paper** with all the actors in slag production and recovery value chain could help developing a real standardization document at EU level to be submitted to the Commission.
- **Schedule meeting with standardization bodies** and industries to develop a common strategy on circular economy concept to boost and enlarge the utilisation of residues across more industrial sectorstarting (shared agenda).
- Update resources like the **Slag Atlas** to ensure unified guidelines and broader impact across the steel value chain.
- **LCA modelling standardization**, overview of waste legislation to give guideline for EU uniformity, re-use vs. recycling.

Enlarge participation at FG CE of stakeholders

- Include topically recycling companies into the CE FG --> scrap recycling (TSR ...), Slag treatment (Harsco), Dust recycling (JGI), ...
- Develop cross-sector collaborations (e.g., cement, chemicals) to ensure unified guidelines and broader impact across the steel value chain.

Needs for R&D activities to increase the Circular Economy within the iron and steelmaking sector https://www.surveymonkey.com/r/BRC8WXY