Contribution ID: **89** Type: **Keynote Presentation (paper for Ironmaking & Steelmaking special issue)**

Industrial evaluation of biogenic secondary carbon carriers in electric arc furnace steelmaking: the BioReSTEEL approach

Tuesday 12 May 2026 16:50 (20 minutes)

The decarbonisation of Electric Arc Furnace (EAF) steelmaking requires the progressive substitution of fossil-based carbon with renewable, biogenic alternatives able to guarantee adequate melting performance, slag foaming behaviour, and process stability. The RFCS project BioReSteel addresses this challenge by developing and validating new biogenic Secondary Carbon Carriers (SCCs), with a specific focus on their industrial implementation in EAF operations.
In this context, to assess the technical feasibility and performance of innovative biochar-based briquettes, characterisation of the materials and experimental campaign have been accomplished. The briquettes were engineered using a 70:30 biochar-to-polymer ratio. In these briquettes the biochar provides renewable carbon for slag foaming and energy input, whereas the polymer is both the biding agent and the component that supports the foam during the melting phase. These effects contribute to the slag stabilisation and improve the thermal protection of the electrodes. In addition, the polymer has a fundamental deoxidizer role since it can release carbon and reductant gases during the pyrolysis at high temperature. In effect, carbon and gases react with the oxides present in the slag, such as FeO and MnO, favoring their reduction and increasing the metallic yield, with advantages in term of energetic efficiency and sustainability of the process.
A multi-scale experimental plan has been established.
1. Laboratory-scale tests included physical-chemical and thermogravimetric analysis, reduction behaviour, melting tests in controlled atmospheres, and preliminary assessment of foaming potential.
2. Pilot-scale experiments carried out to simulate injection/melting dynamics more closely and to refine briquette formulations and feeding strategies.
3. Industrial EAF trials at ORI Martin facilities that validated the optimised materials under real operating conditions, evaluating their impact on:
• slag foaming effectiveness and stability,
• electrical energy consumption and arc stability,
• carbon yield and off-gas behaviour,
• operational robustness and repeatability.
This integrated approach provided a comprehensive assessment of biogenic SCCs as practical substitutes for fossil coal in industrial EAF operations. The outcomes supported the roadmap for large-scale deployment of renewable carbon materials in electric steelmaking, contributing to the EU's strategic objectives for climate neutrality and circular economy.
These activities have been carried out in the frame of Research Fund for Coal and Steel within the RFCS project n. 101112383: "Valorization of wet biomass residues for sustainable steel production with efficient nutrient recycling –BioReSteel".

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Session Classification: Recycling, circular economy and reduction of environmental impact in steelmaking I

Track Classification: EEC 3 - Materials and Raw Materials: EEC 3.D Recycling and circular economy in steelmaking