GreenHeatEAF

Gradual integration of REnewable non-fossil ENergy sources
and modular HEATing technologies in EAF for progressive CO2 decrease

Flowsheet model for the prediction of the effects of the use of renewable non-fossil carbon sources in electric arc furnace

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ESTEP ANNUAL EVENT 2023
A CIRCULAR ECONOMY DRIVEN by European Steel
3 – 5 October | Barcelona

Content

- EU Green Deal & Circular Economy policies
- Circular Economy & Electric Steelmaking
- Biomass use in electric steelworks
- GreenHeatEAF project
- Starting model
- Model adaptation
- Use of the model

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EU Green Deal & Circular Economy policies

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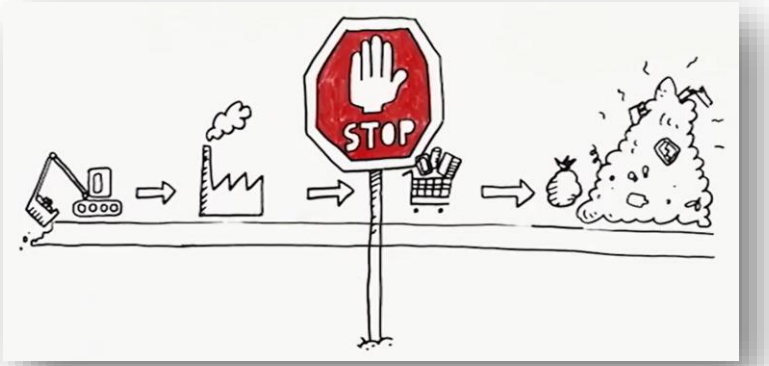
EU Green Deal & Circular Economy policies

The European Green Deal

A New Circular Economy Action Plan



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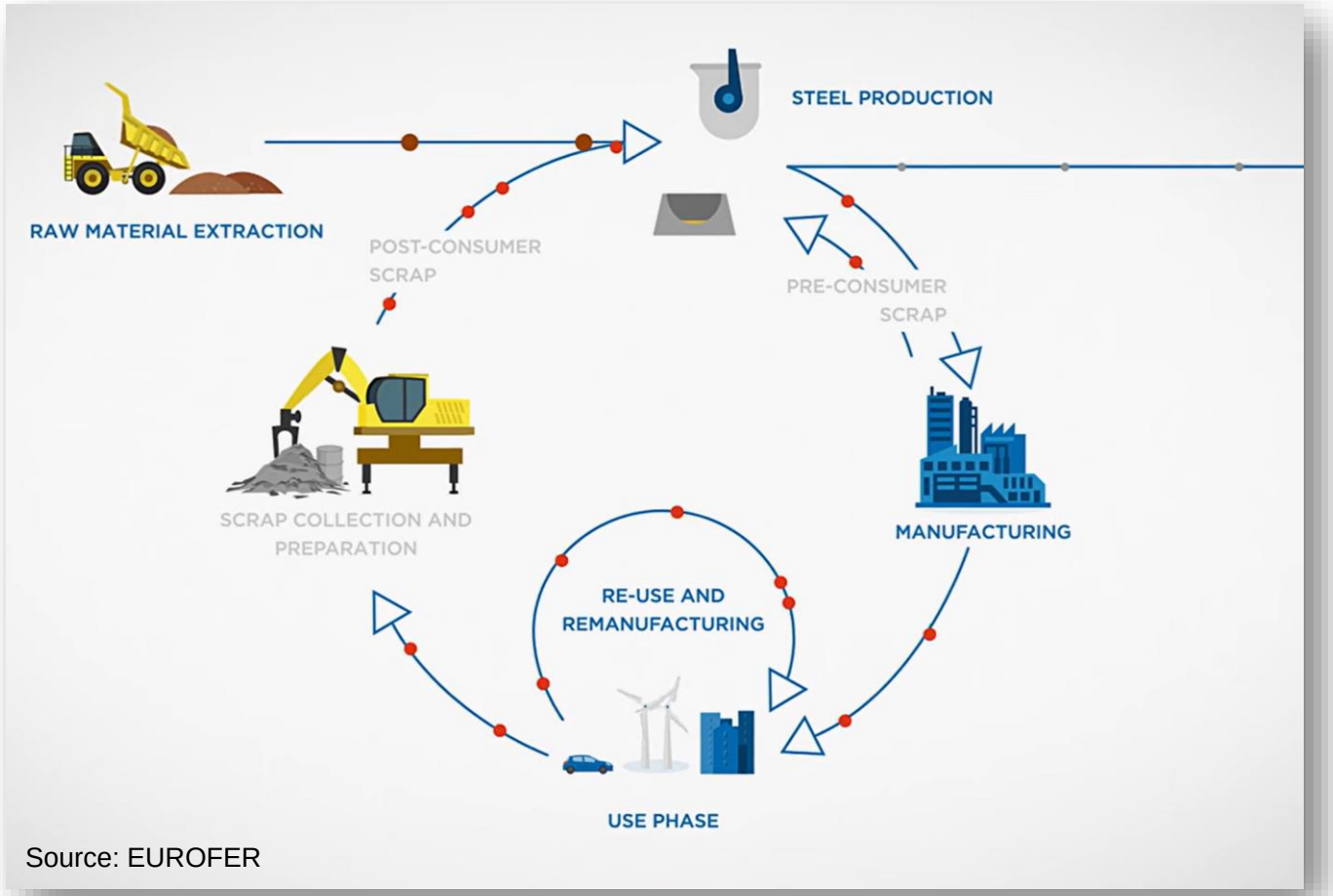
Circular Economy & Electric Steelmaking



Source: EUROFER

- Electric steelmaking is playing a fundamental role as it is directly involved in the recycling of steel scrap.
- Further actions can be pursued to enable further circular economy practices and enhance process sustainability

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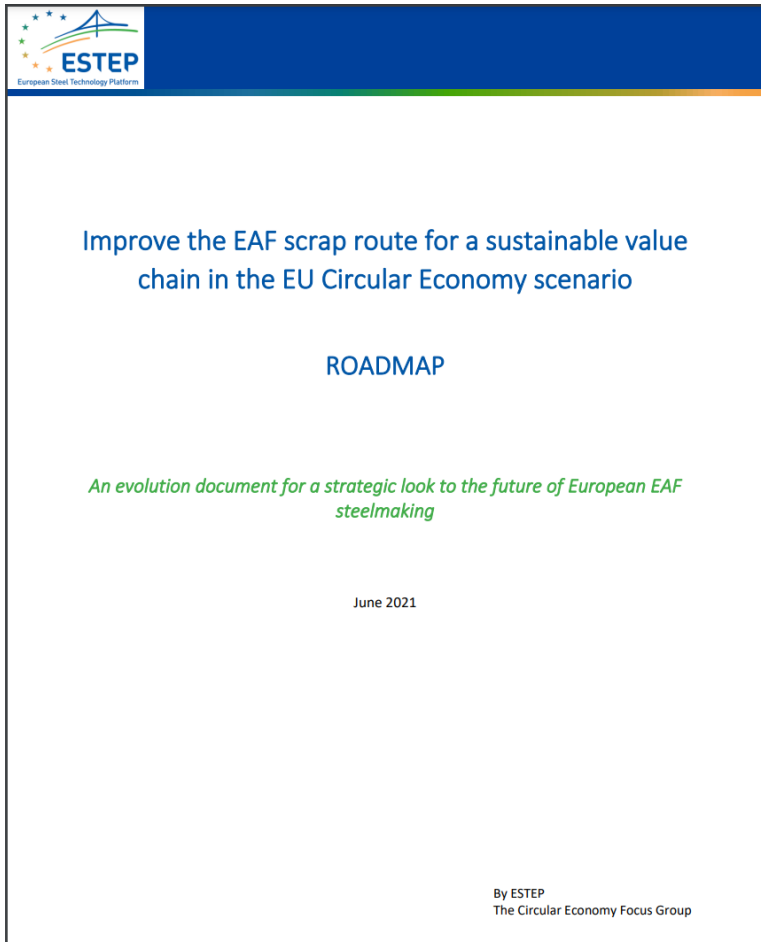
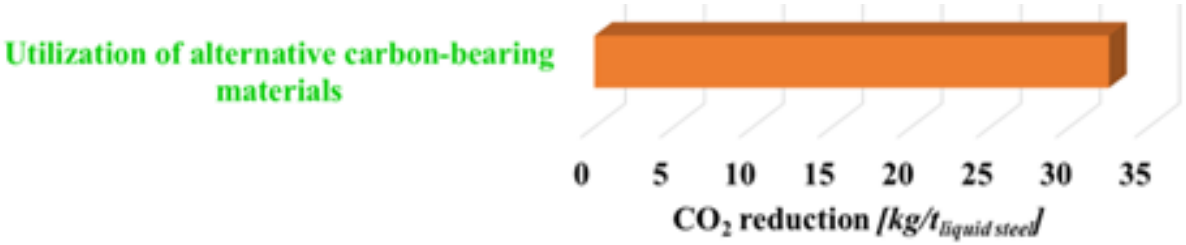
Circular Economy & Electric Steelmaking



Replacing fossil fuels with other alternative C-bearing renewable materials such as biomass, biochar, plastics can reduce fossil CO_2 emissions



ESTEP, Improve the EAF scrap route for a sustainable value chain in the EU Circular Economy scenario – ROADMAP, 2021

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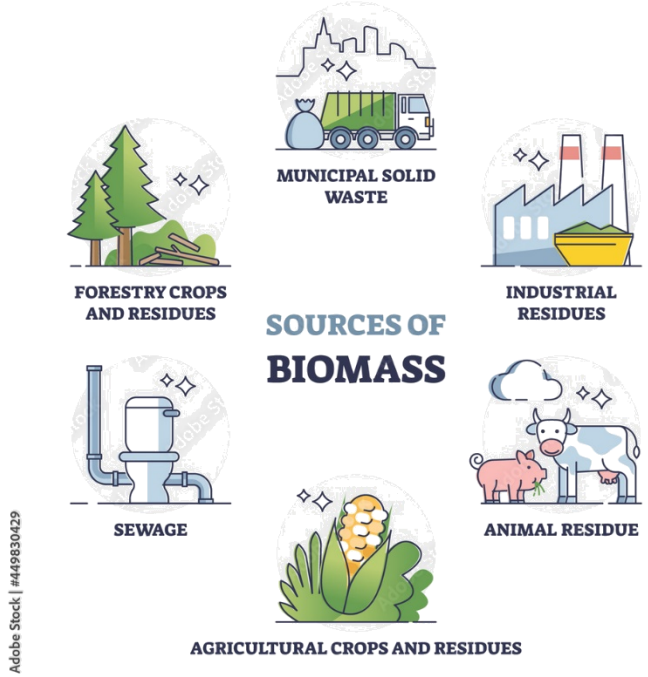
Biomass use in electric steelworks

- Biomass perfectly fit the circular economy concept of "*the value of resources being maximised indefinitely, requiring that virtually no unrecoverable waste occurs*"
  - Uncertainties exist on the effect of these materials on the process behaviour and evolution.

  - Real experimentation issues:
    - horizon of exploration generally limited
      - to avoid issues on the process
      - to avoid interrupting standard production plan
  - Simulation advantages:
    - Help in exploring several scenarios
    - Complementary to industrial trials to demonstrate the technical feasibility of the proposed solutions



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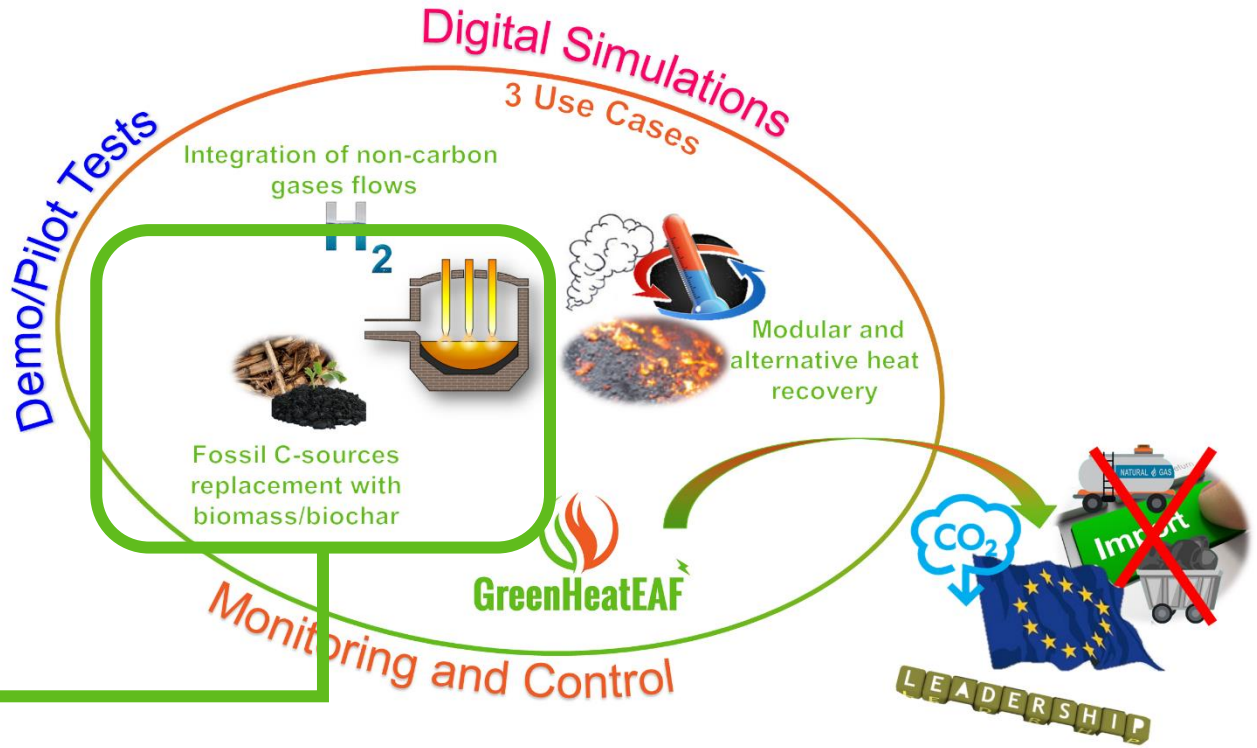
The GreenHeatEAF project

GreenHeatEAF

"Gradual integration of Renewable non-fossil Energy sources and modular HEATing technologies in EAF for progressive CO_2 decrease"
G.A. No. 101092328



Among other activities, both industrial trials and simulations are planned to focus on the alternative renewable carbon sources usage in EAF.

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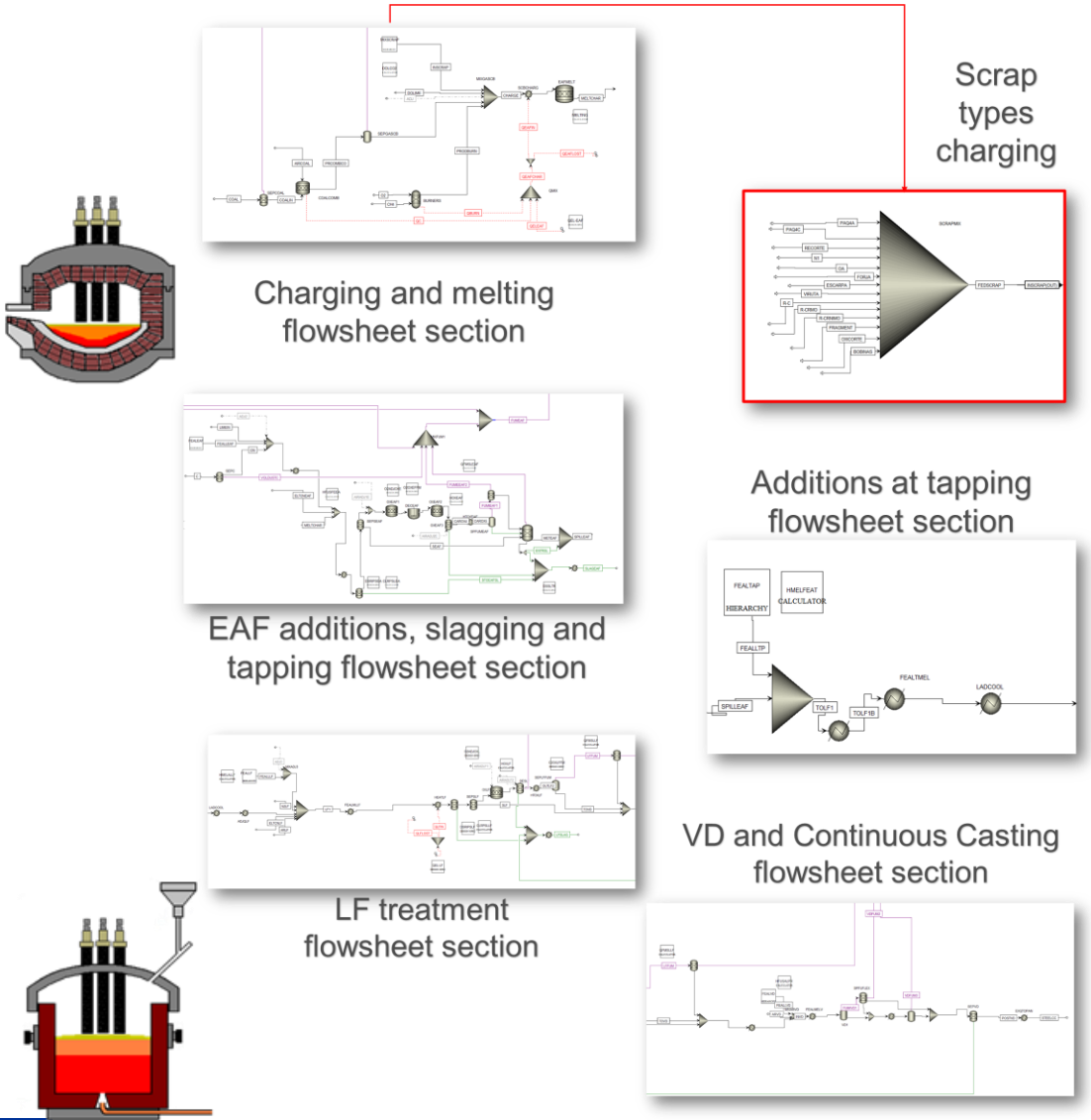
The starting point



- The starting point: an already existing EAF process route flowsheet model developed in Aspen Plus environment
- It has been continuously updated during other EU-funded projects
- It has been furtherly adapted to investigate the effects of the use of alternative renewable carbon sources.

Matino, I., Alcamisi, E., Colla, V., Baragiola, S., Moni, P. (2016). Process modelling and simulation of electric arc furnace steelmaking to allow prognostic evaluations of process environmental and energy impacts. Matériaux & Techniques, 104(1), 104.

Petrucciani, A., Zaccara, A., Matino, I., Colla, V., Ferrer, M. (2022). Flowsheet Model and Simulation of Produced Slag in Electric Steelmaking to Improve Resource Management and Circular Production. Chemical Engineering Transactions, 96, 121-126.

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Model adaptation: modelling of alternative C-sources

- Several alternative C-sources available at regional and international levels have been selected and information collected

- They have been modelled as non-conventional solids
  - Materials that are not pure chemical species, for which generally there is a lack of equilibrium and physical property data and characterized in terms of empirical factors called component attributes
    - Component attributes represent component composition by one or more constituents

- Ultimate, proximate and sulphur analyses have been used for defining the non-conventional solids
  - ultimate analysis refer to the composition of the biomass in the main components (i.e. carbon, sulphur, oxygen, hydrogen, chlorine, nitrogen)
  - proximate analysis refer to the content of moisture, ash, fixed carbon and volatile matter
  - sulphur analysis refer to the type of sulphur compounds (I approximated them as organic)

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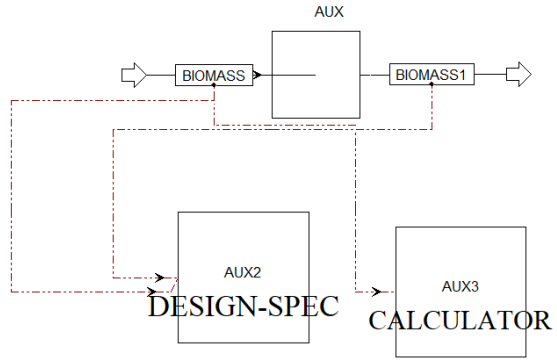
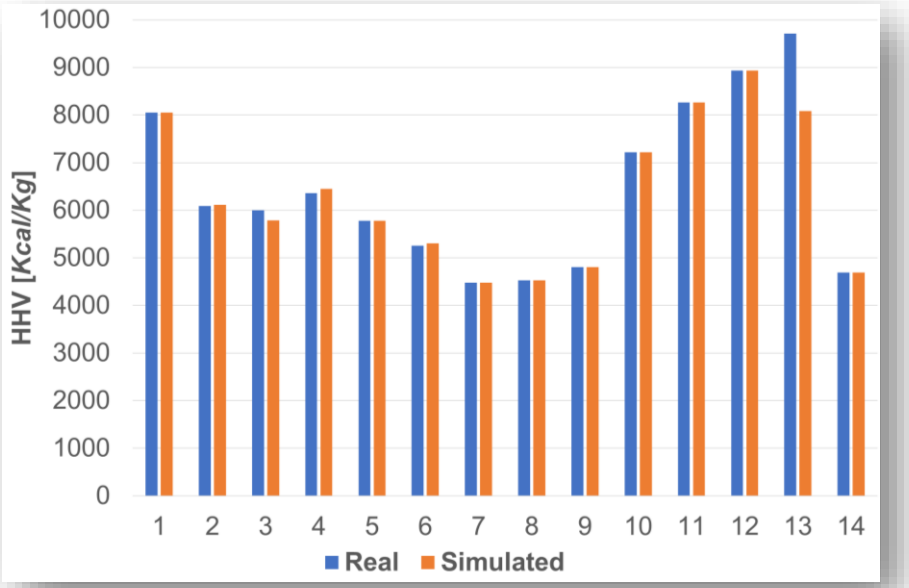
Model adaptation: modelling of alternative C-sources

- Missing data (i.e., content of Hydrogen and Oxygen) have been estimated for fitting the known higher heating value (HHV) with an auxiliary model.



ID	Material	Fixed C	S	N	H (from model)	O (from model)	Moisture	Volatile	Ash
					%				
1	Biochar	87.7	0	0	3.45	6.35	32.6	9.8	2.5
2	Biochar	62.2	0	0	4.92	13.38	12.9	18.3	19.5
3	Biochar	64	0	0	2.67	9.33	0	0	24
4	Biochar	80	0.8	2	0	9.2	13	12	8
5	Biochar	70	0.85	2	1.57	18.08	13	21	7.5
6	Biochar	41.3	0.26	0	8.61	16.03	0	24.9	33.8
7	Biomass	20.4	<0.1	0	16.26	61.98	0	78.3	1.31
8	Biomass	13.9	<0.1	0	18.88	67.03	0	86	0.14
9	Biomass	20.3	0.01	0	17.46	62.22	0	79.4	0.0035
10	Biochar	80	0.03	0	3.36	12.45	7	8.9	4.16
11	Biochar	95	0.01	0.29	1.55	1.74	0.8	3	1.4
12	Tires	28.7	1.8	0.54	27.02	34.64	0.49	64	7.29
13	Plastics	97.2	0.03	0	0.2	0	0.15	0.23	2.57
14	Charcoal	48	0.08	0.58	5.81	32.03	5.3	69.3	13.5



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Model adaptation: alternative C-source injection in EAF

- The model has been modified for
  - allowing alternative C-source injection/charge in EAF
  - considering the effects of these alternative C-bearing materials on
    - Process
    - material and energy streams
    - liquid steel and by-products compositions

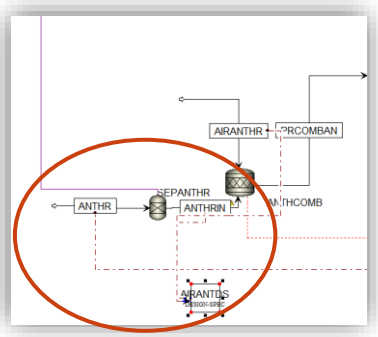
- Used data:
  - literature information
  - Real industrial data on production trials where biochar was introduced in the EAF through the 5th hole

- Main adaptations:
  - Addition/change/tuning of dedicated streams, blocks and reactions for considering different injection/charge of biomass (e.g. directly through basket, 5th hole) and related effects

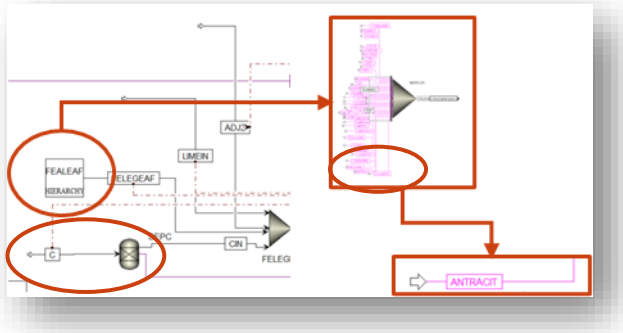
Main units changes

Before

Basket

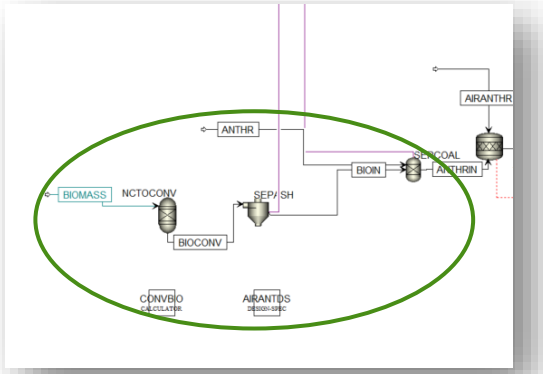


5th hole / direct injection



Now

Basket



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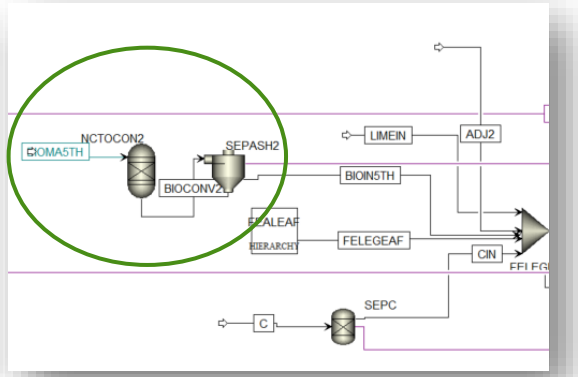

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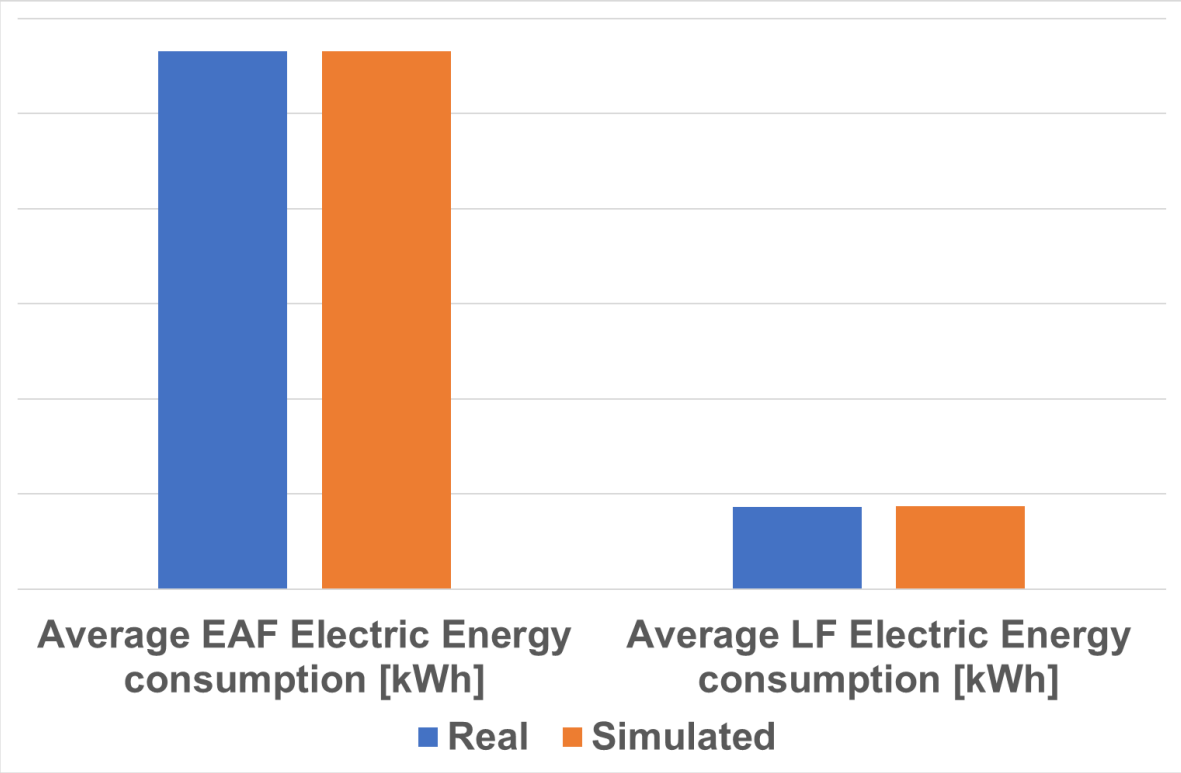
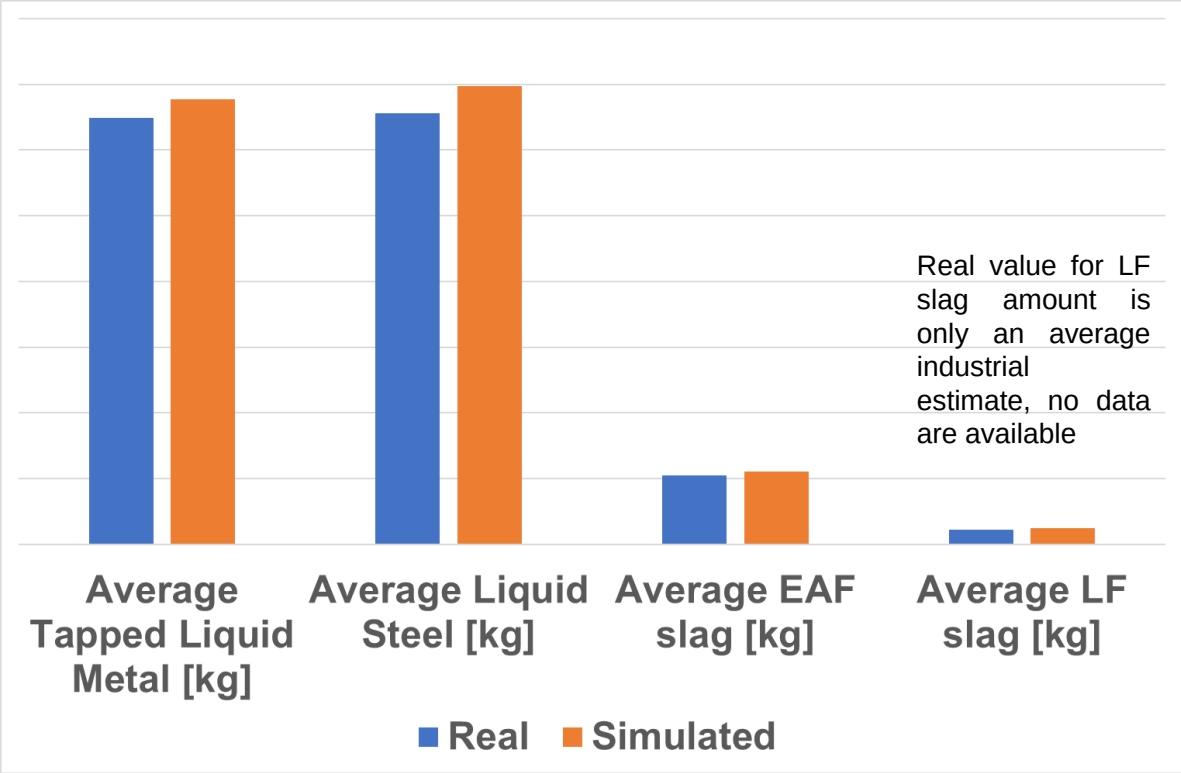
Model adaptation: tuning & validation

- The model has been validated simulating, for each considered steel family, a heat using average data and then comparing related results with related average data

Example for a family





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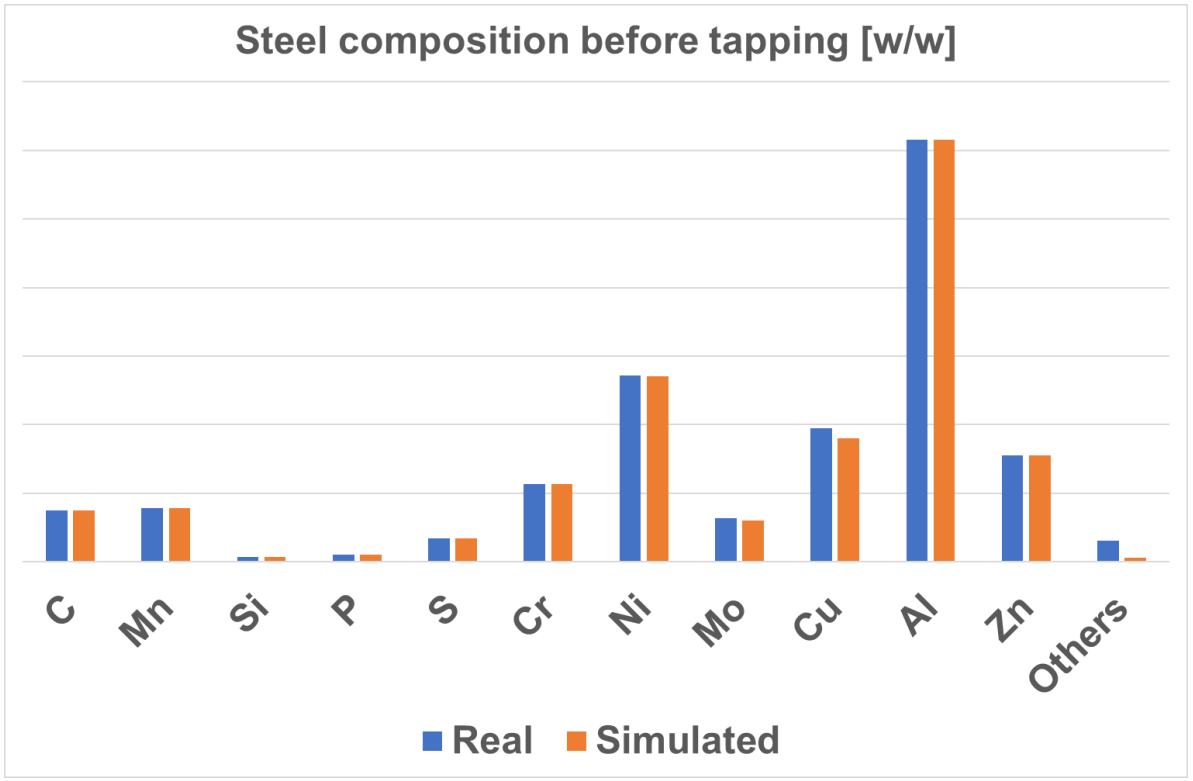

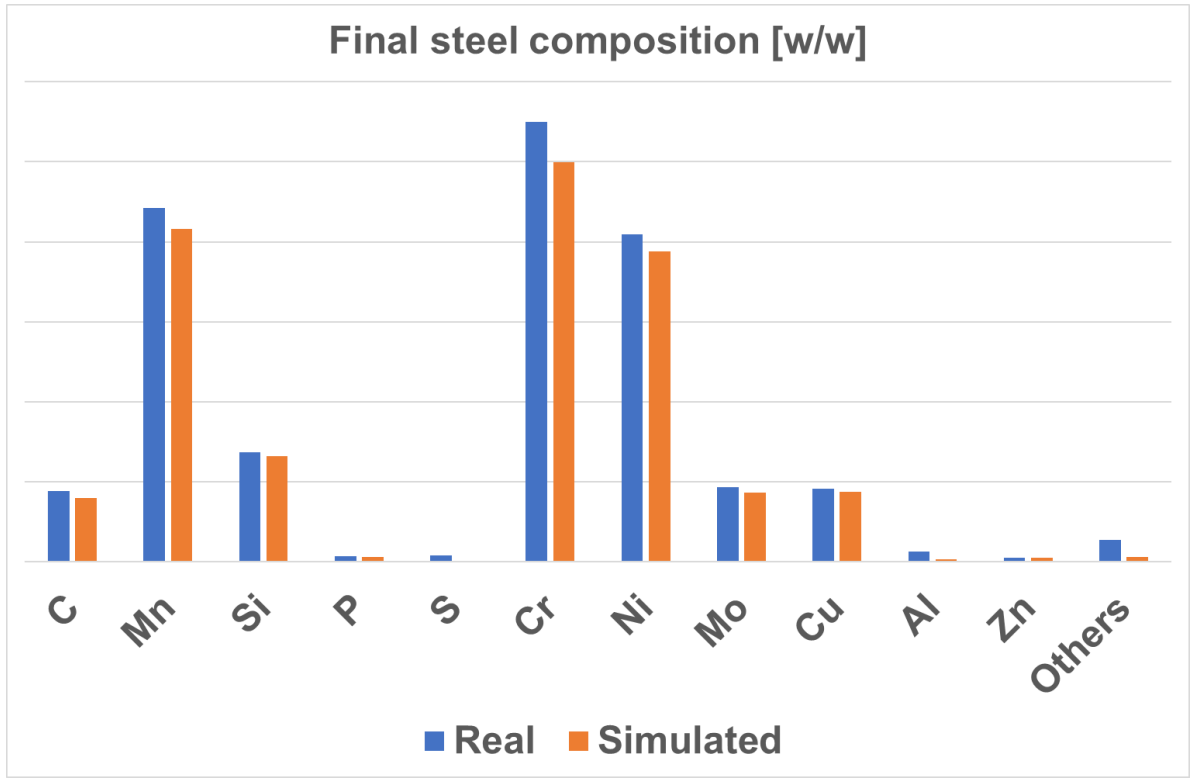

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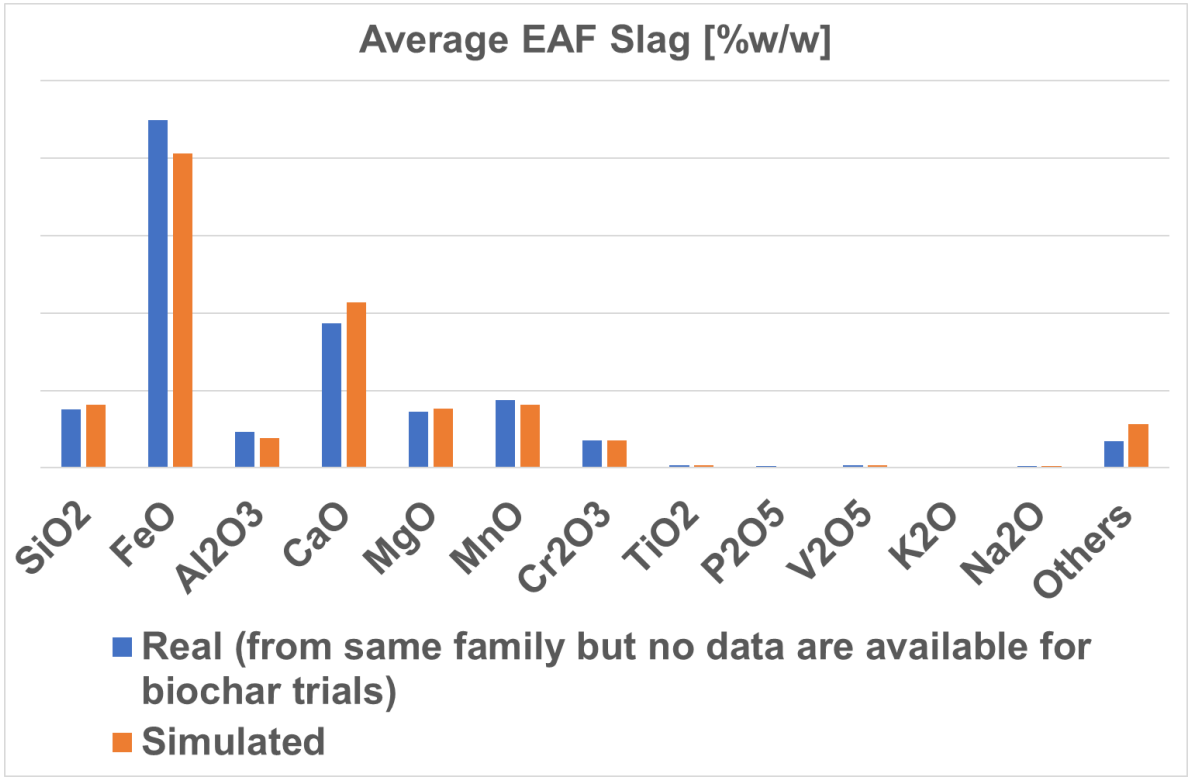

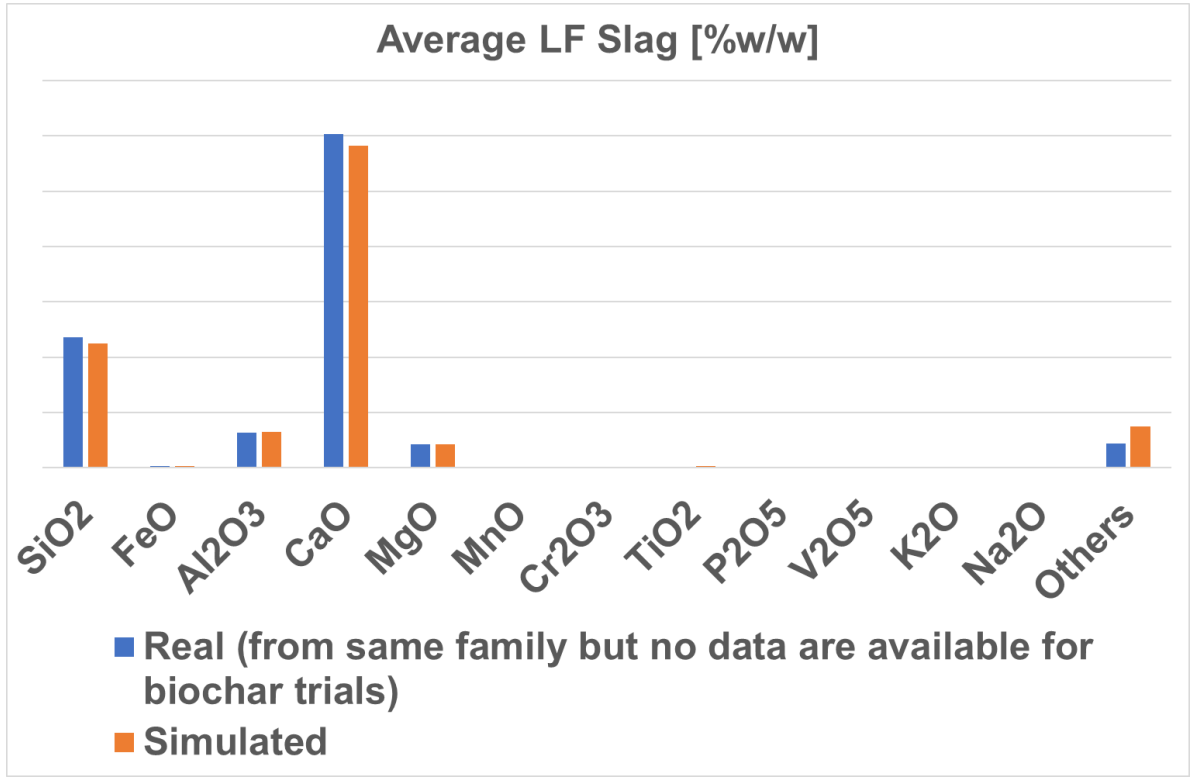

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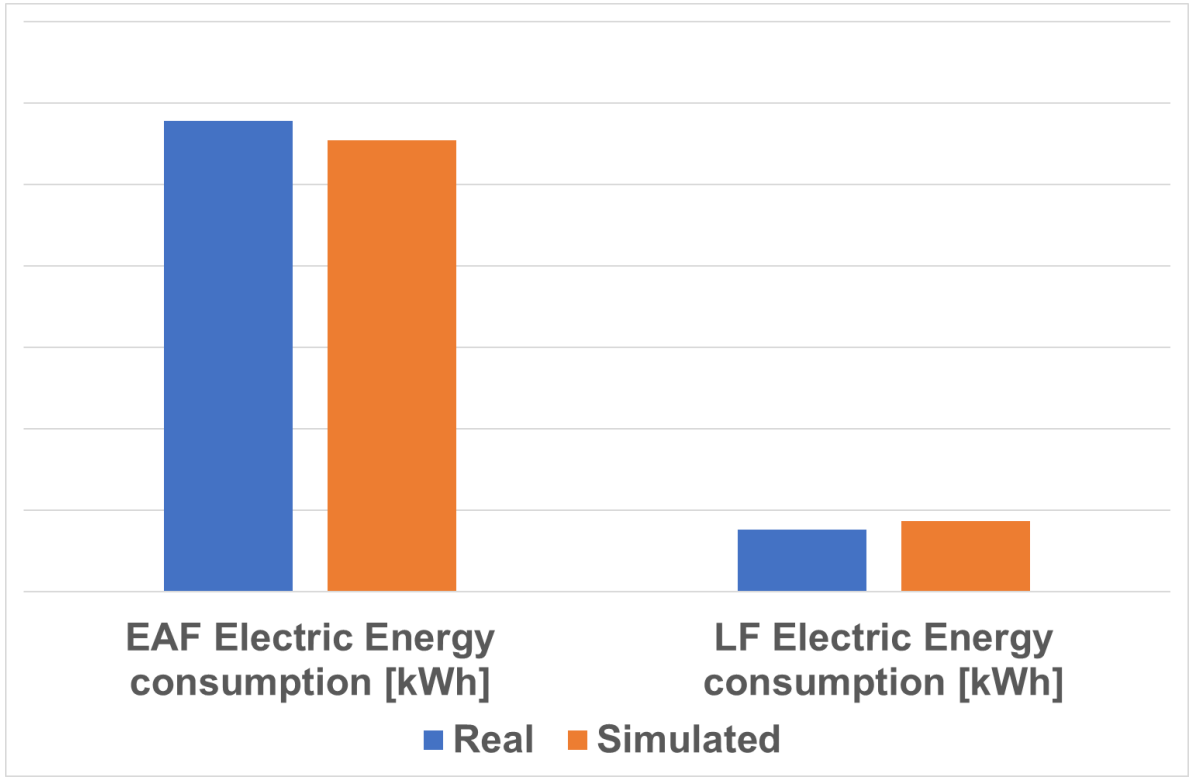
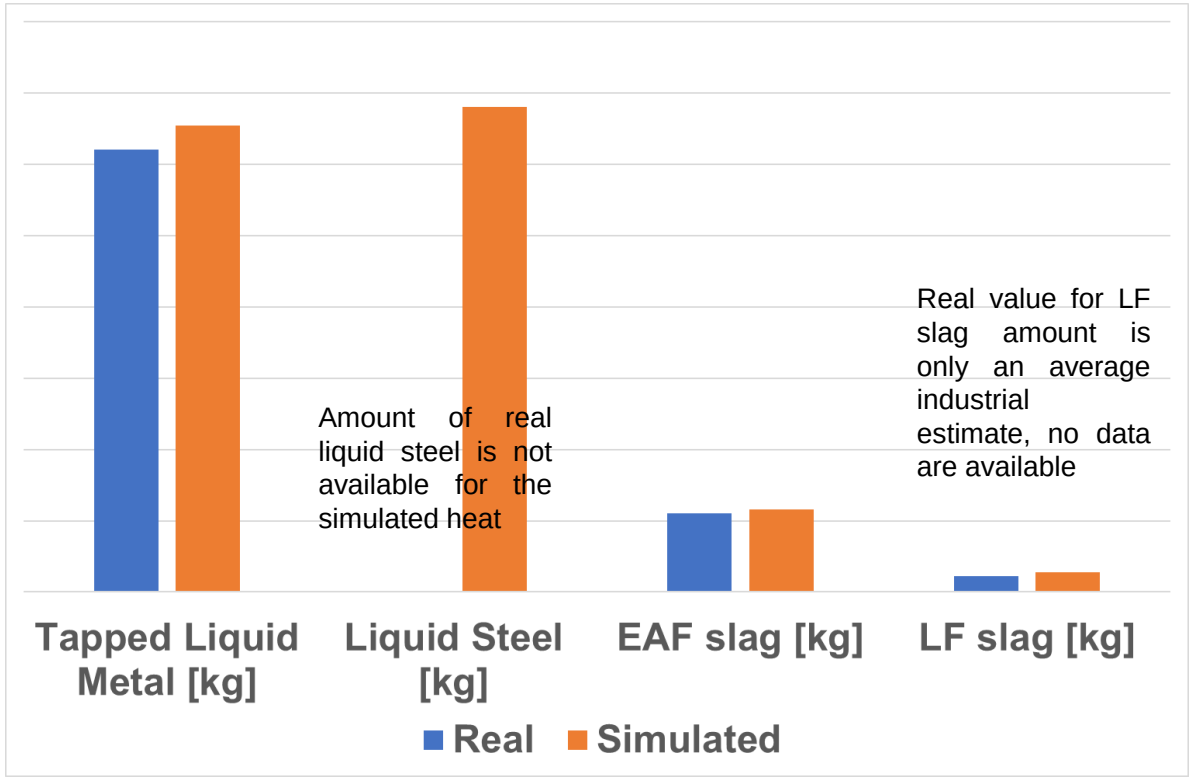
Model adaptation:test

- The model has been then tested simulating specific historical heats and comparing simulated results with real data belonging to the simulated heat

Example for a family





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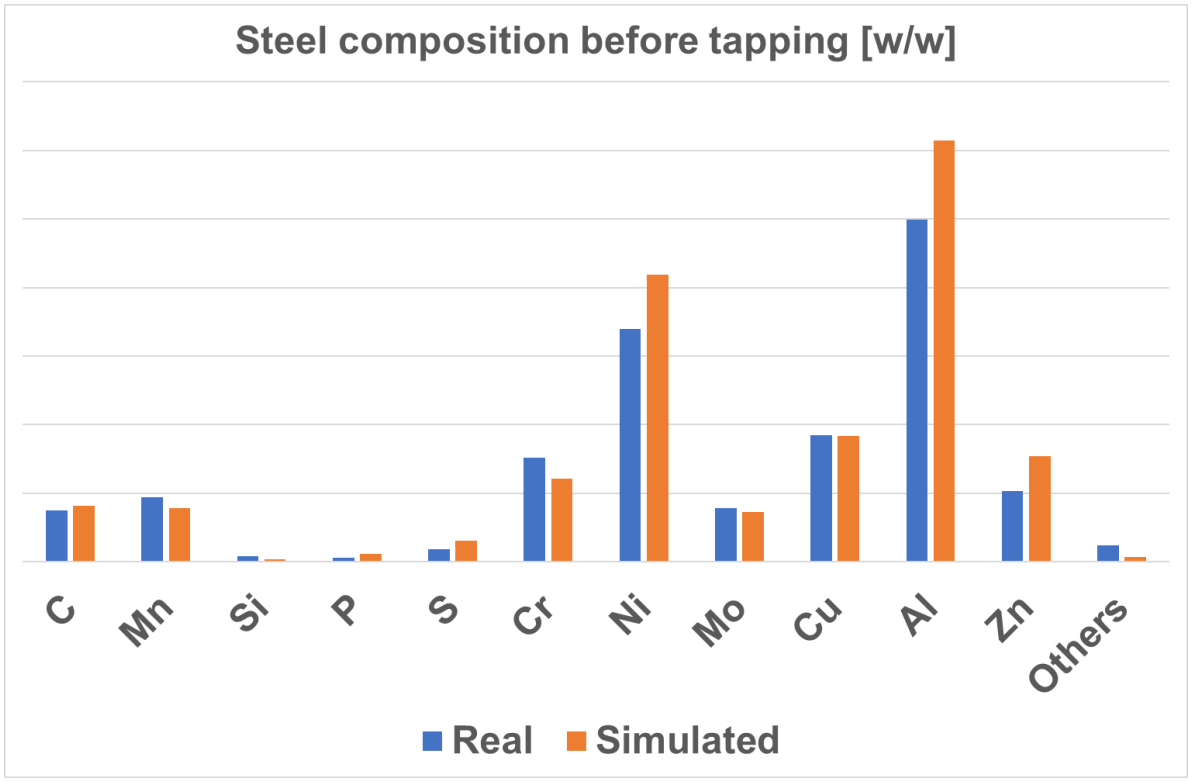

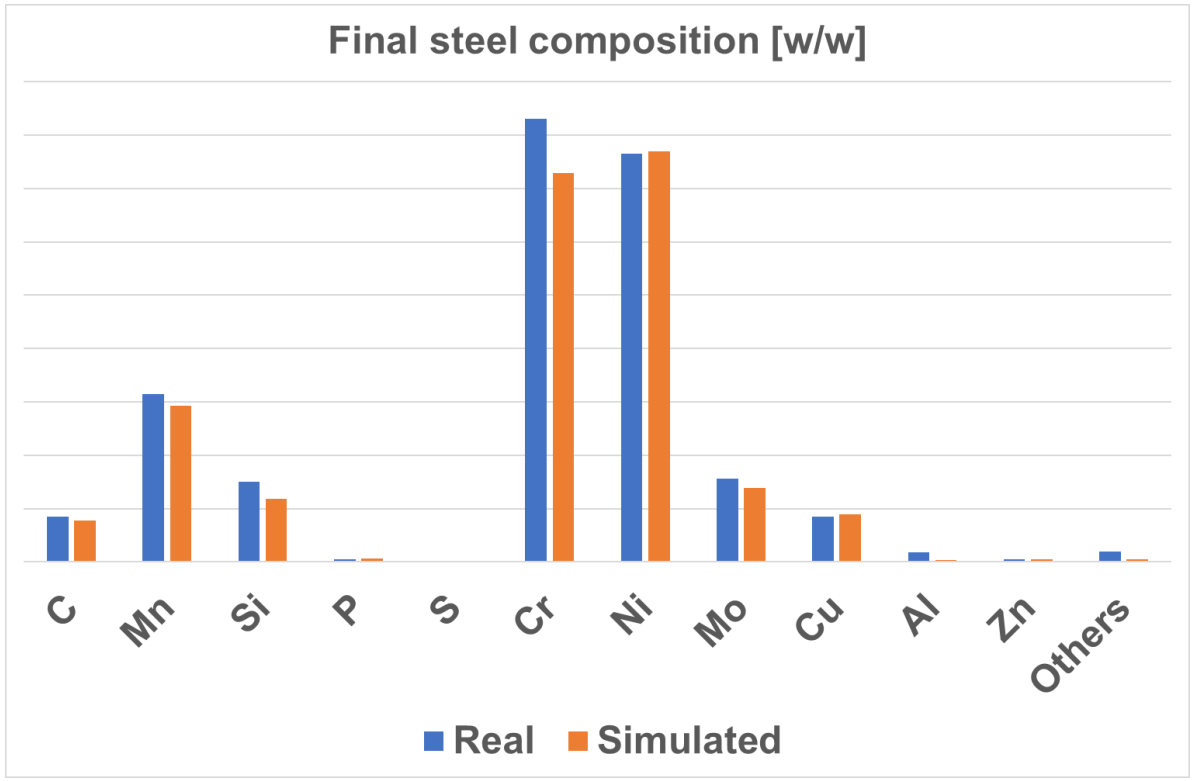

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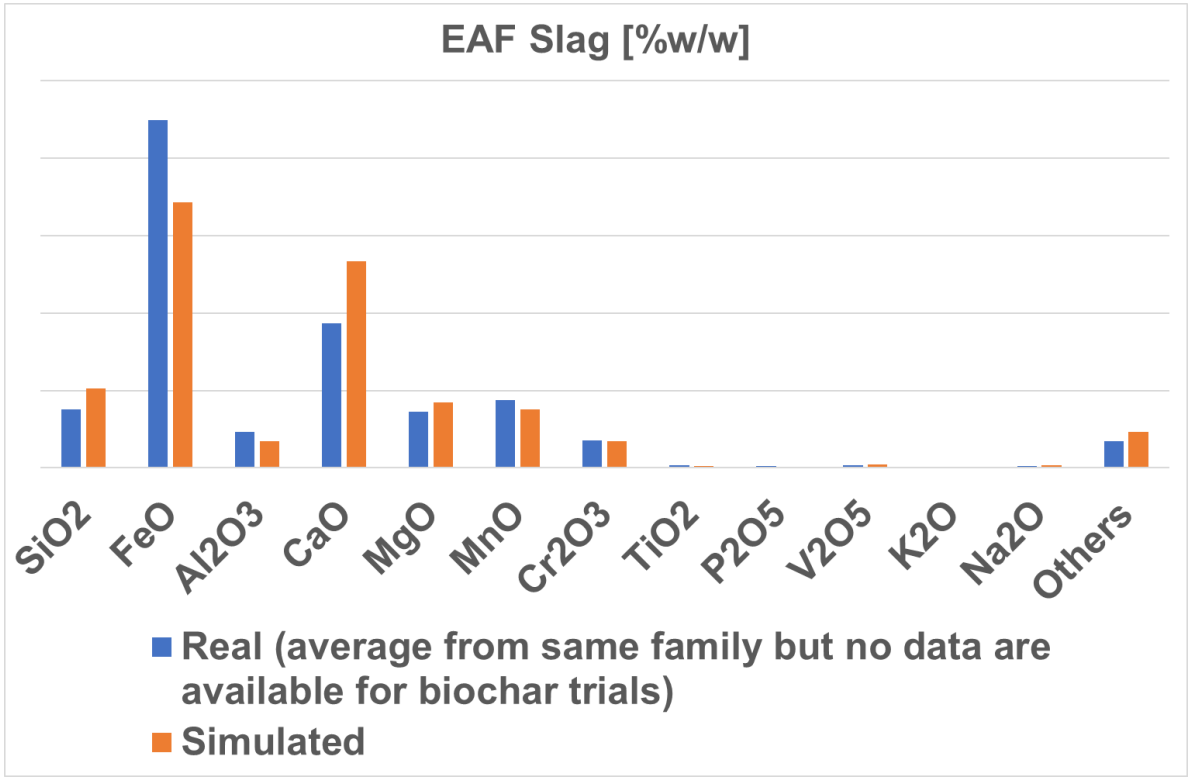

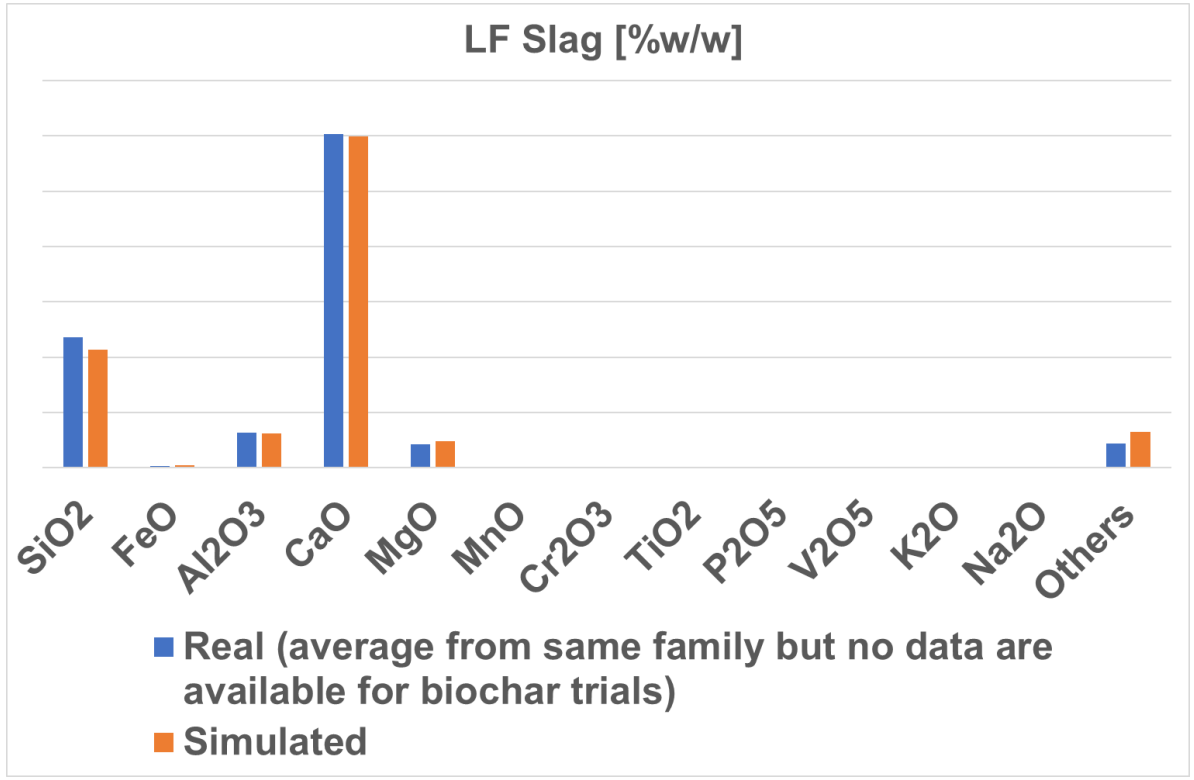

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Use of the model

- Adapted model will be used in GreenHeatEAF to simulate several scenarios and by computing different Key Performance Indicators to evaluate the impact in terms of environmental and energetic sustainability of the process.

Potential scenarios

- Different C-bearing materials
- Different ratios of renewable and fossil C-bearing materials

Potential KPIs

- Electric Energy Efficiency
- CO_2 reduction
- Metal material efficiency
- Not-metal material efficiency
- Slag production

- The simulations will provide indications for field tests to be developed in a later stage of the project.
- Based on simulations and real trials, reliable operating strategies will be defined on the use of these renewable C-bearing materials.

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Thank you

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