EVALUATION THROUGH MASS FLOW ANALYSIS OF THE PRODUCTION AND MANAGEMENT OF STEEL SLAGS IN THE PROVINCE OF BRESCIA (ITALY)

Alan Piemonti, Antonio Conforti, Luca Cominoli, Antonella Luciano, Giovanni Plizzari and Sabrina Sorlini

Speaker: Alan Piemonti

a.piemonti001@unibs.it

UNIVERSITÀ DEGLI STUDI DI BRESCIA

ENEA
Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Steel production processes

INTEGRAL CYCLE

1st Step: production of pig iron in the blast furnace | *2nd Step: production of steel in the basic oxygen converter*
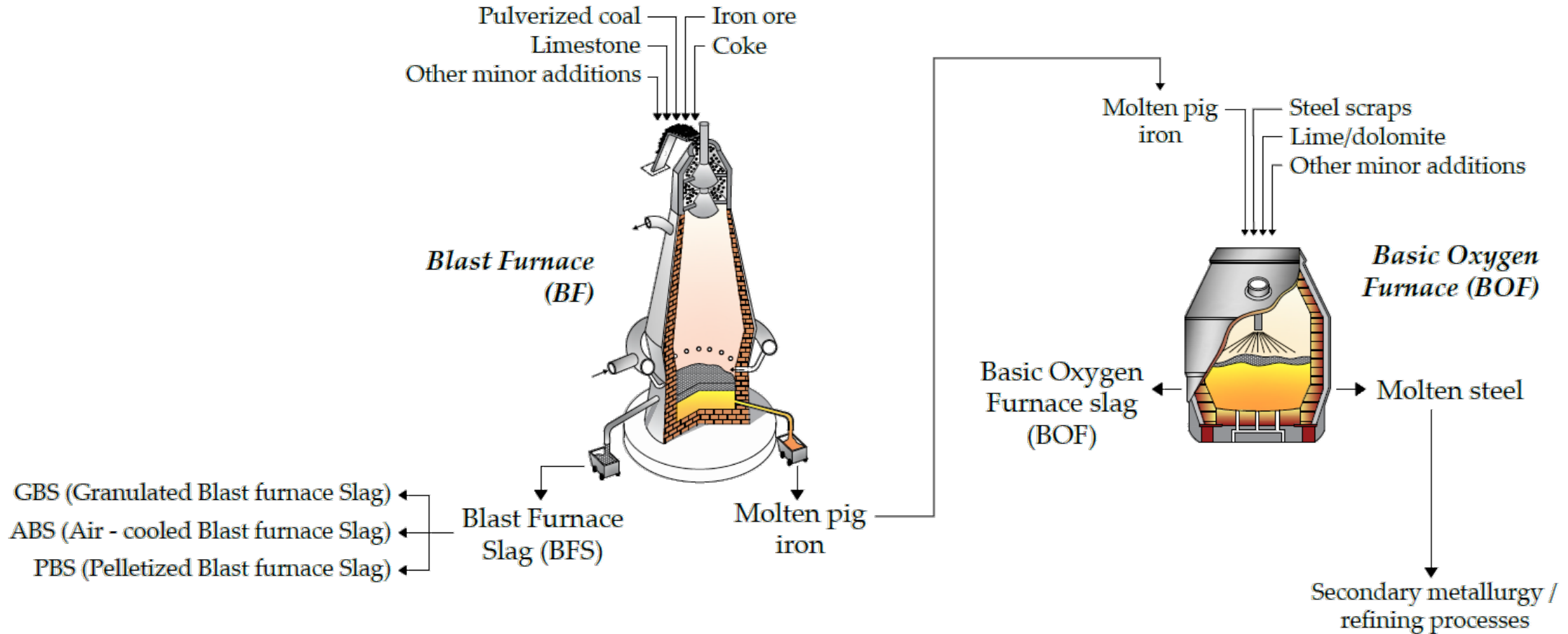
Pulverized coal — Iron ore
Limestone — Coke
Other minor additions

Blast Furnace (BF)

Molten pig iron — Steel scraps
Lime/dolomite
Other minor additions

Basic Oxygen Furnace (BOF)

Basic Oxygen Furnace slag (BOF) ← → Molten steel

GBS (Granulated Blast furnace Slag) ←
ABS (Air - cooled Blast furnace Slag) ←
PBS (Pelletized Blast furnace Slag) ←

Blast Furnace Slag (BFS)

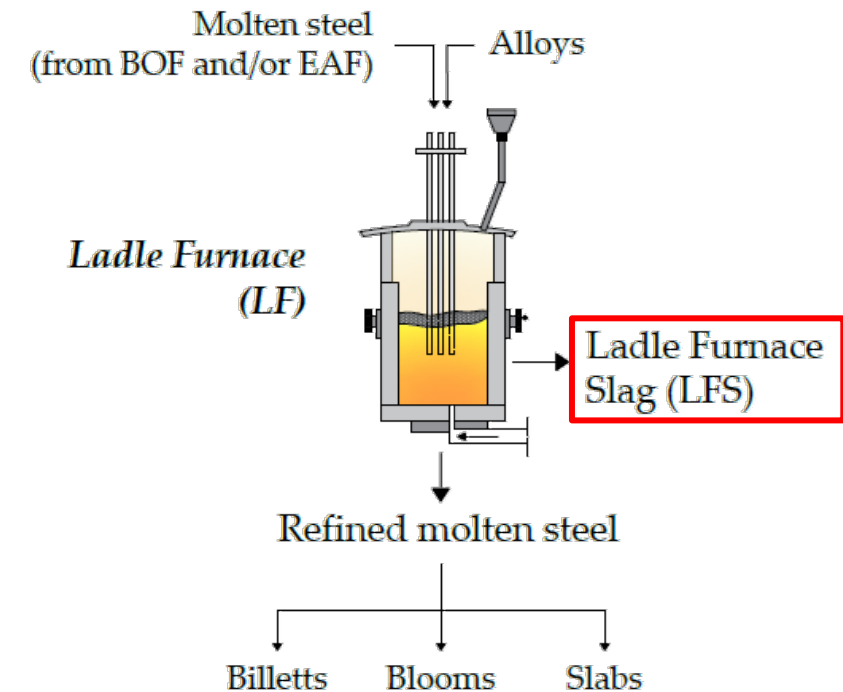Molten pig iron

Secondary metallurgy / refining processes

* Figures from Piemonti, A., Conforti, A., Cominoli, L., Luciano, A., Sorlini, S., Plizzari, G. Use of Iron and Steel Slags in Concrete: State of the Art and Future Perspectives. S*ustainability* **2021**, *13, 556.*

Steel production processes

ELECTRIC CYCLE

Steel scraps
Pig iron in small quantities
Other minor additions

Electric Arc Furnace (EAF)

Electric Arc Furnace slag (EAF)

Molten steel

Secondary metallurgy / refining processes

EAF - C (Electric Arc Furnace slag from Carbon steel production)

EAF - S (Electric Arc Furnace slag from Stainless/high alloy steel production)

SECONDARY METALLURGY / REFINING PROCESSES

Molten steel (from BOF and/or EAF)   Alloys

Ladle Furnace (LF)

Ladle Furnace Slag (LFS)

Refined molten steel

Billetts   Blooms   Slabs

* Figures from Piemonti, A., Conforti, A., Cominoli, L., Luciano, A., Sorlini, S., Plizzari, G. Use of Iron and Steel Slags in Concrete: State of the Art and Future Perspectives. S*ustainability **2021**, 13, 556.*

Steel production sites in Italy and Lombardy

Steelmaking sites in Italy

▌ **Blast Furnaces** – Piombino, Taranto, Trieste

▌ **Basic Oxygen Furnaces**– Piombino, Taranto

● **Electric Arc Furnaces** – Aosta, Bergamo, Bolzano, Brescia, Catania, Cremona, Cuneo, Padova, Potenza, Reggio Emilia, Torino, Terni, Trento, Udine, Varese, Verona, Vicenza

* Source: '*Siderurgia in cifre – 2019*', Federacciai

Steel mills in Lombardy
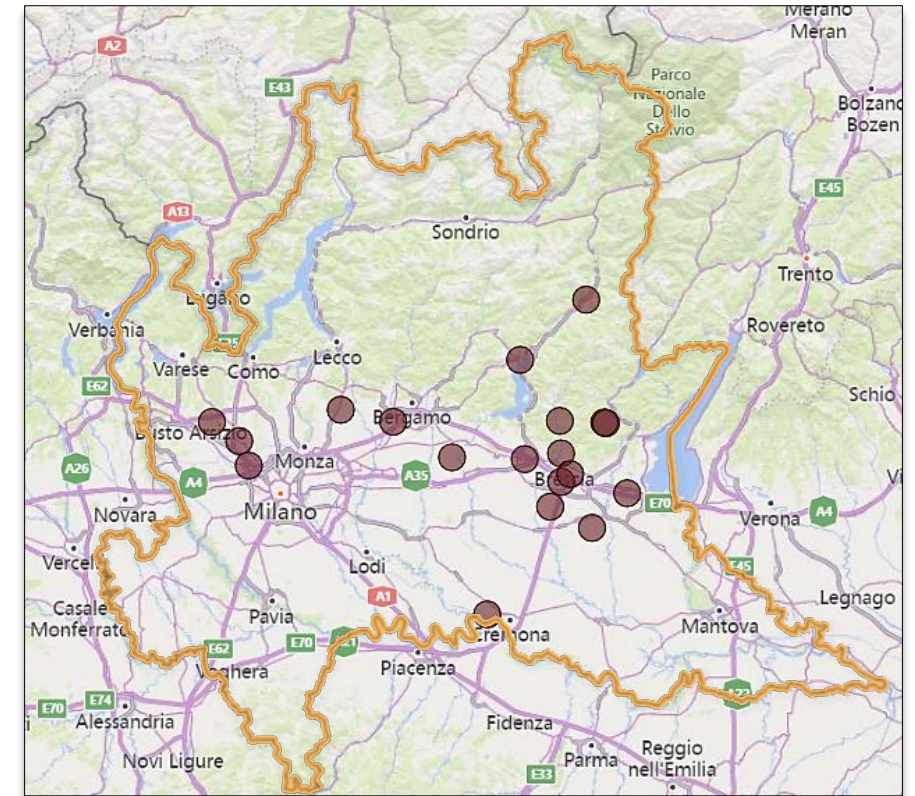
In Lombardy there are **19 steel mills** (**11 in the province of Brescia**), **all equipped with electric arc furnaces and ladle furnaces** for secondary metallurgy processes.

MUD database

The MUD is the "***M**odello **U**nico di **D**ichiarazione ambientale*" (single model for environmental declaration) and represents the set of declarations that producers, transporters, recoverers and disposers of waste must present annually and in which the waste produced is distinguished and identified by type, producer and origin.

- Section AA;
- Section BA;
- Section BB;
- Section BD;
- Section BE.

EWC codes analyzed:
- 10.02.01 – "*Waste from the processing of slag*";
- 10.02.02 – "*Unprocessed slag*";
- 10.09.03 – "*Furnace slag*"

Results from the MUD database analysis

Elaboration: steel slags production in the province of Brescia

Filter

Steel mills in the province of Brescia

Tutte

Summary table

Steel mill	Slag produced [t]	Slag delivered to third parties [t]	EWC code
ALFA ACCIAI SPA	184.417,48	194.939,10	CER 100903
FERALPI SIDERURGICA S.P.A.	159.226,85	155.087,04	CER 100202
FERRIERA VALSABBIA S.P.A.	120.386,08	120.347,76	CER 100202
ORI MARTIN S.P.A.	103.295,56	120.235,04	CER 100202
ACCIAIERIE VENETE S.P.A.	95.415,68	95.415,68	CER 100202
TRAVI E PROFILATI DI PALLANZENO S.R.L.	81.979,37	81.979,37	CER 100201
ACC. DI CALVISANO SPA	76.137,66	76.105,64	CER 100202
INDUSTRIE RIUNITE ODOLESI I.R.O. S.P.A.	69.732,00	70.682,42	CER 100202
ALFA ACCIAI SPA	59.134,86	59.134,86	CER 100202
TRAVI E PROFILATI DI PALLANZENO S.R.L.	55.218,26	55.218,26	CER 100202
ASO SIDERURGICA SPA UNIPERSONALE	34.425,84	34.425,84	CER 100202
ITALFOND SPA	21.100,00	21.642,17	CER 100202
METALCAM S.P.A.	6.629,88	6.629,88	CER 100202
Totale	**1.067.099,52**	**1.091.843,06**	

Location

Location of steel mills in the province of Brescia

© 2021 TomTom. © 2021 Microsoft Corporation. Terms

Subdivision by EWC codes

Percentage of slag production for each steel mill in the province of Brescia: subdivision by EWC codes

- 75,04% CER 100202
- 17,28%
- 7,68%
- CER 100903
- CER 100201
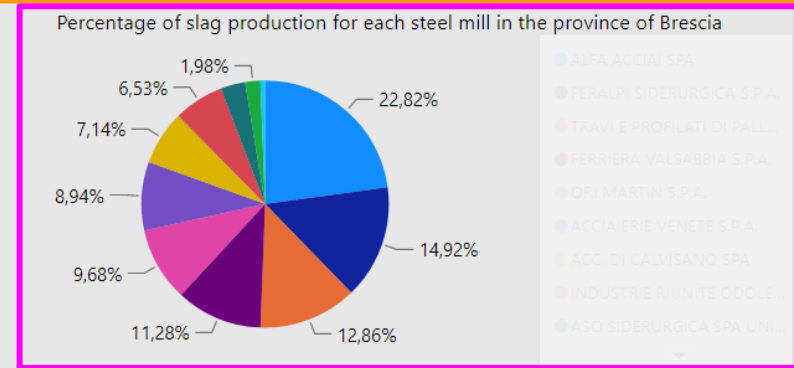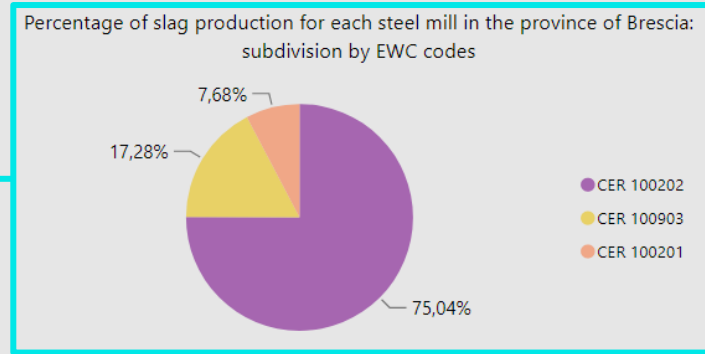
Production percentages for each steel mill

Percentage of slag production for each steel mill in the province of Brescia

- 22,82%
- 1,98%
- 6,53%
- 7,14%
- 8,94%
- 9,68%
- 11,28%
- 12,86%
- 14,92%

ALFA ACCIAI SPA
FERALPI SIDERURGICA S.P.A.
TRAVI E PROFILATI DI PALL...
FERRIERA VALSABBIA S.P.A.
ORI MARTIN S.P.A.
ACCIAIERIE VENETE S.P.A.
ACC. DI CALVISANO SPA
INDUSTRIE RIUNITE ODOLE...
ASO SIDERURGICA SPA UNI...

Results from the MUD database analysis

Elaboration: steel slag flows produced in the province of Brescia and destined for recovery

Filter

Steel mills in the province of Brescia

Tutte

Summary table

Recovery plant	Recovery quantity [t]	Province	EWC code
DI.MA. SRL (Calvisano)	122.961,60	BRESCIA	CER 100202
ZEROCENTO SRL	48.683,38	PADOVA	CER 100202
F.M. RECUPERI SRL	41.811,69	BRESCIA	CER 100202
VEZZOLA S.P.A.	22.797,98	BRESCIA	CER 100202
CO.R.L. SRL	21.936,74	CREMONA	CER 100202
PORTAMB SRL (recupero)	14.424,18	BRESCIA	CER 100202
DI.MA. SRL (Montichiari)	11.466,94	BRESCIA	CER 100202
ATI SRL	1.125,04	PAVIA	CER 100202
FREALDO ASFALTI S.R.L.	30,74	VICENZA	CER 100202
Totale	**285.238,29**		

Steel slag produced in the province of Brescia and destined for recovery: mass flow diagram

○ Steel mills

Flows

Subdivision by EWC codes

Steel slag produced in the province of Brescia and destined for recovery: subdivision by EWC code

● CER 100202

100,00%

Steel slag produced in the province of Brescia: provincial recovery percentages

Province	Recovery quantity [t]
BRESCIA	213.462,39
PADOVA	48.683,38
CREMONA	21.936,74
PAVIA	1.125,04
VICENZA	30,74
Totale	**285.238,29**

7,69%
17,07%
74,84%

PROVINCES
- BRESCIA
- PADOVA
- CREMONA
- PAVIA
- VICENZA

Quantities and percentages for each province

Results from the MUD database analysis

UNIVERSITÀ DEGLI STUDI DI BRESCIA

Elaboration: steel slag flows produced in the province of Brescia and _destined for disposal_

Filter

Summary table

Subdivision by EWC codes

Flows

Quantities and percentages for each province

Steel mills in the province of Brescia
Tutte

Disposal plant	Disposal quantity [t]	Province	EWC code
BETTONI S.P.A. (discarica inerti)	129.958,33	BRESCIA	CER 100202
ECO.PA SRL	97.688,76	BRESCIA	CER 100903
BETTONI S.P.A. (discarica inerti)	93.804,62	BRESCIA	CER 100903
CAVA CALCINATO SRL	92.468,15	BRESCIA	CER 100202
REZZOLA SCAVI SRL	88.945,95	BRESCIA	CER 100202
ECO.PA SRL	57.597,20	BRESCIA	CER 100202
VERGOMASCO S.C.A.R.L.	55.793,56	BRESCIA	CER 100202
REZZOLA SCAVI SRL	44.315,25	BRESCIA	CER 100201
BETTONI S.P.A. (discarica inerti)	37.664,12	BRESCIA	CER 100201
BETTONI S.P.A. (cava Via Padana Superiore)	30.186,24	BRESCIA	CER 100202
BETTONI S.P.A. (cava Via Lunga)	26.365,64	BRESCIA	CER 100202
EDILQUATTRO SRL	17.564,11	BRESCIA	CER 100202
ALICE AMBIENTE SRL	3.374,94	VERCELLI	CER 100202
S.A.P. SRL	452,66	ALESSANDRIA	CER 100202
Totale	**776.179,53**		

Steel slag produced in the province of Brescia and destined for disposal: mass flow diagram

○ Steel mills

Steel slag produced in the province of Brescia and destined for disposal: subdivision by EWC code

- 10,56%
- 24,67%
- 64,77%

● CER 100202
● CER 100903
● CER 100201

Steel slag produced in the province of Brescia: provincial disposal percentages

Province	Disposal quantity [t]
BRESCIA	772.351,93
VERCELLI	3.374,94
ALESSANDRIA	452,66
Totale	**776.179,53**

- 0,43%
- 99,51%

PROVINCES
● BRESCIA
● VERCELLI
● ALESSANDRIA

Results from the MUD database analysis: summary

Location of steel sector operators and summary of steel slag management in the province of Brescia

- Steel mills (11)
- Treatment/recovery plants (6)
- Disposal plants (10)
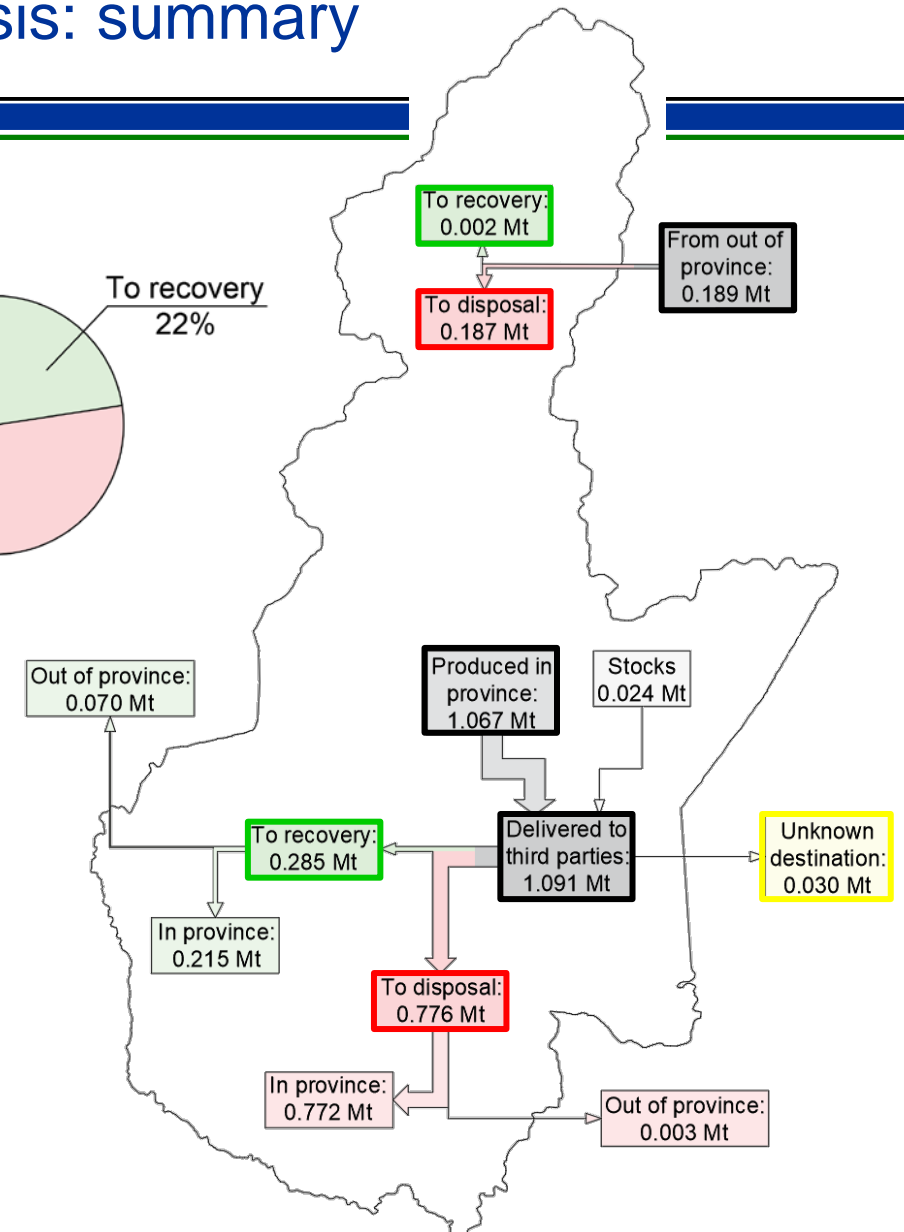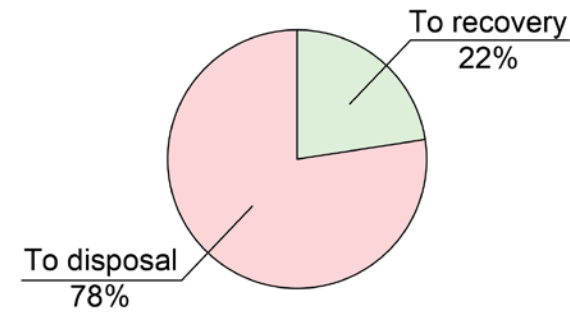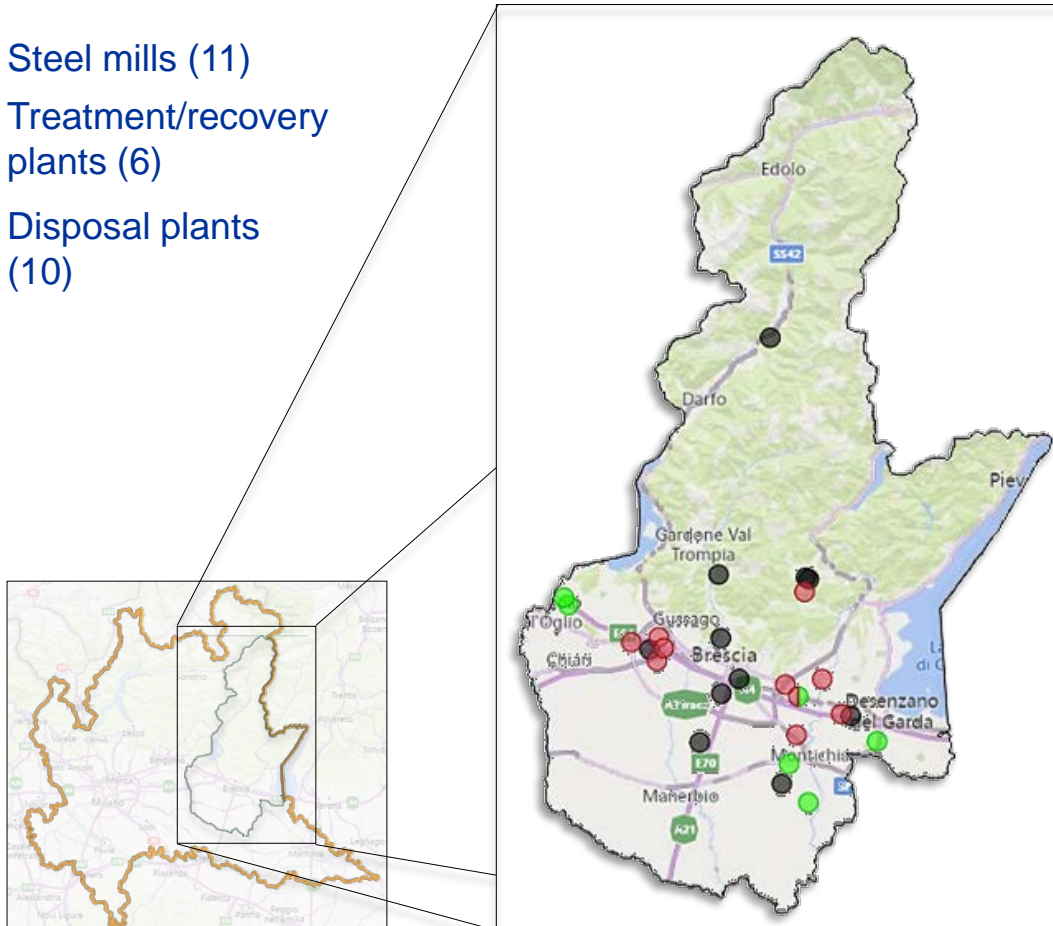
Weaknesses points of the MUD database

- Electric arc furnace slag (EAF) and ladle furnace slag (LFS) are, in most cases, classified under the same EWC code (a consequence of the classification performed by the steel mills);

- Disposal and recovery are only identifiable by the codes in Legislative Decree 152/2006. There is no further information about the actual field of reuse of the examined slags (e.g., road construction, concrete mixes, etc.);

- The database contains information only on steel slags classified as "waste" and there is no information on slag classified as "by-product".

- Direct involvement of the steel sector operators and consortia:

    - Quantities of steel slags classified as "by-product";

    - Subdivision between EAF and LFS slag;

    - Production data update to 2020;

    - Typical reuses of the steel slags considered in the territory.

Impact of the slag classified as "by-product"

EAF

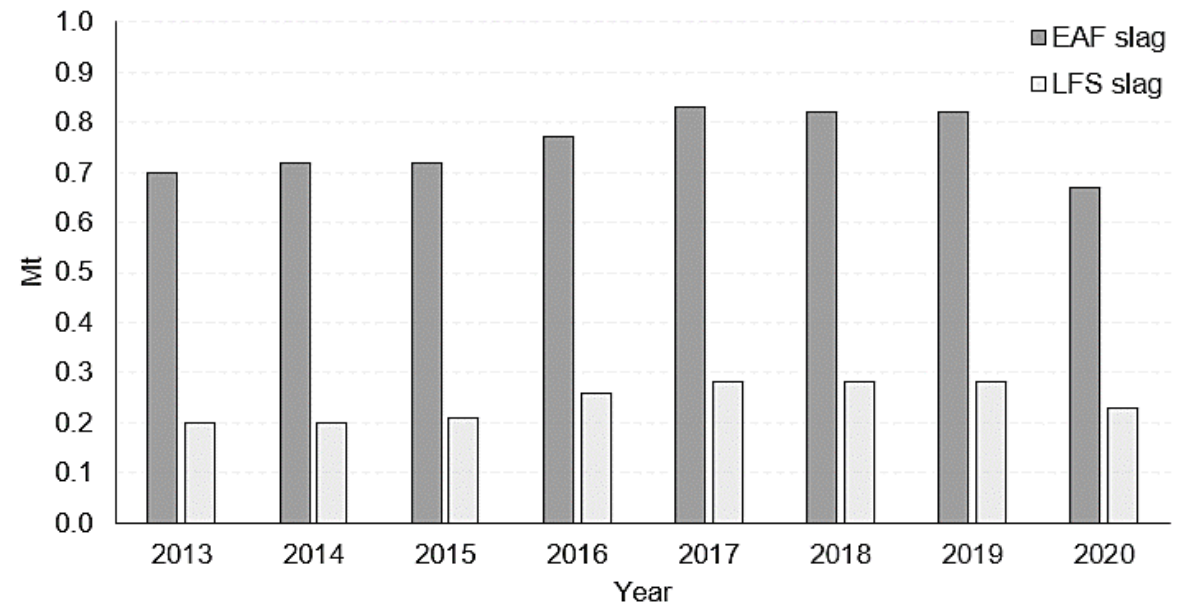| Year	Steel production [Mt]	EAF slag production [Mt]	EAF slag as by-product [Mt]	EAF slag as waste - Recovery [Mt]	EAF slag as waste - Disposal [Mt]
2013	4.81	0.70	0.21	0.33	0.25
2014	4.98	0.72	0.29	0.24	0.27
2015	5.32	0.72	0.39	0.12	0.27
2016	5.71	0.77	0.16	0.19	0.31
2017	6.05	0.83	0.18	0.24	0.46
2018	N/D*	0.82	0.09	0.32	0.42
2019	N/D*	0.82	0.14	0.33	0.35
2020	N/D*	0.67	0.12	0.37	0.18

* N/D: no data available

LFS

Year	Steel production [Mt]	LFS slag production [Mt]	LFS slag as by-product [Mt]	LFS slag as waste - Recovery [Mt]	LFS slag as waste - Disposal [Mt]
2013	4.81	0.20	0.0003	0.0007	0.29
2014	4.98	0.20	0	0.0004	0.23
2015	5.32	0.21	0	0	0.21
2016	5.71	0.26	0	~ 0	0.24
2017	6.05	0.28	~ 0	0.0003	0.28
2018	N/D*	0.28	0	0.0003	0.28
2019	N/D*	0.28	0	0.0002	0.28
2020	N/D*	0.23	0	0.0001	0.23

* N/D: no data available

Comparison between EAF and LFS slag production in the province of Brescia

Impact of the slag classified as "by-product"

EAF

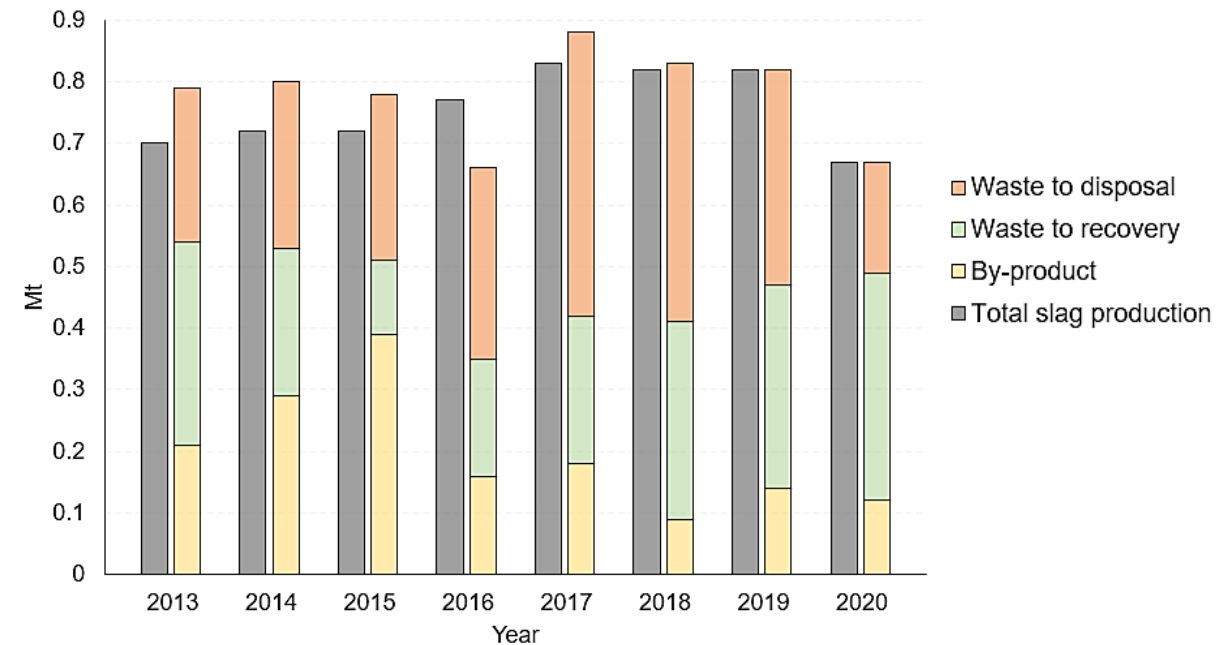| Year	Steel production	EAF slag production	EAF slag as by-product	EAF slag as waste - Recovery	EAF slag as waste - Disposal
	[Mt]	[Mt]	[Mt]	[Mt]	[Mt]
2013	4.81	0.70	0.21	0.33	0.25
2014	4.98	0.72	0.29	0.24	0.27
2015	5.32	0.72	0.39	0.12	0.27
2016	5.71	0.77	0.16	0.19	0.31
2017	6.05	0.83	0.18	0.24	0.46
2018	N/D*	0.82	0.09	0.32	0.42
2019	N/D*	0.82	0.14	0.33	0.35
2020	N/D*	0.67	0.12	0.37	0.18

* N/D: no data available

LFS

Year	Steel production	LFS slag production	LFS slag as by-product	LFS slag as waste - Recovery	LFS slag as waste - Disposal
	[Mt]	[Mt]	[Mt]	[Mt]	[Mt]
2013	4.81	0.20	0.0003	0.0007	0.29
2014	4.98	0.20	0	0.0004	0.23
2015	5.32	0.21	0	0	0.21
2016	5.71	0.26	0	~ 0	0.24
2017	6.05	0.28	~ 0	0.0003	0.28
2018	N/D*	0.28	0	0.0003	0.28
2019	N/D*	0.28	0	0.0002	0.28
2020	N/D*	0.23	0	0.0001	0.23

* N/D: no data available

EAF slag: subdivision between "by-products", "waste" for recovery and "waste" for disposal

Impact of the slag classified as "by-product"

EAF

| Year	Steel production	EAF slag production	EAF slag as by-product	EAF slag as waste - Recovery	EAF slag as waste - Disposal
	[Mt]	[Mt]	[Mt]	[Mt]	[Mt]
2013	4.81	0.70	0.21	0.33	0.25
2014	4.98	0.72	0.29	0.24	0.27
2015	5.32	0.72	0.39	0.12	0.27
2016	5.71	0.77	0.16	0.19	0.31
2017	6.05	0.83	0.18	0.24	0.46
2018	N/D*	0.82	0.09	0.32	0.42
2019	N/D*	0.82	0.14	0.33	0.35
2020	N/D*	0.67	0.12	0.37	0.18

* N/D: no data available

LFS

| Year	Steel production	LFS slag production	LFS slag as by-product	LFS slag as waste - Recovery	LFS slag as waste - Disposal
	[Mt]	[Mt]	[Mt]	[Mt]	[Mt]
2013	4.81	0.20	0.0003	0.0007	0.29
2014	4.98	0.20	0	0.0004	0.23
2015	5.32	0.21	0	0	0.21
2016	5.71	0.26	0	~ 0	0.24
2017	6.05	0.28	~ 0	0.0003	0.28
2018	N/D*	0.28	0	0.0003	0.28
2019	N/D*	0.28	0	0.0002	0.28
2020	N/D*	0.23	0	0.0001	0.23

* N/D: no data available

LFS slag: subdivision between "by-products", "waste" for recovery and "waste" for disposal
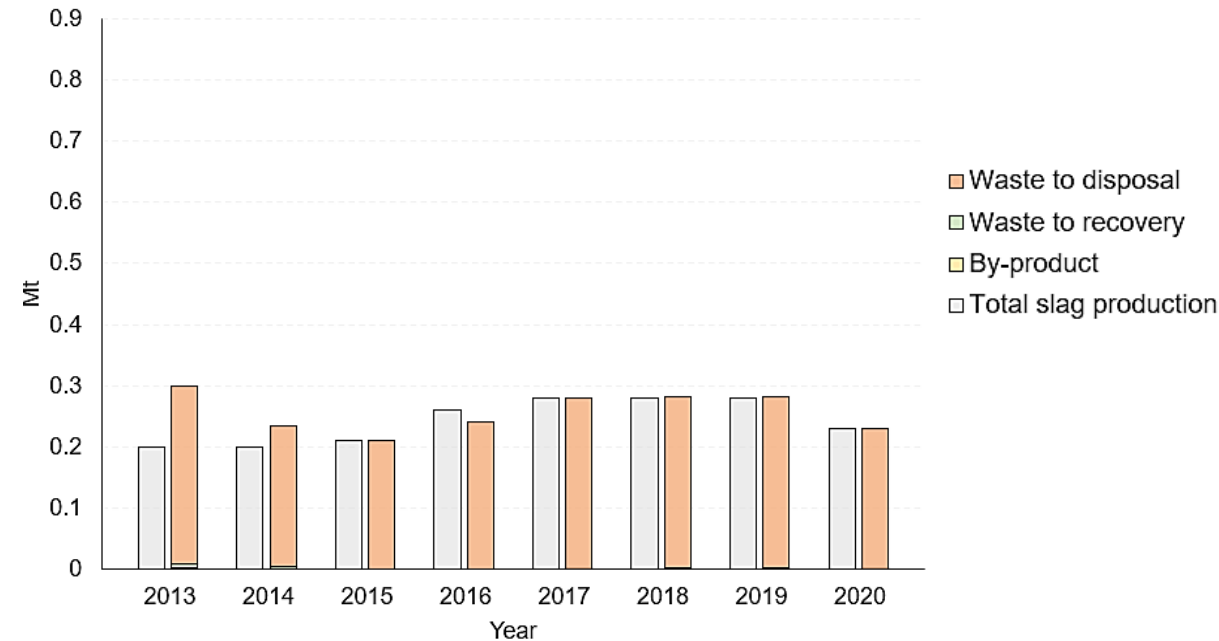
Conclusions

- Due to some weaknesses, consulting the MUD database alone would lead to an error in estimating the amount of steel slags produced in the province → Need to directly involve operators and consortia of the steel industry;

- In recent years (except for the production of 2020, which was strongly influenced by the SARS-CoV-2 pandemic), the production trend of primary steel and, consequently, of steel slags, has showed a slight increase;

- Of the total reused for various applications, increase in steel slags classified as "waste" and destined for recovery at the expense of steel slags classified as "by-products";

- In the province of Brescia, EAF slags are reused mainly in cement mixes, road sub-bases, to produce certified products (e.g., aggregates to be reused in concrete or bituminous conglomerates), landfill covering layers, filling, embankments, etc.;

- The percentages of EAF slag classified as "waste" and destined for landfill disposal are still very high → Need to increase the reuse of this material;

- All the LFS slag produced is still classified as "waste" and destined for landfill disposal → Further and in-depth studies are extremely necessary in order to find suitable applications for its reuse.
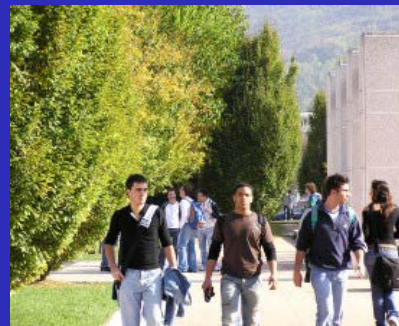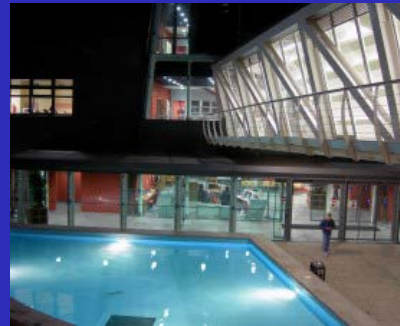
Thank you for your kind attention!

University of Brescia, Italy