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Slags valorization in the EU: tapping the full potential

6th Slag Valorization Symposium
Mechelen, 2019-Apr-03

Overview

- Introduction
- ArcelorMittal EU slag production and valorization
- Best practices: a regional perspective on the regulatory framework
- Conclusions

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Transforming tomorrow

- The world's leading steel and mining company, with around **209,000** employees in more than **60** countries
- Leader in all major global steel markets, including Automotive, Construction, Household appliances and Packaging, with leading R&D and technology
- An industrial presence in **18** countries exposes the company to all major markets, from emerging to mature
- The largest producer of steel in the EU, North and South America and Africa, a significant steel producer in the CIS region, and a growing presence in Asia, including investments in China and India
- One of the world's largest producers of iron ore and metallurgical coal strategically positioned to serve our network of steel plants and the external global market

Underpinning all our operations is a philosophy to produce safe, sustainable steel

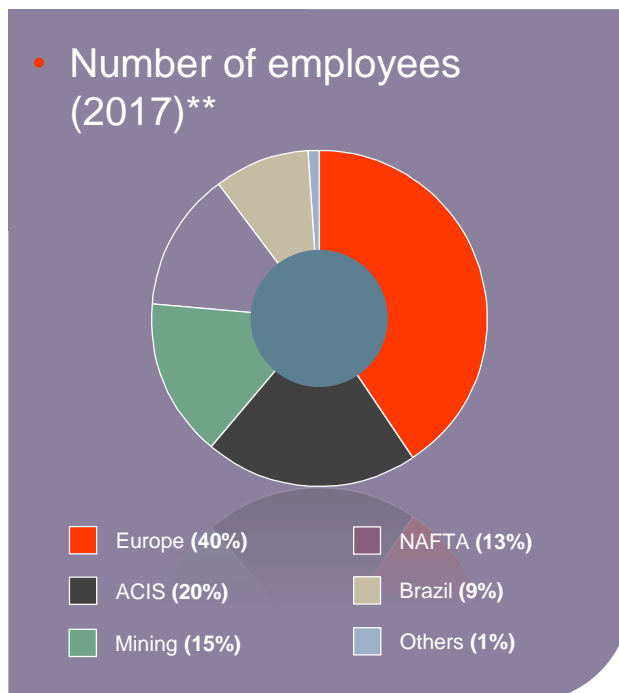
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Key figures

	2016	2017	2018
Sales (US\$ billion)	56.8	68.7	76
Ebitda (US\$ billion)	6.25	8.4	10.3
Operating income / (loss) (US\$ billion)	4.2	5.4	6.5
Net income / (loss) (US\$ billion)	1.8	4.6	5.1
Steel shipments (million tonnes)	83.9	85.2	83.9
Crude steel production (million tonnes)	90.8	93.1	92.5
Own iron ore production (million tonnes)*	55.2	57.4	58.5

*Own iron ore and coal production excluding strategic long-term contracts

**Source: Fact Book 2017

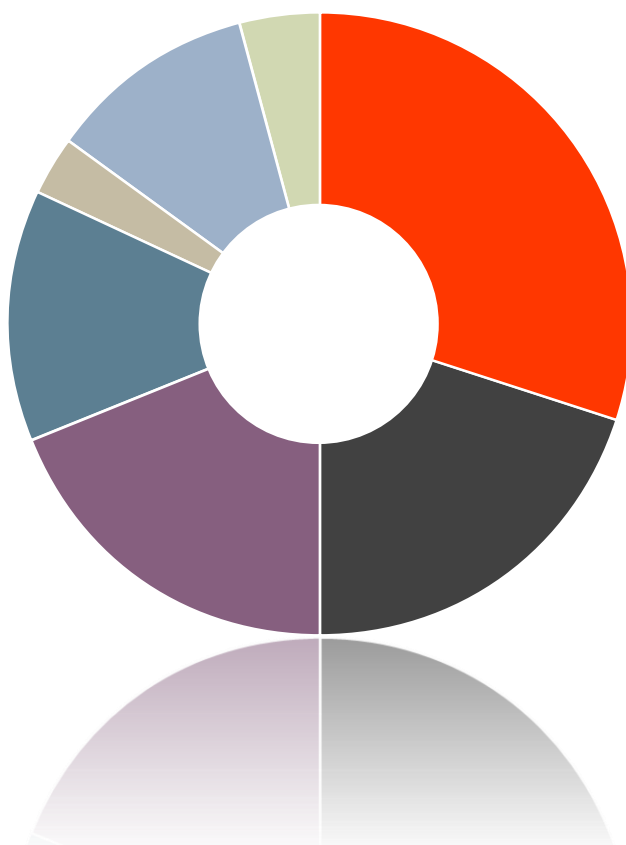


Leader in the metals and mining sector

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Sales by market

Source: 20F report – 2018



- Distribution **(30%)**
- Construction **(20%)**
- Automotive **(19%)**
- Primary Transformation **(13%)**
- Packaging **(3%)**
- Other Steel sales* **(11%)**
- Other sales** **(4%)**

* metal processing, machinery, electrical equipment and domestic appliances

** slag, waste, sale of energy, transport services, mining, chemicals and water

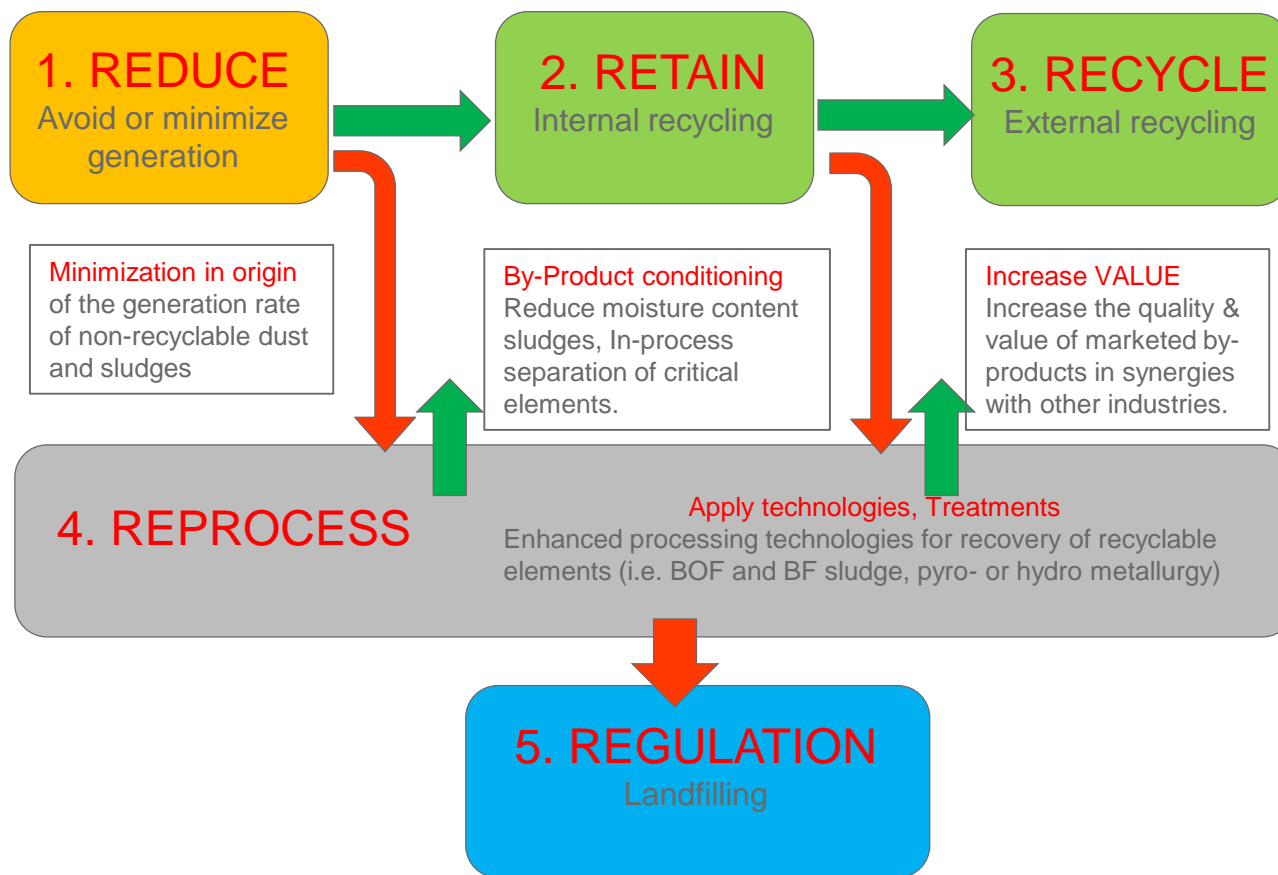
Meeting our customers' needs



The landscape

- Valorization of slags can save resources? (Y)
- If you were the regulator, would you strive for a framework that:
 - Minimizes the production of fatally co-generated substance? (Y/N)
 - Promotes their uptake? (Y)
 - How do you provide incentives? In Europe:
 - Industrial Emissions Directive, Best Available Reference Techniques
 - Emission Trading Scheme
 - Product promotion by Green Public Procurement, Eco-labels

ArcelorMittal by-product roadmap





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Steel making process: steel products



Design by double-ill.com / Cover photo: ThyssenKrupp Steel / Tubes photo: Sefrighter - The process shown above is illustrative only and is not designed to show the steelmaking process in detail. Not all steel plants produce all of the products shown in this diagram.

worldsteel.org



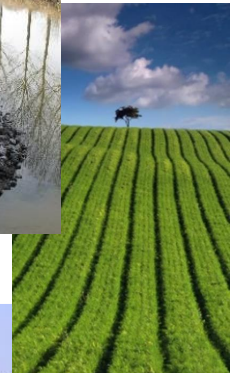
Slag type and naming

No.	Substance	EINECS Name	Common name	EINECS No. CAS No.
1	GBS	Slag, ferrous metal, blast furnace (granulated)	Granulated Blast furnace Slag	266-002-0 65996-69-2
	ABS	Slag, ferrous metal, blast furnace (air-cooled)	Air-cooled Blast furnace Slag	266-002-0 65996-69-2
2	BOS	Slag, steelmaking, converter	Basic Oxygen furnace Slag (converter slag)	294-409-3 91722-09-7
3	EAF C	Slag, steelmaking, elec. furnace (carbon steel production)	Electric Arc Furnace slag (from Carbon steel production)	932-275-6
4	EAF S	Slag, steelmaking, elec. furnace (stainless/high alloy steel production)	Electric Arc Furnace slag (from Stainless/ high alloy steel production)	932-476-9
5	SMS	Slag, steelmaking	Steelmaking slag	266-004-1 65996-71-6

Figure 1: Slag families and corresponding CAS- and EINECS-numbers

Valorizing slags in applications

	GBS	ABS	Hot metal de-S	BOS	SMS from BOF	EAF	SMS from EAF
Int. recycling			✓	✓	✓		
Cement	✓ additive			✓ raw mat.			
Glass	✓						
Roads building		✓		✓ uncovered		✓	
Stone wool		✓					
Fertilizer				✓			✓
Water works				✓			
Backfill				✓			
Soil stabilization							✓
Water treatment, drainage		✓					
Landfilling			✓				



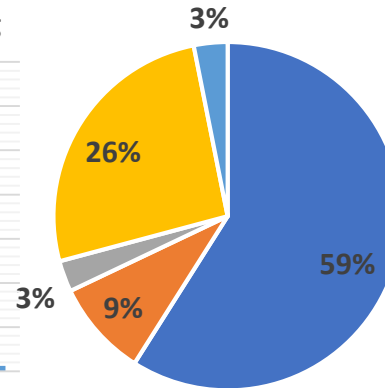
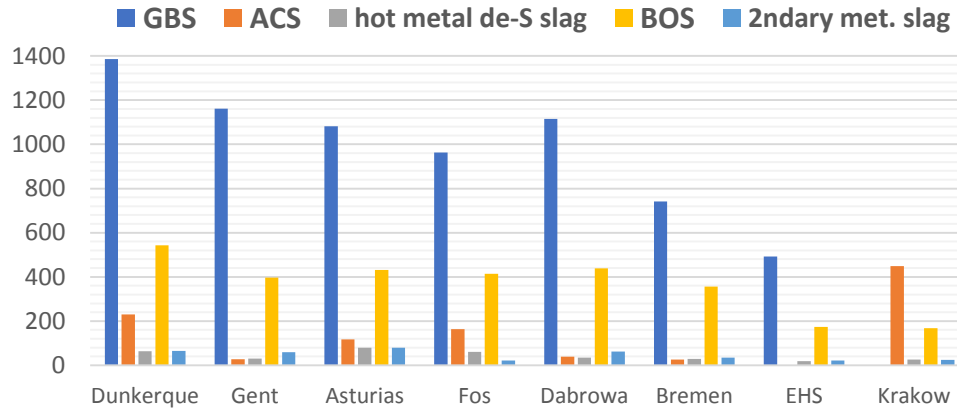


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ArcelorMittal Europe*: slag production

Slag production 2018 - BF route (kt)

* Excludes divestments and acquisitions over 2018

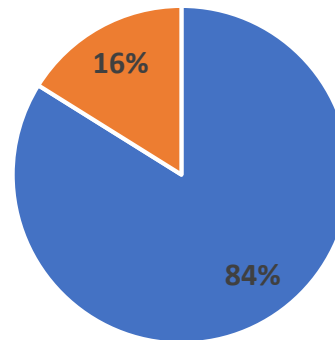
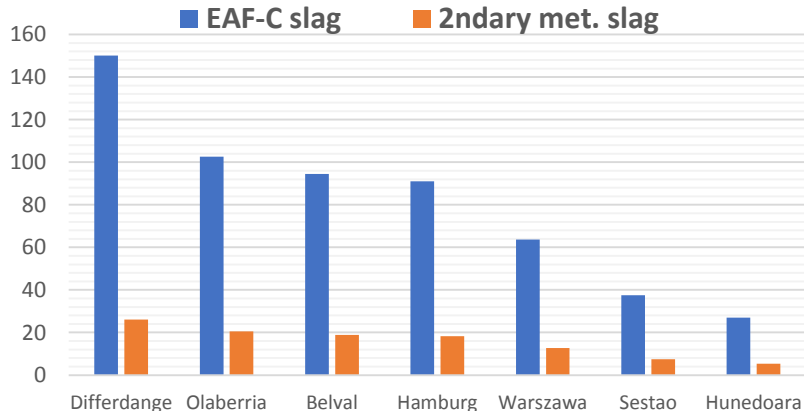


BF route	Mt
GBS	6.9
ACS	1.1
de-S slag	0.3
BOS	3.1
SMS	0.4
Total	11.8



Grand Total = 12.4 Mt

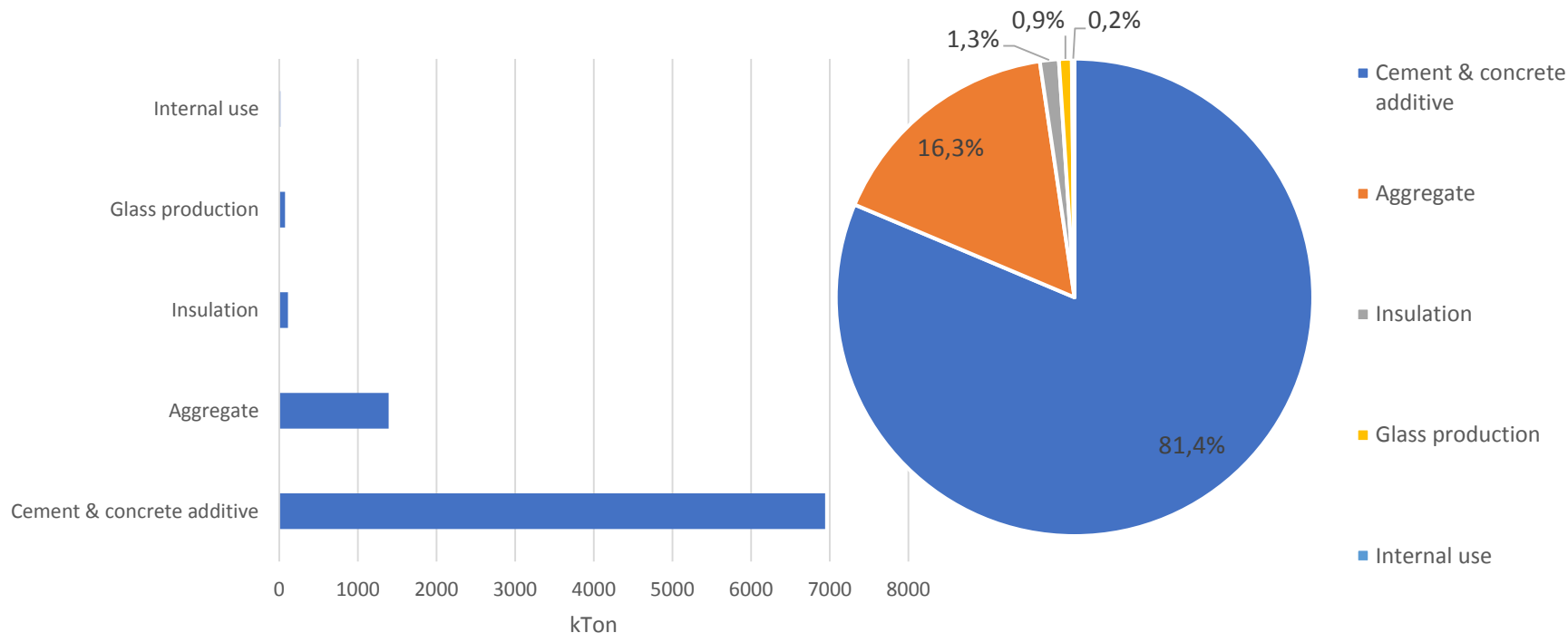
Slag production 2018, EAF-C route (kt)



EAF-C	kt
EAF slag	567
SMS	109
Total	676



Blast Furnace slag usages (GBS+ABS)

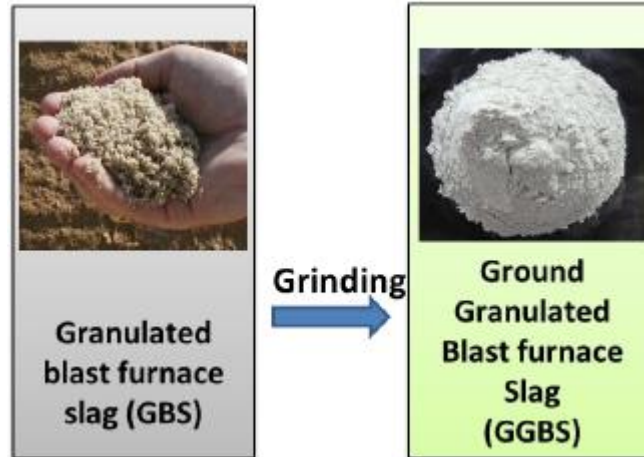


The production (2018) is valorized 100%



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ArcelorMittal & ECOCEM: producing & marketing Ground Granulated Blast furnace Slag (GBS)



- GBS has unique properties versus clinker:
 - Resistance against sulfates and chlorides
 - Lower contraction
 - Higher long term strength: 40 Mpa after 1 year
 - White colour
- ECOCEM France: JV 49% ArcelorMittal + 51% Ecocem Ltd (Ireland)
 - Over 500 kt production in Fos and the same in Dunkerque

GBS properties offer a panel of novelties



Shotcrete for tunnels

50 to 75% GBS → high durability



Liquid screed

Low contraction rate 200 µm/m



Treatment of dredging sludge

Heavy metals stabilization



Tile adhesive

Up to 70% GBS: low CO2 product



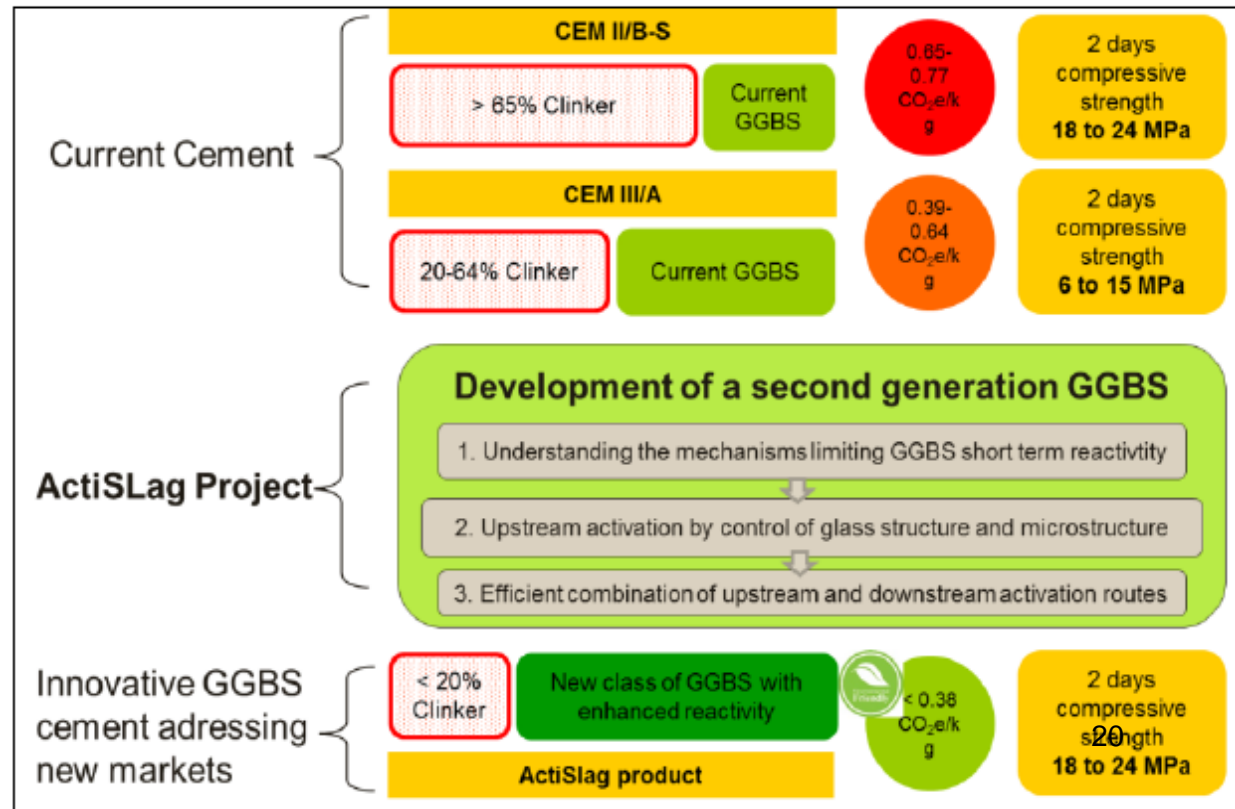


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“Actislag”: making GBS even more attractive

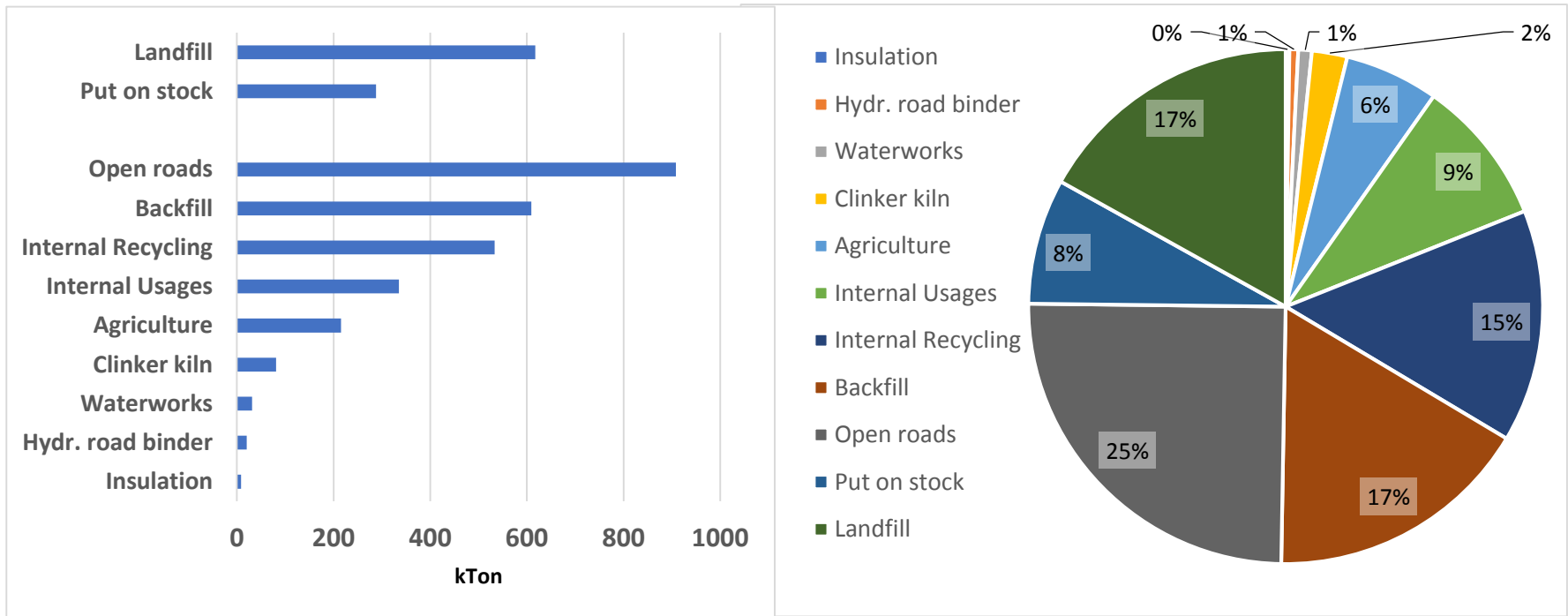
- GBS demonstrates a lower reactivity in comparison with clinker;
- An international RFCS project started in July 2017, with the objectives to understand the mechanism and develop solutions to raise GBS reactivity;

Actislag Project Structure



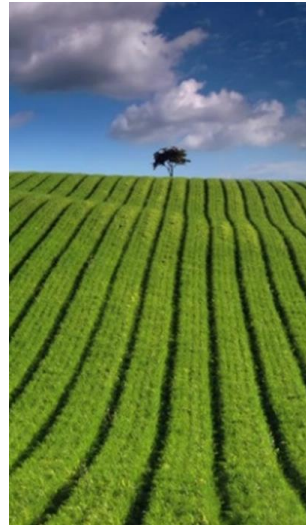
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Basic Oxygen Furnace slag: remaining potential



The production (2018) is valorized for 83%

How much value is being created?





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New BOF slag applications

BOS filters against
acidification of rain &
groundwater

High efficiency
Save limestone
and CO₂



Suitability BOS for windmills
ballasting demonstrated

**Preserve resources of
high density natural
stone (olivine)**

ballast

Best practices in Europe

“Vérité en deça des Pyrénées, erreur au delà”

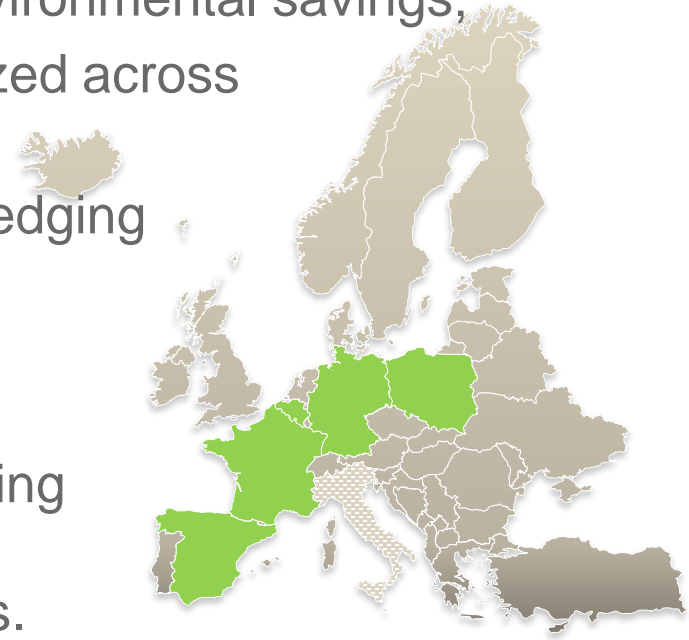
(What holds true on one side of the Pyrenees may be false on the other)



- Already in 1670 the famous philosophe Blaise Pascal describes how relative the laws are.
- 350 years later one can still agree with him as legal status and norms are not harmonized! As a global player in Europe, we are facing it.

Regional perspective on BF slags

- Blast furnace slags can be offered as higher value products in the market with granulation maximizing the environmental savings;
- Even without the legal status fully harmonized across Europe, 100% valorization occurs;
- Extensive use in national projects acknowledging the specific properties of GBS:
e.g. Netherlands, “Delta” water works
e.g. France, “Grand Paris” tunnels
- Investment on-going in expanding granulating capacity and optimizing the technical performance for wider range of applications.



Regional discrepancies in valorization **BOF** slags

- Even several “fill” applications cannot assure that all of the BOF slags generated are valorized;
- Member states apply different legal status, incentives and technical limits in existing applications:
 - Public bidding: shall promote slags, not exclude them.
E.g. Positively, NL/BE use amour stone for water works.
 - Technical limits: Fertilizer (Cr) , Road stone (swelling)
 - Transport cost remains an issue;
- Commercial development of new applications:
 - Ballast for off-shore windmill towers: not yet taking off
- Investment in development new/existing applications.
E.g. Steam box treatment (Harsco): swelling -30% & dust abatement



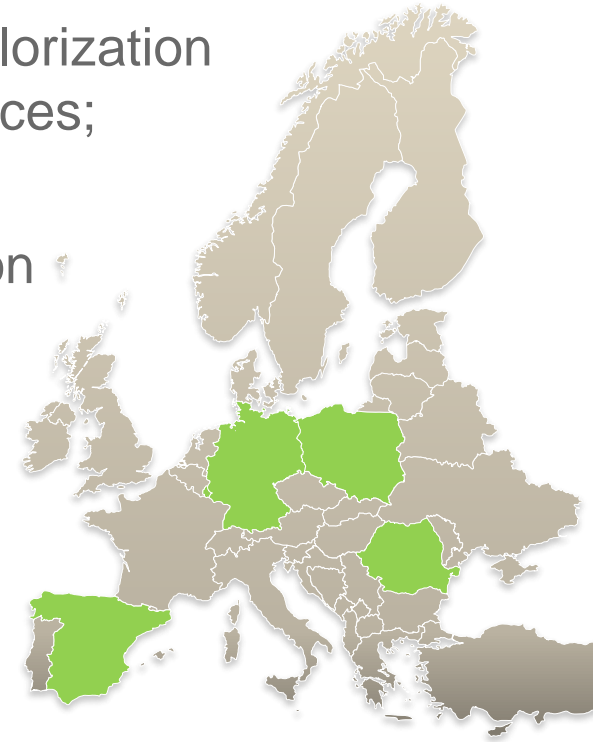
Fertilizer

Country	AM production: BOF slag+SMS	AM sales as fertilizer	Regulation
BE	456 kt	0	Regulation for slag exists Size < 340µm Cr: total Cr <125ppm
DE	748 kt	190	Regulation for slag exists Size < 3.15mm Cr6 limit < 2ppm SMS from EAF route: OK Mix BOF + SMS: OK
ES	532 kt	0	No regulation for slag as fertilizer
FR	1 044 kt	43	Regulation for slag exists Size < 630µm --> only ground slag Cr6 limit < 4 ppm Slag from EAF route: no! SMS: no!
LU	45 kt	0	Regulation for fertilizer applicable
PL	706 kt	0	Regulation for fertilizer applicable Size < 2 mm

Even though the volumes sold are driven by the market demand, they are also largely influenced by the regulations in place.

Regional perspective on EAF C- slag

- EAF C- slags represent a minor share of total amount of slags generated by ArcelorMittal.
- No specific regulatory roadblocks preventing valorization in the member states where ArcelorMittal produces;
- EAF SMS: its powdery nature makes valorization more challenging. R&D work ongoing.



Conclusions: tapping the full potential

1. Important **CO2 emission and resource savings** can be **realized today** if public authorities assure optimized use of the higher added value by-products already produced;
 - GBS is a main by-product of iron making process that offers significant CO2 emission savings and tailoring of technical properties.
2. Green public procurement (GPP) criteria aimed at valorization of by-products should **evolve from voluntary into mandatory framework**, equally supporting uptake of by-products with a more limited added value or special technical properties;
 - Voluntary GPP criteria - e.g. for BOS in road construction - result in only partial valorization of BOS today. Assure BOS use is included as option in specifications and a 'circular assessment' indicator e.g. "% of secondary material" and "% of by-product" ;
3. Harmonize **technical criteria based on science** and ensure market trust. Prevent emergence of market barriers from standardization, a process that can be dominated by incumbent market actors.
 - GBS as addition in concrete: max content in France < 30% vs UK: unlimited ...;
 - Ground BOS in cement/concrete (China); Fertilizer (CrVI or Cr total limit), Aggregate (swelling limit),
4. Producers to ensure **dedicated organizational support** for the valorization of by-products. E.g. ArcelorMittal has central unit to implement best practices and R&D resources:
 - Slag segregation and characterization: defer from internal/external landfill
 - Guidance on correct use: prevent reputational damage due to accidental inappropriate operational procedures;
 - Association support: e.g. FEhS (DE), CTPL (FR), Unisid (ES)

Thank you for your interest !

Further questions?

Contact:

Jan Bollen | Manager
Environmental aspects of products
ArcelorMittal Europe
Environmental & Climate Change affairs

Keizerinlaan, 66 | B-1000 Brussels
T +32 2 700 94 92 | M +32 495 53 28 61

