# Sustainable steel sheet piles

St.

ArcelorMittal Sheet Piling – Luxembourg November 2021



11 ....





Permanent: Quay wall | Gdansk | Poland



Temporary: Tunnel | Kérino | France

steel sheet piles can be re-used several times before being recycled



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### Circular economy

KE	DU	JCE

1970 - 2020 build same structure with **50%** less steel

# REUSE

rental (temporary applications)sales with buy-back option

• sales of second hand

## RECYCLE

steel is **100%** recyclable & ssp out of **100%** recycled steel

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Steel sheet piling. Historical overview

First hot rolled steel sheet pile in USA: Lackawana type, 1908.





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### REDUCE. Gain in efficiency – optimized shape





		W <sub>el</sub> (cm³/m)	mass (kg/m²)	∆ mass (%)
2008	AZ 26-700-0.5	2 515	141.8	
2015	AZ 25-800	2 500	128.2	-10%
1950's	BZ IIR	1 370	140.0	
2010's	AZ 14-770	1 355	103.2	-26%

 $W_{el}$ : elastic section modulus



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### REDUCE. Gain in efficiency - steel grade



Steel grades

use of high steel grades can save up to 30% of steel

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### Life Cycle Assessment (LCA). Definition & principle

"Analysis of the potential environmental burdens of a product or service in its production, use phase and disposal (end of life)." [ISO standard]



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### Life Cycle Assessment (LCA) & Environmental Product Declaration (EPD)

- EPD = independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products (EN 15804 and ISO 14025)
- does not imply that the declared product is environmentally superior to alternatives
- different modules



Module A



### Life Cycle Assessment - Steel loop



Worldsteel methodology

Transfer part of the burdens from BOF/BF to EAF through scrap (LCI)

 $\Rightarrow$  not penalize primary route (BOF)





Impact of lifespan on scrap availability (2017)





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### Crude steel production & CO<sub>2</sub> intensity (annual report 2020)

Crude steel production by process and s	egment 2020 (000's	Mt)			
(000's Mt)	Blast oxygen furnace	Electric arc furnace	Open hearth furnace	Total crude steel	%
1 NAFTA	12,669	5,143	-	17,812	25
2 Brazil	6,134	3,406	-	9,539	13
3 Europe	28,510	5,494	—	34,004	48
4 ACIS	9,752	218	201	10,171	14
Total	57,065	14,261	201	71,527	100

The Company's key metrics above include the U.S. operations prior to its sale to Cleveland Cliffs on December 9, 2020. The U.S. operations produced 9.93 million tonnes of crude steel in 2020 predominantly from the blast oxygen furnace route.

			Performance			
Metric	Unit	2018	2019	2020		
CO2 intensity (steel)*	tCO2e/tonne of steel	2.12	2.11	2.08		
- CO <sub>2</sub> intensity (BF only)	tCO2e/tonne of steel	2.33	2.32	2.30		
– CO <sub>2</sub> intensity (EAF only)	tCO2e/tonne of steel	0.61	0.60	0.60		
% sites below Arcelor Mittal carbon efficiency benchmark	%	44	48	52		
Carbon footprint intensity improvement since 2007 (target = 8% by 2020) <sup>8</sup>	%	4.9	6.1	7.9		



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### Emissions outlook and improvements forecast





2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018

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Figure 15: carbon efficiency improvement per tonne

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- ArcelorMittal's ambition is to significantly reduce its carbon footprint by 2050 carbon neutrality.
- we are undertaking extensive research and pilot programs within our operations, as well as evaluating the opportunity from off-setting
- interim target for ArcelorMittal Europe is to reduce by 35% its carbon footprint by 2030.

More details: "Climate Action Report" published in May 2019.

https://corporate-media.arcelormittal.com/media/yw1gnzfo/climate-action-in-europe.pdf





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### Our ambition – reducing $CO_2$ emissions

Box 5: possible low-em	issions technology pathways using diffe	erent energy sources						
All technology pathw costs and require time	vays to low–emissions steelmaking e ne, investment and clean energy infr	entail higher rastructure.						
Energy sources	Low-emissions steelmaking technology pathw	ways		Incremental costs to produce stee!* (OPEX and CAPEX)	Commercial horizon	Energy infrastructure challenge	Energy technology challenge	Steel technology challenge
TI L	Water	Iron electrolysis EAF	Iron electrolysis Develop iron ore electrolysis from clean electricity	To be determined	20-30 years	Power infrastructure exists – to be expanded to accommodate steelmaking needs		Electrolysis ironmaking
Clean Power	electrolysis	H, DRI-EAF	Green hydrogen DRI Develop hydrogen-based DRI production from clean electricity	+60-90%	10-20 years	Green hydrogen economy needs to be created – can be done incrementally	Lowering green hydrogen production costs	Hydrogen ironmaking
Circular Carbon		BF-BOF	Smart carbon Produce steel with circular carbon and hydrogen, and manufacture carbon-based products from waste gases	+20-35%	5-10 years	Circular carbon and hydrogen economy expansion – can be done incrementally	Develop commercial bio-coals, bio-cokes and bio-gases for steelmaking	Commercial combined carbon and hydrogen steelmaking; upside of carbon capture and use
		H, DRI-EAF	Blue hydrogen DRI Develop hydrogen-based DRI production from reformed natural gas	+35-55%	10-20 years	Develop large commercial natural gas-based hydrogen and carbon storage projects		Hydrogen ironmaking
Fossil Fuels		DRI-EAF	DRI with carbon capture Use existing technology incorporating carbon capture and storage	+35-55%	5-10 years	Develop economy-wide commercial carbon transport and storage infrastructure		Commercial CO <sub>2</sub> capture technologies
with CCS		BF-BOF	Blast furnace with carbon capture Use existing technology incorporating carbon capture and storage	+30-50%	5-10 years	Develop economy-wide commercial carbon transport and storage infrastructure		Commercial CO <sub>2</sub> capture technologies

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### Iron production is the major source of $CO_2$ in primary steelmaking process



### H<sub>2</sub> Hamburg: reducing iron ore with hydrogen



- Technologies can be developed to replace the feedstock of natural gas in the Direct Reduced Iron (DRI) process with increasing levels of hydrogen. This can either be extracted from natural gas while the CO<sub>2</sub> is captured and stored (blue hydrogen), or through the electrolysis of water (green hydrogen).
- €65 million pilot project in Hamburg, which will produce enough hydrogen to run an experimental DRI installation (EAF) on 100% pure hydrogen, producing 100,000 tonnes of iron per year.

#### What will our roadmap to 2050 cost?

	Invest nee	Production cost increase	
	ArcelorMittal Europe steel footprint	Clean energy infrastructure	
Smart Carbon	€15-25 billion	€15-165 billion <sup>1</sup>	+30-60%1
DRI route	€30-40 billion	€40-200 billion <sup>2</sup>	+50-80%2

1 Lower end of range leveraging bioenergy and CCS infrastructure; high end of range leveraging green hydrogen infrastructure.

2 Lower end of range leveraging CCS and blue hydrogen infrastructure; high end of range leveraging green hydrogen infrastructure.



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- campaign launched by the new CEO of ArcelorMittal Europe in March 2021 at European level
- XCarb<sup>®</sup> steels with low / lower / zero CO<sub>2</sub>-eq. emissions
- use of renewable electricity / innovative processes
- for steel sheet piles produced in Luxembourg
  - EcoSheetPile<sup>™</sup> Plus steel produced with renewable electricity in the EAF with 100% of scrap







### **Technical Solutions**

- Green Hydrogen DRI
- EAF green energy
- Carbon Capture, Usage and Storage (CCUS) over 100 facilities operating / designed

•

Huge investments are required! Some are already under way...

The Daily Telegraph - 24.1.2021
Norway digs deep to tap carbon storage boom
Richard Orange
The country is leading a major Carbon capture operation to store up to 5 m tonnes of CO<sub>2</sub> per
Year. The contractors have already started dynamiting the steep rocky fjord side to make way for tanks which will in three
years start receiving the world's first deliveries of industrial CO<sub>2</sub> emissions for storage beneath the North Sea.
...
In mid-December, Norway's parliament voted to spend 16.8bn kroner (£1.5bn) on Longship, calling it "the largest-ever
climate project in Norwegian industry". This covers more than two-thirds of the total cost of developing and operating
carbon capture at two industrial plants, as well as transport and storage of the CO<sub>2</sub>. Northern Lights project, a partnership
between Equinor, Norway's majority state-owned energy company, Royal Dutch Shell, and the French oil major Total, is
responsible for the transportation and storage side. When it is fully up-and-running, the project's facility outside the city of
Bergen is expected to take shiploads of CO<sub>2</sub> from as far south as the north of Spain and as far east as Helsinki.
...

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- Sept 2021: ArcelorMittal and the EIB announce €280 million of funding for research and innovation supporting the steel company's decarbonisation objectives.
- Sept 2021: German Federal Government commits its intention to provide €55 million of funding for ArcelorMittal's Hydrogen DRI plant (total cost of the plant: €110 million)
- Sept 2021: ArcelorMittal announces that it has signed a letter of intent with the Governments of Belgium and Flanders, supporting a €1.1 billion project to build a 2.5 million-tonne direct reduced iron (DRI) plant at its site in Gent, as well as two new electric furnaces. ArcelorMittal Belgium will reduce CO<sub>2</sub> emissions by 3.9 million tonnes per year by 2030. The EAF will operate alongside its state-of-the-art blast furnace that is ready to take waste wood and plastics as a substitute for fossil carbon.
- July 2021: ArcelorMittal Sestao (Spain) to become the world's first full-scale zero carbon-emissions
  steel plant. It is the result of a memorandum of understanding signed with the Government of Spain that will
  see an investment of €1 billion in the construction of a green hydrogen direct reduced iron (DRI) plant
  at its plant in Gijón, as well as a new hybrid electric arc furnace (EAF). By 2025, the Sestao plant which
  manufactures a range of flat steel products for the automotive and construction sectors, and general industry will produce 1.6 million tonnes of zero carbon-emissions steel.



- Mar 2021: ArcelorMittal is planning to build a large-scale industrial plant for the direct reduction of iron ore (DRI) and electric arc furnace (EAF)-based steelmaking at its site in Bremen, as well as an innovative DRI pilot plant in addition to an electric arc furnace (EAF) in Eisenhüttenstadt, following the announcement of the planned expansion of Germany's hydrogen infrastructure. Using green hydrogen, up to 3.5 million tonnes of steel could be produced by 2030. Depending on the amount of hydrogen available, CO₂ savings of more than 5 million tonnes could be possible. The technology conversion requires investments in the range of €1-1.5 billion.
- Mar 2021: Air Liquide and ArcelorMittal have signed a memorandum of understanding (MoU) with the objective of implementing solutions to produce low-carbon steel in Dunkirk (FR). Goal: transform the steel production process through the development of innovative solutions involving low-carbon hydrogen and CO<sub>2</sub> capture technologies. The project will reduce yearly CO<sub>2</sub> emissions from ArcelorMittal's steel-making facilities by 2.85 Mt by 2030.
- Feb 2021: ArcelorMittal Asturias starts coke-oven gas injection for Blast Furnace B. Use of this innovative technology will result in a reduction in CO<sub>2</sub> emissions of 125,000 tonnes a year.



### Steel industry – roadmap to net-zero carbon steel



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### Steel industry - roadmap to net-zero carbon steel

Steelmaker	Percentage of 2020 global primary steel production	Interim goal	Long-term net-zero goal
hina Baowu Group	6.14%*	30% absolute emissions reduction by 2025 (from 2023 peak)	Carbon-neutral by 2050
ArcelorMittal	4.18%	Global: 25% absolute reduction by 2030; Europe: 35% absolute reduction by 2030 (2018 baseline)	Global: carbon-neutral by 2050
HBIS Group	2.33%	30% absolute emissions reduction by 2030 (from 2022 peak)	Carbon-neutral by 2050
Nippon Steel Corporation	2.21%	30% absolute emissions reductions by 2030	Climate-neutral by 2050
POSCO	2.16%	15% reduction in absolute emissions and 30% in emissions intensity by 2030	Climate-neutral by 2050
U.S. Steel Corporation	0.62%	20% emissions intensity reduction by 2030 (2018 baseline)	Carbon-neutral by 2050
Thyssenkrupp Steel Europe	0.57%	30% absolute emissions reduction by 2030 (2018 baseline)	Carbon-neutral by 2050
Tata Steel Europe	0.54%	30% to 40% absolute emissions reduction by 2030 (2018 levels)	Carbon-neutral by 2050
Voestalpine	0.38%	n/a	80% to 95% absolute emissions reduction by 2050
Liberty Steel Group	0.37%	n/a	Carbon-neutral by 2030
SSAB	0.23%	Sweden: 25% absolute emissions reduction by 2025	Global: Fossil-free by 2045
Salzgitter	0.21%	n/a	95% absolute emissions reduction by 2050 without offsets
BlueScope	0.15%	12% reduction in GHG emissions intensity by 2030 (2018 baseline)	Net-zero GHG emissions by 2050

# Companies that committed to reducing significantly their carbon footprint by 2050 and possible technologies.





excludes ongoing shandong steer dequisition

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- requires investments in the order of €30 billions per year, provided sufficient "green hydrogen" and "green electricity" is available at a reasonable price!
- relies heavily on Carbon Capture, Use & Storage (CCUS), which also needs huge investments!







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ArcelorMittal: "long products" such as **beams** & **sheet piles** manufactured in Europe are mainly produced with steel from EAF, which in the production phase ("cradle to gate") has a lower carbon footprint than BF/BOF. There are some exceptions...

Competitors offer steels from EAF and BOF/BF.

### Steel sheet piles:

- ArcelorMittal in Luxembourg: production from EAF, optionally with renewable electricity
- ArcelorMittal in Poland: production from BF/BOF
- Vitkovice (CZ): buys semi-products (slabs) from manufacturers using the BF/BOF route
- Anshan Zizhu (China): production from BF/BOF
- Nucor (USA): production from EAF

consider the production route of the crude steel (EAF vs BOF), but also the **rolling** of the beam-blanks / slabs into the finished product, **fabrication**, **productivity** and **transport** (mainly for long distances)  $\Rightarrow$  **EPDs** allow *under certain conditions* the comparison of the environmental footprint.



- independently verified and registered document that communicates transparent and comparable information about the life-cycle environmental impact of products (EN 15804 and ISO 14025)
- does not imply that the declared product is environmentally superior to alternatives
- $\Rightarrow$  environmental impact of products
- declared unit: 1 t (metric tonne)
- cradle-to-gate with options:
  - A1-A3, C3 & D
- End-of-Life scenario:
  - varies by EPD !!!
- transport (within Europe), installation & use phase ≈ negligible





EPD 'EcoSheetPiles<sup>™</sup> Plus' from ArcelorMittal (07/2021)



valid for hot rolled ssp produced by ArcelorMittal – up to S 355 GP

EAF in Differdange

fed with 100%

renewable electricity

- mix of shapes & production sites LU production of 2019
  - Belval & Differdange, LU
- manufacturing
  - − LU: EAF  $^{(1)}$  ⇒ ≈ 100% recycling, based on scrap
- End-of-Life scenario: 30% of ssp used 5 times
  - 60% recycling, 25% reuse, 15% landfill ⇒ 85% recycled
- published by the German Institute IBU
- database: Gabi

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<sup>(1)</sup> EAF: Electric Arc Furnace



### Global Warming Potential [kg CO<sub>2</sub>-eq / t]

Module(s)	EcoSheetPile™	EcoSheetPile™ Plus
Database	Gabi	Gabi
(A1 – A3)	520	370
(A1 – A3) + D	517	694
(A1 – A3)	Reference	-29%



	Global Warming Potential [kg CO <sub>2</sub> -eq / t ]						
Module(s)	EcoSheetPile™ Plus	EcoSheetPile™	Hot rolled steel sheet piles	Cold formed steel sheet piles	Hot rolled steel sheet piles (NL - 2021)		
(A1 – A3)	370	520	937	2 440	429		
(A1 – A3)	- 29 %	reference	+ 80 %	+ 369 %	- 18 %		
(A1 – A3) + D	694	517	603	760	406		
(A1 – A3) + D	+ 34 %	reference	+ 17 %	+ 47 %	- 21 %		
Year	2021	2016	2018	2019	2021		
EPD Program	IBU DE	IBU DE	IBU DE	IBU DE	MRPI Stichting NL		
Route	100% EAF 100% scrap + renewable electricity	100% EAF 100% scrap	Mix EAF / BOF (Belval / Dabrowa)	100% BOF	100% EAF 100% scrap		
Reuse / Recycling / Landfill (%)	25 / 60 / 15	25 / 74 / 1	25 / 74 / 1	2 / 97 / 1	51 / 49 / 0		
Database / Software	Gabi	Gabi	Gabi	Gabi	Ecolnvent / SimaPro		

• Differences also due to assumptions & tools: mix of mills, electricity, software, date of databases,...

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- generic EPDs / industry EPDS not forbidden per se, but can be quite misleading
- intent: compare at high level different alternatives (steel vs. concrete vs. timber), before the engineer knows which product / solution will effectively be installed / executed

### Examples

- EPD Norge Ferrometal trading Chinese ssp (published by the The Norwegian EPD Foundation
  - valid for almost any steel product manufactured in ASIA



PORT TALEN STATE

- average of steel production in ASIA (not for a specific product, nor for a specific mill, nor a specific manufacturer)
- manufacturing in Liangong, China
  - World Steel Association data for rolled steel sections (ASIA) used for A1. Recycled input (scrap) used in the study is 43%.
- NOTE: Chinese production of ssp is most probably made with Chinese BOF steel, which has even a bigger impact than steel from a European BOF.
- EPD Norge *Tibnor* trading beams from ArcelorMittal and others uses "*Histar*" EPD and adds transport from supplier in Norway to jobsite (mean value)



(wrong) communication ....

Example: Luxembourg (CR 2020)

• there are 3 scopes

direct & indirect emissions 272 kg  $CO_2$ -eq / t CS (CS = crude steel)

### • EPD EcoSheetPiles: **520** kg CO<sub>2</sub>-eq / t (of finished product !!)

Indicators	2018	2019	2020
Energy consumption (GJ/tCS) Gigajoules per tonne of crude steel (tCS: tonne Crude Steel)	8.68	8.76	8.96
The evolution is mainly related to the fact that electricity is sourced green.	-		$\frown$
CO <sub>2</sub> emissions per tonne of crude steel (kg CO <sub>2</sub> /tCS) Kilogram per tonne of crude steel (tCS: tonne Crude Steel)	300	289	272
Direct emissions (Scope 1 set by the GreenHouse Gas protocol) corresponding to the CO <sub>2</sub> directly emitted by the furnaces	179	180	186
Indirect emissions (Scope 2 set by the GreenHouse Gas protocol) corresponding to the CO <sub>2</sub> emitted to generate the energy consumed: electricity and heat (hot water, steam)	77	65	42
Other indirect emissions (Scope 3 set by the GreenHouse Gas protocol) corresponding to CO <sub>2</sub> emissions from products used in our workshops such as quicklime and industrial gases (oxygen, nitrogen)	44	44	44

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- **Norway**: tender documents for public works (i.e. BaneNor) sometimes impose a minimum recycled content (different classes), depending on the project
- **France**: environmental impact of every new building will have to be done (including maintenance, energy consumption,...), considering also the Heath and Safety of the products during the whole lifetime (Réglementation Environnementale RE2020). Postponed to 2022. The maximum threshold for a building will gradually diminish in a few phases. <u>https://www.ecologie.gouv.fr/reglementation-environnementale-re2020</u>
- **France**: some large construction companies have committed to net-zero carbon emissions in 2050 and started analysing the impact of their suppliers
- Belgium: for buildings free TOTEM tool LCA of the building based on Belgian EPDs (EN 15804 with additional impact categories) – can even import BIM models - <u>https://www.totem-building.be/</u>. Goal: help the Belgian construction sector to objectify and reduce the environmental impact of buildings.
- UK: contractors have to include Scope 3 (main contributors such as steel, concrete, asphalt,...) emissions in their environmental assessment for specific projects. The "*Environmental Agency*" already used environmental criteria.
- PEF (**Product Environmental Footprint**) will probably replace the EPDs  $\Rightarrow$  more consistency



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### Revision of standards

- Revision of EN 15804 in 2019 you need to consider Module D!
- New prEN 17662 (CEN-TC135 N1000 TC135 WG17 c-PCR enquiry 12/2020 complements EN 15804
  - better rules, more defaults values (less space for uncertainties variables), for instance for transport,...

Metal	Product	%Collected	%Collected	%Landfilled
		for reuse	for	
			recycling	
Steel [13,	Structural sections/tubes (hot rolled, welded)	11%	89%	0%
14, 15, 16]				
	Light structural steel (cold formed)	5%	93%	2%
	Internal light steel (e.g. plaster profiles, door frames)	10%	89%	1%
	Composite floor decking	10%	89%	1%
	Profile steel cladding (roof/facade)	15%	81%	4%
	Steel piles (sheet and bearing)	15%	71%	14%
	Other (e.g. stainless steel)	4%	95%	1%
	Rebar	0%	90%	10%
Aluminium	Aluminium alamante 1)	0%	06%	10/

### Table H.1: Default values for reuse, recycling and landfill for the End of life scenarios for various structural metal products

\* prEN 17662-2021: "Execution of steel structures and aluminium structures – Environmental Product Declarations - Product category rules complementary to EN 15804 for steel, iron and aluminium products for use in construction works"



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### Summary

- circular economy can help reduce the environmental impact of construction industry  $\Rightarrow$  optimization
- carbon neutrality can only be achieved through massive investments & R&D over a long period
- not only subsidies  $\Rightarrow$  cost of steel will thus increase
- short term solutions: renewable energies
- incentives through credits for lowest environmental impact such as in NL (most advantageous economical tender)
- LCAs based on specific EPDs should be preferred
- difficulty is to find a fair and transparent method for all the cases and construction products comparisons (allocations!!)
- ArcelorMittal leads the path... innovative production processes





# Thank you for your attention

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