Low Carbon Ukraine

Policy advice on low-carbon policies for Ukraine

Ukraine's Steel Sector: State of Play and Pathways to a Greener Future

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Executive Summary

- Ukraine's steel sector has traditionally been a key pillar of the economy accounting for 10% of pre-war GDP. Over 38% of production capacity has been lost due to the Russian invasion, making the reconstruction of the sector critical for Ukraine's economy.
- The sector is highly CO_2-intensive (2.3 tCO_2 per tonne of steel) due to reliance on fossil fuel-based production processes, contributing to 14.6% of national emissions in 2021.
- Transitioning to low-carbon steelmaking is vital. In the short- to medium-term, scrap-based EAF route is a viable option. This route could reduce CO_2 emissions by 43% by 2035 (9.8 $MtCO_2$ reduction) with a required capital investment of EUR 1.1-2.0 billion.
- For long-term decarbonisation, adopting H_2-DRI-EAF technology after 2030 could achieve 63% emissions reduction by 2035 (14.5 $MtCO_2$ reduction), requiring an additional EUR 2.0-5.3 billion investment for H_2-DRI capacity expansion.
- This will require a robust investment strategy and financial support mechanisms tailored to Ukraine's high-risk profile to attract funding for low-carbon steelmaking projects.

EAF: Electric Arc Furnace, DRI: Direct Reduced Iron

Contents

Low Carbon Ukraine

1. Introduction and background

- The iron and steel sector is crucial for Ukraine's economy. In 2021, it was the world's 14th largest steel producer[1] and contributed to 10% of Ukraine's gross domestic product. The Russian invasion in February 2022 destroyed 38% of Ukraine's steel production capacity.
- However, Ukraine's steel sector is highly CO_2 intensive. This creates a risk for Ukraine's economy, especially as the EU's Carbon Border Adjustment Mechanism (CBAM) could lead to annual EBITDA losses of up to EUR 248 million in the iron and steel sector from 2026 to 2030.[3]
- Given these factors, prioritising investments in low-carbon steelmaking technologies that support a long-term decarbonisation strategy is crucial to rebuilding the sector's destroyed capacity.
- Ukraine's significant renewable energy generation potential, high-quality iron ore reserves near its steel plants, and strategic location near European green steel markets may all act as enablers to the transition to low-carbon steelmaking.
- This policy brief reviews the state of play in Ukraine's steel sector, examines its decarbonisation potential, and proposes strategies to address existing challenges as well as pathways for future decarbonisation.

[1] Worldsteel (2022). (Link)
[2] Reuters (2023). (Link)
[3] Kyiv School of Economics (2021). (Link)

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2. Ukraine's steel production capacity (1/3)

- Ukrainian steel production relies on fossil fuel-based and highly CO_2 intensive BF-BOF and BF-OHF routes with 22.1 Mtpa and 4.1 Mtpa pre-war capacities, respectively.
- In contrast, Electric Arc Furnace (EAF) steelmaking, which uses electricity and scrap instead of fossil fuels and is 70% less CO_2 intensive compared to BF-BOF route, accounts only for 2.3 Mt of production capacity.

Plant	*Production route**	*Nominal steel capacity (Mtpa)*	*Steel production (Mtpa)*				
			2020	*2021*	*2022*	*2023*	*2024 H1*
Azovstal Iron and Steel (Metinvest)**	BF-BOF	6.6	4.2	4.3	0.6	0.0	0.0
Dnipro Metallurgical Plant (DCH)	BF-BOF	1.2	0.2	0.3	0.0	0.0	0.0
Dniprospetstaal Zaporizhzhia	EAF	1.0	0.3	0.2	0.1	unknown	unknown
Ilyich Iron and Steel (Metinvest)**	BF-BOF	4.3	4.1	4.3	0.7	0.0	0.0
Interpipe Steel Dnipro	EAF	1.3	0.8	1.0	0.6	0.5	0.4
Kametstal (Metinvest)	BF-BOF	3.5	2.6	1.0	1.5	2.0	1.0
Kryvyi Rih (ArcelorMittal)	BF-BOF	6.5	4.7	4.9	1.2	1.0	0.7
Zaporizhstal (Metinvest)	BF-OHF	4.1	3.8	3.8	1.5	2.5	1.5
Total production, Mtpa (Company reports)			20.5	19.7	6.1	6.0	3.7
Total production, Mtpa (State Statistics Service of Ukraine) [4]			**20.6**	**21.4**	**6.3**	**6.2**	**3.7**

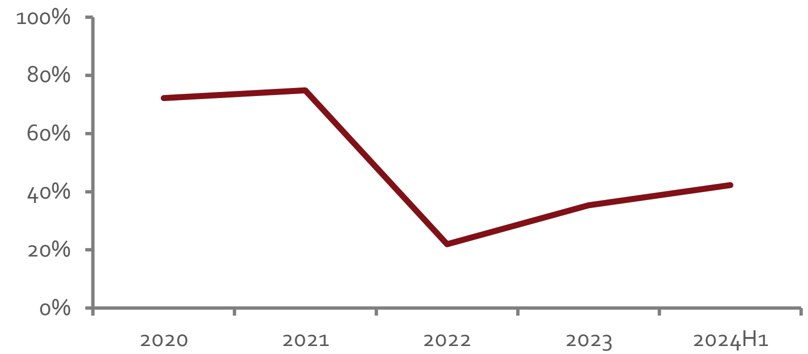
[4] In order to have a full account of the distribution of production between assets, production routes, and impact of war on total capacity, we traced back production amounts to each plant via various company and sectoral reports, which for some were unavailable. So, the difference between the official State Statistics Service of Ukraine data and the aggregate of company reports could be due to the differences in reporting methodology or unavailable information.

* BF: Blast Furnace; BOF: Basic Oxygen Furnace; OHF: Open Hearth Furnace; EAF: Electric Arc Furnace
** Plants fully destroyed, occupied, or retired due to damages.

2. Ukraine's steel production capacity (2/3)

- Prior to war, Ukraine's steel sector had 28.5 Mt nominal production capacity.
- Ukrainian steelmakers operated at 75% capacity before the war, which plummeted to 22% after 2022 due to:
  - Destruction of Azovstal plant, and damages to and occupation of Ilyich plant (represented 38% of Ukraine's total production capacity, total estimated damage EUR 3.9 billion[4]).
  - Security risks, logistical challenges, energy and labor shortages.
- Utilisation rate recovered to 42% in 2024 but still well below pre-war levels.

Ukraine steel sector capacity utilisation, %



Source: Global Energy Monitor, company reports. Author's calculations.

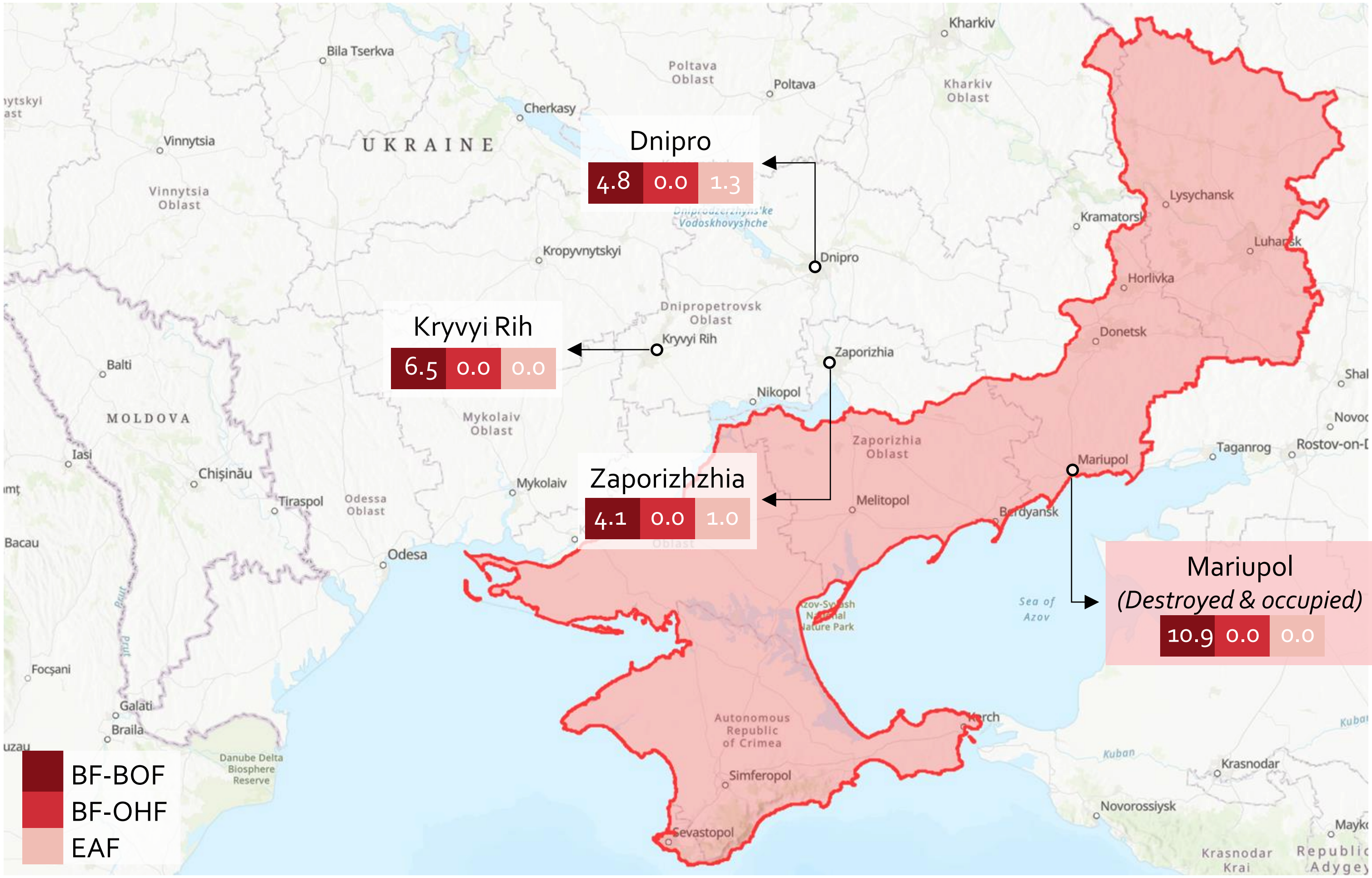
Nominal steel capacity lost due to destruction

Plant Name	*Nominal capacity lost (Mtpa)*	*Share within Ukraine's total capacity*
Azovstal Iron and Steel Works	6.6	23%
Ilyich Iron and Steel Works	4.3	15%
Total	**10.9**	**38%**

Source: Global Energy Monitor, company reports. Author's calculations.

[4] Ukraine Third Rapid Damage and Needs Assessment (RDNA3). February 2024, the World Bank, the Government of Ukraine, the European Union, the United Nations. Amount converted from USD to EUR.

2. Ukraine's steel production capacity (3/3)



Source: Map captured from ISW (10:00 CET, 23 October 2024). Global Energy Monitor, company reports.

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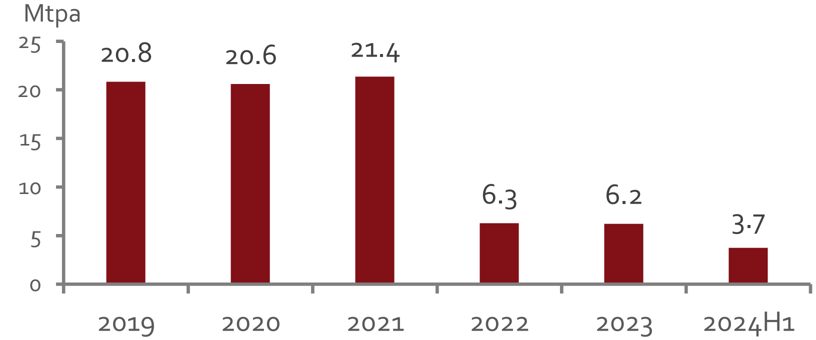
3. Ukraine's steel output and production routes (1/2)

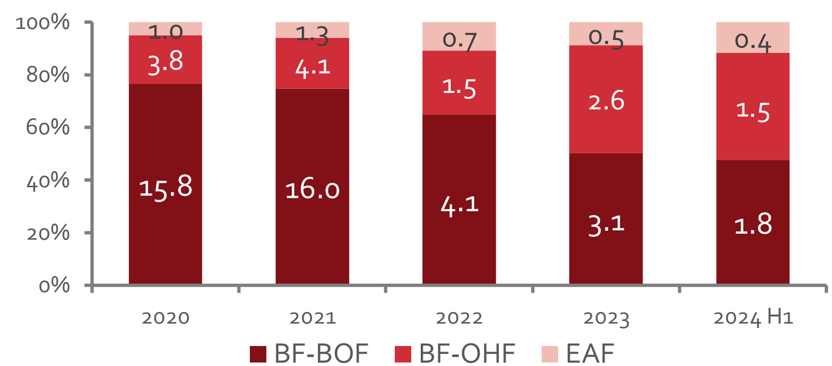
- Before the war, from 2019 to 2021, Ukraine's crude steel production exceeded 20 million tonnes annually.
- In 2022, following the Russian invasion, production plummeted by 71% to 6.3 Mtpa.
- By the first half of 2024 the steel sector gradually recovered but still is far below pre-war levels.
- Production relies on CO_2 intensive fossil-fuel-based BF-BOF and BF-OHF routes, with one of the highest shares globally.
- These are still the dominant steelmaking routes. Share of EAF production was increasing only due to the loss of BF-BOF assets due to war.

Ukraine crude steel production, Mtpa



Source: State Statistics Service of Ukraine, NIR (2023).

Ukraine steel production by route, Mtpa

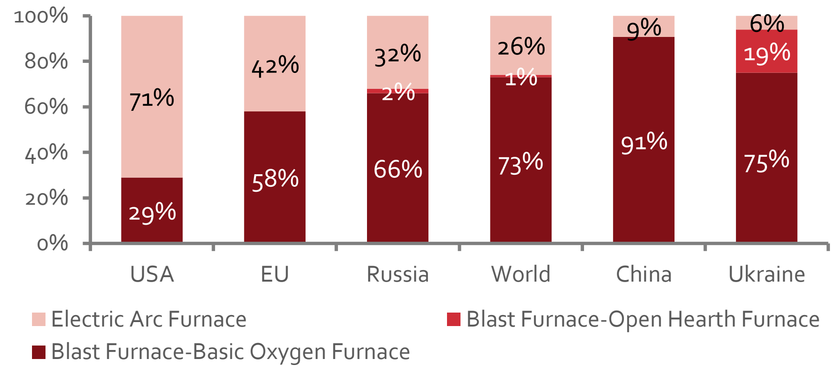


Source: State Statistics Service of Ukraine, NIR (2023). Author's calculations.

3. Ukraine's steel output and production routes (2/2)

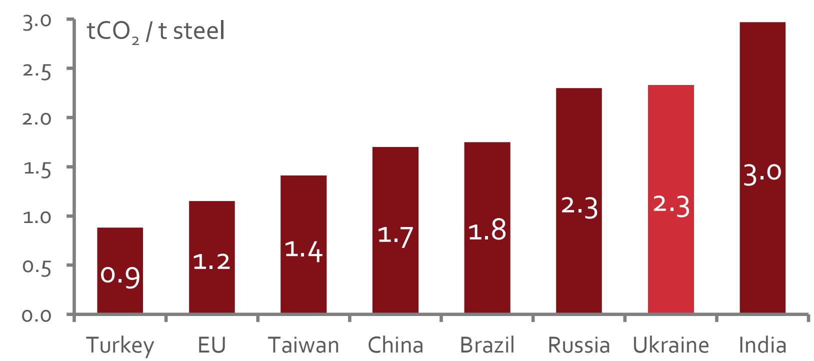
- Before the war in 2021, 94% of Ukraine's steel production relied on fossil fuel-based BF-BOF and BF-OHF steelmaking routes.
- This results in a CO_2 intensity higher than the European average (2.3 tCO_2 / t steel vs 1.2 t CO_2 / t steel).
- Although China also has one of the highest shares of BF-BOF steelmaking globally, it avoids reliance on the more polluting BF-OHF route, resulting in a lower CO_2 intensity than Ukraine.
- In 2021, European steel sector accounted for 7.6% of total emissions in the region, while Ukrainian steel sector accounted for 14.6% (49.8 $MtCO_2$ emitted).

Steel production technological shares, %



Source: Narivskiy et. al. (2022) (Link)

Steel production CO_2 intensity by country



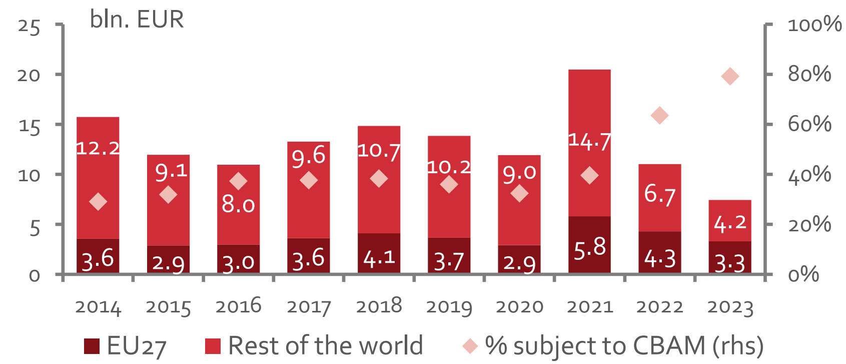
Source: JRC (2022)[5], NIR (2023). Author's calculations.

[5] Koolen, D. and Vidovic, D., Greenhouse gas intensities of the EU steel industry and its trading partners, EUR 31112 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-53417-4 (online), doi:10.2760/170198 (online), JRC129297.

4. Implications of Carbon Border Adjustment Mechanism (CBAM)

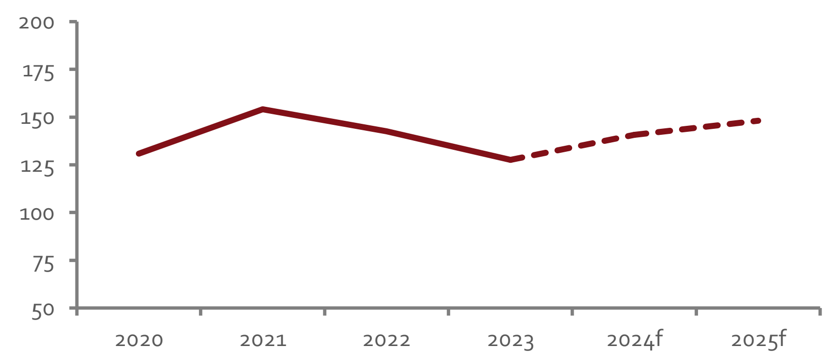
- Despite a sharp drop in exports to rest of the world, Ukraine's iron and steel exports to Europe have remained stable.
- In 2023, 79% of Ukraine's iron and steel exports were subject to CBAM, up from 40% in 2021, due to reduced trade elsewhere.
- Although demand for steel in Europe is currently low, it is expected to recover in the coming years.
- CBAM payments starting in 2026 will make CO_2 intensive Ukrainian steel products less attractive in Europe.
- With CBAM payments starting in 2026, Ukraine should invest in low-carbon steelmaking to remain competitive in the European market.

Ukraine's export of iron and steel products



Source: UN Comtrade data. Author's calculations.

Europe steel demand forecast, Mtpa



Source: worldsteel (2024).

5. Potential decarbonisation pathways (1/3)

- While various green steel technologies exist, the options listed below are the most viable in the short to medium term. Among them, the scrap-based EAF route stands out with technological maturity, low CO_2 intensity, and lower CAPEX.

Technology	CO_2 Intensity [6]	CAPEX (EUR / t steel) [7]	Technology Readiness Level	Considerations
Blast furnace relining	1.7-2.3	48	TRL 9 Market uptake	No CO_2 abatement, lock-in risk, delays transition to low-carbon technologies
EAF (100% scrap)	0.3	254-467	TRL 9 Market uptake	Scrap and electricity availability; but net-zero if renewable electricity
Natural Gas DRI-EAF	1.4	592-751	TRL 9 Market uptake	Fossil fuel dependency, low CO_2 reduction potential
H_2 DRI-EAF	0.05	886-1600	TRL 5-8 Prototype & demonstration	High costs, requires infrastructure, green-H_2 availability

DRI: Direct Reduced Iron

[6] IEEFA(2022) (Link), Agora Energiewende (2020) (Link).

[7] Adopted from Vogl et. al. (2018) (Link) and DIW (2024) (Link). The low and high range are the medians of the amounts from literature and announced green steel projects. CAPEX of H_2 DRI-EAF technology includes the cost of electrolyser.

5. Potential decarbonisation pathways (2/3)

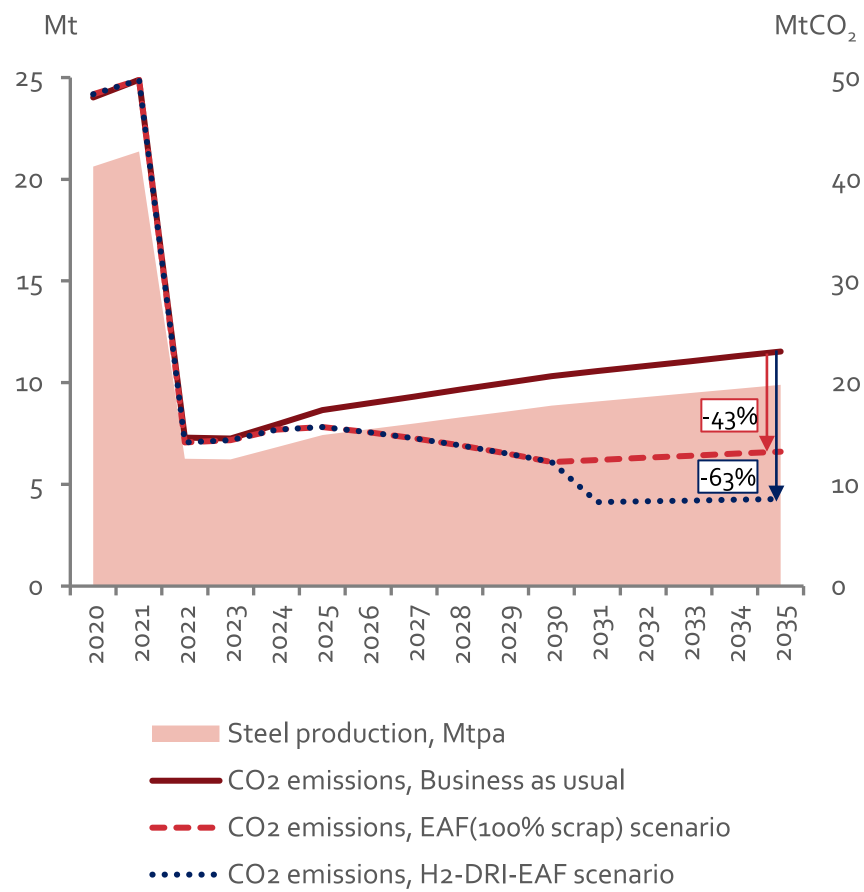
- Retrofits to traditional production routes (e.g. Blast Furnace relining) might seem preferable in the short term, but it should be avoided to prevent lock-in risks and delaying the adoption of low-carbon technologies.
- Best option in the short- to medium-term is the scrap-based EAF route. It is a mature technology with lower CAPEX, 70% less CO_2 intensive than the BF-BOF route, and can be net-zero if renewable electricity is used. Resolving Ukraine's current electricity deficit and a steady supply of scrap are important pre-requisites to the rollout of EAF capacity.
- Another option is to implement DRI technologies capable of flexibly transitioning from natural gas to hydrogen as soon as cheap hydrogen becomes available in sufficient quantities. The risk lies in dependence on natural gas if affordable hydrogen does not become available soon.
- Long-term option: Shift towards H_2 DRI-EAF. Currently very expensive and under development. If business case improves and renewable hydrogen becomes largely available, it offers near-zero emissions (0.05 tCO_2 / t steel[8]). It could also leverage Ukraine's renewable energy potential for using locally produced green hydrogen.

[8] Agora Energiewende and Wuppertal Institut, (2019), "Klimaneutrale Industrie: Schlüsseltechnologien und Politikoptionen für Stahl, Chemie und Zement"

5. Potential decarbonisation pathways (3/3)

- Two low-carbon steel transition scenarios were modeled: increasing steel production with either new scrap-based EAFs or, after 2030, with H_2-DRI-EAF capacity.
- Transitioning to scrap-based EAF route could cut CO_2 emissions by 43% by 2035, achieving a reduction of 9.8 $MtCO_2$.
  - This would require a capital investment of EUR 1.1-2.0 billion.
- Introducing the H_2-DRI-EAF route after 2030 could raise emission reductions to 63% by 2035 (14.5 $MtCO_2$ reduction).
  - This would require an additional EUR 2.0-5.3 billion for H_2-DRI capacity expansion.

Steel sector production and CO_2 emissions forecast



Source: NECP, State Statistics Service of Ukraine, NIR. Author's calculations.

6. Recommendations

- Ukraine needs to establish a clear timeline for shifting from fossil fuel-based production to low-carbon steelmaking technologies.
- The rollout of low-carbon steelmaking technologies should be incorporated into the larger national strategies such as the National Energy and Climate Plan (NECP).
- Investing in activities that prolong the operation of traditional blast furnaces, such as Blast Furnace relining, should not be prioritized to decrease the lock-in risks.
- Instead, investments in mature low-carbon steelmaking technologies should be prioritised. Electric Arc Furnace (EAF)–based production routes are a proven method for producing low-carbon steel, contingent on a stable security situation and a reliable supply of electricity and scrap materials.
- Due to Ukraine's high-risk profile from the ongoing war, investment conditions have to be improved through financial support mechanisms, including de-risking policies such as investment guarantees and political risk insurance. This would help steelmakers secure financing for CO_2 emissions reduction projects.

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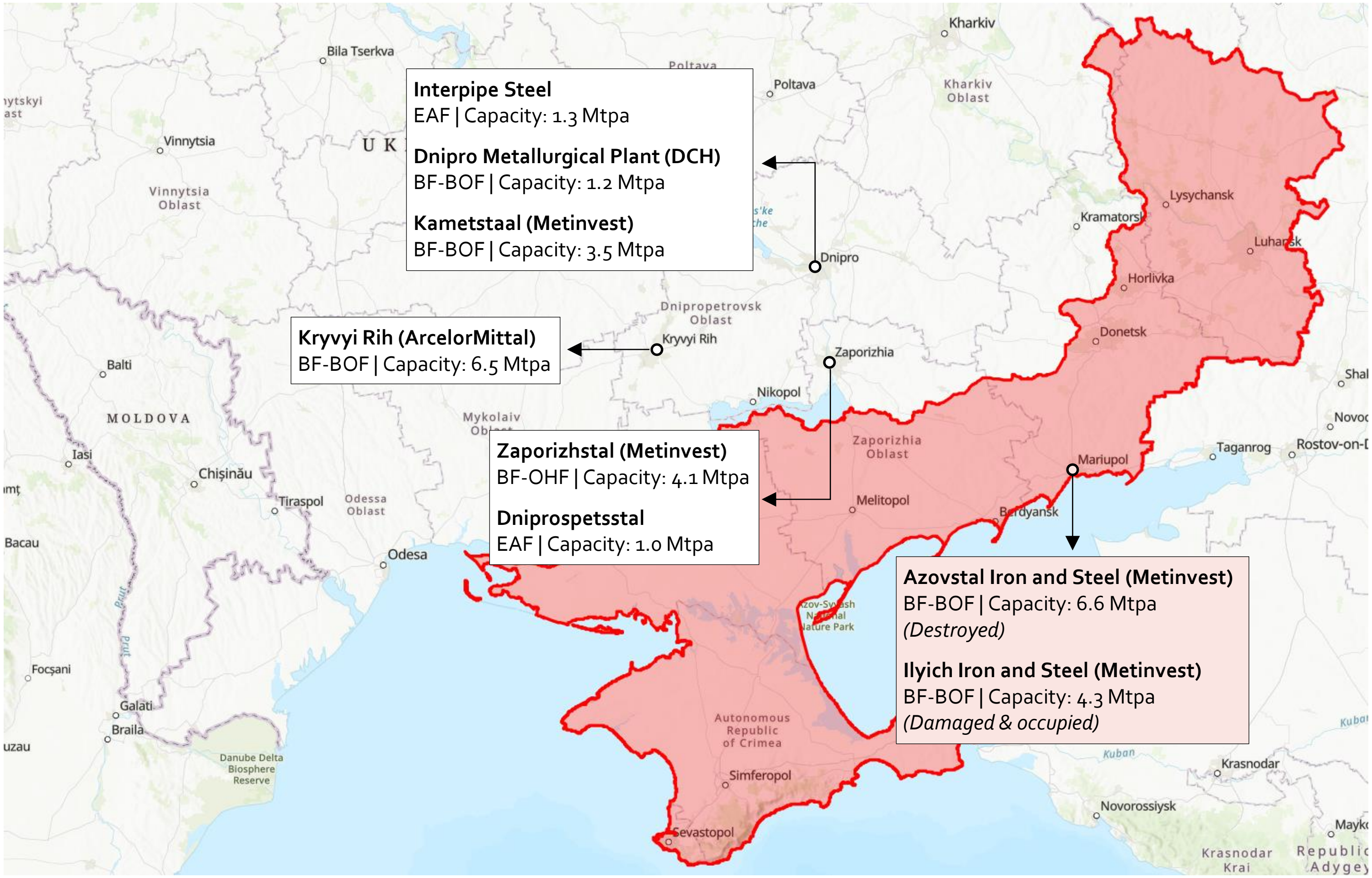
Annex: Map of Ukrainian steel plants



Source: Map captured from ISW (10:00 CET, 23 October 2024). Global Energy Monitor, company reports.