The Sustainable STEEL Principles: Differentiating Between Primary and Secondary Steel Production

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Key Takeaways

- The carbon intensity of steelmaking varies by technology type and the metallic inputs used.
- Primary steel production is significantly more carbon-intensive than secondary steel production, since it uses largely metallurgical coal to reduce iron ore.
- Utilizing a single global steel carbon budget to measure the sector's emissions could incentivize steel producers to increase the utilization of scrap as a decarbonization strategy. However, since global scrap availability is limited, this strategy could result in the reshuffling, rather than reduction in the sector's overall emissions.
- Instead, the Sustainable STEEL Principles separate the sector carbon budget into decarbonization scenarios for primary and secondary steel. This shifts the focus to transitioning primary steel production, leading to the adoption of clean end-state technologies for steelmaking.
- This approach reflects the market realities of the sector and equips the sector's lenders with the insights they need to support the climate alignment of their steel lending portfolios.

I. Approach

To measure the alignment of a steelmaker's emissions compared to climate targets, the methodology of the Sustainable STEEL Principles splits the global steel carbon budget for primary and secondary steel production. This results in separate abatement scenarios for both sources of steel, rather than a single emissions reduction benchmark for the sector.[1]

II. Rationale

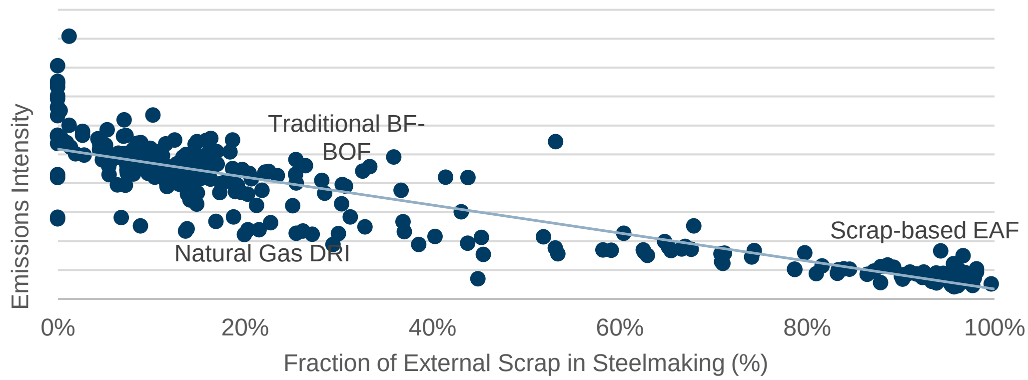
The carbon intensity of steelmaking varies by technology and inputs used.

Today, the majority of steel is produced via two main technologies: the Blast Furnace-Basic Oxygen Furnace (BF-BOF) and the Electric Arc Furnace (EAF). BF-BOF and EAF are often used as proxies for primary (i.e., steel made from iron ore) and secondary (i.e., steel made from scrap) steel production; however, these and other steelmaking processes (e.g., Direct Reduced Iron (DRI)) can vary in the mix of primary and secondary inputs used.

Steelmakers use fossil fuels—largely metallurgical coal—to reduce iron ore for primary steel production, and as a result, it is much more carbon-intensive than secondary production (Figure 1). Consequently, BF-BOF and DRI-based steelmaking produces 94% of the sector's emissions (Figure 2).

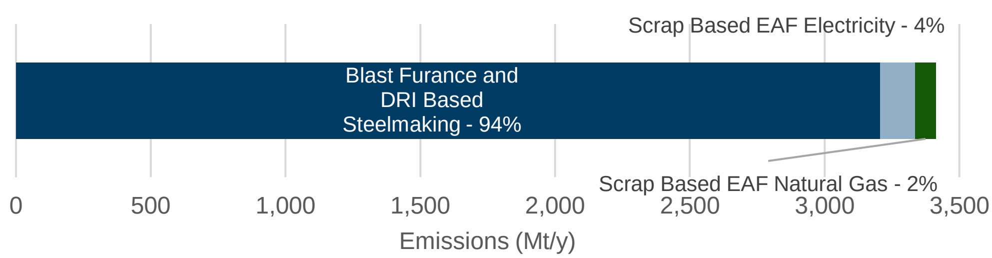
[1] This approach is based in part on the recommendations of the Net Zero Steel Pathway Methodology Project (NZSPMP).

Figure 1. Global emissions intensity of steelmaking by technology and input mix



Sources: ResponsibleSteel and CRU Steel Cost Model and Emissions Analysis Tool

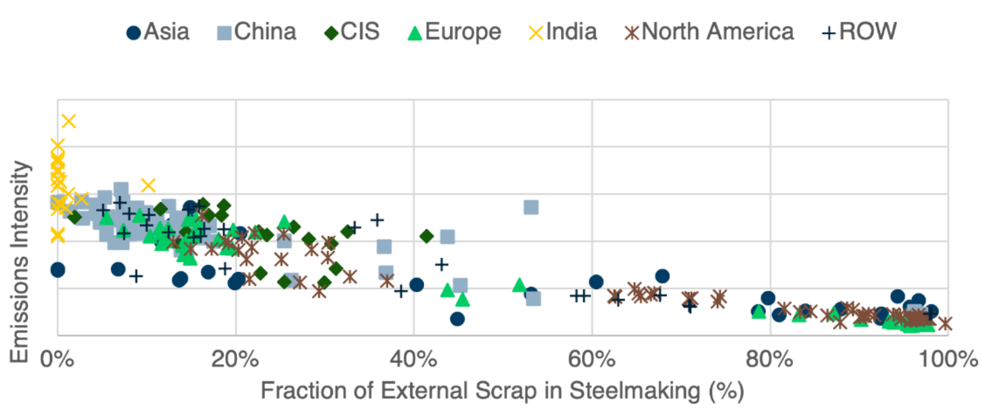
Figure 2. Global steelmaking emissions by technology



Source: Mission Possible Partnership, "Net-Zero Steel Sector Transition Strategy," October 2021

Additionally, scrap use differs by region, resulting in a large disparity in emissions intensity between various geographies (Figure 3).

Figure 3. Global emissions intensity of steelmaking by region and input mix



Sources: ResponsibleSteel and CRU Steel Cost Model and Emissions Analysis Tool
Note: CRU's cost model includes calculations of all major global mills but does not include all existing steel mills, which may have different characteristics.

A separate decarbonization scenario for primary and secondary steel production ensures that efforts focus on transforming primary production.

Given that secondary steel production emits a fraction of the emissions of primary production, a single emissions intensity scenario for steel would incentivize steelmakers to increase the use of scrap to reduce emissions. The ability to reduce the sector's emissions through increasing secondary production alone, however, is constrained as global scrap availability is limited (see Box 1).

Scrap availability depends on existing buildings, vehicles, and other infrastructure and equipment reaching the end of their life cycle. Today, only about 30% of global steel demand can be satisfied by secondary sources, and projections indicate that primary production will remain the main source of new steel into 2050. Under the International Energy Agency's Net Zero by 2050 Scenario (IEA NZE), for example, scrap as a share of inputs in steelmaking only reaches 46% in 2050.[i]

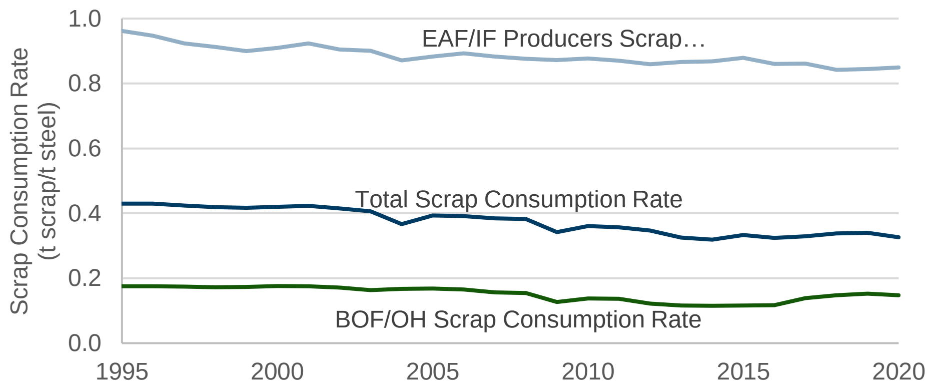
In this context, an approach focused largely on incentivizing the use of scrap may result in scrap flowing to the regions of highest demand, thereby redistributing, rather than reducing, overall emissions. While any individual steel company might be able to rely on scrap-based production to decrease its emissions, primary steelmaking would continue to produce most of the sector's emissions.[ii]

Box 1. Why is steel scrap availability limited?

In the last quarter century, as urban centers have been built in China and elsewhere, a huge amount of iron has been converted to steel. So why is there not enough scrap to meet global demand for steel?

The answer is that much of this potential secondary material is tied up in existing infrastructure. To satisfy demand for scrap on the scale needed, recovery and processing would have to increase to an unprecedented scale. As an example, if all steelmaking today were to use as much scrap as the EAF and Induction Furnace (IF) segment, the steel industry would require an additional 900 million tons of scrap, above the 600 million tons it currently consumes (Figure 4).

Figure 4. Scrap consumption rates by technology (1995-2020)



Source: CRU https://www2.crugroup.com/EmissionsAnalysisTool

Note: Steel is defined as carbon steel (i.e., excluding stainless steel)

To increase scrap supply at this scale, processors and suppliers would need strong incentives, including a sharp rise in the effective price of scrap. To maintain the incentive to utilize scrap, despite higher input costs, the steel price would also have to rise, or governments could intervene to bridge the gap.

Ultimately, however, best available modeling, including from the IEA and the Mission Possible Partnership (MPP), maintain that there is not sufficient scrap to meet all demand for steel by 2050. The scale of transformation needed to decarbonize the steel sector will thus require a framework for emissions reductions that promotes scrap use, as well as other competing and complementary solutions.

III. Defining the decarbonization scenarios for primary and secondary steel production

To determine the decarbonization scenarios, the total carbon budget[2] for the sector was split between emissions from primary and emissions from secondary steel production, using the following approach:

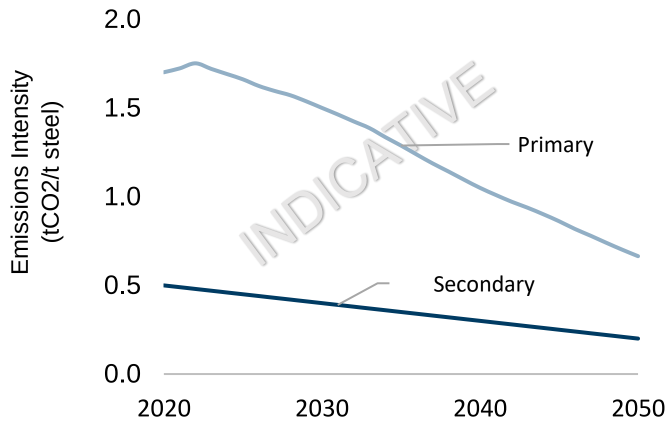
1. The fraction of steel production from primary and secondary inputs was determined using data from the MPP Steel Sector Transition Strategy. This required identifying the share of external scrap, as opposed to other metallics by weight.

[2] Derived from IEA's NZE scenario (International Energy Agency, Net Zero by 2050, IEA, 2021) and the Mission Possible Partnership's Steel Sector Transition Strategy (Mission Possible Partnership, "Net-Zero Steel Sector Transition Strategy," October 2021). Please refer to the "Sustainable STEEL Principles: An Alignment Zone Approach" for further details on the scenarios serving as benchmarks in the Sustainable STEEL Principles.

2. The emissions intensity benchmark for secondary steel production was established at above average emissions of EAF producers, using data from scrap-based EAF emissions.
3. The remaining portion of the sectoral carbon budget was allocated to primary steel production.

This approach results in separate decarbonization scenarios for primary and secondary steel (Figure 5), which are used by the Signatories to the Sustainable STEEL Principles to determine the alignment of their steel lending portfolios.

Figure 5. Indicative decarbonization scenarios for primary and secondary steel production



Source: RMI elaborations

The split scenario approach creates tradeoffs, which can be managed in time by the Sustainable STEEL Principles Association.

Tradeoff 1: The sector's carbon budget is less stringent for secondary steel production

- This methodology allocates a smaller portion of the carbon budget to primary production, resulting in a more ambitious primary scenario; yet a less stringent decarbonization scenario for secondary production. Consequently, many or most EAF steel producers, which largely use electricity as an energy source for steelmaking,[3] will be able to meet the decarbonization targets set by the Sustainable STEEL Principles in the short run.
- While it is also important for EAF producers to decarbonize their business activities, the Sustainable STEEL Principles include the mechanism to adjust the secondary scenario to increase its ambition over time. This can occur once primary production switches to clean end-state technologies, and the need to focus on the primary sector becomes less critical.

Tradeoff 2: A split scenario does not create as much of an incentive to recycle steel, as compared to a single carbon intensity scenario.

- This concern is mitigated by the fact that the secondary emissions intensity scenario is established at a point that still incentivizes scrap optimization in the short run for BF-BOF producers. This can contribute to emissions reductions before much of the sector's relining is necessary (Appendix).
- Additionally, the carbon budget models a significant growth in scrap utilization rates, thus serving as a constraint to incentivize greater scrap-based production. For example, the IEA's NZE model assumes that scrap as a share of inputs will reach 46% in 2050.

[3] Some EAF producers also use natural gas combined with electricity (see Figure 2 for total emissions from both sources).

Ultimately, the aim of the Sustainable STEEL Principles is to establish a common, industry-appropriate baseline to quantitatively assess and disclose the alignment of steel lenders with climate goals. By nature of its simplicity, such an approach cannot capture the full range of tools needed to fully decarbonize the global steel industry. It is intended to establish a level playing field with broad buy-in, which will contribute materially to the development of further tools and strategies.

IV. Implementation and reporting

Lenders who are Signatories to the Sustainable STEEL Principles use this methodology to calculate their steel lending portfolio alignment by:

- Obtaining data on a borrower's (i) use of external scrap as a share of total production inputs and (ii) CO_2 emissions on a comparable basis per tonne of steel produced (see Table 1, Step 1).
- Calculating a single target for each borrower, for each year, as the weighted sum of the two scenarios, with the weights being the share of external scrap (for secondary production) and other metallic inputs (for primary production) (see Table 1, Step 2).
- Assessing the borrower's alignment by calculating the percent deviation of reported emissions compared to the client's target (see Table 1, Step 2).
- Calculating steel portfolio alignment by weighing clients' alignment scores by portfolio exposure (see Table 1, Step 3).

Table 1. Example calculation of methodology implementation for portfolio alignment

				Steelmaker A		Steelmaker B	
	Parameter	Terms & Equations		Primary	Secondary	Primary	Secondary
Step 1 Reporting	Production mix 2022	P_p	P_s	0.90	0.10	0.10	0.90
	Emissions 2022 *(t CO2/t steel)*	E_i		2.40		0.35	
Step 2 Borrower-level calculations	IEA NZE Benchmark 2022 *(t CO2/t steel)*	B_{ap}	B_{as}	2.26	0.67	2.26	0.67
	MPP TM Benchmark 2022 *(t CO2/t steel)*	B_{bp}	B_{bs}	2.38	0.73	2.38	0.73
	Borrower Lower Target *(t CO2/t steel)*	$T_{li} = (P_p * B_{ap}) + (P_s * B_{as})$		(0.9 * 2.26) + (0.1 * 0.67) = 2.10		(0.1 * 2.26) + (0.9 * 0.67) = 0.83	
	Borrower Upper Target *(t CO2/t steel)*	$T_{ui} = (P_p * B_{bp}) + (P_s * B_{bs})$		(0.9 * 2.38) + (0.1 * 0.73) = 2.22		(0.1 * 2.38) + (0.9 * 0.73) = 0.90	
	Zone Delta *(t CO2/t steel)*	$Z_\delta = T_{ui} - T_{li}$		2.22 – 2.10 = 0.12		0.90 – 0.83 = 0.07	
	Emissions Delta *(t CO2/t steel)*	$E_\delta = E_i - T_{li}$		2.40 – 2.10 = 0.30		0.35 – 0.83 = -0.48	
	Borrower Alignment Score	$\mu_i = E_\delta / Z_\delta$		0.30 / 0.12 = 2.50		-0.48 / 0.07 = -6.86	
Step 3 Portfolio-level calculations	Steel-related Revenues *(% of total)*	R_i		100%		25%	
	Debt Outstanding 2022 *(USD)*	O_i		$100mn		$400mn	
	In-Scope Exposure 2022 *(USD)*	$X_i = R_i * O_i$		100% * $100mn = $100mn		25% * $400mn = $100mn	
	Exposure Weight	$w_i = X_i / X_{total}$		$100mn / $200mn = 0.50		$100mn / $200mn = 0.50	
	Portfolio Alignment Score	$\mu_t = \sum_{i=1}^{N} w_i \mu_i$		(2.50 * 0.50) + (-6.86 * 0.50) = -2.18			

-------- Publicly reported annually

For Step 1, steelmakers would ideally be able to report their emissions intensity from primary steel production and emissions intensity from secondary steel production. At present, however, it is not considered possible for steelmakers to report in this manner at scale. Implementation would require widespread adoption of a standardized carbon accounting framework by steelmakers for reporting primary and secondary emissions intensity separately, when primary and secondary inputs are mixed in a single process, which is not currently available.

In lieu of this framework, the Sustainable STEEL Principles adopted the approach outlined above for differentiating between the emissions from primary and secondary steel production.

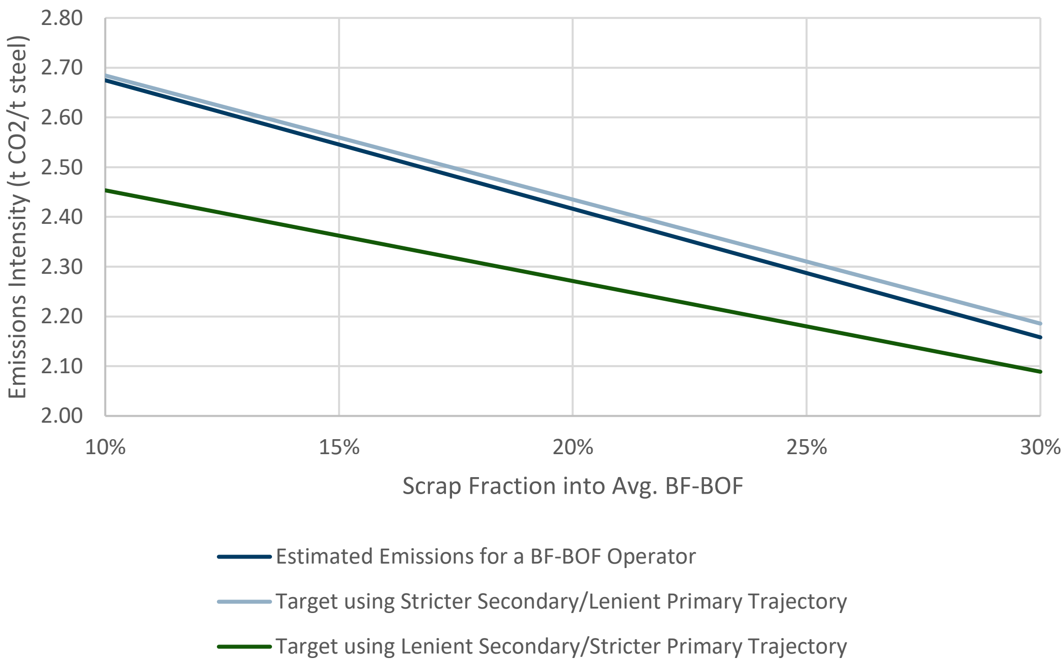
Appendix

When implementing the methodology, a steelmaker will have an individual decarbonization target each year, derived by weighing the primary and secondary scenarios by the fraction of external scrap used. This target will be lower (i.e., more stringent) as the steelmaker uses more scrap (a BF-BOF operation can typically use between 10-30% scrap, for example).

To determine whether a given secondary scenario would maintain the incentive for a BF-BOF operator to increase scrap usage (which will lower emissions), a sample steelmaker's individual weighted targets were compared for different levels of potential scrap usage across two options in one year:

1. *Stricter secondary scenario / Lenient primary scenario:*[4] where the primary and secondary scenarios are derived by splitting the carbon budget using the average emissions intensity of EAF producers in 2020.
2. *Lenient secondary scenario / Stricter primary scenario:* where the primary and secondary scenarios are derived by splitting the carbon budget using the emissions intensity of the 80th percentile of EAF producers in 2020 (i.e., 80% of EAF producers would meet the secondary scenario target), resulting in a stricter scenario for primary production.

These sample, weighted targets for different levels of potential scrap usage in one year are compared to a BF-BOF operator's estimated emissions for 2020 for the same range of scrap inputs (see below[ii]).



Source: RMI elaborations

The "stricter secondary scenario / lenient primary scenario" option results in inadequate short-term incentives for an average BF-BOF to increase scrap usage. This is because:

- The estimated BF-BOF emissions closely follow the "stricter secondary scenario / lenient primary scenario" weighted target as the fraction of scrap increases. Given that the target is met irrespective

[4] As explained in the brief, allocating a smaller portion of the carbon budget to secondary production results in a more ambitious secondary trajectory.

of the scrap fraction used, there would be little incentive for primary producers to maximize scrap in the short-term.

The “stricter secondary scenario / lenient primary scenario” option also results in inadequate incentives for an average BF-BOF to decrease emissions through other means:

- Since the primary scenario is more lenient in this option, the estimated BF-BOF emissions fall below the weighted target for the “stricter secondary scenario / lenient primary scenario,” across the range of scrap inputs. This is not ideal, since an average BF-BOF is estimated to be capable of reducing emissions by ~20% by employing the best available technology (e.g., energy efficiency improvements), in addition to increasing scrap use.[ii] To incentivize these improvements in the short run, BF-BOF producers would have to have an emissions intensity above the “stricter secondary scenario / lenient primary scenario” weighted target.

This analysis indicates that a generous secondary target is required in the short term to ensure the correct incentives to decarbonize primary steel production.

References

[i] International Energy Agency, Net Zero by 2050, IEA, 2021.

[ii] Mission Possible Partnership, "Net-Zero Steel Sector Transition Strategy," October 2021, https://missionpossiblepartnership.org/wp-content/uploads/2021/10/MPP-Steel_Transition-Strategy-Oct19-2021.pdf