MPP Steel Transition Strategy FAQ

- What is MPP?
    - **The Mission Possible Partnership (MPP) is an alliance of climate leaders** focused on supercharging the decarbonisation of seven global industries representing 30% of emissions: aviation, shipping, trucking, steel, aluminium, cement/concrete, and chemicals. Without immediate action, these sectors are projected to exceed the world's remaining 1.5°C carbon budget by 2030 in a Business-As-Usual scenario.
    - **MPP comprises four core partners**: the Energy Transitions Commission, RMI, We Mean Business Coalition and the World Economic Forum.
    - **MPP brings together the world's most influential leaders across finance, policy, industry and business.** MPP is focused on activating the entire ecosystem of stakeholders across the entire value chain required to move global industries to net zero.
    - **MPP is funded by** the Bezos Earth Fund, Bloomberg Philanthropies, Breakthrough Energy, the Climateworks Foundation, the European Climate Foundation, and the Joseph and Marie Field Family Environmental Foundation.
- What is NZSI?
    - The Net-Zero Steel Initiative (NZSI) aims to put the global steel sector on a path to reach net-zero emissions by mid-century by bringing zero-carbon primary steel production technologies to market before 2030 while accelerating the growth of scrap-based production and ensuring that no new high-carbon asset is built post-2030 without a transition plan. It stems from the conviction that achieving net-zero emissions in the steel industry is technically and economically feasible but will require a coherent set of forceful interventions from players across the value chain and policymakers.
    - **The Net-Zero Steel Initiative is led by the Energy Transitions Commission in collaboration with the World Economic Forum and RMI.** Learn more at https://missionpossiblepartnership.org/action-sectors/steel/
    - **The Initiative brings together high-ambition steel producers – alongside energy and feedstock suppliers, equipment suppliers, and buyers, in close collaboration with finance players and policymakers – to pursue a unique end-to-end supply chain approach to decarbonisation.** The Initiative provides a platform for these stakeholders to align on a net-zero transition pathway for the industry and intends to shape a favourable environment to investment in decarbonisation solutions, underpinned by supportive policy frameworks, rising demand for low-emissions steel and financial flows toward the steel transition.
    - **The Initiative is part of the Mission Possible Partnership (MPP)**, an alliance of climate leaders focused on supercharging efforts to decarbonise some of the world's highest emitting industries in the next 10 years. MPP builds on the foundation laid by the Mission Possible Platform, launched in 2019 by the Energy Transitions Commission and the World Economic Forum, by expanding and accelerating the work of seven nascent industry working groups in aluminium, aviation, cement and concrete, chemicals, shipping, steel, and trucking.
- What does MPP try to achieve with its Sector Transition Strategies?
    - The objectives of the MPP Sector Transition Strategies are:
        1. **To demonstrate industry-backed, 1.5°C-compliant pathways to net zero**, focusing on in-sector decarbonisation and galvanising industry buy-in across the value chain.
        2. **To be action-oriented with clear 2030 milestones**: By quantifying critical milestones for each sector in terms of its required final energy demand, upstream feedstock resources, and capital investments, MPP wants to lay the foundation for

tangible, quantitative recommendations of ways to reach these milestones through collaboration among industry, policymakers, investors, and customers.

3. **To be transparent and open**: MPP's long-term goal is to fully lay open the internal machinery of the Sector Transition Strategies, that is, to make its analytics open source and all data inputs open access. In addition, MPP is developing online web interfaces that bring the Sector Transition Strategy reports to life: individual users will be able to explore the results of the reports, study the impact of individual levers, and dive deeper into regional insights.
4. **To break free from siloed thinking:** The transition of a sector to net zero cannot be planned in isolation since it involves interactions with the broader energy system, for instance, via competing demands for resources from multiple sectors. All MPP Sector Transition Strategies are based on shared assumptions about the availability and costs of technologies and resources like electricity, hydrogen, or sustainable biomass. By providing a harmonised, cross-sectoral perspective, we intend to inform decision makers with a fair, comparable assessment of transition strategies for all seven sectors.

- How is net-zero defined?
  - The world needs to get to net-zero GHG emissions by 2050 to avoid the most harmful effects of climate change. Thereby, **"net zero" means priority in-sector decarbonisation, complemented by carbon dioxide removals (CDR).**
  - About **90%–95% of current emissions in each sector need to be reduced by in-sector measures**. This is in line with the Science Based Targets initiative, which prescribes "long-term deep decarbonisation of 90%–95% across all scopes before 2050" as the single most important target for a net-zero world. Due to the uncertainty surrounding Scope 3 emissions, the STS focuses on achieving net zero in terms of Scope 1 and 2 emissions.
  - **The remaining 5%–10% of residual emissions** that cannot be reduced by in-sector decarbonisation **need to be neutralised by CDR**.
- How did MPP define the carbon budget for steel?
  - The Intergovernmental Panel on Climate Change (IPCC) estimates the **global carbon budget to limit global warming to 1.5°C** above preindustrial levels with a probability of 50% to about **500 Gt CO2** from the beginning of 2020.
  - Hard-to-abate sectors are limited in their decarbonisation speed, whereas other sectors like the power or automotive sector could switch to low-carbon technologies more quickly. In a preliminary assessment by the MPP, **roughly 50% of the 450 Gt CO2 has been allocated to the seven MPP sectors**.
  - Following this methodology, **steel production has a 1.5°C carbon budget of about 56 Gt CO2 from 2020 onwards**.
  - Given the variety of other potential sectoral allocation methods, this value should not be taken as the absolute truth but rather as an indicative figure for a 1.5°C carbon budget for global steel production.
- What are the critical levers for the decarbonisation of steel?
  - Exhibit A in the report sets out the key emissions reduction levers to decarbonise steel. In this exhibit, all 2050 emissions reduction levers are compared against a 2020 static technology composition, which projects the technology composition of 2020 onto the increased demand in 2050. The critical levers are:
    - **Increased scrap use** – emissions reductions coming from increased use of scrap both in primary processes (increased scrap ratio in BF-BOFs or use of scrap in Smelting Reduction technologies) and switching from ore-based to scrap-based production (i.e., from BF-BOF to EAF).
    - **Iron ore reduction with natural gas** – emissions reductions resulting from replacing coal-based BF-BOFs with gas-based DRI-EAF or any gas-based permutation (i.e., 50% natural gas/biomethane).

    - **Iron reduction with green hydrogen** – emission reduction resulting from replacing coal-derived reducing agents with green hydrogen, both as partial decarbonisation measure (i.e., injecting hydrogen into blast furnace) or DRI furnaces and green hydrogen-based DRIs.
    - **Iron reduction with biomass** – use of biomass as feedstocks in the BF-BOF and in DRI processes.
    - **Carbon Capture and Storage** – the capture, transportation and permanent sequestration of CO2 emissions.
    - **Carbon Capture and Utilisation** – the capture of CO2 emissions and sequestration of the carbon into long-lived products via utilisation in plastics or construction materials.
    - **Other** – decarbonisation measures that do not fall into any of the other categories, such as switching from BF-BOF to Smelting Reduction, which is also coal-based but could allow for improved energy/resource efficiency and avoid emission-intense burden preparation steps (coking and sintering).
  - Energy efficiency is excluded from exhibit A, given its relatively minor impact when comparing 2050 to 2020. This should not be misconstrued as not advocating for energy efficiency measures – they have an important role, especially in the 2020s. However, their role should not be overstated, given that deep decarbonisation requires industry stakeholders to go beyond efficiency improvements.
- <u>What is the role of bioresources in the steel sector?</u>
  - Carbon-rich biomass can replace fossil fuels to a large degree in the BF-BOF route and completely in DRI processes. It can be used in a BF-BOF as **a direct replacement for pulverised coal injection (PCI) if the biomass has been properly pre-treated** to achieve low moisture content and impurities and high carbon content (i.e., through torrefaction). **It can't, however, replace coke as of today**. The chemical composition of coking coal makes it melt and then resolidify during coking, resulting in the high mechanical strength of coke, which bio-based replacements (i.e., torrefied biomass or wood charcoal) currently lack. Given the large sizes of blast furnaces, such mechanical strength is required to support the charge loaded from the top of the furnace. On the other hand, DRI processes use 100% gaseous reducing agents such as syngas (a mixture of carbon monoxide and hydrogen), typically derived from natural gas. Syngas can be derived from any carbon-rich material either through steam reforming or partial oxidation processes and as such, **it is technically possible to run DRI processes on 100% bio- or waste-based feed, giving its large flexibility in decarbonisation routes**.
- <u>What is the potential role of hydrogen in steel?</u>
  - **Green hydrogen (produced via electrolysis based on renewable power) can serve multiple roles in the decarbonisation of the steel industry**. From a decarbonisation perspective, it is most useful when used as the reducing agent, transforming iron ore into iron, either through partial replacement of coke in a blast furnace or full replacement of natural gas-derived agents in the DRI process. If applied in such a way, it too avoids emissions associated with coking, the transformation of coal and coke in the blast furnace, and upstream emissions (especially methane) associated with the mining of coal or extraction of natural gas.
  - Hydrogen can also be used as energy-dense fuel for steel reheating in hot rolling (especially in EAF facilities) or providing heat for the endothermic reaction of hydrogen with iron ore in the DRI process. However, this application is not accounted for in the STS, given that high-temperature heat can most probably be delivered with electricity-based solutions.
- <u>Why is there limited direct electrolysis of iron ore in the core scenarios?</u>
  - Since direct electrolysis is one of the most power-consuming solutions to make near-zero emissions steel, its economic viability is impacted significantly by power prices. Taking a higher-resolution view of location-specific opportunities than the modelled regional values, it is probable that select locations will offer a combination of low cost and stable power at costs below regional averages. Box 7 of the report provides further detail on this issue.

- What assumptions does the modelling assume for steel demand?
  - Steelmaking (notably ironmaking) is a significant source of GHGs. It is, therefore, essential to assess how total demand for primary steel could be reduced and whether a greater proportion of demand could be met through secondary (scrap-based) production, which is less carbon-intensive than primary production. The STS presents two scenarios for future steel demand: a Business-as-usual (BAU) scenario and a High Circularity scenario.
  - Under BAU, where steel consumption patterns and product life cycles stay relatively consistent, crude steel demand will likely be 30% higher in 2050 than it is today. Much of this growth will be in low-income and emerging economies — India's demand is expected to reach 445 Mt by 2050 from 120 Mt today — more than offsetting declining demand in China, Europe, Japan, and the Republic of Korea.
  - In the High Circularity scenario, three categories of levers (material recirculation, productivity of use, material efficiency) are employed maximally to reduce global steel demand by up to 40% in 2050 against BAU, avoiding 18 Gt of steel production over the next three decades. In India, crude steel demand reaches 295 Mt in 2050 under High Circularity, where domestic scrap supply provides only a fifth of that volume, indicating the need for significant new primary steelmaking capacity. Scrap volumes do, however, have the potential to meet large proportions of steel demand in some regions, notably China, Japan, the Republic of Korea, and Europe. This dynamic has implications for the decarbonisation pathways for steel players in these regions, as scrap-based EAF may have a competitive advantage over ore-based technologies.
- When are CCUS and Hydrogen technologies expected to be commercially available?
  - Near-zero emissions production technologies are not yet at commercial scale (TRL >=9).
  - Hydrogen technologies are expected to reach commercial scale in 2025/26. We acknowledge that the development of new technologies needs to be accompanied by a large-scale build-out of supporting infrastructures, such as utility hydrogen plants or on-site production infrastructure.
  - Most CCUS technologies are expected to reach commercial availability in 2028 (except Smelting Reduction with CCUS, which is expected in 2030). In addition, many technologies, such as CCUS, cannot operate economically at a small scale and thus require large capital investments to prove the concept and economics, which present a barrier to early adoption.
- What are the resource demands of a 1.5ºC-aligned transition?
  - Given that the share of EAF secondary steelmaking of global production is projected to increase from 25% today to 40% in 2050, combined with the power consumption of new (near-) zero emissions technologies, the transition requires around 5% - 7% of the projected annual global demand by 2050 (~6,700 TWh out of 90,000 -130,000 TWh).
  - With the growing use of hydrogen as a reductant in DRI production and to process captured CO2 in CCU technology (i.e. as a substrate in CO2/CO valorisation, through the Methanol->MTO route), by 2050 the steel sector will require about 9% - 15% of annual global production, which translates to about 75 Mt out of 500 – 800 Mt.
  - Near-zero emissions steel will further require up to 9% - 12% of annual global CCUS capacity by 2050 (~0.85 Gt CO2 out of 7 - 10 Gt CO2 stored and used).
  - By replacing the PCI part of the reductant with sustainable biomass, the steel sector will further require 2% - 4% of global sustainable biomass demand by 2050 (~2 EJ out of 50 – 110 EJ). Bioenergy consumption peaks at around 2.4 EJ in the 2030s in the Carbon Cost scenario, which is well within limits outlined in ETC's *Bioresources Within Net-Zero Emissions Economy* report, even when considering the potential needs of other sectors.
- Do different regions have different trajectories for decarbonisation?
  - The ST-STSM covers 11 geopolitical regions. The regional pathways will depend on their local circumstances and, critically, their **current steel production assets, domestic steel demand and scrap availability**.

  - The regional pathway for decarbonisation depends on the available resources (e.g. renewable energy) and their associated prices. We cover regional-specific power-, hydrogen-, coal-, natural gas-, biomass- and CCS transportation and storage costs. We additionally recognise that local electricity grids will decarbonise at different paces, with the Indian and Chinese grids decarbonising more gradually than the European or North American grids.
  - The power price inputs used by the ST-STSM assume grid-supplied electricity with differentiation only at the regional level. It is likely that taking a more granular view would identify locations and contexts in which the cost of clean electricity would be lower. This also applies to other location-sensitive price assumptions (hydrogen, biomass, and CCUS). However, for each of the regions, we do expect the roll out of near-zero emissions steel production capacity to depend on the relining dates of existing steelmaking capacity. Given the capital–intensive nature of steelmaking, the most opportune moment to refurbish a steel plant and switch its production technology to a low–carbon alternative is towards the end of the plant's investment cycle. Half of all steel plants globally are due for their next major investment decision (e.g. relining) before 2030. If technologies compatible with near-zero emissions are not available for commercial deployment in time, the industry risks locking in high–emitting technologies for another 20 years or facing costly early closures of steel assets.
- <u>What are the underlying assumptions of the STS for the trade of steel?</u>
  - The modelling includes a trade module that simulates the import and export of crude steel. The module assesses a region's cost-competitiveness relative to other regions and determines whether that region expands its production capacity or imports to meet local demand.
  - Trade is calculated based on the levelised cost of steel production. Other factors, such as transportation costs and tariffs, are not considered. This simplified approach to modelling provides a consistent long-term outlook that is designed to be resilient to short-term shocks or subjective factors (e.g. new trade tariffs).
- <u>What is the system boundary for steel sector emissions?</u>
  - The system boundaries for emissions align with the approach of the World Steel Association. This includes:
    - Scope 1 direct emissions from feedstock, fuel and energy consumption (excluding electricity)
    - Scope 1 direct process emissions
    - Scope 1 direct emissions from on-site electricity generation
    - Scope 2 indirect emissions from off-site electricity generation
    - Scope 3 indirect upstream emissions from Iron Ore, Natural gas, Coal mining plus credits from Blast Furnace slag production

Scope 1, 2 and 3 emissions are all calculated for each technology archetype and each year (in tonnes of CO2 per tonne of crude steel) using global assumptions. Scope 2 emissions are further calculated for each region on the basis that electricity grids are expected to decarbonise at different rates in the 11 geopolitical regions. Due to the uncertainty surrounding Scope 3 emissions, the STS focuses on achieving net zero in terms of Scope 1 and 2 emissions.