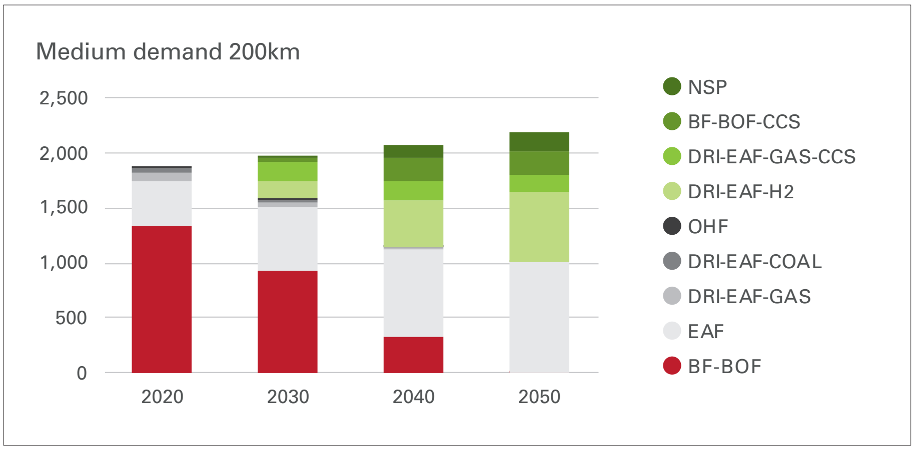
NET-ZERO STEEL PRODUCTION BY 2050
IS POSSIBLE BY SEVERAL DIFFERENT MEANS, BUT WE MUST ACT SOON TO MAKE IT POSSIBLE

PROJECT SUMMARY

This project develops several spatially explicit, facility level pathways to net-zero global steel production by 2050. Its purpose is to understand granular impacts on facilities and countries transitioning to a net-zero compatible steel fleet.

Our pathways start with a database of existing steel facilities worldwide, defined by location, technology, capacity, production, energy consumption and GHG emissions. The Global Energy Monitor (GEM) database, which identifies 622 facilities above 1 Mt per year capacity in 67 countries, is the starting point for these definitions. We also employ the Global Infrastructure Emissions Database (GIEDS), Worldsteel Association production data, and the OECD national capacity database, to cross reference facilities, build energy and emission profiles, and to identify the 14% of global production that is not identified in GEM. While total global 2019 production is identified at 835 facilities in 94 countries, our scenario projections seed future production in an additional 39 countries based on scrap availability and national steel demand. The boundary for emissions includes all direct energy and process emissions that occur at integrated



iron and steel mills, differing from other boundaries (e.g., WorldSteel Association) that include indirect off-site heat and electricity purchases and scope 3 intermediate input emissions.

Future steel demand is driven by three scenarios that converge all countries towards demand of 200, 250 and 300 kg per capita in 2080, based on current global average demand of 222 kg per capita (the US is 290 today, China 630, India 75, UK 150). Steel production is 1.9 Gt per year today, and is 1.9, 2.2 and 2.5 Gt per year by 2050 in our scenarios. Scrap steel availability is based on global and regional forecasts and results in scrap electric arc furnace (EAF) production more than doubling from 0.42 in 2019 to ~1.0 Gt in 2050.

The model tracks the functional age of facilities. At 25 years a furnace relining is required, and the model is presented with several geographically and political preference based options. The model hierarchy identifies how a country can best meet the demand forecast: 1) add scrap EAF if there is incremental scrap available; 2) retrofit for coal blast furnaces (BF-BOFs) and direct reduced iron EAF facilities within prescribed distances to CO_2 reservoirs for post combustion carbon capture; 3) consider whether there is low cost renewable electricity to make electrolytic hydrogen for hydrogen DRI-EAF and finally 4) If none of the previous options apply deploy "Non spatially allocated production" (NSP). NSP can represent any low carbon production technology implemented somewhere else in the world, e.g. green steel or iron imports, or represent additional domestic production that is made from green iron or scrap steel imports at new locations.

The central scenario (medium demand, <=200 km pipeline CCS) forecasts that by 2050 46% of production is from scrap EAF, 29% from DRI-EAF-H_2, 17% uses CCS and 8% from NSP. Emissions decline from 3.0 $GtCO_2e$ to 0.3. Steel electricity demand increases 8+ times to 5,000 TWh in 2050.

Sensitivity analysis identifies that no new BF-BOFs without CCS can be built past 2025 and any delay in plant turnover and retrofit or deployment of low carbon technologies results in missing 2050 net-zero targets. Only one -90% steel technology is currently commercial (methane DRI with CCS), and intensive commericialization is needed to bring hydrogen DRI (11 EU investments planned at time of writing), BF-BOFs with CCS, or alternatives to market by the later 2020s. The modelling also suggests CCS has limited global application without CO_2 transport of at least 200km, highlighting the need for transport infrastructure. Country level analysis identifies major shifts in capital investment from existing producers (e.g., China, South Korea) to new facility sites in Africa and India. While the cost of green steel to end users is low, it is significant and risky for producers - key policies to drive this shift include green public and private procurement to reduce the risk of investment in low carbon technologies and increase production and innovation economies of scale.

Project summary, full report and country data available at netzerosteel.org

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