Leveraging Transatlantic Cooperation to Promote Industrial Decarbonization of High Carbon Industries: Pathways for Green Steel
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Introduction

For the world to meet commitments made in the 2015 Paris Agreement and combat climate change, emissions from heavy industry must fall dramatically. In the United States, industrial emissions account for nearly one-third of all emissions. Globally, fewer than a dozen carbon-intensive industries (namely steel, cement, aluminum, chemicals, fertilizer, paper, and glass) make up the vast bulk of those emissions. Steel is at the top, accounting for approximately 8 percent. Global production of steel more than doubled between 2000 and 2018. Electrification provides promising long-term pathways for deep decarbonization of the power and transportation sectors, but for carbon-intensive industries like steel which require very high heat, large amounts of electrical power and create additional “process emissions” of CO₂ from the industrial processes used, the course has been less clear.

Ambitious national net-zero commitments are now putting pressure on steel and other carbon-intensive industries to develop ambitious decarbonization strategies. Key corporate players are already beginning to move forward with plans to produce “green steel” (our term here for steel whose production, including necessary heat and power, emits very low or zero net carbon), helping the sector transition to a sustainable economy and at the same time supporting economic growth.

But governments are only beginning to address what combination of new government policies, cooperation among key markets, and financing vehicles as well as greater ambition in industry will be necessary to facilitate the development of the new technologies to produce green steel and create markets demanding it. This effort will be difficult and face numerous challenges, but it will have important implications. Growth of green steel would show that deep decarbonization of heavy industries is possible and signal that a global green economy is within reach. At COP26, the EU and the United States announced a major coordinated effort on green steel, the implications of which are unclear. Yet, it paves the way for closer ties. The ideas and recommendations in this report can be relevant to future negotiations. This report examines the pathways to scale up production of green steel and create a global green steel market; summarizes green steel developments in both Europe and the United States; identifies trends in steel trade flows that may be important; highlights the importance of supporting steel workers during the transition; outlines government policies that could be used to promote transition of the steel industry; and identifies opportunities for transatlantic collaboration supporting such policies.

Pathways to Green Steel

Existing Pathways of Steel Manufacturing

Globally, about 70 percent of steel is made in integrated blast furnace-basic oxygen furnace (BF-BOF) facilities, the first step of which is putting the coke (purified coal) and iron ore through a process of oxygen reduction in the blast furnace. Substantial amounts of CO₂ are emitted from this reduction process, and where the electric power is produced in some or large part by coal or gas power plants, additional CO₂ emissions are involved.
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From the blast furnace, the remaining iron and carbon elements move to the basic oxygen furnace where they are combined with additional carbon then alloyed with various metals depending on the intended property of the final product. While the BOF itself produces some CO$_2$ process emissions, again the substantial power required also involves not-insignificant emissions unless it is produced entirely from hydropower, nuclear, or other clean energy sources.

BF-BOF integrated producers have the capacity to produce a variety of steel qualities and types due in part to the various possibilities at the alloy stage. Depending on the efficiency of the facility, the emissions intensity varies but averages around 2.8 metric tons of CO$_2$ per metric ton of steel, with high-efficiency facilities producing between 1.8 tons – 2.0 CO$_2$ per ton. Overall emissions result in part from the (indirect) emissions necessary to produce electric power to run the facility (unless renewable energy is available) but primarily from both the combustion of coke, coal, and coal dust and the reduction of oxygen from iron ore or other initial product inputs that produce large amounts of CO$_2$.

In an electric arc furnace (EAF), scrap metal can be used as the raw material to be melted and recycled. The process through which this happens, often via electrical currents, results in a reduced input material. EAFs require this type of material for production, so in fact reusing the recycled steel is an embedded perk for this process. Although EAFs are capable of producing steel of all types, the portfolio of products and their strength can be limited by the quality and contamination of the raw scrap material. Carbon-intensity of EAF steel depends almost entirely on the source of electricity; an EAF powered entirely by wind or solar power can produce virtually carbon-free steel. Given the cost-effectiveness of EAFs at small scales, particularly in contrast to their costlier BF-BOF counterpart, they are frequently utilized in mini-mills.

A third method, responsible for roughly 6 percent of steel production, is the DRI-EAF approach wherein a Direct Reduced Iron (DRI) method is followed by an electric arc furnace (EAF) process. Typically, the DRI process starts by transforming methane into a hydrogen and carbon monoxide syngas. The resulting briquetted iron is then processed through an EAF to produce steel. The emissions intensity of this process varies depending on the electricity source, but can be as low as 0.7 tons of CO$_2$ per ton when produced with zero-carbon electricity.

**New Pathways to Decarbonization**

**Increased efficiency:** Although efficiency upgrades are important and necessary, most modern steel plants currently operate at a relatively high degree of efficiency allowable by thermodynamics with existing technologies. Thus, there is much more potential in further development of new technologies than enhancing the efficiency of the existing ones.

**Accelerated and enhanced use of existing scrap in EAFs powered by zero-carbon energy:** Increasing the recycling of scrap metal and using it as raw material in existing and new EAFs as opposed to producing virgin metal in conventional BF-BOF mills could cut emissions by 50-70 percent or more. Contingent upon the sufficiency of the scrap steel supply, the promise of EAF powered by renewable energy sources such as wind, solar, hydro, or nuclear could significantly reduce the carbon intensity of steel by over 99 percent relative to the traditional process. A higher deployment of EAF processes in this fashion is likely by 2050, particularly in Germany, where it could account for 100 percent of the country’s steel production. This pathway could be limited,
however, by both the supply of recyclable material and the impurities (like copper) in the raw material that impact the strength of the finished product and make it unsuitable for some uses.

**Hydrogen:** Hydrogen can be used in two ways to reduce process emissions. First, it can be used as an auxiliary agent and cleaner way to produce high heat in the BF-BOF process. However, it appears that even using green hydrogen in this fashion may only reduce emissions by about 40-50 percent. Second, it can be used directly as part of the DRI-EAF process described above. HDRI-EAFs use hydrogen directly (instead of methane-derived syngas) as the iron ore reducing agent, avoiding CO₂ creation. This direct reduction of iron (DRI) process produces a solid porous sponge iron. After direct reduction, sponge iron is then fed into the EAF, where iron is melted by electric current. After the EAF process, liquid steel is produced for final chemical composition adjustment before casting. As discussed below, the HYBRIT project has completed studies, and the first demonstration plant by SSAB, LKAB, and Vattenfall is in operation in Sweden. Authors such as the Fifth Assessment of the Intergovernmental Panel on Climate Change (IPCC) and Weigel et al. (2016) identified hydrogen-DRI as the most promising zero-carbon steel production route through a multicriteria analysis (including economy, safety, ecology, society, and politics).

Extensive use of this pathway will be constrained by the very high current cost of producing hydrogen by electrolysis (which itself produces no CO₂ but only splits water into hydrogen and oxygen) powered by renewable energy (“green hydrogen”). In addition to the high cost of new electrolysers, production of green hydrogen requires substantially increased volumes of renewable energy to drive production. Limiting factors will also include the need to build transportation infrastructure to move hydrogen from its point of production to the steel plant (primarily through hydrogen or refitted gas pipelines).

While there is opposition in some quarters to ramping up production of “grey hydrogen” from natural gas without carbon capture, utilization, and storage (CCUS) to make steel, one recent analysis suggests that given the EU’s current power mix and average emissions from the power sector, using grey hydrogen could compete favorably with BF-BOF steel production.

**Carbon capture, utilization, and storage (CCUS):** CCUS will likely be central to several pathways to green steel. First, by applying CCUS on various routes of escaping emissions from BF-BOF plants, resulting emissions could be reduced by roughly 80 percent. However, this would require substantial upgrades and retrofits to existing facilities, and a layer of complexity given the lack of “one size fits all” designs currently available.

Equally important, to provide low-carbon hydrogen for steel production at a tolerable cost in the short run because of the high cost of green hydrogen, it may be necessary to produce hydrogen in the conventional low-cost method via steam methane reforming (SMR) or auto-thermal reforming (ATR) using natural gas. Since SMR or ATR hydrogen production creates its own process emissions of CO₂, applying CCUS to these plants (“blue hydrogen”) could remove most, though not all (perhaps 75-80 percent), of the CO₂ emissions that otherwise would result from the hydrogen production.

Finally, as penetration of renewable energy in the electrical grid proceeds but demand for power increases steeply with the growing need for electrification of transport, heating, and heavy industry as well as new hydrogen production, there may be a need to continue and even expand the use of natural gas as a bridge fuel to produce electricity, with CCUS taking out most of the
emissions. Applying CCUS to highly efficient combined-cycle natural gas power plants may be critical for a mid-range strategy (2035-2045) that would otherwise require vast new amounts of carbon-free electricity to drive EAF steel mills and produce low-carbon hydrogen through hydrolysis.

The cost of carbon capture as well as the cost and uncertainty of finding large, reliable, and safe reservoirs for its deposit and constructing transportation routes for the CO₂ (or utilization technologies that can be scaled at reasonable cost) will all limit this pathway.

Europe’s Approach to Green Steel

Since 2000, global steel production has more than doubled. European countries together produce about 7 percent of the world’s steel, second only to China (which produced 57 percent in 2020); the next largest producers are India, Japan, and the United States. Germany is the largest producer in Europe with about 25 percent of the Europe’s steel production, followed by Italy, France, Spain, Poland, Sweden, and the UK. World steel production has more than doubled since 2000.

Europe has led the way on green steel, and plans for the industry to transition to a green and digital economy through its European Green Deal. European countries have already cut steel emissions by 26 percent since 1990, largely because of increased efficiency and growth in recycling. But more is needed to spur deep decarbonization. Industry is on board with widespread, ambitious changes to further reduce emissions, understanding that it will have to significantly scale up green steel projects in the coming years to meet long-term climate commitments. Industry players have endorsed a wide range of solutions to mitigate climate change, such as breakthrough low-carbon technologies, efficiency measures, and the use of carbon-free electricity sources including a large potential role for the use of hydrogen. At the same time, the sector wants to see the creation of demand-side incentives for green steel (where market creation has seen less attention to date) and protection against carbon leakage.

Europe updated its Industrial Strategy earlier this year and launched its Fit for 55 Package this summer, which aims to cut emissions by 55 percent by 2030. Part of the European Green Deal, Fit for 55 is a very ambitious legislative package that (once enacted) revamps the way energy will be consumed and produced in Europe, reflecting how much of a challenge the transition will be for steel and other heavy industry. Revisions of the EU’s Emission Trading System (ETS) and the new carbon border adjustment mechanism (CBAM) are intended to spur significant changes throughout the economy by substantially raising the cost of carbon while ensuring that these efforts are not undermined by increased imports from countries with lower carbon costs or by delocalization of EU companies to countries with more lenient climate rules. Even though production costs of higher-carbon steel will increase, the free ETS allowances steel companies in the EU now receive will be progressively phased out, while importers of steel products with a greater carbon content than their EU counterparts will be required to purchase certificates based on the price of ETS allowances. The CBAM takes full account of the carbon price paid in third countries and is designed in a way to ensure that steel and other products imported into the EU are subject to “no less favorable treatment” than borne by EU-like products.
One crucial way for the steel industry to increase production of green steel is through greater use of hydrogen. Fit for 55 looks to spur growth in green steel through initiatives that will reduce costs of green hydrogen. One key initiative to support the penetration of green hydrogen is the revised Renewable Energy Directive (RED) II, which aims for industrial sectors to use green hydrogen for at least half of their hydrogen needs.

Industry and policymakers see CCUS as another crucial technology to reduce emissions, but only as one part of a broad portfolio. CCUS could substantially mitigate emissions in the production of electric power and hydrogen from natural gas, in addition to capturing process emissions from steel furnaces. Establishing a robust CCUS market is key to developing the European Green Deal's goal of a circular economy, which involves capturing CO₂ and then reusing it to manufacture sustainable products (“carbon use, or carbon fabrication”). The EU has just announced that it will prepare a comprehensive Certification Standard early next year for carbon removal and storage in order to accelerate planning and acceptance of broader CCUS deployment.

In the frame of the European Green Deal, the EU's Industrial Strategy has been helped by funding and financing programs such as the Horizon 2020 and now Horizon Europe research and innovation programs, Recovery and Resilience Facility, Innovation Fund (using revenues from sale of ETS allowances), and InvestEU. All of these programs aim to support research and innovation programs and to finance sustainable investments that help decarbonize industry, providing opportunities for growth in both production and demand for green steel. The Clean Steel Partnership launched in June 2021 by the European Commission is a partnership with industry through ESTEP (the European Steel Technology Program) and Eurofer (the European steel trade association) as well as Worldsteel (the global industry association representing about 85 percent of all global steel production). The Partnership is based on a roadmap developed by the partners in 2020. It will rely initially on funding synergies with €700 million coming in equal parts from Horizon Europe and assets of the European Coal and Steel Community in liquidation. During this Fall, it has put out invitations for proposals for technology-development funding in eight different technology areas.

Also relevant to steel is the EU’s sustainable financing taxonomy, a classification system that seeks to help the EU scale up sustainable investment by providing companies, investors, and policymakers with appropriate definitions for which economic activities can be considered environmentally sustainable. The EU Taxonomy Climate Delegated Act, formally adopted on June 4, 2021, provides climate mitigation and adaptation criteria for a range of activities, including steel, other energy-intensive industries, and hydrogen.

Sweden is one European country that has successfully overseen the growth of green steel production in recent years and is ahead of other markets. Sweden has unique circumstances allowing it to promote new technologies that support green steel. Strong public support and access to low-cost and fossil-free electrical generation (most of the country’s power is hydro-electric and nuclear) have been particularly crucial. Industry has supported the transition to green steel, helping garner political buy-in. One key industry leader is SSAB, which is headquartered in Stockholm and has operations in the United States. The company has already begun delivering fossil-free steel to Volvo on a trial basis. This revolutionary development, which utilizes green hydrogen instead of coal and coke in the industrial process, comes from its HYBRIT project, which began in 2016 and
was created with energy company Vattenfall and mining and minerals group LKAB. SSAB plans to scale up fossil-free production by 2026 and to be completely free of fossil fuels in its steel by 2045. H2 Green Steel is another key Swedish company that is taking advantage of favorable conditions in the country and helping transform the industry. It has set up operations that use green hydrogen and plans to start producing green steel in 2024. These companies’ actions reflect that the transition to developing green steel is possible and will provide a blueprint for others in the industry.

Public-private partnerships have also underpinned green steel growth in Sweden. One example is LeadIT, a collaboration that provides a forum between public and private actors. Sweden, along with India and the EU, co-lead the project that has brought together more than 30 countries and industries. The United States recently joined, a major boost as the group is exploring how to use government procurement to create demand for green steel. LeadIT is poised to be a leading voice in the green steel transition by eliciting commitments for green procurement from member countries and providing technical assistance to developing countries. One main challenge targeted by LeadIT is creating consumer demand for green steel to develop a robust global marketplace.

Germany is also a key European market for both production and use in green steel. The German government has provided funding to companies to accelerate their plans to decarbonize their steel production activities. For instance, the German Environment Minister Svenja Schulze late last year provided funds to Salzgitter AG group for its project to transition to green steel production. Steelmaker Thyssenkrupp has also announced ambitious plans to scale up its hydrogen use to replace coal in its operations. The company plans to produce 400,000 tons of green steel by 2025 and 3 million tons by 2030.

ArcelorMittal, one of the world’s largest steel companies, is expected to receive 55 million euros for a demonstration project that will use green hydrogen, with the aim to produce 100,000 tons of green steel by 2025. The company is looking to produce one million tons of green steel at its Hamburg plant in 2030, and it aims to replicate its clean operations at its sites throughout Germany and other countries. In July 2021, the company signed a memorandum of understanding for a 1 billion euro ($1.2 billion) investment to build the world’s first large-scale zero-carbon steel plant in Spain. The plant, planned to come online by 2025, would be the biggest demonstration project of its sort in the world.

United States’ Efforts on Green Steel

The United States, once the world’s leading steel producer, now accounts for roughly five percent of global steel production capacity. It is the fourth largest individual producing country after China, India, and Japan (though producing less than the EU as a whole’s seven percent). U.S. mills have been operating at roughly 80 percent capacity, a figure which is likely to increase as the sector supplies the material necessary to support the Biden Administration’s infrastructure agenda. The Biden plan’s focus on climate-friendliness and domestic sourcing is challenged by the steel sector’s current reliance on fossil fuels in the absence of scalable zero-emissions production technology. But industry leaders in the United States are beginning to set ambitious targets and plan how to achieve them. The Biden administration has made significant progress on transitioning to green
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steel in both programs announced in Rome on October 31 and in the Build Back Better Framework. The United States announced in Rome that it reduced tariffs on steel and aluminum from the EU, paving the way for both sides to agree on negotiating a sectoral system, which will be finalized by 2024, to cut carbon emissions in aluminum and steel. In the Build Back Better framework, part of the massive bill is investments in clean energy manufacturing, which would cut emissions from industry, including the steel sector.

As mentioned above, the U.S. steel industry is different from that of Europe and other countries, as it is concentrated on many smaller EAF mills using recycled steel as raw material; thus, compared to Europe and other jurisdictions, average U.S. steel carbon intensity is relatively low already. Nonetheless, the imperative to design strategies for deep decarbonization is increasingly understood by the private sector. U.S. Steel, for instance, has in place a net-zero by 2050 goal and was the first North American member of ResponsibleSteel, a global partnership of steel supply chain actors that promotes sustainable industry practice. Similarly, U.S.-based producer Nucor, the country's largest steel producer, has committed to a 35 percent reduction in greenhouse gas emissions by 2030. Nucor's pledge is centrally supported by the company's focus on renewable energy purchasing, a trend increasingly mirrored across the industry.

Steel's recyclability has long been an asset, and efforts to recycle at various points along the supply chain have ramped up. Currently, between 60 million-80 million tons of steel scrap are recycled per year in the United States. This is a substantial input into the production process. ArcelorMittal's U.S. production, for instance, is 29 percent recycled scrap. Mills can both recycle their own steel scrap, as well as scrap from other points along the supply chain through EAFs. Around 70 percent of raw metal input in the production process is scrap, and the International Energy Agency estimates that recycled scrap requires roughly one-eighth the producing energy of iron ore.

Particularly amidst an infrastructure overhaul, U.S. demand for steel will likely soon outpace previous supply, meaning that there may not be enough scrap to sustain future needs through recycling alone. This necessitates cleaner production throughout the entire supply chain. There are numerous technological approaches in development, such as Boston Metals' Molten Oxide Electrolysis (MOE) and Hydrogen Direct Reduction, both of which are not yet commercially viable at scale in the United States. CCUS applied to blast furnace mills is another approach under consideration. In fact, the Biden Administration's American Jobs Plan specifically called for the establishment of 10 pioneer facilities for production facilities. However, there is only one operating steel plant using carbon capture at scale, the Al Reyadah plant in Abu Dhabi, and it deposits the carbon captured into enhanced oil recovery (EOR).

The primary mover in the executive branch has been the Department of Energy (DOE), which has driven research, development, and demonstration efforts. The life of steel plants is long, and retrofits and upgrades are costly. Thus, to encourage the necessary enhancements, the technologies need to be proven at scale to provide investment assurance. In July 2021, the DOE launched a $42.3 million funding opportunity to identify new partnerships to decarbonize manufacturing. This new stream is only part of the DOE's recent efforts, which include the H2@Scale program for projects on zero-carbon hydrogen for natural gas in steelmaking, a funding
effort on the development of CCUS projects in the manufacturing sector, and efforts on increased energy efficiency in the steelmaking process.

Congress has played a key role in adapting the regulatory environment for progress. As part of the passage of the Energy Act of 2020, it set the stage by authorizing DOE to install a development program on industrial emissions reduction technology. It has also supported the development of carbon capture technology, namely in the passage of Section 45Q, a federal tax credit program for carbon capture projects. This year, however, is likely to be consequential in Congress for the steel sector and decarbonization efforts more generally. The infrastructure packages, the details of which remain unfinalized, are likely to contain billions of dollars in efforts that will both, directly and indirectly, impact the sector’s decarbonization, including RD&D funding, energy infrastructure financing, resilience planning, and emerging technology deployment pathways. The whole-of-government approach of the Biden administration paired with the private sector’s willingness to engage has created some of the conditions necessary for greening the domestic steel industry.

Trade Patterns and Statistics

The carbon intensity of steel varies widely by country, in large part due to the dominant domestic production method employed. In China, for instance, where commodity steelmakers primarily use blast and basic oxygen furnaces, the steelmaking process results in roughly 2 metric tons of CO$_2$ equivalents for every metric ton of steel produced. In contrast, the United States, which relies heavily on EAF mini-mills, averages around 1 metric ton of CO$_2$ equivalents per metric ton of output. Overall, average EU carbon intensity is slightly higher than that of the United States. While on average blast furnace and EAF plants in many EU countries are slightly more efficient than the same category of each kind of U.S. plant as the United States has a much higher percentage of EAF production, its overall average carbon intensity is slightly lower.

Total production of steel has more than doubled since 2000. In that year, China produced 15 percent of world steel; in 2020, it produced 57 percent. The sector accounts for around 15 percent of China’s total annual emissions. China is also the global leader in exports of steel, followed by Russia, Japan, Korea and the EU (which exports slightly less than half of China’s volume). The United States is the largest net importer of steel – followed by the EU group of countries; within the EU, Germany and Italy are the largest importers. The three largest importers of steel into the United States are Canada, Mexico, and Brazil, followed by South Korea, Russia, Japan, and Germany. The largest four importers into the EU are Turkey, Russia, Ukraine, and South Korea, and China also imports large amounts of steel primarily from Japan, South Korea, and Taiwan.

The steel trade could be an entry point to the decarbonization of the global economy, but the shift will necessitate major coordination amongst partners to avoid trade tensions. For example, the Section 232 tariffs the United States imposed on steel imports in 2018 to combat cheap Chinese steel resulting from both Chinese subsidies and overcapacity (which also included tariffs on steel from the EU imported into the U.S.) have driven up domestic prices, benefitting domestic U.S. industry but harming consumers. They have had little impact on steel production in China but have led to heightened trade tensions with many U.S. trading partners, including the EU. At the EU-U.S. Summit in June 2021, leaders committed to finding a solution to this dispute by December 1.
Following intensive discussions, on October 31 the U.S. announced that it will remove Section 232 tariffs on EU steel exports up to past trade volumes, while the EU agreed to suspend the rebalancing measures against exports from the United States in place since June 2018. In addition, the two sides agreed to start discussions on a Global Arrangement on Sustainable Steel and Aluminum. This Global Arrangement will seek to ensure the long-term viability of the EU and U.S. industries, encourage low-carbon intensity steel and aluminum production and trade, and restore market-oriented conditions. It is intended that the arrangement will be open to all like-minded partners to join.

The point is that trade disputes or even the risk of trade disputes triggered by issues having nothing to do with climate can hinder the adoption of industrial decarbonization strategies. As pointed out below, issues such as structural overcapacity in the steel industry (particularly in China) can trigger geopolitical conflicts that may pose a direct impediment to decarbonization progress. An important element in developing a global approach to green steel will be the need to protect against carbon leakage and satisfy the demands of domestic steel firms for protection in jurisdictions where carbon pricing is driven up by government policy: "a level playing field." To encourage lowering the emissions intensity of domestic production rather than having it move from one country to the next to avoid environmental regulations, there need to be financial incentives to adapt or standardize approaches amongst trading partners. Cooperation could not only enhance their respective industrial decarbonization efforts, but also encourage other major producers to respond. Ideally, this would result in a competitive advantage for carbon-efficient producers and a need for carbon-inefficient producers to adapt, absorb increased costs, or find alternative, dwindling markets.

**Policies To Support Decarbonization Pathways**

The economic viability of these pathways at scale is largely contingent upon supportive government policies. On the European side, supportive policies have been identified and approaches have been embodied in EU strategy documents and in funding mechanisms to support research and pilot projects. Government assistance for some pilot projects has already been extended by both the EU and national governments, and additional support for green steel innovation is in progress. Proposals contained in the Fit for 55 program would also promote hydrogen, CCUS, pricing, competitive protection, and the circular economy, all of which are important components of moving forward on lower-carbon steel production. Although there is not yet a comprehensive roadmap, the European steel sector together with the EC has now initiated a Clean Steel Partnership and has worked with other stakeholders to produce the [2019 masterplan for a competitive transformation of EU energy-intensive industries](#).

In the United States, it appears that only with the incumbency of the Biden administration has the federal government begun to consider industrial policy and strategies to support industrial decarbonization. And that thinking is in its very early stages. For example, the lead climate measure in the Reconciliation Bill supported by the White House deals mostly (though hopefully effectively, if enacted) with the decarbonization of the power sector. In the early months of his presidency, the [United States joined LeadIT](#), signaling its commitment to join the global wave of efforts in the sector. The administration has also explicitly supported using federal purchasing power through
Buy Clean policies as a way to encourage the market growth for green steel. The approach, which aims to reduce emissions in infrastructure and building materials by directing federal agencies to purchase low-carbon steel, has gathered support at the state level but has not yet been enacted at the national level. There is much work still to be done on the formalization of the U.S. approach, but there are numerous policy levers that the U.S. can design and employ.

There should be scope for the EU and U.S. to compare their respective approaches and discuss the possibility to develop common principles for the implementation of green procurement policies, including in the steel sector.

**Emission Limits and Carbon Pricing**

Limits on steel plant emissions and establishing a price on carbon are essential to set a foundation under all other measures. These policies are technology neutral and provide incentives for all channels (process investment, supply chains, markets). They do not rely on an intimate knowledge or detailed planning around one or another set of assumptions about the future of steel production factors or the future of supply chain or power costs.

The EU has adopted such measures with its new EU ETS provisions, which have already had a dramatic impact in increasing carbon pricing, although potentially the resolution of how fast to phase out free ETS allowances may mitigate some future price increases. The United States has no carbon pricing policy or CO$_2$ emissions limits for steel at the national level nor an imminent likelihood of enacting either policy. With respect to carbon pricing, however, it is not clear that even a relatively high and stable carbon price of $50-60$ Mt/CO$_2$ -- which would begin to send important signals to industry and investors -- would be sufficient by itself to drive major long-term investments in new steel technologies at the scale required.

**Research and Development**

Research and development is an essential element to provide the support necessary for emerging technologies. Advanced Research Projects Agency-Energy (ARPA-E), in the Department of Energy, has provided 145 projects with scale-up funds since 2014. Fit for 55 also envisions increased research and development. But these efforts have tended to be work-bench sized basic technology investments, whereas the steel industry has identified major technological breakthroughs that must be tested at scale to see if they can be made more economical. Thus, the real need -- now being recognized by European governments -- is major funding and financing for entirely new start-up facilities at industrial scale. On research and development, governments must work closely with companies and trade associations to identify these challenges.

**Incentives and Financing to Increase Recycling/Use of Scrap in EAF Facilities and Encourage Building Additional EAF and DRI-EAF Mills**

Increased use of recycled scrap material, particularly when an EAF mill can ramp up its use of renewable energy, is the fastest and most efficient way to make short-term emissions reductions in steel production. The EU Circular Economy Strategy and focus on reuse can be an important policy lever. In the United States, the market appears to be driving in this direction. One question in all cases is whether increased demand will cause a shortage of recyclable material.
An Economy-Wide Hydrogen Strategy

Significant development of green hydrogen to produce green steel will require a multi-sector transformation: construction of a new generation of electrolyzers, which among other things must reduce costs or production by 60-80 percent; large amounts of new renewable electric generation to power these plants; and geographical planning to locate hydrogen production near steel production and/or provide for (likely pipeline) transportation. A shorter-term approach would be to use blue hydrogen (natural gas and CCUS) to reduce hydrogen costs, but the geographical challenges increase by adding the problem of locating CCUS facilities near where CO₂ can easily be injected into underground reserves.

The EU and several countries have launched economy-wide hydrogen strategies and announced significant early investments. Germany and some other EU countries are focused on green hydrogen and do not want to prioritize blue or “grey” hydrogen (SMR-produced hydrogen with no CCUS). Industry (and pipeline companies) are beginning to think about hydrogen “hubs” and the ability to use existing natural gas lines which can transmit small percentages of H₂ in these lines. There does not yet appear to be much attention to a hydrogen “strategy” in the United States, though the DOE launched in June a Hydrogen Energy Earthshot program to reduce costs for clean hydrogen.

Carbon Capture, Utilization, and Storage

CCUS has suddenly attracted new attention for three reasons. First, if the huge increase in renewable electricity necessary to move toward zero net carbon cannot be installed in time, there may be a need for aggressive steps to install CCUS on natural gas plants particularly in the period 2035-2050. Second, CCUS may be required for deep industrial decarbonization. Third, with the 45Q tax credit in the United States and carbon prices in the EU ETS going to 50-60 Euros per MT/CO₂, the additional costs of CCUS become much more attractive in both markets. After slow-walking attention to CCUS for a decade, Europe is paying more attention and several major mega-projects are underway. In the United States, after a few projects applied to coal plants failed to meet economic viability, there is suddenly increased attention from the availability of the 45Q tax credit, which was revised in 2018 and finalized in January 2021. The Biden Administration has emphasized the importance of CCUS, and Senator Joe Manchin (D-West Virginia) was instrumental in putting $3.5 billion for it in the bipartisan infrastructure bill, which is still awaiting full congressional approval.

Carbon Border Adjustment Mechanisms

As the EU ETS allowance price increases, so will the risk of carbon leakage (i.e., EU companies relocating to countries with less ambitious policies or EU products being replaced by more carbon-intensive imports). This will likely entail an increase in global emissions. One of the main aspects of the CBAM is that it will enter into force progressively and at the same pace as the phasing out of free allocations under EU ETS. The intention is to avoid any problem of double subsidies and to ensure that imported goods are on equal footing with EU products.

Setting Standards for Carbon Content and Carbon Intensity

Development of a common and widely accepted standard for measuring the “carbon content” in steel and for defining what constitutes low-carbon or “green” steel is essential both for instituting
public purchase programs, influencing private consumer preferences, and applying border carbon measures which assess a price-premium based on carbon content that would have been the subject of a domestic tax or price. Issues include the availability and transparency of the industrial information (from firms, or national governments) used to apply the standard to individual products, agreement on the standard itself, by whom the standard is applied, and how its application is reviewed and verified so that the standard can become reliable and trusted. Since there are well over a hundred separate steel products, and policy decisions will have to be made about "indirect emissions" and supply chain emissions for each of these products, standards issues will not be as straightforward as some might assume.

Public Purchase Programs

A substantial percentage of large infrastructure projects are constructed or partially funded by governments, and such projects customarily use large amounts of steel and cement, the two most predominant carbon-intense commodities. Moreover, public purchase programs can provide examples that encourage private preference for steel labelled "green" enough to merit public purchase, and for channeling new investment (public and private) into facilities whose products can bear this label.

Both Fit for 55 and the Biden Administration contemplate extensive public purchasing favoring low-carbon products in government contracts or on projects that are government-funded, in order to build markets for sustainable products. In the United States, a forthcoming Federal Sustainability Plan stems from Executive Order 14030 in May 2021, which directed the Federal Acquisition Regulatory Council to “require major federal suppliers to publicly disclose greenhouse gas emissions and climate-related financial risk and to set science-based reduction targets; and ensure that major federal agency procurements minimize the risk of climate change, including requiring the social cost of greenhouse gas emissions to be considered in procurement decisions and, where appropriate and feasible, give preference to bids and proposals from suppliers with a lower social cost of greenhouse gas emissions.”

The WTO Agreement on Government Procurement (GPA) should allow the kinds of public purchase campaigns contemplated on both sides of the Atlantic, and the pending bipartisan Infrastructure Investment and Jobs Act provides that public purchase priorities for green products should comply with international obligations. As a practical reality, however, it is possible that aggressive “on-shoring” or “Buy America” programs at the federal level could raise trade issues. Equally concerning is the practical reality that the supply chain for ambitious decarbonization in the U.S. may lie substantially abroad -- whether for solar panels, batteries, wind turbines or rare-earth metals -- making "Buy America" difficult to harmonize with "Buy Clean."

Opportunities need to be explored for government investment in pilot projects (through both direct investments and loan guarantees), funding by sovereign wealth funds and multi-lateral development banks and financing entities, and incentives for private financing such as interest rate reductions, tax credits, and subsidies for both equity and debt financing as well as loan guarantees.

Encouraging private finance to favor more sustainable investments could also be important. Efforts are underway, such as one by Rocky Mountain Institute and a group of banks, to encourage the
financial system to apply standards for decarbonizing technology in industries like steel to prioritize their investment choices.

**Labeling**

Like the DOE/EPA’s “Energy Star” and other labelling programs, assigning and advertising standard values for low carbon steel could have an important impact on private consumer behavior.

**Energy Efficiency Standards**

Generally, efficiency standards can be very effective with mass-produced products such as cars, appliances, and machines, and for components of steel production (compressors, motors, pumps, fans, etc.), but highly integrated process systems present an additional level of difficulty.

**The Importance of Just Transition**

As the industry overhauls its production practices and the global marketplace changes, it is vital that companies and policymakers emphasize just transition for workers. There are currently more than 6 million workers in the steel industry worldwide. In the United States, BF-BOF and EAF steel plants together employed around 81,000 people in 2018, and iron and steel foundries employed an additional 64,000. Indiana accounted for 27 percent of total crude steel production, followed by Ohio (12 percent); Michigan (6 percent); and Pennsylvania (6 percent). The construction sector is the United States’ primary steel consumer at 43 percent, followed by transportation, predominantly the automotive industry (27 percent); machinery and equipment (10 percent); the energy sector (7 percent); appliances (5 percent); and other (8 percent).

Social dialogue and worker participation are crucial components for any just transition strategy. Labor unions have historically allowed for collective action that benefits workers. For a just transition to go smoothly and for workers not to lose out in the shift to green steel production, it is important that labor unions remain strong and workers are an integral part of discussions moving forward. An important factor for just transition is that long-term workforce planning is necessary as the number of jobs will decline amid the shift from blast furnaces to electric. Regional disparities in consideration of workers’ rights will challenge international cooperation on just transition with companies and policymakers striving to create a level playing field for workers. Although creating a pathway for just transition is daunting, it can also provide opportunities for workers. Since decarbonization does not mean deindustrialization, the opportunities will be there if there is proper planning and all stakeholders are part of the discussion.

**Areas for Collaboration Between the U.S. and the EU**

As noted earlier, the United States and the EU agreed within two years to reach a Global Arrangement on Sustainable Steel and Aluminum, working together to promote decarbonization of the two industries and simultaneously addressing overcapacity in both steel and aluminum that is caused by non-market practices in some economies. In response, the United States agreed to drop tariffs up to past trade volumes on most of the steel imported from the EU and also focus on
transshipment issues. No other details have been announced as to how the arrangement will be negotiated, but it is intended to be open to other countries as well.

Areas below can inform an agenda for working together whether bilaterally or in multilateral fora (i.e. the Global Forum on Steel Excess Capacity, GFSEC, launched by the G20) and engaging other critical partners (i.e. China). Other important venues for moving beyond Bilateria discussions include the G7 framework for Industrial Decarbonization and Mission Innovation.

We have tried to identify here specific subjects that could also be the subject of specific, direct “bilateral” discussions focused on green steel between the United States and the EU.

**Standard Setting**

One of the most important initial areas in which the EU and United States must lead is in the setting of standards for measuring the “carbon content” of steel that can be broadly accepted among major steel producers, which in addition to China include EU countries, the United States, Turkey, Japan, Russia, and India.

Developing and socializing such standards is key to promoting public purchase programs, maximizing incentives and building encouragement for private purchases to support sustainable economies, along with trade policy and border carbon issues that confront combat leakage. Among the issues will be information gathering and sharing, calculation of whether and how to use indirect and supply chain emissions are part of the calculation, and the challenges of information transparency, measurement, verification, and certification.

We believe this is one of three areas where mutual action could begin immediately. The other areas are:

**Public Purchase Programs**

EU national governments, the United States, and its states will have somewhat different public purchase programs. However, joint study and communication particularly about the experience of already-operating programs such as California’s “Buy Clean” program would be extremely useful. The EU and U.S. could usefully compare notes on their respective approaches and explore the possibility of developing common principles for green and sustainable procurement.

**Cooperation on Research and Development**

The current need and focus of RD&D in green steel is on technologies that have been identified but need to be refined and tested at scale to confirm their economic feasibility. For that reason, cooperation encouraged by governments between research agencies/institutes and industry leaders is probably the most productive course of action toward progress over the next decade or two.

Additional areas in which consultation and cooperation would be useful are:
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Finance

Consultation among central banks as well as private consortia can investigate new opportunities for public finance and facilitating access to private funding and de-risking. Also, it can lead to discussion of use of techniques such as loan guarantees across national borders.

Hydrogen and CCUS

Consultation about both hydrogen strategies and CCUS would be useful in the green steel context.

Trade

Fit for 55 and Biden’s Build Back Better program promise continuing and new subsidies, tax benefits, and other extensions of support (such as transitional free ETS permits) to the steel industry to encourage and aid in its transition. Many of these provisions could raise issues under existing WTO trade law, and in particular the Agreement on Subsidies and Countervailing Measures. Discussion about how to manage differences and recognize that both sides are seeking to advance a mutual and shared public good -- climate ambition -- could be very useful to avoiding the emergence of new trade disputes that could dampen corporate and investor enthusiasm for green steel.

These “new” issues arising out of the interplay of climate and trade goals will also have to be negotiated in a context of existing and future use of trade defense instruments, the geopolitical tensions around Chinese steel overcapacity, and the EU/China and U.S./China relationships overall.

Recycling and Building Efficiency

Coordination and mutual education in two other areas might be useful: first, in increasing the amount of scrap collected for use in EAF mills; second, in more efficient building practices where engineers and architects believe much smaller amounts of steel would suffice for adequate support of large buildings, bridges, highways, industrial facilities, and other large infrastructure.

Structural Excess Capacity Undermines Decarbonization Efforts

As we move out of the pandemic, structural capacity persists and will certainly complicate, if not impede, steel decarbonization efforts. See the Global Forum on Steel Excess Capacity, Ministerial Report, Oct. 1, 2021: “Despite [the post-Covid market] recovery, excess capacity still looms large as investments in new capacity, including offshore investments, continue to take place at a robust pace in some economies despite uncertain long-term steel demand prospects. Indeed, the current market growth and high steel prices are short-term impacts that are unlikely to resolve the issue of structure.”

The current market growth and high steel prices are short-term impacts that are unlikely to resolve the issue of structural overcapacity created by market-distorting subsidies and support measures.
Reducing structural overcapacity in steel making is essential to improve environmental performance. The ability of the industry to respond to these challenges will depend critically on the investment needed to develop and deploy effective environmental strategies. Eliminating market-distorting government subsidies and support measures contributing to excess capacity would boost the steel industry’s profitability and promote reductions in excess capacity thus helping decarbonization of the steel industry.

Moving Forward

The decarbonization of heavy industry will be important to reaching global long-term climate goals, and the steel industry can lead the way. Policymakers, industry officials, and NGOs have the opportunity to collaborate to grow the green steel industry in all markets, keeping up the momentum that has recently been seen, particularly in Europe. There will be a need for long-term policies that focus on both decarbonization and jobs. Additionally, the need for financial support and creation of new low-carbon markets will have to be continually addressed so that companies can not only reduce emissions but also thrive as an industry. To support and implement sustainable policies, there will need to be further transatlantic bilateral cooperation on this topic, as well as a joint approach on multilateral organizations and when engaging key third countries. Public discussions that bring all relevant stakeholders together will serve as important developments going forward.