Technological Innovations and Climate Change: Green Steel

March 2022

ABOUT ALDERSGATE GROUP

The Aldersgate Group is an alliance of major businesses, academic institutions, professional institutes, and civil society organisations driving action for a sustainable and competitive economy. Our corporate members, who have a collective turnover in excess of £550bn, believe that ambitious and stable low carbon and environmental policies make clear economic sense for the UK.[1] They have operations across the UK economy and include companies such as Wilmott Dixon, WSP, Ramboll, BT, CEMEX, Johnson Matthey, Siemens, SUEZ, and Thames Water. To inform our work on industrial decarbonisation we also work closely with organisations including Liberty Steel, Tata Steel, Materials Processing Institute and others.

We develop independent policy solutions based on research and the expertise and diversity of our members. Through our broad membership, we advocate change that delivers benefits to an ever-growing spectrum of the economy.

1. The technologies there are to produce "green steel"; how close they are to commercialisation; and the benefits and risks of each

Different methods exist for decarbonising both primary and secondary steel production, and a combination of them will likely be needed to decarbonise the sector in the UK and globally.

One of the most established ones is for **secondary steel production**, which melts scrap steel using electric arc furnaces (EAF). With a decarbonised power grid, the emissions from this production route are zero, and it also has the benefit of delivering carbon savings through re-use of materials. The use of scrap-based EAFs is an important pathway for steel decarbonisation, as it is mature and can be deployed now, providing that industrial electricity prices are competitive and sufficient supply of high-quality scrap exists. If secondary steel production is to scale up, it is essential to ensure quality scrap is retained in the UK. Currently, around 11-12 Mt of scrap are generated every year in the UK, three quarters of which gets exported.[2] Designating scrap steel as a strategic asset, investing in scrap sorting capacity to decrease contamination and developing EAF infrastructure will be essential in addressing this.

However, this route to producing green steel can only meet around 22% of the global demand at present, which is why decarbonising primary steelmaking (i.e. producing steel from iron ore) is still essential. In addition, secondary steel can sometimes be of lower quality due to contamination in the production process and can be deemed less suitable for steel products where the carbon content is key – for example in big structures, as sometimes secondary steel can become brittle.

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[1] Individual recommendations cannot be attributed to any single member and the Aldersgate Group takes full responsibility for the views expressed.

[2] UCL (7 September 2021) "Remaking steel for a net zero carbon circular economy"

For **primary steel production**, the use of **hydrogen direct reduced iron (DRI)** with EAF (with EAF replacing blast oxygen furnaces) offers one of the best options for green steel production, with all major European steel players currently trialling the use of hydrogen DRI on different scales. The technology allows replacing coal with hydrogen as a reduction agent in steelmaking, which produces steam instead of CO2 as a by-product. **EAF production combined with hydrogen DRI reduces the emissions intensity of steel production by approximately 99% compared to current blast oxygen furnace (BOF) technology**.[3] Trials are already ongoing in countries including Sweden, China and Spain. However, using this at scale in the immediate term is unlikely, given that it requires wide availability of low carbon hydrogen. To give a sense of the scale, 50-55 kWh of electricity is required to produce 1kg of hydrogen, and 50kg of hydrogen is required for the production of 1 tonne of steel.[4] This is why it will be essential to **prioritise the supply of low carbon hydrogen for sectors like steel or ammonia, where the alternatives are more limited**, instead of diverting it for use in home heating, where mature alternatives like heat pumps exist.

Another option of decarbonising primary steel production is through the use of **'circular carbon'. This involves using biocarbon to fuel blast furnaces, which can come from biomass.** ArcelorMittal has an ongoing trial, Torero, which converts waste wood into a biocarbon that is suitable for the blast furnaces process. The source material typically comes from demolition sites. There are, however, fewer technology trials for circular carbon at present. In addition, the applicability of this technology is limited by the availability of sustainable biomass, given that importing it or using monoculture crops to harvest biomass would have a net negative impact on carbon emissions. In addition, this option will require the use of BOF rather than EAF, which means that whilst emissions are reduced, they are not completely eliminated. The use of circular carbon can thus play a role in delivering some emissions savings whilst low carbon hydrogen supplies scale up and steel plants replace their BOFs with EAFs.

Finally, continuing the use of iron ore steel production with carbon capture and storage (CCS) is sometimes discussed as another way to keep existing assets and infrastructure (such as blast oxygen furnaces), whilst still reducing emissions by fitting CCS technology on existing plants. However, the use of this option ought to be minimised given the fact that CCS has not yet been proved at scale, and volumes of carbon that can be effectively captured and stored will be limited in the near term. In this context, this option might be most suitable for newer legacy plants that are still some way away from the end of their lifetime, where immediate replacement with EAF would not be commercially feasible.

In addition, using CCS with conventional steelmaking to preserve existing assets will ultimately be more expensive for manufacturers, who will need to switch to EAFs in the longer term to improve their productivity. The use of CCS on conventional plants could also serve to prolong the life of less efficient plants and create perverse incentives regarding investment in more promising technologies that could reduce emissions, drive innovation and have positive spillover effects in other sectors (e.g. the development of hydrogen infrastructure and a hydrogen economy could also benefit long-distance transport and other energy intensive manufacturing sectors).

According to Bloomberg NEF predictions, by 2050, green hydrogen could be the cheapest production method for steel and capture 31% of the market. Another 45% could come from

[3] Toktarava et al., Pathways for Low carbon Transition of the Steel Industry – A Swedish Case Study, Energies (2020).
[4] European Parliament (December 2020) *The potential of hydrogen for decarbonising steel production*

recycled material, and the rest from a combination of older, coal-fired plants fitted with CCS and other methods.[5]

2. The relationship between low-carbon steelmaking technologies and the development of other decarbonising technologies

As indicated above, the routes available for green steel production are dependent on scaling up key technologies like CCS or low carbon hydrogen. Whilst the supply of both will be limited in the near term, clearly signalling demand for low carbon hydrogen or CCS will be key in attracting investment in these sectors. As such, government should create with industry decarbonisation pathways for steel and other foundation industries, which clearly signal demand for these technologies and prioritises their deployment to sectors without other feasible alternatives.

However, **demand for CCS and hydrogen will also depend on infrastructure development**. Whilst there is more clarity on the pace and scale of deployment of transmission and storage and hydrogen infrastructure around industrial clusters, steelmaking also takes place in dispersed sites (e.g. the Liberty Steel plant in Rotherham). Getting clarity on the availability of infrastructure in dispersed sites will be key in driving demand for low carbon hydrogen and CCS. At the same time, steel production sites like the one in South Wales are not close to storage spaces, so the use of CCS in such areas will depend on plans for transport and storage being developed.[6]

In addition to hydrogen and CCS, a transition to low carbon steelmaking will require large amounts of low carbon electricity, not just for powering EAF, but also for green hydrogen production and operating CCS infrastructure. At present, industrial electricity prices in the UK are uncompetitive, posing a key barrier to the switch away from fossil fuels. To indicate the scale of the problem, **UK industry currently pays 25-44% more than the EU average wholesale electricity price**.[7] Given this, government needs to take measures to cut both the wholesale price and carbon intensity of electricity in the UK.

To deliver affordable, low carbon electricity prices in the UK, the Government must maintain a policy framework that attracts investment in low-cost renewable energy, whilst supporting timely and coordinated grid development. The recent confirmation of annual Contracts for Difference (CfD) auctions for renewable energy projects is welcome. Going forward, the investment climate could be further improved by providing forward visibility on the volume of projects being auctioned each year, and **greater clarity on the timing of the next Crown Estate leasing round.** Finalising the review of the **Energy National Policy Statement** is key in enabling timely planning consent for the transmission infrastructure needed to support the connection of new offshore wind projects. In addition, **improving co-ordination between the planning process and the roll-out of future transmission and generation infrastructure** (both onshore and offshore) will be key to minimise delays in project delivery.

Accelerating investment in interconnection and storage would also be beneficial as it can lower wholesale electricity prices, as well as boost energy security. **Each 1GW of interconnection capacity can reduce UK wholesale electricity prices by 1-**

[5] Bloomberg NEF (1 December 2021) “Steel industry set to pivot to hydrogen in $278 billion green push”

[6] Even if CCS is not used on BOF plants, it will still play a role in capturing residual emissions from green steelmaking. For example, emissions from hydrogen DRI are anticipated to be low but not zero: currently estimated at 0.025 tonnes of CO2 per tonne of steel produced, compared to 1.6 to 2.2 tonnes of CO2 per tonne of steel produced by BOFs.

[7] UCL (September 2021) *Delivering competitive industrial electricity prices in an era of transition*

2%.[8] Meanwhile, standardised structures of long-term, tradeable zero carbon electricity contracts should be made available to industrial consumers to **mitigate exposure to the indirect costs of carbon prices and the volatility of fossil fuel prices, whilst creating certainty of demand** for low carbon generators.

3. The timescales needed to achieve fossil fuel feedstock replacement and fossil fuel-free energy throughout the supply chain for steel products

The Climate Change Committee recommends that UK steelmaking should reach near zero emissions by 2035. Achieving this will depend on the availability of plentiful, affordable low carbon electricity and at scale deployment of low carbon hydrogen and hydrogen infrastructure. Delivering these in a timely manner requires a supportive policy framework, with business models for hydrogen having the potential to play a key role in driving down the cost of production and accelerate the speed of deployment. A focus on technology application and the availability of demonstrator projects for hydrogen DRI steelmaking will be essential in facilitating a learning by doing approach and enabling industry to better understand what type of fossil fuel feedstock replacement is most suited for different locations. (see questions 4, 7, 8)

4. The targets the Government should set for low-carbon steelmaking in the UK

Firstly, it is essential for government to adopt **a clear target for net zero ore-based steel making by 2035, as recommended by the Climate Change Committee**. In the Net Zero Strategy, government committed to consider the implications of setting such a target. Following consultation with industry, this target should be set without delay to send a clear market signal for industry and start mobilising investment. Current investment levels in the steel sector are not sufficient to for retrofitting plants and shifting production methods to meet net zero – according to IPPR, the annual cost of the transition will be £267m by 2050.[9] A clear target for net zero ore-based steelmaking, accompanied by other key measures outlined below, will be essential in mobilising private investment into this key sector.

In addition to this target, government should work with industry to develop a clear roadmap for decarbonising UK steel. As part of this, businesses should have clarity on:

1. Access to **innovation funding**, in particular for dispersed sites where access to funds like IETF is often difficult and not aligned to business investment cycles. As part of this, bringing forward the Clean Steel Fund is also essential in enabling industries looking to start the transition by offering capex support as soon as possible.

2. Clearer **timelines related to the availability of low carbon hydrogen and CCS and the required infrastructure**. Current uncertainty around timelines for infrastructure deployment effectively increases the expected cost of these investments, as companies that make an investment today need to price in the risk of crucial infrastructure not being available in time. This creates a disincentive to invest in innovative technologies and may skew investment towards less efficient methods. Finalising the business models for hydrogen and CCS will be essential in providing the revenue stability needed to boost investor confidence.

3. Measures to **lower industrial electricity prices** (outlined under question 1).

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8 Ibid p.22

9 IPPR (April 2021) *Forging the future: a vision for northern steel's net zero transformation*

The roadmap should be accompanied by demand-side measures like public procurement mandates and product standards that gradually drive down the permissible level of embodied carbon in steel products, which are essential to grow the market for low carbon steel.

Finally, government should urgently set a target for at least one pilot trialling hydrogen-based steelmaking in the UK (see question 8 for further details).

5. The policy support for low-carbon steelmaking in the UK provided in the Industrial Decarbonisation Strategy and the Net Zero Strategy

There are existing and upcoming policies which are helping the steel sector to transition towards net zero. These include:

1. Industry-wide efficiency programmes such as the **IETF** which will provide funding for steel producers to invest in low carbon technologies;

2. infrastructure programmes such as the **Net Zero Hydrogen Fund**, providing capital for low carbon hydrogen investments; and

3. the steel sector-specific **Clean Steel Fund**, which will assist the steel sector with its transition.

Industry stakeholders Aldersgate Group has engaged with over the course of 2021[10] indicated that the existing policy support framework generally covers their key areas of need. However, more support will be needed to create a business environment conducive to investment and to enable steel manufacturers to take advantage of key opportunities for decarbonisation (see questions 6 and 7 for further details).

6. How effective the Clean Steel Fund is expected to be in helping to deliver decarbonised fuel capacity in the UK

The Clean Steel Fund (CSF) will only start being distributed in 2023. In the meantime, limited financial support has been available to help steel companies start investing in net zero assets and production, especially at a time when they face growing costs on electricity, gas and carbon prices under the ETS. With many companies in this sector having already felt the impacts of the energy crisis last year and pausing production as a result, it is essential to ensure timely support for them. The difficult economic context has reduce companies' ability to invest in low carbon solutions, so we recommend the CSF be brought forward.

In addition, the CSF has been criticised by industry stakeholders as being very small compared to the level of investment needed. In particular, it supports transformation of steel production sites in line with net zero, but before that stage companies will already have had to invest to cover years of pre-engineering studies.

In addition, the CSF should be deployed in parallel with pilot projects for hydrogen DRI to ensure industry learns by doing and that subsequent funds go towards the most impactful projects.

[10] Frontier Economics for Aldersgate Group (September 2021) *Accelerating the decarbonisation of industrial clusters and dispersed sites*

7. **Any additional policy support required to encourage the transition to low-carbon steelmaking**

Whilst stakeholders that Aldersgate Group has engaged with indicated that existing government policy largely addressed key areas of need, what is needed for steel manufacturers (particularly those located in industrial clusters) is increased support within the existing policy framework. In particular, policy needs to be developed further to support:

- **Availability of plentiful, affordable renewable electricity**. This can take the form of policies that shift the burden of policy and network costs off of industrial electricity bills. Other necessary measures are included in response to question 2.

- **Access to low carbon hydrogen**. This can be supported by finalising the business models for low carbon hydrogen, which could be designed like a CfD regime.

- **Certainty around policy and timelines**. In general, this requires clear sign-posting by policymakers, but can also be supported by policies such as CfDs and increased coordination across different levels of government.

- **Incentive policies that account for carbon circularity**. This involves ensuring policy is sufficiently technology neutral to ensure recycling and re-use are taken up where appropriate.

These policies are all part of a broader framework which supports a strong business environment and incentivises investment in the main opportunities for decarbonisation. Given the cost of some of the investments to be made, there is also likely to be a need for some degree of government co-investment or support through policies.

8. **The desirability or otherwise of establishing a low-carbon steelmaking pilot at a UK site**

Hydrogen-based steelmaking pilots, trials and full-scale projects are already underway across Europe, with more than 20 projects planned or started in Germany, Sweden, Austria and more. The world's first hydrogen-based DRI plant is operational in China from 2021[11] and Swedish steel producer SSAB's Hybrit programme in Sweden is aiming to have a demonstration plant in place to produce DRI using hydrogen in 2025 and use this to produce fossil-free steel in 2026.[12]

With plans to trial hydrogen reduction progressing rapidly in other countries, the UK should not wait to have a full decarbonisation plan in place before kickstarting a UK pilot. This trial would **test production, create initial capability, develop world-leading expertise, and create a new anchor market for hydrogen**.

9. **The consequences to the UK steel sector from a failure to invest in alternative technologies in a globally competitive market**

The UK is world leading in research but is falling behind in application due to hesitancy in deploying new technologies. Industry stakeholders highlighted the example of steel manufacturing in Sweden, which until recently was behind the UK in terms of technology and

[11] MPIUK (March 2021) *Decarbonisation of the Steel Industry in the UK*
[12] https://www.ssab.com/company/sustainability/sustainable-operations/hybrit-phases

production efficiency.[13] However, it has now advanced significantly beyond UK manufacturers due to a more ambitious pace of deployment. To compete with increasingly innovative manufacturers abroad, the **UK needs to move rapidly away from research and towards commercialisation and deployment of new technology in steel**. A more definite policy environment and clear timelines on when critical inputs and infrastructure are available could help accelerate this deployment. It could also increase opportunities for innovative UK companies to translate R&D investments into new export opportunities as markets for low carbon products develop globally.

Lack of investment in new technologies can also lead to investment leakage. UK steel companies are global and usually compete for investment across different countries. Without adequate policy support, companies could choose to invest either in countries with clearer support for new technology deployment (Sweden, China) or in countries that offer lower industrial electricity prices (Germany, France). This will ultimately lead to assets becoming run down, making them less competitive and less likely to attract investment – a vicious circle.

[13] Frontier Economics for Aldersgate Group (September 2021) *Accelerating the decarbonisation of industrial clusters and dispersed sites*