ACHIEVING GREENHOUSE GAS GOALS

Metal Industry Strategies For A Low-Carbon Future

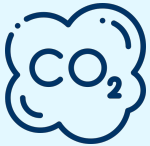
PRESCOUTER

With growing environmental concerns, the iron and steel making industry will spend $160Bn/year by 2030 in carbon credits or related taxes - nearly **double its current spend**. The industry needs to start following three simple strategies to mitigate these costs.

International and national agreements are increasing pressure across all industrial sectors - including the steel the manufacturing sector - to pursue decarbonization. In order to reduce the associated carbon intensity, some countries and regions have launched their own low-carbon steelmaking programmes.

The steel manufacturing industry needs to follow strategies such as these, which we highlight in this report:

Green Hydrogen



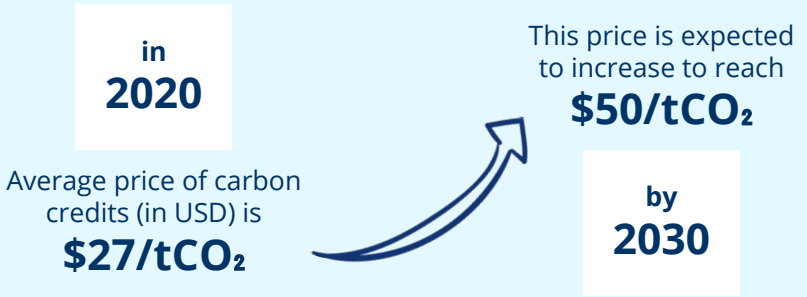
Carbon Capture

Renewable Energy

The price of carbon credits is going up and paying them can only be an acceptable short-term solution.

Carbon credits could cost 85% more in 2030 than they do today. The price of carbon credits has seen an increase in the past few years, with high variability today, ranging from as low as US$1/$tCO_2$ to a maximum of US$139/$tCO_2$. However, the average price today is around US$27/$tCO_2$. Forecasts place it up to US$50/$tCO_2$ in 2030.

Some companies have resorted to increasing their carbon credits by buying or trading credits with other companies, and even buying forests as BP has done.



Relying on carbon credits will represent paying
85% more
for those same emissions by 2030

which translates to an extra

USD 80 Billion
to the total CO_2 emissions in the ironmaking industry **ten years from today**.

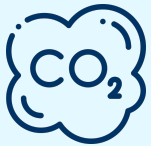
However, relying on carbon credits alone is <u>not</u> a reliable, long-term solution.

In parallel with buying carbon credits, the steel industry should be looking into decarbonization pathways and technologies to achieve CO_2 reduction and, more ambitiously, full decarbonization.

These 3 approaches can and should be combined today to achieve the intermediate target of a carbon footprint reduction in the next few years and the ultimate goal of carbon neutrality in 2050, which is held by many companies.

3 Steps for a Reduced Carbon Footprint

Replacing conventional coal and natural gas-based reduction processes with green hydrogen



Implementing carbon capture, sequestration and utilization concepts for current emissions in standard steel manufacturing routes

Replacing fossil-based energy with renewable energy

The carbon reduction strategies profiled in this report are an example of the insights clients rely on PreScouter for.

PreScouter's research consultancy has helped drive strategic planning and specific solution development decisions for some of the most sustainable and prominent companies in the world, for years.

Rio Tinto · SAAB · Agnico Eagle · AngloAmerican · AK Steel · Coca-Cola · Rousselot · Dow · AIRBUS · Lhoist · VISA

PreScouter's Proven Track Record

500+	4000+	150K+
Clients Worldwide	Challenges Conquered	Hours of Research

"We have actually started speaking with a few potential collaborators - all within 12 weeks of working with PreScouter. So to me, the investment was incredibly well-spent."

Naveen Nair, Director of Engineering, Strategic Partnerships

Baker Hughes

PreScouter is helping iron and steel clients get started with reducing their organization's carbon footprint in three ways.

1. Identifying the most promising technologies to produce green hydrogen and who the best vendors for a strategic partnership for a green hydrogen supply are.
2. Assessing the latest and most impactful technologies in the ironmaking process as well as scouting for key partners in the space.
3. Reviewing and ranking companies offering carbon capture & storage / utilization.

PRESSURE IS INCREASING FOR STEEL MANUFACTURERS TO LOWER THEIR CARBON FOOTPRINT.

14% of the potential value of steel companies is at risk if they are unable to decrease their environmental impact*.

The iron and steel industry, as one of the largest energy-intensive industries worldwide, is expected to undertake the largest contribution to industrial decarbonization. Currently, the steel industry is among the three biggest producers of CO_2, accounting for 7%-9% of annual global CO_2 emissions.

** According to a 2018 CDP report*

Upcoming government sustainability plans across the globe will impact future iron and steel production.

Under the Paris Agreement and the United Nations Framework Convention on Climate Change (UNFCCC), the iron and steel industry is required to reduce CO_2 emissions by 50 Gt cumulatively through 2050.

On the other hand, it is estimated that global crude steel production will grow >50% by 2050. As a consequence, the iron and steel industry is facing a severe challenge to accomplish the mid- to long-term decarbonization target, under the scenario of an increasing CO_2 emission load but a diminishing CO_2 budget with time up to 2050.

2019

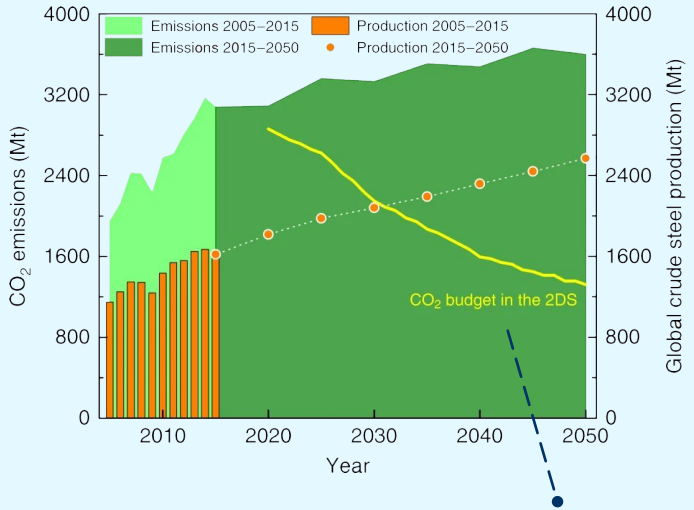
United Nations	European Green Deal	SUSTAIN - Research Hub
Over 60 countries, including the U.K. and the EU (with the exception of Poland), had committed to carbon neutrality by 2050. China, India, and the United States were not among that number.	The EU aims to be climate neutral in 2050. Some actions include: investing in environmentally friendly technologies; supporting industry to innovate, etc. Financing: €1 trillion of investments over the next decade (public investment and private funds through EU financial instruments).	A £35M project funded by £10M of Engineering and Physical Sciences Research Council (EPSRC) funds, as well as by Universities, Trade Bodies, RTOs and businesses. The aim is to develop initiatives for decarbonizing the steel industry for over 7 years.

NOTE:
In 2018, every ton of steel produced emitted on average 1.85 tons of CO_2.

The steel and iron industry is facing a number of decarbonization challenges.

There is a growing demand for carbon-friendly steel products in addition to growing investor and public interest in sustainability. This is coupled with challenges in complying with new political regulations and varying carbon dioxide prices.

Despite the launch of international and national programmes for low-carbon steelmaking, some techno-economically feasible solutions are still in research and development.



Limiting global warming to within 2°C above preindustrial temperatures by the end of this century (Paris Agreement)

Figure. Evolution of annual crude steel production, CO_2 emissions, and the CO_2 budget of global iron and steel industry up to 2050, and the sectoral contribution to CO_2 emission reduction in the 2 °C scenario (2DS). Source:

PRESCOUTER EXPERT NOTE:

“Investment in lowering emissions today, will pay its dividends in the future, when more restrictions on greenhouse gases are very likely to be implemented, while other strategies could lead to considerable losses for steel manufacturing companies.”

- Christian Salles, PreScouter Technical Director

Who are some key players to reducing CO2 emissions?

What are some pioneers from the steel industry doing?

ArcelorMittal

This year ArcelorMittal Europe published its climate action report: using clean electricity (solar and wind energy), hydrogen-based DRI technologies, circular carbon (bioenergy) and carbon capture utilization and storage.

SSAB

With a pilot plant under construction, the company is expecting be the first steel company to bring fossil-free steel to the market in 2026 by using renewable energy and Hydrogen Direct Reduction of Iron ore (H-DRI)

Some major players in the steel industry are already working on overcoming the challenges and planning for a carbon-neutral future.
Here we show two examples

Who can help providing the technology?

MIDREX UK LTD. | IFP Energies nouvelles | C-Capture

A number of equipment and system suppliers are developing carbon-neutral technologies to support steel manufacturing.
Here, we showcase three examples.

GOAL

Reducing CO2 emissions in steel manufacturing

ArcelorMittal - Going all in to reduce emissions

At a glance	
Target	30% lower CO_2 emissions by 2030; carbon neutrality by 2050.
Partners	LanzaTech (waste to energy), Midrex (hydrogen-based DRI), Dow Benelux, University Lille, ISPT and POM EF (carbon capture).
TRL	5-7 (design, pilot and demonstration plants)

Smart Carbon is a carbon-neutral steelmaking route using clean energies, including circular carbon (use of bio-waste material to solar and wind energy), clean electricity (solar and wind energy) and carbon capture and storage (CCS). In its first phase, Smart Carbon will primarily use circular carbon. It is expected that Smart Carbon has the potential not only to provide carbon-neutral steel, but also carbon-neutral cement, and the building blocks to make recycled carbon materials to replace polyethylene-based plastics.

Reaching **carbon-neutral steelmaking via DRI-EAF** involves moving from using predominantly natural gas to hydrogen as the key reductant in ironmaking. As this hydrogen becomes 'green' (made using clean electricity), the steelmaking process would come close to carbon neutrality.

According to the company, "*the major technological challenge for this route is bringing hydrogen-based DRI production to commercial maturity, and so industrial scale production is unlikely to be significant before the 2030s*". In 2019, the company announced a partnership with Midrex to design a hydrogen-based DRI demonstration plant in Germany. However, hydrogen needs to become 'green' to allow the process to be carbon neutral.

Strategies

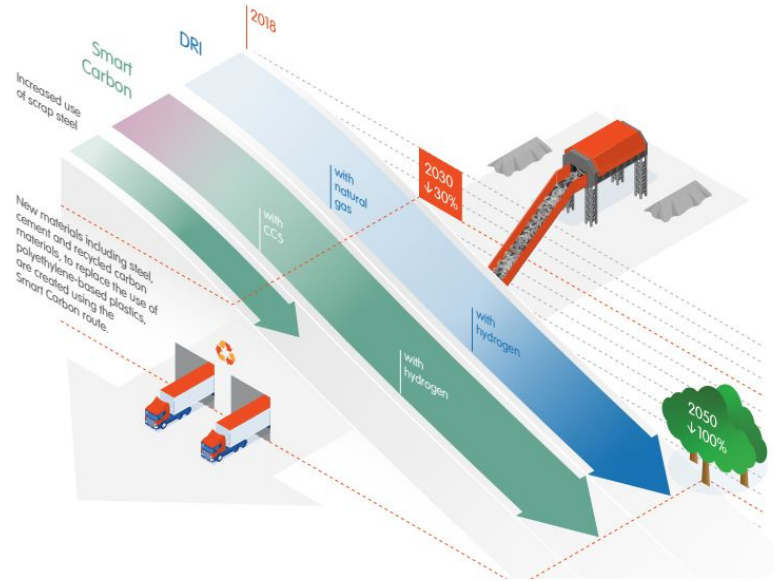
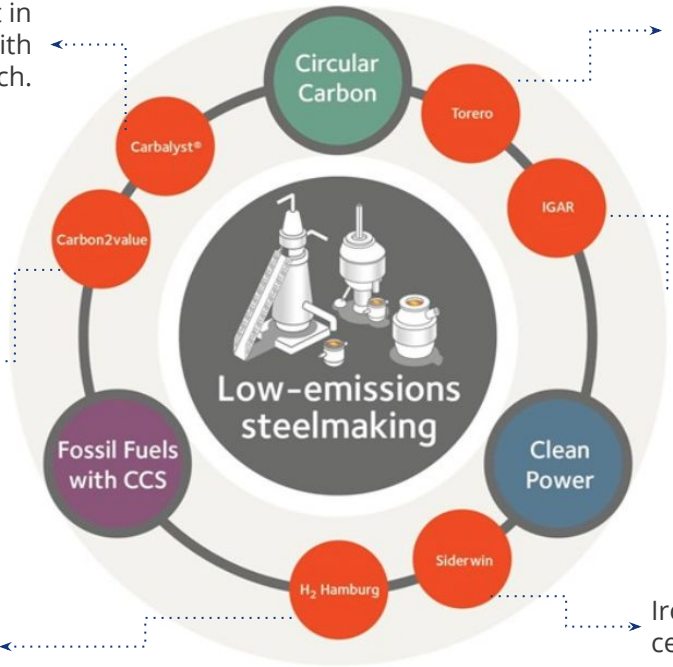


Figure. ArcelorMittal carbon-neutral technology routes: 1) Smart Carbon; and 2) an innovative DRI-based route. Both routes will benefit from a shift towards hydrogen in the long term.

ArcelorMittal - Going all in to reduce emissions

Waste to chemicals pathway. Converting off-gases into bio-ethanol. Pilot plant in Ghent, Belgium. Partnership with LanzaTech.

Waste wood replacing coal for use in iron ore reduction. Demonstration plant in Ghent, Belgium.



Fossil fuel carbon capture for storage or re-use. Pilot plant in Ghent, Belgium. Partnership with Dow Benelux, University Lille, ISPT and POM EF.

Making synthetic gas from waste CO_2 as a replacement for fossil fuels. Pilot demonstration in Dunkirk, France.

Hydrogen-based iron making. Demonstration plant in Hamburg, Germany. Commissioned to Midrex.

Iron ore reduction via electrolysis. Industrial cell under construction in Maizières, France.

Figure. ArcelorMittal's technologies to carbon neutrality for steelmaking

ArcelorMittal - Going all in to reduce emissions

ArcelorMittal has committed around $356.07 million (€300 million) towards carbon-neutral technologies via both routes (smart carbon and innovation in DRI). Based on market conditions today, the **smart carbon route is less capital intensive** than the innovative DRI route. The company expects that the technologies could reach commercial maturity before 2025.

Key Advantages:

ArcelorMittal has established different partnership to achieve its carbon emissions targets.

Key Limitations:

The viability will be dependent on when the technology matures, and when enough cost-effective hydrogen is available. Hydrogen needs to become ‘green’ to allow the process to be carbon neutral.

WANT TO LEARN MORE ABOUT HOW COMPANIES IN THE NATURAL RESOURCES SECTOR ARE SHIFTING TO RENEWABLE ENERGY?

A number of examples can be found in the PreScouter report, Renewable Energies: The Place to Go

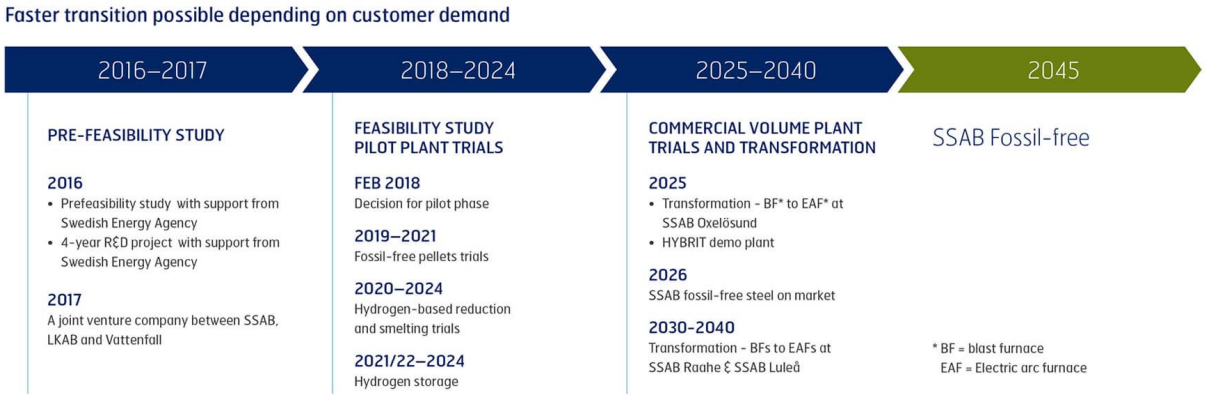
SSAB AB - Targeting first fossil-free steel

At a glance

Target	Cut CO_2 emissions in Sweden by 25% by as early as 2025 and bring fossil free steel to the market in 2026.
Partners	LKAB and Vattenfall (hydrogen-based EAF).
TRL	5-6 (pilot plant under construction)

Strategies:

The HYBRIT initiative aims to replace coking coal, traditionally needed for ore-based steel making, with fossil-free energy hydrogen. In the HYBRIT pilot plant (located in Luleå, Sweden), the hydrogen is produced by electrolyzing water and then using the hydrogen to test the direct reduction of iron ore to make direct reduced iron (DRI), also called sponge iron. The DRI is then used as virgin material together with recycled scrap for steelmaking. Instead of CO_2 emissions, the by-product will be water. The pilot plant for fossil-free steel production will be used from 2021 to 2024.



SSAB AB - Targeting first fossil-free steel

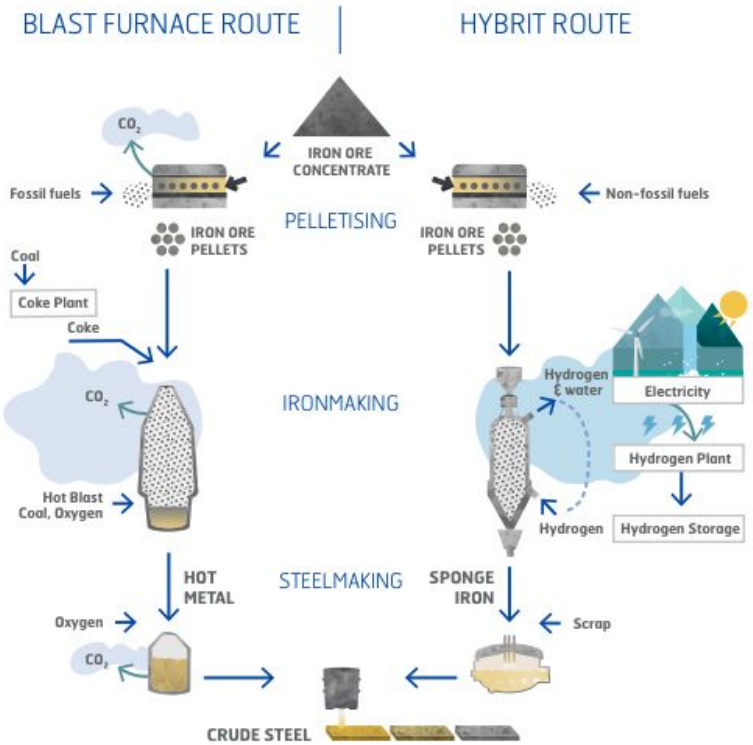


Figure. HYBRIT initiative.

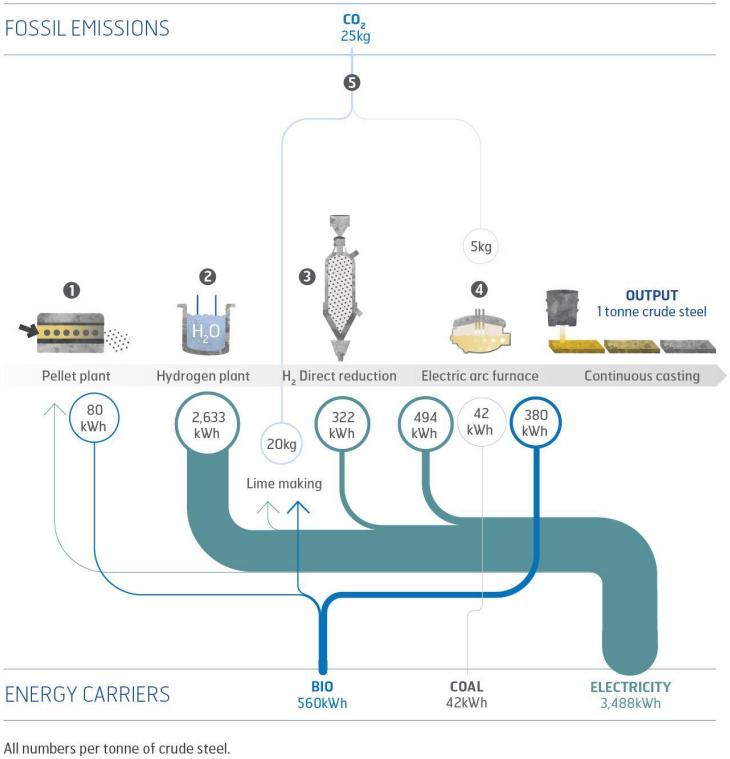


Figure. HYBRIT fossil emissions.

SSAB AB - Targeting first fossil-free steel

The total cost committed of the HYBRIT initiative during the pilot phase is estimated to be SEK 2 billion. The Swedish Energy Agency has committed to contribute SEK 599 million and the three owners, SSAB, LKAB and Vattenfall, are contributing the remaining costs in equal shares.

SSAB's initiatives are focused on: a) production of fossil free pellets; b) testing alternatives, such as CO_2-free plasma and fuels not yet commercialized; and c) storage of hydrogen.

Key Advantages:

Hydrogen replacing carbon as reductant. Water as a by-product instead of CO_2.

Key Limitations:

The production cost for steel via the HYBRIT route is approximately 20-30% higher than for the Blast furnace route. However, it is expected that this will change.

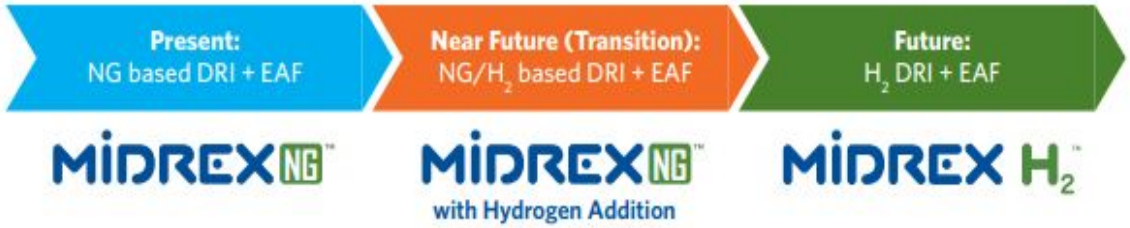
Midrex - Implementing hydrogen for the steel industry

At a glance	
Target	DRI powered with natural gas and hydrogen to reduce CO_2 emissions.
Partners	ArcelorMittal (hydrogen-based DRI)
TRL	9 (natural gas) and 6 (hydrogen)

Strategies:

Midrex is a company specialized in direct reduction technologies for the steel industry. Midrex designs Direct Reduced Iron (DRI) plants, providing engineering, proprietary equipment, and project development services. Their customers include NUCOR, CLIFFS, Metalloinvest, ArcelorMittal, and Hadeed.

Among Midrex's technologies is the MIDREX® Process, which can utilize either natural gas (MIDREX NG) or coal (MxCol) to produce quality DRI, HBI and HDRI. Furthermore, the company is developing a demonstration plant for hydrogen steel production (MIDREX H2) to decrease CO_2 emissions and to help transition to the hydrogen economy in the steel industry.



Midrex - Implementing hydrogen for the steel industry

ArcelorMittal will build a demonstration plant at ArcelorMittal Hamburg (Germany) in collaboration with Midrex in mid-2020. The 100,000 tons per year module will utilize 100% hydrogen as the reductant first sourced from the existing MIDREX plant. Green hydrogen produced from renewable energy sources can be added or substituted at later stages.

Key Advantages:

The company is specialized in DRI technologies.

Key Limitations:

Hydrogen is not currently available at sufficient scale and low enough cost for rapid adoption.

IFPEN - On the path to achieve efficient carbon capture

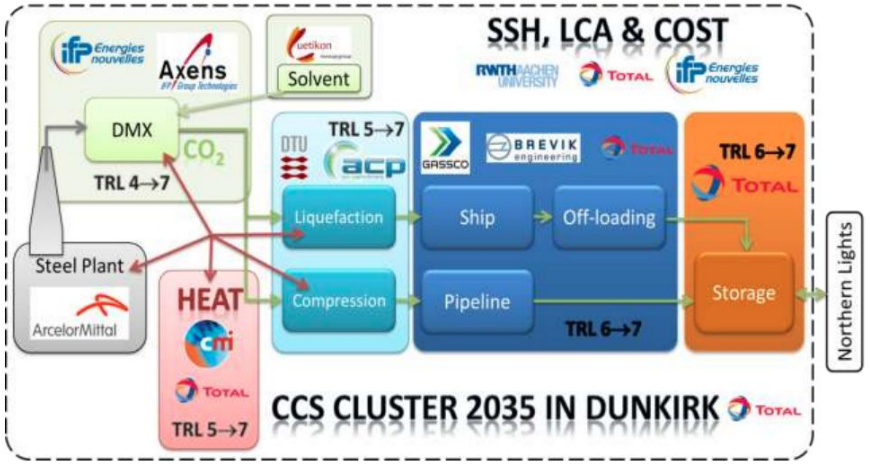
At a glance		
	Target	Carbon capture usage and storage with high cyclic capacity solvent
	Partners	ArcelorMittal, Total and Axens (pilot design)
	TRL	4-7 (demonstration plant under construction)

Strategies: CO_2

IFP Energies Nouvelles (IFPEN) is a public research, innovation and training organization in the fields of energy, transport and the environment. Currently, IFPEN is contributing to diverse carbon capture projects in partnership with industry and government bodies in France - one of which being the “3D” (DMX Demonstration in Dunkirk) project, launched in 2019.

The demonstration project (“3D”) is an industrial-scale demonstration on steel industry exhaust gas in partnership with ArcelorMittal, Total and Axens. The DMX™ process is dedicated to capturing the CO_2 in the emissions of industrial facilities, including coal-fired power plants, cement plants, and steelworks, among others.

The project will demonstrate the effectiveness of the DMX™ process on an industrial pilot that will capture 0.5 tCO_2/hour from steel mill gas by 2021. This H2020 project (Grant agreement N° 838031) has a €19.2 million budget over 4 years, including €14.7 million in European Union subsidies.



IFPEN - On the path to achieve efficient carbon capture

The IEA estimates that CCUS will prevent the emission of some 8.2 billion tonnes of CO_2 between now and 2060, representing 14% of the reduction needed.

Capture remains the most costly step in the CCS process, representing between 65 and 75% of the overall cost.

Key Advantages:

The agency claims that the process uses a solvent that reduces the energy consumption for capture by nearly 35% compared to the reference process.

Key Limitations:

It is needed to demonstrate the feasibility of large-scale, secure storage in deep saline aquifers and develop long-term control and monitoring technologies.

C-Capture Ltd - A cross-industry carbon capture technology

At a glance

Target	Carbon capture solvent based technology. CO_2 can be sent for storage in geological reserves or utilised in some way.
Partners	IP Group, Drax and BP
Technology/ Pathway	Carbon capture storage (CCS)
TRL	6 (pilot plant)

Strategies: 

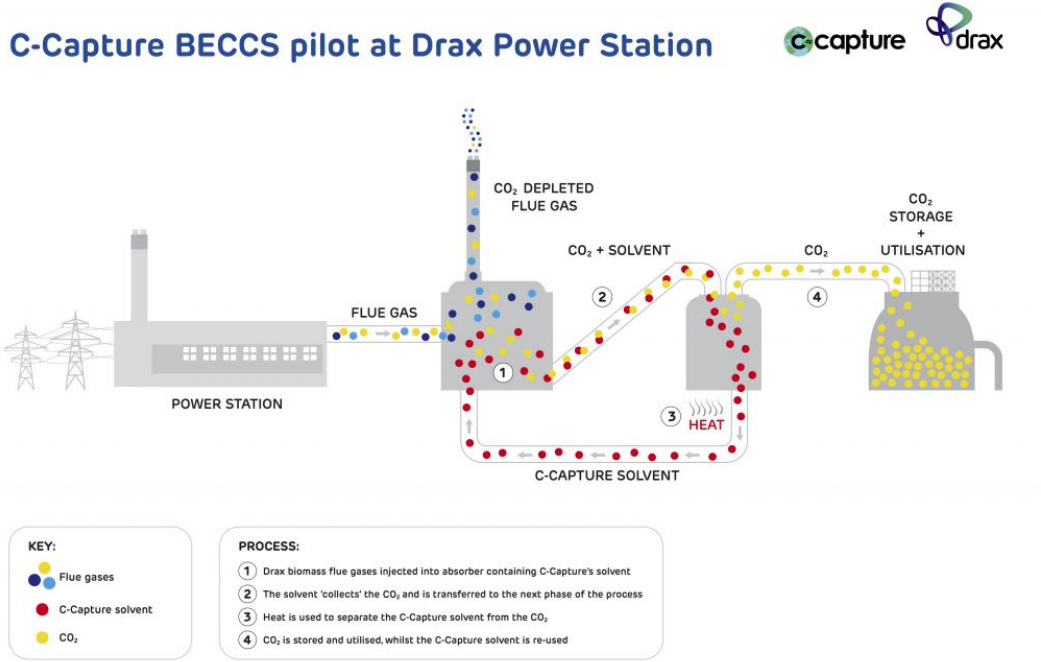
C-Capture Ltd was founded in 2009 as a spin-out from Department of Chemistry at the University of Leeds. The company has since received investment from IP Group, Drax and BP, and has received funding by the UK Government's Department of Business, Energy and Industrial Strategy.

Its technology, C-Capture, is a patented carbon capture solvent-based technology (patent WO2019025804A1). The technology can be deployed on most processes requiring CO_2 separation from other gases, including power stations, cement plants, hydrogen production facilities, steel or glass making factories, or natural gas upgrading plants.

C-Capture Ltd - A cross-industry carbon capture technology

C-Capture is a chemical-based system to remove CO_2 from power plants, steel works, and cement factories. The technology uses a new class of capture solvents that are amine and nitrogen free, not classified as hazardous, inexpensive, and can be manufactured on a large scale. C-Capture's technology can also separate CO_2 from natural gas or hydrogen, and from biogas from anaerobic digestion to produce biomethane as a renewable fuel.

Each stage of the industry process produces its own waste gas stream, with differing levels of CO_2 as well as trace impurities and pollutants. C-Capture's solvents can be optimized to each stack as required.



C-Capture partnered with Drax Power Station in North Yorkshire, U.K. on a bioenergy carbon capture and storage (BECCS) pilot plant, which will remove carbon dioxide from emissions produced by generating electricity from sustainable biomass. The company claims that the project is the first of its kind in Europe. The investment demonstration project is ~$524,000 (£400,000). The pilot is currently capturing one tonne of CO_2 per day.

C-Capture Ltd - A cross-industry carbon capture technology

C-Capture received £3.5M equity investment round by Drax, BP Ventures, and IP Group in 2018. Drax and C-Capture project is supported by £4.9 million funding from the UK government.

A report by the Energy Technology Institute in 2016 has suggested that by the 2050s BECCS could deliver roughly 55 million tonnes of net negative emissions a year in the UK, this is approximately half the nation's emissions target.

Key Advantages:

Low-cost technology. Low environmental impact technology. The company has received financing from different companies and the government agencies.

Key Limitations:

Still under research and development.

FURTHER READING

Turning carbon emissions into plastic

About PreScouter

PRESCOUTER PROVIDES CUSTOMIZED RESEARCH AND ANALYSIS

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Christian is one of PreScouter's Technical Directors. He has helped many clients in the Natural Resources and Energy vertical by bringing solutions that align with their sustainability, efficiency and financial goals. He ensures PreScouter clients receive the latest insights into any disruptive or groundbreaking technologies within Carbon Capture & Utilization, Waste Management, Biofuel Developments, O&G, Mining, Renewable Energy generation and storage, among others. Christian has a background in Materials Engineering and Science and brings to PreScouter years of experience in the energy industry in aging management, failure analysis and testing, as well as technical consultancy and troubleshooting for special alloys manufacturing.

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