TECH FOR NET ZERO ALLIANZ

Reducing emissions by innovating industries:

How to design CCfD for scaling climate technology in Germany

dena Deutsche Energie-Agentur

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Executive Summary

- Carbon Contracts for Difference (CCfD) are a competitive market mechanism that mobilises private investments for innovative climate technologies. The mechanism is essential to accelerate the transformation of industries with high greenhouse gas emissions.

- Technologies that require CCfD to achieve the climate targets of their respective industries include (i) steelmaking and processing, (ii) cement production, as well as (iii) green hydrogen-based production of basic chemicals such as ammonia and methanol.

- CCfD need to be set up sector-specific for the tendering process in order to foster competition between technologies within specific industries as well as drive the continuous innovation that results from it. Given that different technologies with varying cost structures are required to decarbonise the cement, steel and chemical industries, the CCfD market mechanism works best when adapted individually to each sector.

- CCfD need to have a two-sided strike price in order to ensure fiscal efficiency. With this setup, the government guarantees a minimum return, while having excess revenues flow back to public coffers. Capital returns should then be used to finance further CCfD. In this manner, it is possible to bring more technologies for climate protection to market while further reducing greenhouse gas emissions.

- CCfD periods should cover 10–15 years of operation to leverage private investments in climate technologies by aligning risks and returns.

- CCfD tender documents should include reference prices for the most important input variables (feedstock, electricity and so on) to ensure a level playing field for all participants in the bidding process. Input prices should be adjusted automatically when moving outside a certain bandwidth to hedge against price risks.

- In the medium term, the reform of the EU ETS and introduction of a Carbon Border Adjustment Mechanism (CBAM) and subsequent removal of free allocation of emission allowances can drive down the financial requirements of CCfD and promote the market penetration of climate technologies in general.

- CCfD will be most effective in promoting climate technologies when paired with other instruments of climate policy. They pave the way toward a market for climate-neutral industrial products that is driven by price signals (EU ETS) and incentives for demand (through application quotas or appropriate public procurement, for example).

- Legal analysis shows that CCfD comply with EU State aid guidelines, particularly if awarded through public tenders. CCFD should also be harmonised at EU level in order to foster climate technologies through competition even more.

CCfD as an instrument to bolster climate tech innovation in Germany

Carbon Contracts for Difference (CCfD) are a competitive market mechanism that mobilises a great deal of private investment in climate technologies. In practice, CCfD are project-related contracts between companies and a public institution that are intended to offset additional costs for the operation of low-emission technologies, which establishes a guaranteed business case. The mechanism is essential to accelerate the transformation of industries with high greenhouse gas emissions and achieve sectoral climate goals. In order to produce in a largely climate-neutral manner, all existing production processes based on fossil resources will need to be replaced by sustainable technologies and fuelled by alternative energy sources.[1]

For most industries with high greenhouse gas emissions such as steelmaking, as well as the production of cement and certain basic chemicals, suitable climate technologies exist today. These technologies need to be adopted widely to decarbonise the respective industry sector (see section *Which climate technologies require CCfD?*). Either due to their technical novelty, higher prices of feedstock (e.g. green hydrogen), or because of the effort required for conversion of existing sites and plants, many of these technologies are not competitive to conventional production pathways processes. Further optimisations through innovation and cost digressions are expected to occur due to economies of scale only once a critical number of projects have been realised.

[1] dena (2021).

The commercialisation of climate technologies in these sectors must begin on a large scale by the middle of this decade for two reasons: First, they are required in order to meet Germany's 2030 sectoral emission reduction targets. Second, long investment cycles for industrial plants (often exceeding 20 years) pose a significant risk of carbon lock-in and/or producing stranded assets if investments in technologies for fossil fuels continue to be made.

There are significant hurdles in transitioning to a carbon-neutral economy based solely on the EU Emissions Trading System (EU ETS). Carbon prices rise only gradually and fluctuate significantly, posing a high risk to long-term investments in carbon-neutral production technologies. Furthermore, the current practice of free allocation of emission allowances reduces the incentives to make these investments. And investment risks will remain for the time being, even if the free allowance allocation is phased out (and replaced by other carbon leakage prevention measures) and carbon prices exceed €80/metric ton of CO_2 (like in early 2022). As a result, additional policy instruments are required to foster the uptake and scaling of climate technologies in industry in good time. CCfD are advantageous for several reasons:

- CCfD provide an effective hedge against low EU ETS price trajectories, thus reducing investment risk in climate technologies and enabling them to be introduced quickly.
- CCfD promote the introduction of climate technologies in local industry and make significant emissions reductions possible without resulting in carbon leakage.
- CCfD enable decarbonisation of industry without harming German exporters on the domestic or global market.

The previous German government had already developed a framework for implementing CCfD in 2021.[2] As part of Germany's Climate Protection Programme, the current government intends to present a concrete proposal for its design in spring 2022.[3] The criteria described in this discussion paper should be taken into account in order to optimally support Germany's ambitious climate targets through the use of climate technologies.

[2] BMU (2021).
[3] BMWK (2022).

Functional principle of a Carbon Contract for Difference (CCfD)

As an example, figure 1 depicts the production costs of two approaches to steelmaking. One is the conventional route utilising a coal-fuelled blast furnace. The other one is a relatively new, low-emission technology based on direct reduced iron (DRI) with green hydrogen and melting it in an electric arc furnace. Looking at the cost of production, the clean technology incurs a 'surcharge' (green premium) of about €255 per metric ton of steel. Procurement costs of green hydrogen drive substantially higher operational expenditure (OPEX). This is typical for an emerging technology whose costs must be reduced through technological development and a larger market volume. Until the technology has matured sufficiently to compete with conventional technologies, this green premium needs to be bridged.

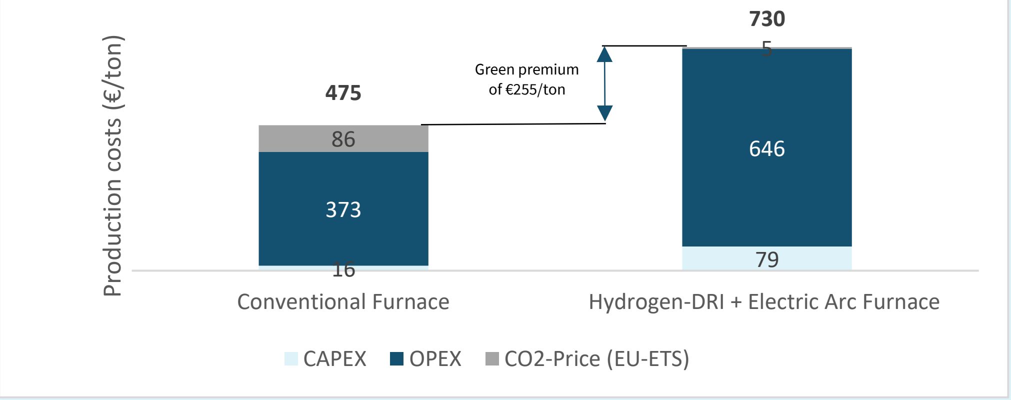

Figure 1: Green premium for steelmaking (example)[4]

In order to achieve this, a CCfD would now define a project-specific abatement of total emissions and a **strike price**. The strike price quantifies the carbon abatement costs of the innovative technology as the quotient of the green premium and the verified CO_2 reduction per tonne.[5] In the example with steelmaking, the strike price would be around €208/ton of CO_2, which would result in compensation payments to the operator of €158/ton of CO_2 that would be avoided by this operator's project.[6]

Over the duration of the CCfD, the project operator is compensated the difference between the agreed strike price and current ETS price if the former exceeds the latter.

[4] Agora Energiewende, FutureCamp, Wuppertal Institut and Ecologic Institut (2021a); taking into account an H_2 cost of €140 per megawatt-hour calorific value and an ETS price of €50/ton of CO_2.

[5] Calculating product-based emissions abatement (CO_2 benchmarking) requires a sound methodology for a comprehensive means of balancing carbon emissions. The EU ETS benchmarks can be a starting point for this, but need to be examined in detail whether it is possible to apply them.

[6] Agora Energiewende, FutureCamp, Wuppertal Institut and Ecologic Institut (2021a).

When the carbon price rises above the agreed strike price, excess revenue is transferred to the public agency (as shown in figure 2).

Through this principle, CCfD create revenue stability and reduce the commercial risk of applying and scaling innovative technologies. By attracting private investment, they can contribute to kick-starting the deployment of climate technologies and the resulting cost digression through scaling effects.

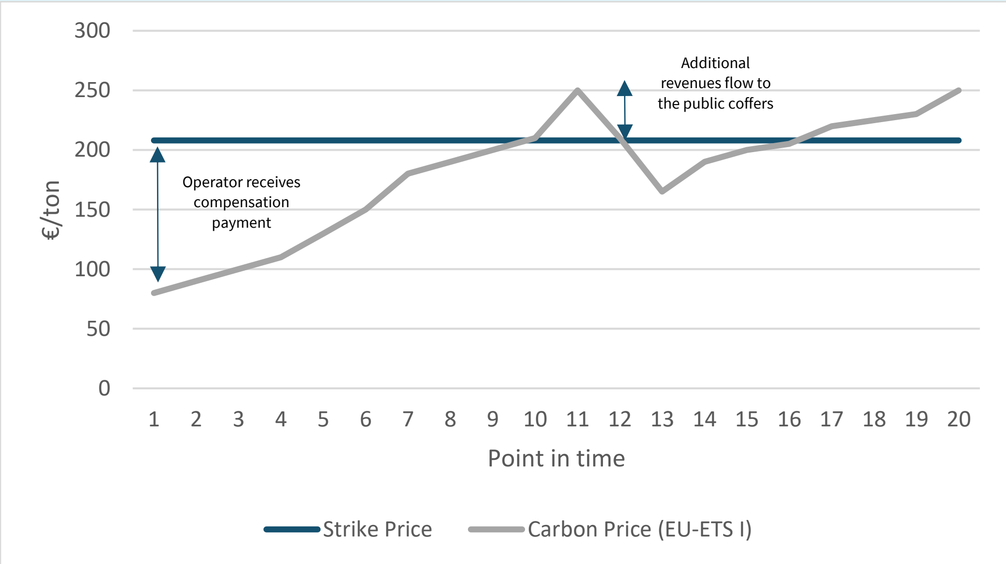

Figure 2: Functional principle of a Carbon Contract for Difference (CCfD)

Which climate technologies require CCfD?

CCfD are particularly well-suited to promoting climate technologies with high investment risks in sectors with time-critical transformation trajectories. In these, product-related CO_2 abatement costs are often higher than CO_2 price levels, which inhibits the introduction of new technologies. As established above, that is due to climate technologies' high incremental OpEx. CCfD reduce the risk of investing in new technologies with high OpEx by providing long-term support throughout the operational phase. Eligible technologies should be beyond the demonstration phase in order to ensure sufficient maturity and reliability for commercial operation (TRL6-9). The following subsections point out climate technologies in various industries that meet these criteria and could enter the market with CCfD support. CCfD could also be an optimal instrument for de-risking climate technologies in other sectors. For this reason, the process for identifying eligible technologies should include an in-depth applicability analysis based on the criteria presented, which would then provide a foundation for policymaking.

Technologies for green steelmaking

Today, the German steel industry annually emits close to 60 million metric tons of CO_2, or around 30 per cent of total industrial emissions in Germany. In order to achieve climate neutrality by 2045, the sector will have to convert a good third of its primary steel production to climate-friendly hydrogen-direct iron reduction before 2030.[7] However, as illustrated in the bar graph above (figure 1), the production of green steel via the envisioned Hydrogen–DRI + Electric Arc Furnace route incurs a significant green premium, mostly due to high prices for the required green hydrogen. As a result, both steelmakers and investors are currently reluctant when it comes to these technologies.

These circumstances make steelmaking a predetermined application case for CCfD that can offset these high OPEX to enable the required speed of transformation. Nevertheless, additional market development instruments must accompany CCfD in order to create a thorough support landscape for green steel technologies. This includes the implementation of demand-side measures such as certification or labelling standards, as well as the creation of lead markets for green steel products and upstream green hydrogen.

Technologies for climate-neutral cement production

Cement production is another large industrial source of greenhouse gases in Germany, emitting 20 million metric tons of CO_2 per year[8]. Several emerging technologies can reduce the sector's carbon footprint substantially: Electrification as well as biomass or hydrogen combustion can replace fossil-fuelled technologies for process heat generation, which accounts for 35 per cent of cement production's emissions. Looking at the remaining 65 per cent of emissions stemming from calcination processes during production, Carbon Capture Utilisation and Storage (CCUS) pose a solution. Fundamentally new cement production technologies that reduce clinker usage can also contribute to emissions reduction.

All of the mentioned technologies raise OPEX of cement plants (driven by prices for electricity, bio-based feedstock, oxygen and/or the capture, transportation, and storage of carbon); however, specific emission abatement costs in the cement industry undercut those in other industries. Analyses suggest that a CCfD strike price of €53–80/ton of CO_2 is sufficient to create a business case for low-carbon processes in

[7] Agora Energiewende, FutureCamp, Wuppertal Institut and Ecologic Institut (2021a); dena (2021).
[8] VDZ (2020).

cement production.[9] If the emission price remains at the current level of about €80/ton of CO_2 (like in early 2022), CCfD payout volumes would be very limited and its main function would be to hedge any investment risk.

Technologies to produce green basic chemicals

The chemical industry in Germany is responsible for the emission of 56 million metric tons of CO_2 per year.[10] Most of these emissions are a result of the production and end-of-life phase of certain basic chemicals including ammonia, methanol and their main derivatives olefins and aromatics (ethylene, propene, benzole, etc.). A twofold approach covering both energy emissions and process emissions is required, similar to the decarbonisation strategies in the cement industry. While energy emissions can mostly be avoided by substituting fossil fuels with hydrogen and electricity from renewable sources (as done with an electric steam cracker, for example), process emissions are harder to abate, as they are a result of utilising fossil feedstock. The production of methanol mainly takes place by hydrolysis of heavy oil or natural gas, while for olefins and aromatics naphtha, crude oil or natural gas are processed in a steam cracker.

These processes must largely be replaced with climate-friendly alternatives: Green methanol can be produced through biomass gasification or by reacting (green) hydrogen with CO_2 captured from the air (DACCU) or biomass (BECCU). On the other hand, olefins and aromatics can be produced either from green methanol or from green naphtha, which is synthesised from green hydrogen and CO_2 by the Fischer-Tropsch process.[11] Green ammonia can be produced by fuelling the Haber-Bosch process with green hydrogen rather than natural gas-derived hydrogen.[12]

These climate technologies result in a relatively high green premium compared to traditional production trajectories, driven by costs for green hydrogen and carbon capture, transportation and storage. Recent studies indicate a CCfD strike price of up to €317/ton of CO_2 in order to become economically viable.[13]

[9] Cleantech for Europe (2022) and DIW Berlin (2021).
[10] Future Camp and DECHEMA (2019); contains Scope 1 and 2 emissions only.
[11] Ideally the CO_2 for this process is obtained by direct air capture (DAC) or bioenergy conversion with carbon capture and utilisation (BECCU) to ensure carbon neutrality.
[12] dena (2021).
[13] DIW Berlin (2021); strike prices are highly dependent on the prices of certain input variables (such as natural gas and other fossil fuels).

Design principles for innovation-friendly CCfD

Determination of strike price and CCfD tender design

The CCfD strike price needs to adhere to market principles to avoid unintended consequences to competition and the innovative capacities of the various industries. Competitive tenders are a proven instrument to ensure the cost-effective award of contracts. A tender-based approach is also in line with EU state aid guidelines (see section below). To facilitate innovation, tenders should be technology-neutral where possible. Different tenders are needed for each sector to take into account varying technology cost between industries. The design of these tendering procedures requires careful evaluation of various design elements, such as prequalification rules, remuneration basis, pricing rules and penalties for non-compliance. In addition, only projects that ensure emissions abatement and are compatible with the goals of climate neutrality should be eligible to participate in the tendering process.

Within these sector-specific tenders, key parameters such as product qualities would have to be specified to provide clear guidelines for bidders. It is advisable to predefine reference prices for inputs (feedstock, electricity, etc.) to provide a level playing field. While these requirements might somewhat increase the complexity of tenders, they facilitate an efficient functioning of CCfD.

Duration of contract and strike price re-evaluation

The steel, chemical and cement industries are characterised by relatively long investment cycles. Subsequently, CCfD should cover at least 10–15 years of operation to ensure that projects become bankable.[14] Input prices for key viariables (green hydrogen, electricity, etc.) should be automatically adjusted when moving outside a certain bandwidth to hedge against price risks.

[14] Agora Energiewende, FutureCamp, Wuppertal Institut and Ecologic Institut (2021b).

Compliance with EU state aid guidelines

Depending on the exact financing mechanisms, CCfD are expected to be classified as state aid, therefore falling under EU's state aid regulation. However, given their relevance for climate-friendly transformation of the economy and environmental protection, both of which are in the interests of the EU as well as the individual member states, legal analysis assumes that CCfD will be subject to exceptions of state aid guidelines. They are also expected to comply with guidelines on state aid for environmental protection and energy, particularly if they are assigned through tenders as discussed above.[15]

Refinancing

Recent analysis indicates that the total costs incurred by the introduction of climate technologies in the above-mentioned industries reaches approx. €10 billion by 2030.[16] The additional operating costs that have to be financed via CCfD can be reduced to around €2 billion. A prerequisite for this would be the combination of CCfD with other policy instruments, as pointed out in the following section ('Interplay with other policy instruments').

Interplay with other support instruments

In addition to high OPEX, some of the introduced climate technologies require significant upfront investments (capital expenditure, CAPEX). Looking at a support scheme based on CCfD only, this singular expense would have to be depreciated over a variable time and production volume. In this respect, a **separate grant-based support** would increase the flexibility of the contracts.[17]

In the medium term, a **reform of the EU ETS** establishing clear price signals holds the potential to promote climate technologies. Today, all of the industries found potentially eligible for CCfD in this paper receive free emission allowances. It limits the effectiveness of carbon pricing as a market-based signal to transition to climate technologies. In fact, introducing a climate technology can in some cases even reduce the eligibility for free emission allowances.[18] Current plans[19] to eliminate the circulation of free emission allowances by the mid-2030s come too late to help climate technologies achieve a breakthrough in the decisive coming years. This also undermines the CCfD, which are intended to enable the transformation in the near term: the allocation of free emission allowances increases the price

[15] COM (2021).
[16] Agora Energiewende, FutureCamp, Wuppertal Institut and Ecologic Institut (2021b); including CapEx and OpEx.
[17] Agora Energiewende, FutureCamp, Wuppertal Institut and Ecologic Institut (2021b).
[18] For example, by replacing the furnace with H_2-DRI.
[19] As outlined in the European Commission's Fit for 55 package.

difference between reference and climate technologies. This, in turn, leads to higher financial compensation needs through the CCfD.

Clear demand-side incentives (**lead markets created through application quotas or public procurement**) are a supplementary approach to commercialising green products. The two instruments can form a symbiosis, if they are properly designed. CCfD can enable the transformation for industries in the near term and pave the way toward a market for climate-neutral industrial products that is shaped by price signals (EU ETS) and incentives for demand. The interdependencies between the two instruments need to be carefully monitored to ensure fiscal efficiency and create a viable pathway for climate technologies from the first set of projects to market-based competitiveness.

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TECH FOR NET ZERO ALLIANCE

The alliance brings together key players in innovation in Germany to collectively demonstrate the potential that innovative technologies have to achieve climate neutrality in Germany and define ways to provide impetus to political decision-makers. It reveals areas requiring action in order to consolidate Germany's role as a technological pioneer, driver of the energy transition and innovative business location.

Legal information

Publisher:
Deutsche Energie-Agentur GmbH (dena)
Chausseestrasse 128 a
10115 Berlin, Germany
Phone: (+49-30) 667-770
Fax: (+49-30) 6677-7699
Email: info@dena.de
www.techfornetzero.de
www.dena.de

Authors
Joscha Müller, dena
Tobias Lechtenfeld, 1.5° Ventures

Reviewers
Martin Albicker, dena
Tim Mennel, dena
Philipp Offenberg, Breakthrough Energy
Julia Reinaud, Breakthrough Energy
Peter Sweatman, Climate Strategy & Partners
Lucy Chatburn, Cleantech Group

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