CFM TRACTION

Carbon Contracts for Difference

An assessment of selected socio-economic impacts for Germany

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Report for Project CFM TRACTION (Climate Friendly MaTeRials - mArket CreaTIon through pOlicy iNnovation

About CFM TRACTION

Working with stakeholders in Poland and Germany, the Climate Friendly Materials – Market Creation through Policy Innovation (CFM TRACTION) project has co-created new insights into the policy toolkit to support systemic transformation of the EU basic materials sector to net zero by 2050.

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Introduction

The aim of this report is to provide insights to support key German stakeholders for the implementation of an innovative and promising policy instrument for the decarbonization of the basic materials sectors: project-based Carbon Contracts for Difference (CCfDs) .

To this end, we provide analysis of selected socio-economic impacts of introducing this policy instrument in Germany. We also account for the perspective of all relevant groups of stakeholders, which emerged in the two project worshops and in other stakeholder engagement activities implemented during the project.

In particular, the analysis contained in the report is structured in two parts. First, an assessment of design options and scale of funding for CCfDs based on case studies for specific materials industries in Germany. Second, a discussion on award mechanisms for CCfDs and potential to combine CCfDs with other instruments, such as the Innovation Fund.

Carbon Contracts for Difference:

An assessment of design options and costs and a discussion on award mechanisms

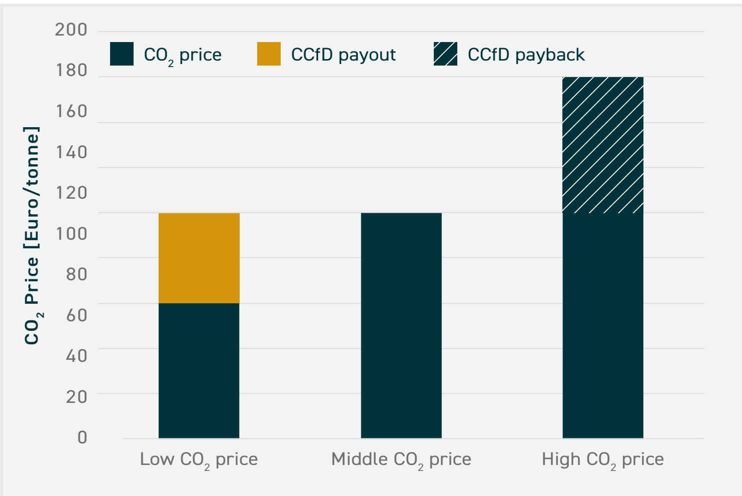
In many industries, the low-carbon technologies needed for achieving the climate goals are known and technologically ready for deployment (see e.g., Chiappinelli et al. 2020). However, due to increased operational and investment costs compared to conventional technologies these are not yet commercially viable. Hence, governments aiming for emission reduction could support the industrial transformation through a sufficiently high level of carbon pricing, and have proposed to do so as Germany in its national hydrogen stragegy (BMWi, 2020) In the absence of sufficient carbon prices in emission trading systems, Carbon Contracts for Difference (CCfDs) can provide for risk and burden sharing between governments and private companies, while at the same time achieving the joint goal of decarbonizing the industry.

Description of CCfD mechanism

FIGURE 1

CCfD-mechanism

Source: Based on Richstein 2017



CCfDs are a project-based financial instrument through which the government would guarantee companies a fixed carbon price level for emissions reductions below a benchmark baseline over a specified period. The mechanism behind CCfDs is shown in Figure 1. When the realized carbon price is below the CCfD price level the government pays the industrial company a premium on the carbon price. On the other hand, when the carbon price exceeds the agreed upon CCfD price level the company pays the difference back to the government. Thereby, CCfDs act as a hedging instrument by reducing the carbon-price risk for the companies and allowing for long-term financial planning.

Analysis on design options and cost assessment

Model description

The analysis in this report is based upon the model outlined in Richstein (2017).[1] We take a cash-flow simulation of an investment in a conventional process to establish a long-run equilibrium price for the material, and typical debt shares in the industry to estimate a short-run worst-case material price. We then investigate the decision of a representative industrial company to invest into either a conventional or a clean industrial process. For this, we use the model to find the carbon price levels at which the company is indifferent between the two processes based on the internal rate of return of the projects. The key channel through which the profitability of projects varies in the model is through its debt share. Due to low interest rates, an increased share of debt leads to lower financing costs and thereby a higher internal rate of return. We assume that the share of secure revenues determines the debt share of a project.[2] CCfDs affect the debt share of a project as they stabilize the revenue a project can expect from the sale of allowances. Next to the debt-share, the risk for the equity investor also affects its expected return on investment.[3]

For this report, we present the results of three separate analyses. First, we discuss how CCfDs compare to the introduction of minimum carbon prices. Second, we discuss how different CCfD design options affect the CCfD price level needed for investment into a clean process. Finally, we present an estimate of the funding scale needed for achieving an ambitious decarbonization policy in the near future.

1 And further developed based on research pursued under the Mistra Carbon Exit project. Full details of the analysis can be found in Richstein et al 2021.

2 In the comparison of CCfDs and minimum carbon pricing, and the funding scale analysis, the secure outcome is defined as the worst-case scenario of the bounded CO_2 and product price probability distribution. In case of the CCfD design options analysis we define secure revenues as the revenues that can be realized in 95% of all simulations, corresponding to typical Value-at-Risk criteria of lenders, as we model unbounded probability distributions.

3 By solving for a constant average of internal rates of returns over stochastic scenarios in a monte-carlo simulation, calibrated to a conventional investment. Alternative investment criteria are analysed in Richstein et. al. 2021.

Comparison of CCfD and Minimum Carbon Pricing

TABLE 1

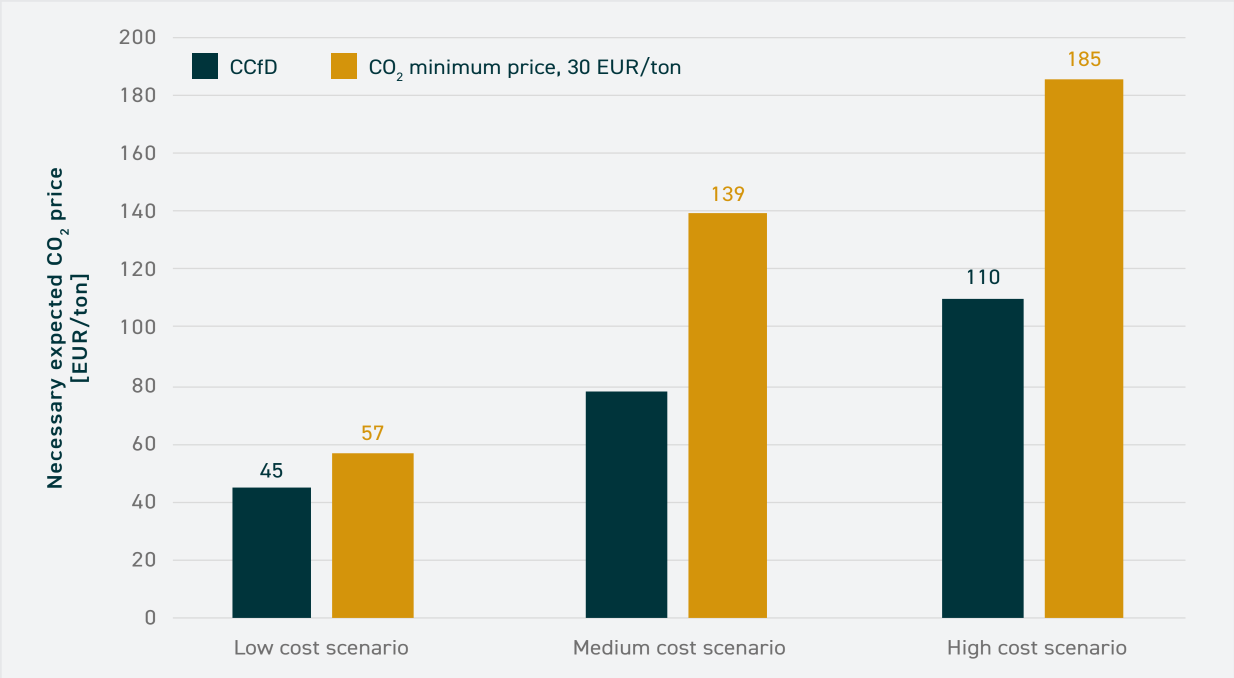
Assumptions used for comparison to minimum carbon price

SECTOR	Steel
INVESTMENT TYPE	Brownfield
CONVENTIONAL TECHNOLOGY	Blast furnace
INNOVATIVE TECHNOLOGIES	Hydrogen direct reduction
COST SCENARIOS	– High Cost (65 Euro/Mwh power price, 120% investment cost), – Medium Cost (50 Euro/Mwh power price, 100% investment cost) – Low Cost (35 Euro/Mwh power price, 80% investment cost)

In our first analysis, we compare the introduction of a CCfD to the introduction of a minimum carbon price at 30 Euro. We find that the CCfD enables investment into the clean technology at lower expected CO_2 prices than a CO_2 minimum price. In the low cost scenario, investment into the clean technology is already profitable at expected CO_2 prices of 77 EUR compared to 139 EUR under a minimum CO_2 price scheme (see Figure 2). The reason is that the minimum CO_2 price level is insufficient to cover even the incremental operational cost of the plant. Thus, the company runs the risk of investing, and be in a situation where it is more profitable to cease operation, rather than produce. Hence, by insuring the companies against the risk of a fluctuating carbon price, as well as not producing at all, the CCfDs aid the transformation in the industrial sector. In addition, by doing so at lower expected carbon prices than a minimum CO_2-price, CCfDs facilitate industrial transformation at a lower cost for the economy and consumers.

FIGURE 2

Effect of CCfD and CO_2 minimum price on carbon mitigation cost



Source: Richstein et al 2021

KEY TAKEAWAYS:

CCfDs lead to investment into clean technology at lower expected carbon prices than for commonly discussed CO_2-minimum price levels.

CCfD funding scale

TABLE 2

Assumptions used for funding scale analysis

SECTORS	Steel, cement, ammoniac
INVESTMENT TYPE	Brownfield
CCfD PERIOD	20 years

CONVENTIONAL TECHNOLOGY

Blast furnace (Steel), Rotary kiln (Cement), Steam cracker (Ammoniac)

INNOVATIVE TECHNOLOGIES

Hydrogen direct reduction (Steel), CCS + Oxyfuel (Cement), Hydrogen electrolysis (Ammoniac)

CARBON PRICE SCENARIOS

- High carbon prices (180 Euro by 2050),
- Medium carbon prices (80 Euro by 2050),
- Low carbon prices (65 Euro by 2050)

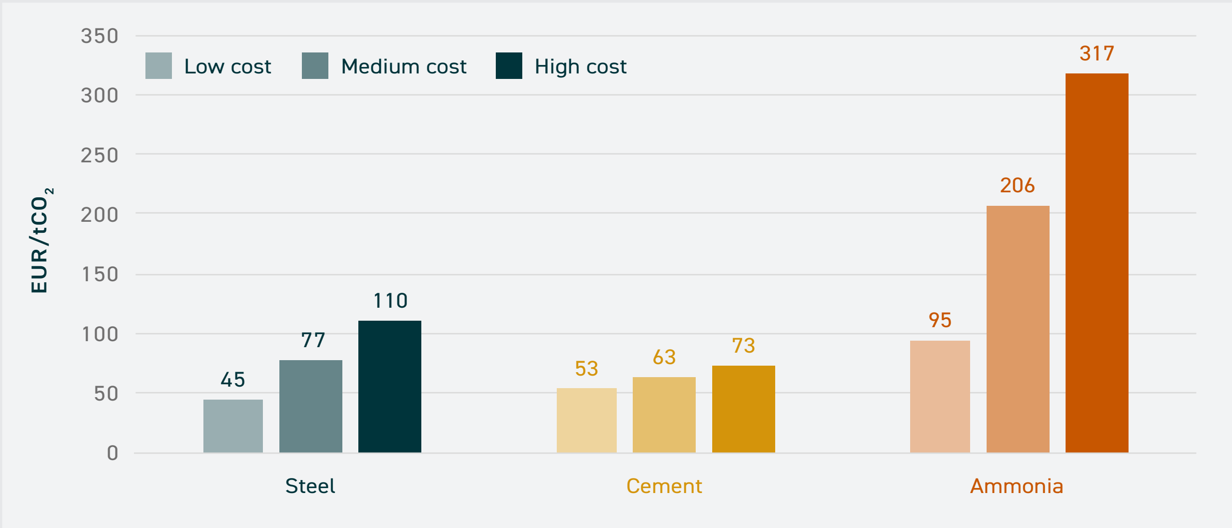
COST SCENARIOS

- High Cost (65 Euro/Mwh power price, 120% investment cost),
- Medium Cost (50 Euro/Mwh power price, 100% investment cost),
- Low Cost (35 Euro/Mwh power price, 80% investment cost)

CCfDs can be an attractive option for governments looking at cost-efficient solutions to support industrial decarbonization, as they have components of a hedging instrument rather than a pure subsidy. Thus, if the realised carbon prices are high enough, CCfDs will lead to a positive cash flow for the government in later years, and even to positive discounted cash flows over the entire contract period. To analyze the costs of an ambitious CCfD program, we investigated a scenario in which ten percent of German cement and steel production, as well as eight percent of German ammoniac production are transformed to clean production processes by 2025. This policy would lead to an emission reduction of approximately 7.5 Mt CO_2 per year and its development over time can be seen in Figure 2. We investigate how supporting this transition with a 20 year CCfD hedging scheme would affect government cash flow.

In Figure 3 we present the CCfD strike price per technology and cost scenario. We can see that they vary widely with both the technology and the cost scenarios used for analysis. The difference by scenario is particularly large for ammoniac, where large quantities of electricity are needed for the clean process. This suggests that it may be infeasible to support ammonia in this framework jointly with the other technologies using the same CCfD price level and that other ammonia-producing technologies might be supported simultaneously. On the other hand, steel and cement seem to be more viable and a price in the order of 60 EUR/tonne, as well as simultaneous support via other funding mechanisms and provision of affordable green electricity via a contract for difference for renewable electricity, could be a reasonable basis for allocation mechanisms of CCfDs.

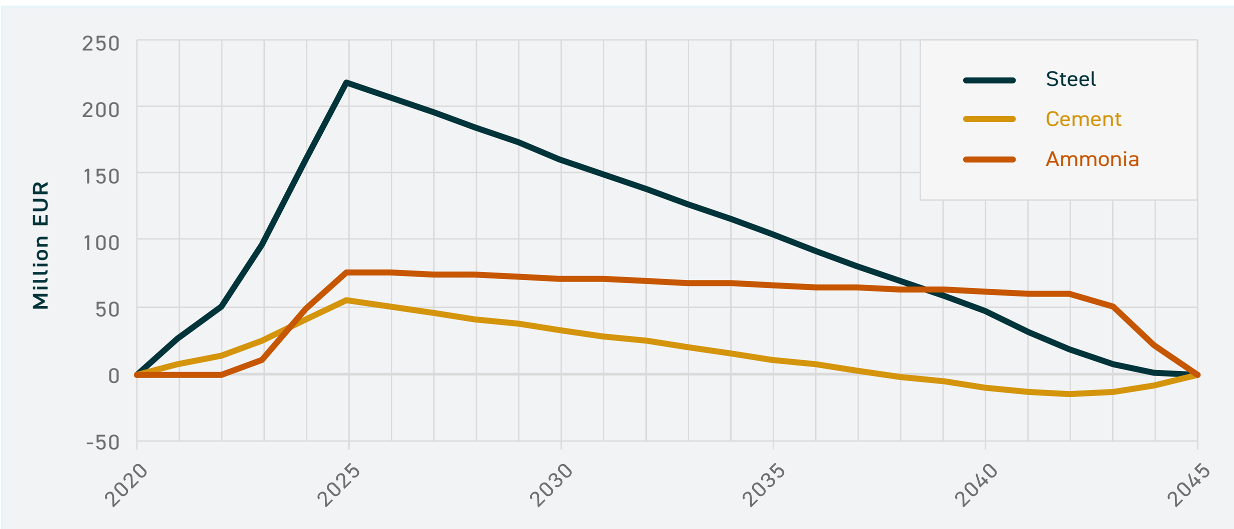
FIGURE 3
CCfD-price per technology and cost scenario



Source: Richstein et al 2021

In Figure 4 and Figure 5, we show the evolution of the required CCfD funding scale by technology for the "Medium CO_2 price" scenario, as well as the "High CO_2 price" scenario. In both cases, we consider our baseline "Medium cost" case. It is apparent that the increase in the carbon price in later years leads to a significant reduction in net government payments. The net payment flows eventually become negative, as carbon prices rise above the CCfD strike levels. After 20 years, the installations are no longer covered by the CCfD scheme, such that the government payment flows from this policy scenario are equal to zero after 2044.

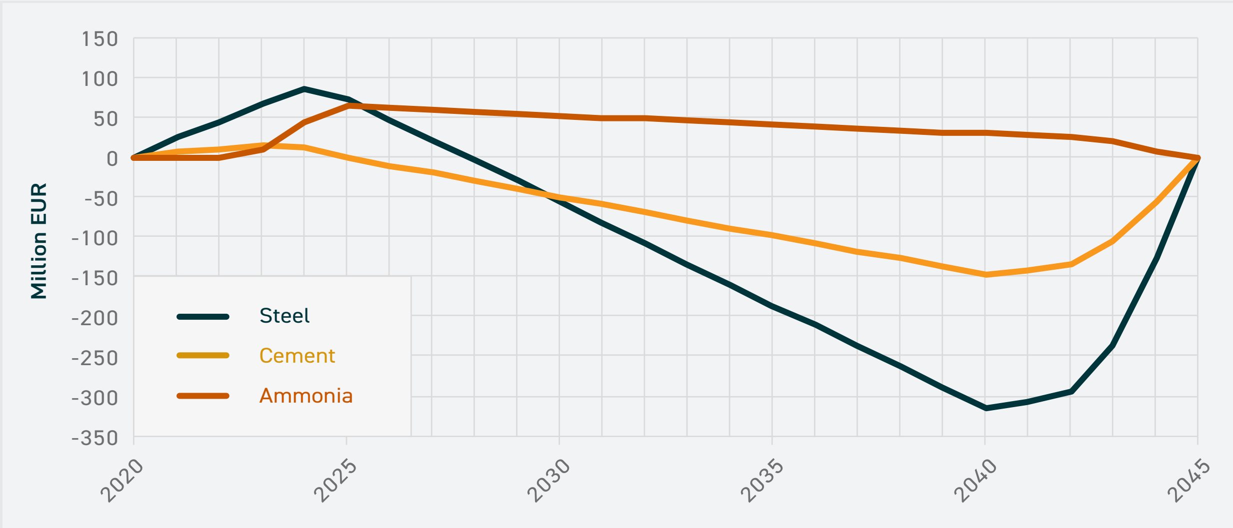
FIGURE 4
Funding scale at "Medium CO_2-price, Medium Cost"



Source: Richstein et al 2021

FIGURE 5

Funding scale at "High CO_2-price, Medium Cost"



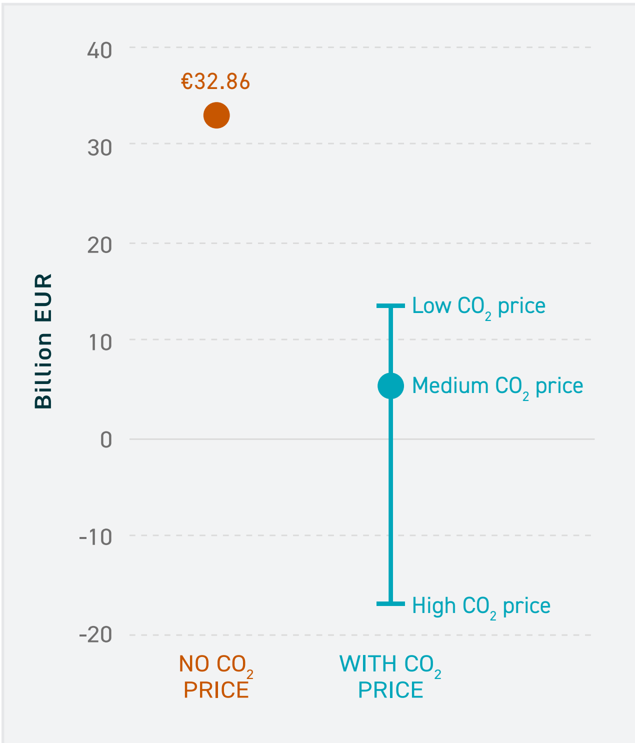
Source: Richstein et al 2021

To analyze the net present value of a larger, long-term CCfD program, we investigate the cost of decarbonizing up to 30% of cement, ammoniac and steel production until 2035.[4] The results can be seen in Figure 6. In the medium cost scenario, this policy proposal would lead to a net present value of the CCfD-funding scale between -17 billion and 13.5 billion Euro, depending on the carbon price path. For the medium carbon price scenario, we estimate a net present value of government payments of 8 billion Euro.

FIGURE 6

Net present value of government funding by CO_2 price scenario for the medium cost scenario

Source: Richstein et al 2021



4 Assuming constant technology costs.

In the absence of a carbon price, the necessary net present value of government subsidies for achieving the same transformational targets would be 33 billion Euro. Thus, introducing a combination of carbon price and CCfD leads to a large reduction in government expenditure. The results also underscore the fact that CCfDs can be a hedging instrument through which governments insure producers against the risk of fluctuating carbon prices rather than a subsidy scheme, as a net present value of zero lies within a reasonable range of CO_2 price scenarios.

KEY TAKEAWAYS:

- CCfD introduction can significantly reduce the NPV of government funding for industrial transformation;
- High carbon prices lead to positive cash flows for government in later periods;
- Depending on carbon price development and technology costs, the NPV can become neutral or even positive for governments.

CCfD design options

TABLE 3

Assumptions for CCfD design options analysis

SECTOR	Steel
INVESTMENT TYPE	Greenfield
CONVENTIONAL TECHNOLOGY	Blast furnace
INNOVATIVE TECHNOLOGIES	Hydrogen direct reduction
UNCERTAINTIES	Carbon price, steel price, coking coal price (on average 94.9 Euro/tCoal), electricity price (on average 65 Euro/MWh, reduced to 50 Euro/MWh with a RES-CfD)

In the context of an introduction of a CCfD, various extensions to the instrument are being discussed. By covering additional risks, the instrument of a CCfD could be made more effective and the necessary CCfD strike price could be further reduced.

In our analysis, we consider the case of a steel producer deciding between investing into a greenfield blast furnace or hydrogen direct reduction project (with on-site hydrogen electrolysis). In contrast to the previous analyses, electricity (for the production of hydrogen) and coking coal risks are added to the model.[5] As possible extensions to the CCfD, we are now considering contractual elements covering these risks.[6] In addition, we investigate CCfDs in combination with a contract for difference for renewable electricity. We then analyse how the necessary CCfD strike price varies when these uncertainties are covered under different policy regimes outlined in Figure 7.

FIGURE 7
CCfD design options

	CO_2 Risk	Electricity Risk	Coking Coal Risk
SCENARIO 1 **CCfD**	Covered	Not Covered	Not Covered
SCENARIO 2 **CCfD + E-Index**	Covered	Covered	Not Covered
SCENARIO 3 **CCfD + CC-Index**	Covered	Not Covered	Covered
SCENARIO 4 **CCfD + RES-CfD**	Covered	Covered + Lower Financing Cost	Not Covered
SCENARIO 5 **CCfD + RES-CfD + CC-Index**	Covered	Covered + Lower Financing Cost	Covered

Source: Richstein et al 2021

Figure 8 illustrates the effect of combining the CCfD with other risk-reducing instruments. By covering additional risks, the project's risk is significantly reduced. In the model used for our analysis, the reduction in risk implies that a project can increase its debt share and thereby reduce its financing costs, as debt capital has lower interest rates than equity capital. Hence, covering the risks reduces the carbon price necessary for investing into the transformational project.

Including the electricity price risk leads to a reduction in the necessary CCfD price by 19%. Due to a high correlation of electricity and coking coal prices in the past, covering the coking coal risk leads to a similar reduction in price risks, as the two risks are partly correlated, and thus partly covered by the other hedge.

5 The uncertainty in input factors is modelled based on historical data.

6 The previous sections implicitly assumed these risks to be covered and thus most closely correspond to Scenario 5.

The figure also shows that combining the CCfD with a CfD for renewables can lead to a large reduction in the strike price. The rationale behind this is that the operational costs of the hydrogen-based steel production are largely dependent on the electricity price. Thus, reducing the average cost of electricity by 15 Euro/MWh leads to a reduction in the CCfD price of 28 Euro/tCO_2. As before, we can see that covering an additional, correlated risk does not lead to a further significant reduction in CCfD strike prices.

FIGURE 8

CCfD prices needed under different CCfD design options

Source: Richstein et al 2021

KEY TAKEAWAYS:

- Covering additional risks leads to a reduction in the necessary CCfD strike price;
- Correlation between input prices might bring less marginal benefit to cover all of the risks associated with a clean technology;
- Combining the CCfD with a CfD for renewables leads to reduced financing cost in the power sector, leading to overall lower carbon mitigation costs.

Design of award mechanisms for CCfDs: a discussion

A relevant question to be addressed regards the award of the CCfDs, namely how can public policy makers decide on what technologies and projects to support and how the award mechanisms should be designed. In particular priority questions, as emerged in the stakeholders workshops, are as follows:

1. How to ensure that CCfDs are awarded to multiple technologies and sectors rather than only the cheapest technologies and sectors, as to achieve emission reductions in line with 2050 climate targets in all relevant sectors?
2. How to ensure that CCfDs are awarded to multiple technologies so that technological lock-ins are prevented?
3. How to ensure sufficient competition in the award mechanism? E.g. should technology- or sector-specific price-ceilings be imposed, should implementation be national or EU-wide?
4. Should the CCfDs be allocated through tenders or through negotiations? How to deal with asymmetric information issues (potentially leading to overcompensation)?
5. Who are the actors that should allocate CCfDs? Where should the funds to cover CCfDs come from?

This section provides a conceptual framework to qualitatively answer to these questions also in the light of learnings from the theory and practice of procurement of (environment-friendly) innovation.

Goals of CCfDs

The question on what are relevant award criteria for CCfDs and how awarding procedures should be designed is very much related to the question of which are the priority goals we want to achieve through CCfDs. Learnings from policy discussions on design of award of innovation funding (DIW Berlin 2018) can help to inform and structure the discussion.

The main goals of innovation funds and demonstration projects are i) Technology diffusion; ii) Emission reduction; iii) Learning benefits – knowledge creation and knowledge dissemination; iv) Creation of new supply chains redesign of supply chains; v) Technological diversity; vi) Technology scaling up; vii) Containment on and effectiveness of public fund spending; and viii) other political (e.g., geographical distribution) and economic objectives (e.g., employment stimulus).

The most relevant goals in the specific case of CCfDs seem to be i) advancement of a portfolio of technology options to allow a move towards climate neutrality in all relevant sectors ii) technological diversity to avoid technological lock-in iii) sufficient price competition and low informational asymmetries on cost of emission reduction to ensure effectiveness of public fund spending.

These different goals can possibly compete against each other, which might create trade-offs in the choice on the structure and type of the award mechanism and in particular on two dimensions. First, how should projects and technologies be clustered to compete against each other and – consequently – how should complementarities across clusters be accounted for. Second – once the relevant clusters of competition are specified - whether contracts should be awarded via tenders or rather negotiations and what the design of these processes should look like (e.g. whether a pre-qualification stage and a price ceiling should be included). These aspects are discussed in turn in the following.

Clusters for competition: balancing technological and sectoral diversity and competition

Three main options are possible depending on the breadth of clustering of technologies for competition:

1. **broad clustering cross-sector cross-technology competition:** all projects are allowed to compete against each other across technologies and sectors (e.g. CCS in cement can compete against direct reduction (hydrogen) in steel) , as suggested by Sartor & Bataille (2019);
2. **intermediate clustering within-sector cross-technology competition:** only projects belonging to the same sector are allowed to compete against each other but across different technologies (e.g. direct reduction (hydrogen) in steel can compete against Hisarna+CCS in steel);

3. **narrow clustering within-sector within-technology competition:** only projects belonging to the same sector and to the same technology category can compete against each other (e.g. only different types of direct reduction (hydrog.) in steel are allowed to compete against each other

On the geographical dimension of clustering, a single member state, a group of member states or EU-wide award processes would be possible, with implications for the level playing field between industries and countries, and state aid (Gerres & Linares, 2020)

A first consideration is that the breadth of the clustering might create a trade-off between the level of price competition in the award mechanism and the sectoral and technological diversity achieved.

A broad clustering option - e.g. a joint European award mechanism with a joint clearing price across sectors and across technologies - on one side may promote competition by allowing a larger set of bidders. This is important as the market of materials producers is dominated by few incumbents per sector even at the European scale. On the other hand, as CO_2 abatement costs are very different in different sectors and for different technologies, a broad mechanism may result in a focus only on a single sector or few sectors with the lowest abatement cost (probably cement), which would not be sufficient to meet long-term climate goals as well as create technology lock-in risk.

On the other hand, a narrow clustering option – e.g. a (within-sector and) technology-specific award mechanism - would promote technological diversity – e.g. ensuring that most promising technologies in all relevant sectors are awarded contracts, but might have an issue of market power. Separate technology-specific award mechanisms with technology-specific price clearing with very few bidders would imply that "cheap" technologies will likely be able to inflate prices and bid the upper price limit, in case one is imposed (see section on award mode below).[7] The intermediate clustering option might be superior to the extreme ones is terms of allowing diversification of technologies and lock-in avoidance while ensuring sufficient competition.

Regardless of the clustering choice, achieving the 2050 targets requires that decarbonization starts in all sectors and that complementarities across awards are accounted for, such that over time and across sectors a comprehensive set of "right" technologies is advanced. In addition, innovative technologies evolve and exploit learning effects over time so this dynamic needs to be taken into account at the award stage.

7 Experience from tenders for renewables technologies, reports mixed evidence as to whether average prices are lower in multi-technology than single-technology auctions (European Commission 2020).

In particular, there is a relevant trade-off between allowing a longer experimentation phase at a higher cost and a shorter one at the higher risk of lock-in with the wrong technological standard.

Favouring a long experimentation phase by supporting lagging technologies is especially relevant if the life cycle of the technology is expected to be relatively long (so that ending up with the wrong standard is relatively costly) (Cabral and Kretschmer 2006) and when the potential for technology improvement is significant enough (Cabral et al 2006). In the case of CCfDs therefore, it might be too premature to only prioritise the currently least-cost technologies as the ones with higher mitigation potential that currently are more expensive might become cheaper over time, similar to the experience with renewable technologies (e.g. for steel: if the tender goes by cost effectiveness, then direct reduction using natural gas would have an advantage over direct reduction using hydrogen (due to lower costs), but the latter has a larger mitigation potential).

Therefore, for broad and intermediate clustering options, it might make sense to not focus only or primarily on current costs of the technologies but to adopt a scoring rule to include some measure of emission reduction performance (related to project or to pathway of technology development and emission reduction potential over time) as an additional award criterion. An implementation option for such a scoring rule is indicated from Rijkswaterstaat (RWS), the Dutch Road and Waterways Administration, which for the procurement of large and complex low-carbon transport infrastructure projects adopts an algorithm where bids are discounted proportionally to the potential of reduction of environmental impact (including emission reduction) of a given project design (monetized using shadow prices) so that he lowest discounted bid wins the tender (Kadefors et al 2019).

Another option to take into account about complementarities is to adopt a joint clearing algorithm that accounts for links between individual awards therefore allowing some demand flexibility for the contracting authority (e.g. if two CCS in cement are already in place, an extra steel project can be valued more highly). In this case experiences from joint clearing algorithms for transmission mechanisms from the power sector can be instructive (see e.g. Roos 2017).

Both options (scoring rule and joint algorithm) would imply a higher clearing price (and lower cost options may capture inframarginal rents) but at the benefit of a larger sectoral and technological diversity. However, these options might increase complexity and potentially transparency issues at the award stage (e.g. if soft factors such as technological pathways are used in the scoring rule) (see section below on governance).

Related, avoiding technological lock-in would require that for each sector at least two different technologies are awarded a contract. In this sense multi-sourcing experiences (including with options of stepwise procurement or termination of contracts with individual partners) from EU mechanisms of innovation procurement – e.g. Public Procurement of Innovation, Innovation Partnership or Pre-commercial procurement might be of help.[8] Also, facilitating over time the entry of small new actors might be important to ensure diversity and competitive pressure on incumbents (e.g. to invest in improvements of the technology). If having small diverse innovators is important versus exploiting scale economies in R&D, it might be important to unbundle total supply in more and smaller lots/awards (to facilitate entrance of small actors), and allow for package bidding (to allow incumbents to exploit economies of scale) (Cabral el al 2006).

On the other hand for a narrow clustering (technology-specific award) the award criterion can be price alone but there would be a need of pre-allocating budget to sectors and technologies, or require certain shares of emission reductions from these, or have some elasticity on this, which might come at the cost of higher complexity and discretionality at the pre-award stage (see section below on governance). In addition, innovative solutions are best stimulated when requirements as well as evaluation criteria are based on a set of functionalities that the contractor must provide, rather than pre-specified technological solutions (Cabral et al 2006). In the case of CCfDs award therefore the focus should be on the potential for emission reduction regardless of the technology used to achieve that.

Award mode

Once the relevant cluster of competition is determined, another relevant question is how the contracts should be awarded, i.e. trough tenders or rather through negotiation and how these processes should look like, i.e. whether they should or not include a price ceiling.

Pre-selection stage or not?

All options will have to include a pre-selection stage that guarantees that only projects aligned with climate-neutrality objective qualify for competition for a CCfD (Richstein 2017). Participation constraints should be based on sector-specific minimum emissions reduction (e.g. for steel: Steel Benchmark [tCO_2/tSteel*0.30 = maximum qualifying emissions of innovative projects on CO_2/tSteel). The CCfD price should then be an efficient incentive to actually ensure that the project strives to reach its own maximum in the following time periods (leaving apart renegotiation risk - see below) .

8 CCfDs falls in the realm of Public Procurement of Innovative solutions (PPI) (defined by Horizon 2020), where the procurer is a first buyer for an innovative solution not yet available on a large scale. For technologies still at the early stage of R&D, PPI can be combined with Pre-commercial Procurement (PCP) a practice for the procurement of radical innovations (excluding the commercialization phase) where alternative solutions are developed in parallel and sequentially shortlisted along the R&D phases. When the benefits of bundling outweigh the costs, an alternative to PCP + PPI is Innovation Partnership, a new scheme where R&D and commercialization stage are bundled in the same contract and where synergies between the two stages can be taken into account (see Iossa et al 2018).

Auctions or negotiations?

An important issue that drives the choice between auctions and negotiations is the extent and nature of asymmetric information between the contracting parties. Learnings from procurement literature indicate that auctions perform best for the award of standardized and well-defined products where the priority is to trigger price competition, while negotiations can be superior for technically, legally and financially complex projects for which ex-ante description of the project might be incomplete and therefore the priority is to reduce risk of ex-post costly renegotiations (Bajari and Tadelis 2006, 2009). Ex-ante information sharing and dialogue with the private sector on contract design allows to reduce uncertainty and minimize the risk of costly renegotiations. In addition, in the contexts where the expected number of potential bidders is low, the relative benefit of auctions might be even lower (Albano et al., 2006; Bajari and Tadelis 2006, 2009).

In the context of CCfDs, the object of the contract is emission reduction through innovative and therefore non-standard low-carbon technologies and there is ex-ante uncertainty on the post-award stage, on the performance of a new technology (e.g. on O&M costs and failure rate). In addition, there is an issue of adverse selection as suppliers might opportunistically use their informational advantage on pilot cost drivers such as investment and O&M costs to e.g. submit a low bid and then ex-post renegotiate the strike price to recover profits. This type of opportunistic behavior (referred to as "low-balling strategy") has been observed in the procurement of infrastructure works, which despite being technically complex contracts are typically awarded via competitive bidding (the rational being that competition should drive project costs down). By anticipating ex-post price (and time) adjustments, bidders undercut bid prices at the award stage and initiate opportunistic renegotiation after the award. Then, ex post contract adjustments actually happen exactly because of too aggressive bids. Notice that incentives for this behavior are strong as the projects are also financially large, plus the suppliers can "hold up" the procurer as a consequence of being in the midst of the project, and rebidding or re-awarding is prohibitively costly. Therefore, governments have no choice but to allow these cost overruns and delays (Iimi 2013). Knowing this, the procurer may expect to be overcharged and the two parties are likely to engage in contentious adversarial negotiations (Albano et al. 2006).

Therefore, there seems to be room for renegotiation risk for CCfDs, which can be very costly especially given that the contract is envisaged to last for many years. Thus, unless the uncertainty can be ex-ante reduced, it seems that awarding procedures that allow for (some degree of) negotiation/dialogue before the award of the contract (e.g. when setting price ceilings as well as deciding pre-allocation of budgets to sectors or technologies) might be preferable over pure bidding. In addition, the one of CCfDs seems to be a context where the expected number of bidders is rather low, so pure competitive bidding seems to have even lower relative benefit.

The EU regulation on public procurement (2014 Procurement Directives) already envisages two options that allow negotiation with bidders and encourage their use (over pure bidding) in the case of large complex and innovative project. The first one is the Competitive Procedure with Negotiation: after a pre-selection stage of potential suppliers the authority invites the shortlist of suppliers to submit initial offers which shall be the basis for the subsequent negotiations. After evaluation of the initial offers, the authority may decide to award the contract to one of the bidders (only if it reserved this possibility in the call for competition) or negotiate with them on an equal treatment basis. Once the negotiation phase is concluded, bidders are invited to submit new or revised tenders and the contract is awarded to the bidder with the most economically advantageous tender (on the basis of the award criteria stated in the procurement documents)

Another option allowed by procurement regulation that allows for greater flexibility (and larger role for bidders in the definition of solutions), but the use of which is restricted to the case of highly risky, complex innovative projects is Competitive Dialogue (CD). It can be especially beneficial when the authority is unable to define requirements e.g. technical, financial or legal solutions. The process is very similar to negotiation with the differences that: i) bidders do not submit initial offers before the dialogue phase ii) after the dialogue phase, bidders (at least three) submit their final tenders on the basis of the solutions presented and specified during the dialogue. Those tenders shall contain all the elements required and necessary for the performance of the project, iii) some flexibility on the final bid of preferred bidder is allowed. This helps, for example, in situations where a preferred bidder needs to secure final planning permission for a project before the contract can be concluded, iv) contracting authorities may specify prizes or payments to the participants in the dialogue.

Both procedures can take place in successive stages in order to reduce the number of tenders to be negotiated/dialogued with. It is important to notice that relative to auctions both procedures and in particular CD would increase procurement timeline and, especially for CD the process is costly and resource intensive for both authority and bidders.

CD was for example adopted in the Netherlands by Rijkswaterstaat (RWS), the Dutch Road and Waterways Administration for the procurement of large and complex low-carbon transport infrastructure projects (Kadefors et al 2019). In the CD process, the authority engages in parallel planning and design development processes with several contractors and each tendering contractor develops a design and a tender price, and also identifies opportunities for reductions in environmental impact (relative to a baseline for environmental impact, including carbon, using standard data and the DuboCalc tool).

Before CD, a reduction goal is set based on a careful analysis of the reduction opportunities in the specific case.[9] Given the financial and resource intensity of the system (three parallel designs and financing solutions are developed and much input is required from the authority), there is currently a discussion in The Netherlands about whether the CD model is viable.

Price ceiling or not?

While price caps are less crucial in a market with a high number of expected participants, where price competition would emerge naturally (and risk of collusion is low), it is crucial to set a price ceiling to ensure price discipline in the context of CCfDs award where the expected number of participants is low, especially in the narrower clustering options. Price ceiling can also discourage collusion by limiting the maximum gain from successful collusion (Asubel and Cramton 2006).

As for the procedure to calculate the reserve price, usually, the value of the reserve price is calculated on the basis of the average price that prevails in the market at the awarding date (resulting from internal market analysis), economic indicators, and, when available, the previous awarding price. In other cases, it can result after a discussion with the suppliers invited to the competitive bidding (as established for instance by the EU Directive within the competitive dialogue) (Carpineti al. 2006). In the context of CCfDs where previous award data and market information may lacking, this second appaoch seems more feasible. Obviously negotiation needs to allow for some degree of discretion which relates to the point on governance discussed in section below.

Last, it will be important to set a system for monitoring delivered contractual performance and penalties in case contractual terms are not respected/targets not achieved. In this sense also learnings from relational contracting, where mutual commitment and reputation over time play an important role might be helpful, especially given the long-term nature of CCfDs (see e.g. experience Anglian Water on the procurement of low-carbon infrastructure, Kadefors et al 2018).

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9 This is a two-stage process as outlined below (from Kadefors et al 2018)

Phase 1 (3 months): In the first phase, European contractors may submit tenders, and tenderers are then reduced to three in a dialog process. Each tenderer presents their team and a plan for the main project process which is evaluated by the client. In this stage, costs are not the focus. However, the client sets a maximum allowed price and the contractors must state that their tender will not exceed that level.

Phase 2 (5-6 months): In the second phase, the three qualified contractors develop their plans and designs further, along with estimations of cost and time. There are also negotiations with lenders for financing. There are five formal meetings between the client team and each contractor, plus informal meetings. Final selection is based on a combination of quality, time and price. A committee of 5-6 people on the client side manages the procurement, and the contractors are reimbursed for a part of their tendering costs (around 23-30%).

Governance of CCfDs award

Another important question involves the governance of the award of CCfDs e.g. on who are the actors that should make the award decision and whom the contract issuer should be: it could be national governments, the European Union and its institutions like the European Investment Bank, or Financial Markets.

A central consideration is that award of funds and complex contracts like CCfDs is a complex activity involving discretionary choices, which needs to be allowed for. This raises the importance of the qualification and professionalism as well as independence/ transparency of the staff/board that awards the CCfDs. Therefore, potential administrative constraint differential across different levels of governance might be relevant in the choice of the counter party of the contract. Support policies to provide relevant guidance (e.g. on State aid) to counterparties are also desirable.

Also, the degree of complexity and discretionality depends on the choice of the award mechanisms and the clustering of competition as discussed above. It needs to be assessed at which stage/in which dimension of the award is complexity higher and discretion is more harmful. In relation to the discussion on breadth it is likely that the broader the clustering is, the more complex it will be to design the scoring rule or the clearing mechanisms to ensure technological and sectoral diversity, but the lower will be the complexity related to earlier stages e.g. defining per-sector budgets (as well as defining a price ceiling, can be avoided in a context with sufficient competition). Viceversa, a narrower clustering will reduce complexity on the clearing mechanism but increase complexity e.g., in pre-allocation of budget across sectors and definition of price ceiling.

Funding of CCfDs: combination with Innovation Funding

At least for initial projects, CCfDs might be combined with Innovation funding (Richstein, 2017). This approach may offer various benefits. In initial years, with limited competition and limited information to set ceiling on auction price, a fixed CCfD price could be set and the auction/negotiation could be moved to the innovation funding. As innovation funding is more grant based, public officials might be more familiar with the approach. Also, as ex-post renegotiation is not only an issue for auctions, but in principle also for negotiation, taxpayers might be better protected.

KEY TAKEAWAYS:

- Award mechanisms should assess projects not only based on cost of abatement but also on potential of emission reduction over time;
- Complementarities between individual awards across sectors and technologies should be accounted for;
- Negotiations might be better suited than auctions to reduce asymmetric information issues and risk of overcompensation;
- A pre-qualification stage should be included to ensure that only projects aligned with climate neutrality goals can be awarded a contract
- CCfDs can be combined with the Innovation Fund

Conclusion

The analysis on CCfDs provided for this report indicates that CCfDs can be an effective and efficient policy instrument for supporting the industrial decarbonization. By reducing the firm's uncertainty with regard to the carbon price path they can increase the financial viability of a transformation project and thus lead to investment in clean technology. At the same time, we have quantified the scale of a program to support the industrial decarbonization by transforming 10% of the production of key industrial sectors, and shown how CCfDs can limit government exposure and even lead to positive government revenue in periods with high carbon prices. Our analysis of different CCfD design options indicates that a "CCfD + Index" option does not have to cover all risks associated with transforming the production process. Instead, it might be enough to insure the company against one of multiple correlated risks. Additionally, the analysis indicates that combining CCfDs with a Contract for Difference for renewable energy has the positive externality of reducing the financing costs for renewable energy. The lower electricity prices resulting from this effect will lead to a reduction of the necessary CCfD strike price and thereby reduce the costs of transforming industrial processes that are electrified and highly sensitive to electricity costs. The main insights from the discussion on award mechanisms are that i) balance should be ensured between price competition and technological and sectoral diversity when choosing the relevant cluster of technologies to compete against each other, ii) mechanisms should assess projects not only based on cost of abatement but also on potential of emission reduction over time, iii) complementarities between individual awards should be accounted for, iv) negotiations might be better suited than auctions to reduce asymmetric information issues and risk of overcompensation, v) a pre-qualification stage should be included to ensure that only projects aligned with climate neutrality goals can be awarded a contract.

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