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Commercialisation contracts: European support for low-carbon technology deployment

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Executive summary

MANY OF THE technologies that can help the European Union become a net-zero emissions economy by 2050 have been shown to work but are not yet commercially competitive with incumbent fossil-fuel technologies. There is not enough private investment to drive the deployment of new low-carbon alternatives. This is primarily because carbon prices are neither high enough nor stable. There are a number of benefits from the deployment of low-carbon technologies that private firms do not factor in. These include the benefits of decreasing industry-wide costs over time, and the global climate benefits from the development of low-carbon technologies within the EU that can subsequently be exported. The result is an investment level below the socially optimal value in the EU.

COMMERCIALISATION CONTRACTS COULD be implemented as a temporary measure to remove the risk associated with uncertain carbon prices for ambitious low-carbon projects. The aim of the contracts would be to increase private investment to the socially optimal level. Contracts would be allocated through auctions in which fixed prices for abated emissions over a fixed duration would be agreed on a project-by-project basis. On an annual basis, public subsidies amounting to the difference between the agreed carbon price and the actual EU carbon price would be provided to investors, depending on the total carbon emissions abated. As long as EU carbon prices are low, investors would receive larger subsidies to ensure their competitiveness.

CONTRACTS WOULD BE auctioned at EU level. This would generate increased competition compared to national auctions, leading to more efficient outcomes and preventing fragmentation of the single market. From about €3 billion to €6 billion would be provided to the main industrial emitting sectors annually, with the amount reducing as the EU carbon price rises and low-carbon technologies become competitive without subsidy.

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1 Introduction

To cut the cost of decarbonisation significantly, the best solution would be to provide investors with a predictable carbon price that corresponds to the envisaged decarbonisation pathway. This would put a broad portfolio of low-carbon technologies on an equal footing in competitive terms with high-carbon technologies presently in use. However, the European Union's carbon price has so far been very volatile and is likely to remain insufficient, by itself, to drive all of the long-term investment in low-carbon technologies needed for net-zero to be reached in an efficient way.

The problem of the insufficient carbon price arises for political economy reasons, with policymakers reluctant to allow higher prices because of concerns about competitiveness or social issues. Over the last 15 years, prices have fluctuated between zero and €50/tonne. These levels have been sufficient to phase out production of electricity from coal in favour of production from gas, but are neither high nor consistent enough for other necessary investments. The subsequent underinvestment in deployment of new technologies means investors do not learn from experience as quickly as they might, and the benefits for global decarbonisation from EU decarbonisation are realised less quickly than they could be.

Policies to complement the EU carbon price are therefore necessary, because the alternative of waiting until carbon prices reach high enough levels will result in capital turnover that is too slow for the EU to hit its climate targets. At both national and EU level, policymakers recognise the need for supplementary policies[1]. We argue that a cost-effective approach should be based on the principle of providing long-term certainty around a sufficiently high carbon price on a project-by-project basis for low carbon investments. This should be done through a transparent competition at the European level which would both enable lower-cost decarbonisation and prevent nationally-focused plans from disrupting the EU single market. In this Policy Contribution, we outline the case for 'commercialisation contracts' (a form of carbon contracts for difference) to provide this transparent competition.

2 Commercialisation contracts

2.1 What are they?

We use the term 'commercialisation contracts' to refer to an instrument analogous to carbon contracts for difference (CCfD), as detailed by Richstein (2017), among others[2]. In a CCfD, a private buyer and a public seller agree a fixed carbon price for a fixed period. The agreed price is compared to the actual carbon price. If the actual price is below the agreed price, the public seller makes up the difference to the private buyer. If the actual price is above the agreed price, the buyer refunds the difference to the seller. In contrast to CCfDs, in commercialisation contracts, private buyers would not be required to pay money back when carbon prices are high.

Commercialisation contracts would remove the risk to ambitious low-carbon projects that arises from uncertain carbon prices. Such contracts would support technologies that are proven at the demonstration stage (ie they work technically), but have not yet been able to compete in commercial markets because of the lack of financing or unfavourable market

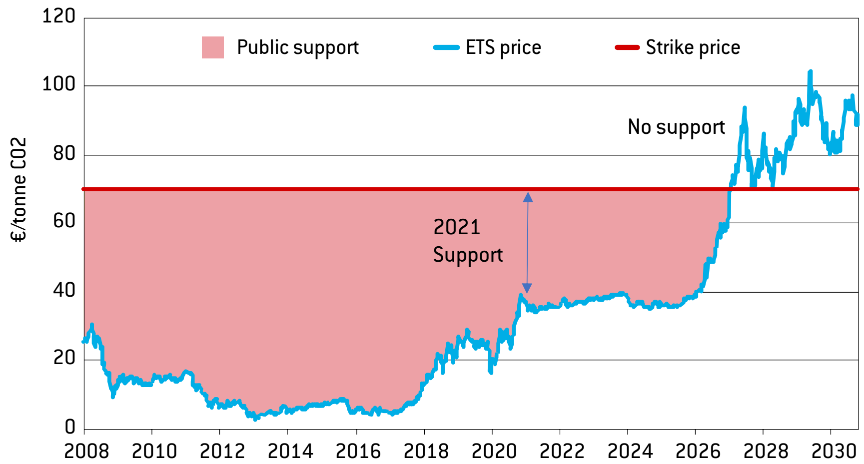
1 For example, the Dutch SDE++ scheme (see Box 1) and the under-development German industry carbon contracts for difference scheme. The Innovation Fund operates at the EU level.

2 See also Helm and Hepburn (2005), Sartor and Bataille (2019), Chiapinelli and Neuhoff (2020), Zachmann (2013) and Gerres and Linares (2020).

conditions. The closer technologies move to commercialisation, the more financial risks become the major obstacle (Vogl *et al*, 2021).

Commercialisation contract would be signed between governments (or public bodies) and the private parties responsible for a low-carbon project. The contract would guarantee a fixed carbon price (strike price) for a set number of years for the carbon emissions abated by their project. Potential project funders would take part in an auction to determine a fair strike price, which in a perfect world would just tip the low-carbon investment into profitability. The necessary support per tonne of carbon emissions is calculated as the difference between the average EU emissions trading system price and the strike price (Figure 1). Thus, when the ETS price is higher, lower volumes of public support will be issued. When the ETS price exceeds the strike price, no public support will be provided[3]. The carbon emissions abated by the project are calculated by comparing the project's emissions per volume of output to benchmark emissions for the same output from average industry operations.

Figure 1: Illustrative commercialisation contract



Source: Bruegel.

We can consider the example of a low-carbon steel plant awarded a 20-year commercialisation contract with a strike price of €70 per tonne of carbon dioxide. Investors in the low-carbon steel plant receive a guaranteed carbon price for the emissions abated thanks to their upfront capital investment. Each year, the steel plant records how many tonnes of steel it produced (eg 1 million tonnes). The emissions associated with each tonne of steel are compared to the benchmark average emissions for primary steel production in the EU. This difference multiplied by total output is the plant's annual abated carbon emissions that are eligible for support. If each tonne of steel eliminates two tonnes of carbon dioxide, relative to the industry's benchmark carbon emissions, the avoided amount would be two million tonnes of carbon dioxide. The annual subsidy is then calculated as the difference between the average ETS price and €70, multiplied by two million tonnes of abated carbon. For example, if the average ETS price over the period was €40, then the plant would receive an subsidy for that year of 70 minus 40 = 30 x 2 million = €60 million.

In this way, carbon price risk is removed from the project. As long as the strike price is set at an appropriate level, upfront private capital investment becomes attractive.

3 In contrast to CCfDs our proposal is more akin to a 'put' option, as the private counterpart would not pay back to public funds when the ETS price exceeds strike price.

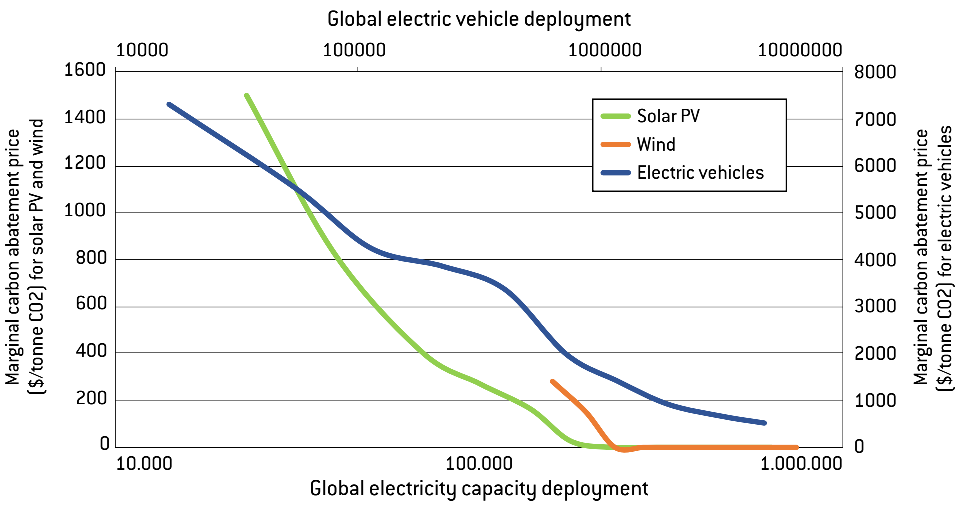
2.2 Why are commercialisation contracts needed?

Turning low-carbon technologies into viable propositions has a number of positive spillovers for society that do not translate directly into profits for investors. Consequently, companies invest less in the development of low-carbon technologies than is socially optimal. There are four reasons for private underinvestment which justify intervention in the market.

The first reason is a form of late-mover advantage. While pioneer companies take on the full risk of failure in the rollout of a low-carbon technology, some of the very valuable side effects, such as proving its commercial potential, showing how to bring down the cost, developing a new value chain and possibly developing an enabling system (such as electric charging) spills over to competitors, which are able to pick the best elements of what was shown to work and may then be able to provide a better product at lower cost than the pioneer. Public support is necessary to encourage these first investments into large-scale deployment of low carbon technologies.

The second reason is that falling costs arising from the early deployment of low-carbon technologies has high societal value. The more an industry produces a product, the cheaper it becomes, because of technological and economic innovation and scale effects (Figure 2). If the cost decrease is steep enough, the excess cost over the incumbent technology at the beginning of the learning curve will be dwarfed by the cost savings when the new technology overtakes the incumbent technology. There are many examples of this for low-carbon technologies. Renewable technologies for producing electricity, for example, in principle required a carbon price of over €400/tonne for their competitive operation in 2010. Following significant public support, they are now competitive in many cases without a carbon price at all. Had policymakers waited only for carbon pricing to drive adoption of renewable electricity technologies, they might be nowhere near commercial adoption today. The market failure is that individual investors have a suboptimal incentive to contribute early on to the deployment of low-carbon technologies, when they are not yet competitive with incumbent technologies. For the EU to remain on track to achieve its net-zero 2050 goal, it is essential that investments and progress along the learning curve for many low-carbon technologies begins today. For this to happen, public support will be required.

Figure 2: Global learning curves for electric vehicles and renewable electricity technologies



Source: Bruegel. Note: Lazard LCOE analysis is used to compare solar and wind prices to combined cycle gas plants. Solar deployment data from Solar Power Europe. Wind deployment data from GWEC. Electric vehicle deployment data from the IEA. Data on the price of an electric motor taken from Statista, compiled from Bloomberg NEF. A 50KWh electric motor is compared to the price of a 2L internal combustion engine. Electricity data starts in 2009, electric vehicle data in 2010. The figure shows annual data.

The third reason is that industry does not believe that policymakers will let carbon prices drive out high-carbon technologies. There remains considerable uncertainty around future carbon pricing levels, because of political pressures for policymakers to renege on carbon pricing schemes. Competitiveness and social concerns place a political constraint on the acceptable carbon price, that is to say, policymakers might at some point intervene if they become concerned that the carbon price has societal/political effects that are too damaging[4]. Intervention is plausible within the EU as policymakers have many tools to influence the ETS price paid by companies (maintaining free allowances, including foreign allowances, adjusting the number of permits issued). Accordingly, current carbon prices do not fully reflect the optimal future scarcity of allowances and markets do not provide long-term guidance for investors (eg in the form of a liquid long-term futures market). The carbon market alone thus does not provide the necessary hedging against the risk of too-low future carbon prices required for low-carbon investments that depend on the carbon price for their competitiveness with incumbent technologies.

Finally, investment in low-carbon technologies in the EU might only make commercial sense if the products of those technologies also find a sufficiently sizeable export market. As many third countries do not have some form of climate policy that provides a premium to low-carbon technologies, compared to high-carbon technologies, EU companies will only invest in the rollout of low-carbon technologies if there is a large enough EU market to pay for (or even overcompensate) the emission mitigation potential of a technology, which when made competitive can be deployed globally. Beyond export benefits, the potential for abated emissions outside of the EU through the rollout of new low-carbon technologies provides a clear public benefit. The example of renewable electricity technologies shows that public policy in the EU can have an enormously positive effect on global climate policy.

2.3 Why are commercialisation contracts an important addition for deployment support?

Commercialisation contracts allow deployment support to be better targeted than it would be by other low-carbon support policies alone (eg upfront capital subsidies, preferential markets, public procurement, carbon standards)[5].

Over the last five years, policies supporting renewable electricity generation deployment have shifted toward contracts for difference designs in countries including the UK and France. Renewable electricity contracts for difference work similarly to commercialisation contracts but using an electricity rather than carbon strike price. The fact that countries have shifted toward contracts-for-difference designs suggests that they are an attractive policy option.

Historically, pegging the cost of emerging technologies to that of incumbent technologies was a way to speed-up switching. The European natural gas industry, for example, relied for decades on oil-price indexation before maturing into its own liquid market. While different in nature, the purpose of commercialisation contracts is also to provide certainty to investors that their upfront capital investments (often into complex value chains) will generate secure long-term returns.

Commercialisation contracts are attractive for five reasons. First, the level of the subsidy adjusts with the carbon price. As carbon prices increase, the subsidy decreases. Given that carbon prices can be expected to rise over time, this avoids the problem of significant 'legacy'

4 See for example Pádraig Collins, 'How not to introduce a carbon tax: The Australian experience,' *The Irish Times*, 3 January 2019, available at https://www.irishtimes.com/news/environment/how-not-to-introduce-a-carbon-tax-the-australian-experience-1.3746214. The French 'gilets jaunes' movement was also sparked by an unpopular attempt to increase fuel taxes. See Benjamin Dodman, 'A year of insurgency: How Yellow Vests left "indelible mark" on French politics,' *France24*, 16 November 2019, available at: https://www.france24.com/en/20191116-a-year-of-insurgency-how-yellow-vests-left-indelible-mark-on-french-politics.

5 In fact, commercialisation contracts can and most likely will be introduced as a complement to, and not as a substitute for, other support policies. A well-balanced mix would enable different policies to address different market barriers.

(locked-in) costs, instead allowing for a smooth convergence towards the first-best solution: a single carbon price for all sectors (Edenhofer *et al*, 2021). Consequently, the policy also frontloads investment, which is useful given the need for stimulus spending in response to the COVID-19 economic crisis, and in the context of low interest rates. At the same time, guarantees of longer-term support are essential for mature markets to develop.

Second, by eliminating carbon-price risk, projects' overall financing conditions are improved. The increased certainty of pay-offs allows projects to increase the share of debt in overall project financing relative to equity. As debt is cheaper, this reduces the cost of capital and hence reduces the breakeven carbon price in a virtuous cycle (Richstein, 2017).

Third, the instrument facilitates competitive market outcomes because contracts can be auctioned. An auctioning scheme could be designed at EU level to address the problem of overwhelmingly national industrial climate policy fragmenting the EU single market.

Fourth, the policy can be viewed as an important commitment device. Lower carbon prices would become a liability on public balance sheets, and there would therefore be clear public desire for higher carbon prices. This would send strong market signals.

Finally, the policy is politically attractive because the volume of funding translates visibly to reduced carbon emissions.

2.4 Where are they needed?

Commercialisation contracts are useful in situations in which large upfront capital costs are required for investments for which the return depends on the price of carbon, because payments for emission rights constitute a significant share of the variable cost of price-setting competitors. This is typically the case for heavy industrial processes which require large production sites. For this reason, most of the literature has focused on basic industrial materials including steel, cement, aluminium and chemical feedstocks such as ammonia. Such contracts have also been prominent in hydrogen strategies[6].

In principle the concept of commercialisation contracts could be adapted to a wide range of sectors. For example, households investing in a clean fuel-switching technology (such as heat pumps or electric vehicles) could receive variable operations subsidies which would ensure that the clean fuel (eg electricity or hydrogen) is always cheaper than the displaced fossil fuel. This would depend heavily on the carbon price. However, in this Policy Contribution we focus on the use of commercialisation contracts for abatement of industrial emissions covered by the ETS.

3 Designing commercialisation contracts

Commercialisation contracts, or similar schemes, are already part of the political debate, with schemes under development. The Dutch SDE++ scheme is not strictly a commercialisation contract, but shares many elements that illustrate how such a scheme could be designed (Box 1). Germany is committed to running pilot programmes under its hydrogen strategy (BMWI, 2020) and its environment ministry is developing a CCfD-programme for industrial decarbonisation (BMU, 2021). The European Commission (2020) has also referred to the need for commercialisation contracts in its hydrogen strategy. Moreover, in its updated industrial strategy, the European Commission signalled it was "c*onsidering proposing a European approach to carbon contracts for difference*" as part of the revised ETS Directive (European Commission, 2021).

Commercialisation contracts can be designed in different ways. The design will have a

6 The German and EU hydrogen strategies explicitly mention carbon contracts for difference for the production of low-carbon hydrogen.

strong effect on the efficiency and effectiveness of the support, on which technologies receive funding and on the distribution of costs and benefits. In the following section, we discuss key design elements, with a focus on the trade-offs they imply. We address three broad areas: political scope, allocation process and technological scope.

Box 1: The Dutch SDE++ scheme

The Netherlands operates the SDE++ scheme, which is similar in nature to commercialisation contracts. SDE++ is the follow-up scheme to SDE+ which operated from 2013. The SDE+ scheme was exclusively for the support of renewable electricity generation projects, while since 2020, the SDE++ scheme has been open to a broader range of technologies which contribute to reduced greenhouse-gas emissions, including low-carbon heat, renewable gas, low-carbon hydrogen production and carbon capture and storage.

The scheme offers an operating subsidy equal to the difference between the cost of low-carbon technologies and the market price of the products delivered. Projects compete in auctions for SDE++ contracts. Each year, the operating subsidy that a project receives depends on the long-term product price and volume of production. Technologies are ranked by an emissions factor, which allows different technologies to compete fairly. The end result is that the technologies which are able to reduce emissions at the lowest cost receive subsidies. The scheme aims to mobilise operating support up to €3 billion annually.

Source: Dutch Ministry of Economic Affairs and Climate Policy (2020).

3.1 Political scope

3.1.1 Should contracts be organised at national or EU level?

The first consideration is whether commercialisation contracts will be issued or auctioned at national or European level. European level would be preferable because this would increase the competitive pressure on industry, leading to more efficient outcomes. Conversely, if schemes were designed at the national level, they would pose a significant threat to the integrity of the internal market, as EU countries might use such instruments to give their domestic industries an unfair advantage.

The obvious obstacle to design at the European level is political. National governments strongly guard industrial policy and there would be resistance to significant finances being distributed via the European institutions to competing companies in other EU countries. Moreover, countries are moving at different paces on low-carbon industrial reorganisation. In some countries, discussions around commercialisation contracts are already maturing; in others they are yet to seriously begin. A further consideration is that in countries that have moved more slowly on decarbonisation, there might be a higher share of projects with low carbon abatement costs, compared to countries that have moved faster. Projects from previously slower moving countries would be more competitive in an auction based on abatement costs.

Compromises may be considered. Countries could join together to issue commercialisation contracts[7]. Richer countries might be keen to begin in this way. Over time, countries could apply to join the issuing group. Alternatively, if initially organised at the national level, bilateral links could be envisaged to enable other countries to participate. For example, if Germany moves first to set up a contracting scheme, an invitation to participate might be

7 A group of countries could cooperate in line with the 'enhanced cooperation' procedure. This allows a minimum of nine member states to cooperate in an area without other members being involved. For example, this procedure underpins the Schengen area.

extended to Belgium. Over time, systems that began at the national level should evolve and expand to the European level.

3.1.2 Who will pay for the subsidies?

The sources of revenue to fund commercialisation contracts will depend on geographical organisation. At national level, support can come from national budgets. If operated at EU level, funding could come from the EU budget. Alternatively, a fund could be created from the auctioning of ETS emissions permits. While ETS revenues are frequently earmarked for every new proposed investment, their use for a low-carbon deployment option would be appropriate and within the spirit of the ETS.

The Innovation Fund has been established as one of the first EU funding instruments for the demonstration of low-carbon technologies. The revenues for the Innovation Fund come from the auctioning of 450 million ETS allowances between 2020 and 2030. During the drafting of the policy, this was envisaged to amount to approximately €10 billion[8], but given current carbon prices the budget might be double that. The Innovation Fund proves that the use of ETS revenues for funding low-carbon projects is politically possible. Use of commercialisation contracts could be combined with the Innovation Fund. For example, projects could progress from demonstration stage funding under the Innovation Fund to deployment-oriented support through contracts.

The volatility of the ETS price might cause a problem. When revenue is denominated in ETS permits, price fluctuations mean annual revenue in terms of euros is not certain. At the same time, the annual subsidies required for commercialisation contracts are also dependent on the ETS price. This creates an unwelcome positive correlation between low revenues from ETS auctions, and larger requirements to fund commercialisation contracts. However, certainty is required to ensure annual payments. To mitigate this risk, the European Investment Bank could be tasked with smoothing revenues. This would involve borrowing so that years with lower ETS prices would ultimately be paid for by higher future prices.

3.2 Allocation process

3.2.1 How should commercialisation contracts be awarded? Is auctioning the preferred option?

Regardless of geographic scope, commercialisation contracts should be allocated via a competitive process. This would involve bids from individual low-carbon projects. The core of a project's bid should be the strike price, or the guaranteed carbon price the project asks for in order to proceed with commercial operation. The central component of allocation should be an auctioning system: the lower the strike price, the more attractive the bid. Auctions work as a mechanism because of the information asymmetry between industry and policymakers. Industry better understands the true costs of decarbonisation and their preferences would be revealed through auctioning. However, certain caveats are required beyond only strike prices.

The purpose of commercialisation contracts is to stimulate low-carbon innovation in order to meet the 2050 net-zero target. Accordingly, support should be given only to projects that are compatible with this. This means not supporting incremental carbon emission reductions. For example, a power plant submitting a bid based on a new technology which allows for more efficient combustion of coal should not be considered.

Funding of projects that facilitate replication and future cost decreases should also be preferred (ie projects with significantly steep learning curves)[9]. For the EU climate policymaker concerned about global action, this replication clause should be extended to the global level.

8 Including €700 million left over from NER300 (the previous EU-wide low carbon support scheme). By the end of 2021, the Innovation Fund will have distributed €1.1 billion in support.

9 *"Technical and market potential for widespread application or replication, or future cost reductions"* is already a selection criterion under the Innovation Fund, Article 11 (European Commission, 2019).

That is to say, projects should be preferred if they are based on technologies that can more easily be replicated across the world. For example, the costs of small modular products tend to decrease more rapidly than that of large non-modular units (Neij, 2008). Projects must also be clearly ready for commercialisation, meaning they should at least demonstrate a certain maturity regarding planning.

In a first application phase, projects could be assessed on these potentially more qualitative points of eligibility and the strike price would not yet be considered. For projects that pass this first assessment, a second application phase would see projects compete by promised strike price. While projects would submit a requested strike price, the contracts would be signed according to the clearing strike price, or the strike price agreed with the marginal producer who receives support. An *ex-ante* maximum strike price can set limits to the volume of public support committed.

3.2.2 How long should contracts last?

Contracts will need to cover sufficiently long periods to compensate upfront capital investment risk. This is likely to be in the range of 10-20 years depending on the technology. For example, the German environment ministry plans to sign carbon contracts for difference ('Klimaschutzverträge') with industry for 10 years, while many renewable support systems run for 20 years. Given that the carbon price will likely rise to meet the strike price, support would not necessarily be distributed each year.

3.2.3 How frequently should new commercialisation contracts be auctioned?

Frequent auctions, eg every year, would help alleviate information asymmetries as industry preferences would be frequently revealed and updated. However, in sectors that require large capital projects it may be too ambitious to run auctions every year, and a thinning of the market might lead to volatile annual bids. Depending on other design choices, some form of 'tendering' might also be necessary, with governments negotiating commercialisation contracts bilaterally with individual providers of large capital investments. This would be less likely if Europe-wide competition was encouraged.

3.3 Technological scope and differentiation

3.3.1 How to design an auctioning scheme to provide effective support across the range of sectors and technologies required for net-zero

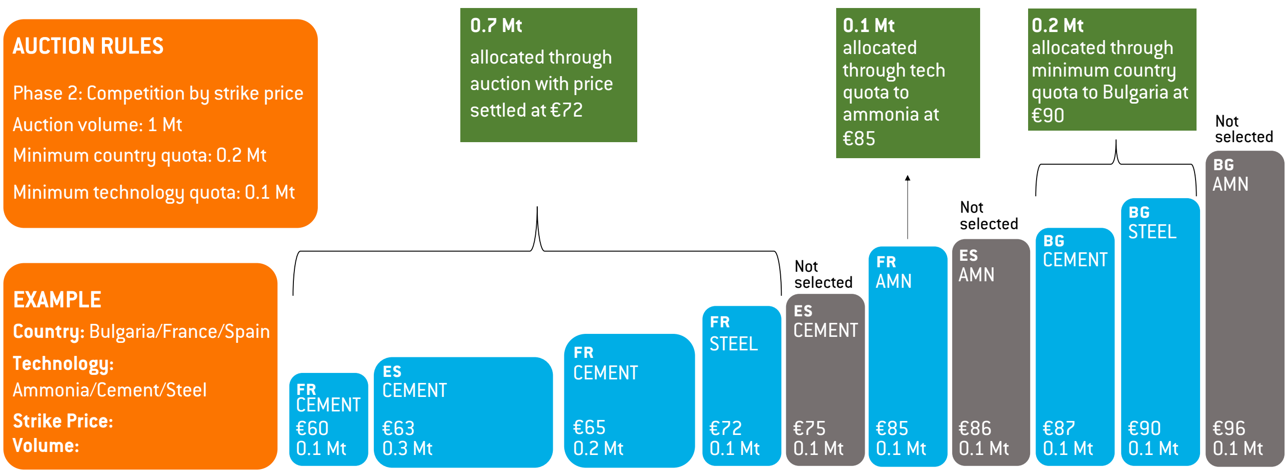
Allowing projects based on every technology covered by the ETS to compete in single auctions would be unlikely to be effective. Technologies at different stages of maturity require different strike prices, both across and within sectors. A single broad auctioning system would therefore result in excessive public support being awarded to the cheapest technology for reducing carbon emissions in a particular year. While this might appear attractive from a static standpoint, it neglects the benefits of supporting a range of technologies that will be required in the future.

Contracts for difference schemes for renewable electricity markets solve this problem by holding auctions for different 'technological pots'. One auction is held for technologies with anticipated low strike prices, and another for those with higher anticipated prices. A similar format can be followed for commercialisation contracts. This leads to a trade-off between efficiency and resilience. Less technological disaggregation (ie fewer pots) will lead to lots of support for today's more efficient technologies. More disaggregation (ie more pots) will support a broader range of technologies, likely creating more resilience but being less efficient because policymakers have imperfect information.

The result will be a number of 'auction pots', of which each is assigned a volume of public support, which can be denominated in terms of the tonnes of abated carbon. A project's bid will then be considered against others within the same pot. These pots could correspond directly to a sector, eg cement or ammonia, or could allow for the grouping of multiple sector technologies. For example, similar sectors might be grouped and then further decomposed by established technologies (lower strike prices), and less-established technologies.

Fabra and Montero (2020) suggested that these separate auction pots need not take the form of separate auctions *ex ante*. Instead, a general auction can be designed that contains minimum quotas for desired technologies. In this way, if technology-neutral competition is efficient at providing a range of support, the system functions. If not, minimum quotas would force some support to be provided across a range of technologies. At European level, minimum quotas could also be built in for individual countries, so that each country receives at least a minimum volume of support from the scheme (Figure 3).

Figure 3: Illustrative example of an EU commercialisation contract auction



Source: Bruegel.

4 Towards a European solution

The best approach for the implementation of commercialisation contracts would be a coordinated system of EU project selection and funding. Bids should be submitted by low-carbon projects from throughout the EU. Evaluation would be by an EU agency such as the European Climate, Infrastructure and Environment Executive Agency[10] using the two-step approach detailed in the previous section.

Allocating contracts at European level would lead to considerably more competition and a more efficient outcome. It would allow for significant technological disaggregation of support while maintaining competition, because of the increased number of firms able to bid. It would also prevent fragmentation of the EU single market.

4.1 Coordinating framework for project selection

The project selection framework would involve:

- Determining which technologies are eligible for commercialisation contracts. These would be low-carbon projects that are in line with net-zero ambition, and can be feasibly replicated across the EU (and ideally the world).

10 The agency already manages several EU-level climate programmes, including the Innovation Fund.

- Grouping technologies into separate pots: this should be done on the basis of data from the ETS (industry codes). Design would have to be dynamic so that it responds as information about marginal abatement costs is progressively revealed.
- Decisions on the type of contract which will be offered to each pot. This would include maximum strike price, maximum volume of support to be allocated to each pot. Some elements such as length of contracts may be uniform across all pots.

In case political obstacles prevent Europe-wide contracts from being issued, a coordinating framework would still be essential for the alternatives we have discussed (clubs of countries, bilateral linkages). In this case, the coordinating framework will be necessary to promote the convergence of national schemes over time. Within an overall framework, countries could be free to issue their own contracts, safe from state-aid restrictions. Coordinated design of technology pots to ensure fair competition would be particularly important.

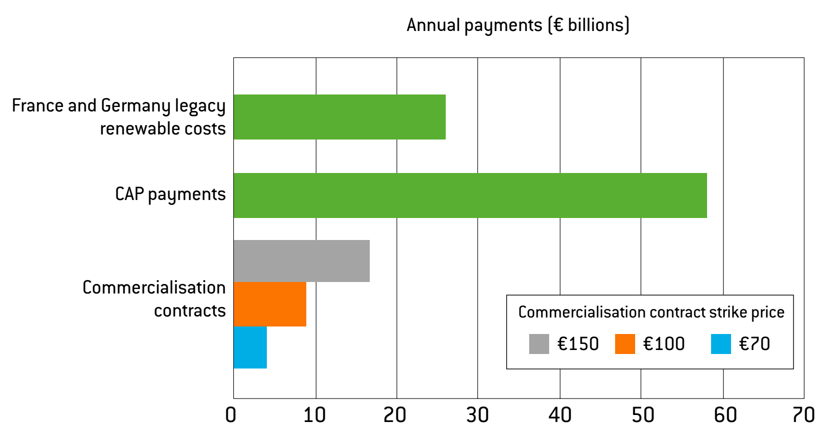
4.2 European funding

Beyond coordination, funds will also be required at the European level. Realistically, an EU wide 'commercialisation contract fund' should look to distribute €3 billion to €6 billion per year (or 0.0003 percent of EU27 GDP) when focused only on industrial emissions. This could be conceived as an extension or reform of the Innovation Fund.

Commercialisation contracts should be a temporary form of industrial support. Once deployment reaches a certain threshold, sufficient learning curves will be triggered, and combined with rising carbon prices, new installations will then not need subsidies. For the following calculations we take 20 percent as a rough estimate of the necessary market penetration of a new technology to be supported. This is in line with estimates in previous literature, such as Sartor and Bataille (2019). To calculate annual support levels, we assume a constant carbon price of €45/tonne. Figure 4 compares the volume of annual EU support that would be required to provide commercialisation contracts at €70, €100 and €150 /tonne for low-carbon production processes to replace 20 percent of existing installations across all industrial emissions[11].

These numbers are very much an upper bound as not all industrial emissions would be considered appropriate for support. Comparison with the ongoing legacy costs for just French and German renewable electricity support, as well as the annual Common Agricultural Policy payments at the EU level, show that this policy would be significantly cheaper.

Figure 4: Comparison of annual payments



Source: Bruegel.

11 Taking our threshold of 20 percent market penetration, our calculations assume that support is offered to all industrial sectors. This involves a total of 800 megatonnes of greenhouse-gas emissions from industrial processes and combustion for industry.

A possibility would be co-financing at the national level. A scheme could be designed in which competition occurs at the European level, but when a domestic project wins, the relevant EU country agrees to provide a share (eg 40 percent) of the financing. This would allow limited EU budgets to be stretched further.

4.3 Timeline for implementation

Based on the previous calculations, we outline an illustrative timeline for implementation of commercialisation contracts by the EU over the next decade:

1. There is a substantial learning process for a new policy. A core difficulty for commercialisation contracts would be the lack of information about the appropriate abatement costs for different industries. A first auction can be split into two separate technology pots: mature and less-mature technologies, with maximum strike prices of €70/tonne and €100/tonne. The European Commission would have to decide which technologies can compete in which pot.
2. In 2022, the first auction could issue contracts for 5 million tonnes of carbon to be abated under each pot, ie annual support of €125 million and €275 million for the mature and less-mature technology pots respectively[12].
3. In subsequent years, auctions would allocate further support. As auction design reveals industry preferences (marginal abatement costs), the European Commission could group technologies into more appropriate pots.

An initial objective could be to allocate the equivalent of an additional €1 billion of annual funding every year starting from 2024. This might take the form of auctions for €2 billion in subsidies every other year if deemed more appropriate. By 2030, annual maximum operation subsidies would then be in the order of €6 billion per year (plus whatever was issued in 2022-2024). This would be a maximum based on today's carbon price of about €45. The reality is that by the time such contracts are finally issued, the ETS price is likely to have increased. Annual operating subsidies are thus likely to be substantially lower.

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