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Synthesis Articles

Underwriting 1.5°C: competitive approaches to financing accelerated climate change mitigation

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ABSTRACT

Delivering emission reductions consistent with a 1.5°C trajectory will require innovative public financial instruments designed to mobilize trillions of dollars of low-carbon private investment. Traditional public subsidy instruments such as grants and concessional loans, while critical to supporting nascent technologies or high-capital-cost proj ... tments towards ... e value of emission ... r long time horizo ... also cata...

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price floors can be applied to a variety of sectors with greater efficiency and scalability than traditional subsidy instruments. We explore how this new class of instrument can enhance the cost-effectiveness of carbon pricing and complementary policies needed to achieve a 1.5°C outcome, including through large-scale adoption by the Green Climate Fund and other international and domestic climate finance vehicles.

Key policy insights

- Traditional public climate finance interventions such as grants and concessional loans have not mobilized private capital at the scale needed to decarbonize the world economy consistent with the 2°C target, much less 1.5°C, and will likely face ongoing constraints in the future.
- Auctioned price floors – subsidies that offer a guaranteed price for future emission reductions – maximize climate impact per public dollar while incentivizing private investment in low-carbon technologies.
- This new subsidy instrument, if applied at scale via the Green Climate Fund and other domestic and international climate finance vehicles, can promote private sector competition to bring down technology costs and drive innovation, thereby supporting a longer term transition to regulation and sector- or economy-wide carbon markets.
- To facilitate the transition from public subsidy to the market-based support of climate mitigation, auctioned price floors should work in tandem with carbon pricing and complementary policies, using the same accounting and monitoring, reporting and verification toolkits.

KEYWORDS: Auctions capital investment carbon finance market mechanisms financial incentives economic efficiency

I. In

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finance inadequate for meeting even a 2°C scenario, the toolkit of existing public finance instruments such as grants, loans and loan guarantees will fall far short of mobilizing the private investment required to achieve a 1.5°C target.

The OECD foresees only incremental growth in climate finance, estimating that public, North–South flows will increase from $45 billion in 2014 to $67 billion in 2020, while mobilized private investment will grow from $17 to $24 billion over the same period (OECD & Climate Policy Initiative, 2015; Bodnar, Brown, & Nakhooda, 2015). Total climate finance flows (including private, North–North and South–South investments) averaged $364 billion in 2011–2014 (CPI, 2015). These figures – both current and projected – pale in comparison to the scale of required investment, with the IEA estimating that a 2°C scenario will require $16.5 trillion in global low-carbon and energy-efficient investment over the next 15 years – an annual average of $1.1 trillion (IEA, 2017).

Limiting warming to 1.5°C is more difficult still, with Rogelj et al. (2015) finding that a 1.5°C scenario will cost roughly '1.5–2.1 times' more than a 2°C scenario between 2010 and 2100 (Rogelj et al., 2015, p. 525). Hof et al. (2017) corroborate these estimates in their models for 2030 emission levels and abatement costs, finding that the global abatement costs of achieving 1.5°C are 'twice as high' as those for 2°C, and 'even five to six times as high' as those for all actions proposed in current nationally determined contributions (NDCs) under the Paris Agreement; the aggregate incremental cost of achieving 1.5°C against current NDCs has been estimated at $600 billion annually (Hof et al., 2017, p. 35). Notably, these models are among the few that solve for a 1.5°C scenario, with Clarke et al. (2009) and IPCC (2014) pointing to the difficulty of achieving even the 2°C target. In short, limiting global warming to 1.5°C requires transformative, not incremental, growth in climate finance flows. Given the inherent limits of public finance tools, the innovation in financial instruments must be correspondingly transfor

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down technology costs and foster the innovation required to help achieve the 1.5°C target.

We first survey the current state of climate finance and carbon markets in the context of the Paris Agreement's objectives, describing the context in which auctioned price floors have emerged. We then introduce the theory of auctioned price floors, including the potential for this instrument to mobilize private climate finance and build on carbon market infrastructure (Betz, Seifert, Cramton, & Kerr, 2010; Milgrom, 2004; Pizer, 2011). We then describe the experience with pilot applications to date, principally in the context of the World Bank's Pilot Auction Facility for Methane and Climate Change Mitigation (PAF) and the UK's Contracts for Difference (CfD) programme for renewable energy. Building on the analysis of these programmes, we discuss lessons learned and considerations for policy makers. Finally, we explore the potential for replicating and scaling the model, including applications to the Green Climate Fund (GCF) under the UN Framework Convention on Climate Change (UNFCCC).

II. Delivering climate finance in the context of the Paris agreement

i. Subsidies and effective climate policy

Subsidies, together with carbon markets, taxes and other climate policy instruments, form an important part of the overall climate policy portfolio (Aldy, Barrett, & Stavins, 2003; Keohane & Victor, 2011). Similar to the negative global warming externality demanding a price on GHGs, the positive learning-by-doing externality calls for a direct subsidy on low-carbon technologies well beyond merely substituting for the inadequacy of carbon pricing systems (Acemoglu, Aghion, Bursztyn, & Hemous, 2012). Subsidizing low-carbon technologies also lowers the cost of climate policy, thus smoothing the political ... er et al., 2015).

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Subsidies have been an integral part of the global climate regime for decades, enshrined in the 1992 UNFCCC via the concept of ‘agreed incremental cost’ to be paid by developed countries for mitigation actions in developing countries (UNFCCC, 1992). The Paris Agreement explicitly maintains the financial obligations of developed countries as set out in the UNFCCC. Although the Paris Agreement establishes the general objective of ‘making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development’ (UNFCCC, 2015), it does not offer a roadmap for achieving the requisite transformation of current financial investment patterns.

ii. The state of climate finance

The Paris Agreement’s emphasis on continuity – including carrying forward the $100 billion North–South mobilization goal articulated under the 2009 Copenhagen Accord and the 2010 Cancun Agreements – raises the question of whether an incremental evolution of the current climate finance toolkit is likely to deliver investments needed to keep 1.5°C within reach. To be sure, the last 10 years have seen an explosion of climate funds and finance initiatives at the global, regional and national levels. The GCF has been capitalized with an initial $10.2 billion (Peake & Ekins, 2017). The Climate Investment Funds have allocated $8.3 billion (Climate Investment Funds, 2017) and development finance institutions have substantially increased climate finance; for example, the US Overseas Private Investment Corporation (OPIC) increased clean energy investment from $155 million in 2010 to an average of over $1.2 billion in 2013–2015 (OPIC, 2010, 2011, 2012, 2013, 2014,2015). Multilateral development banks have similarly rebalanced their portfolios, with the Asian Development Bank pledging to double annual climate finance from $3 billion in 2015 to $6 billion in 2020, while the African Development Bank has proposed to triple its climate funding to 40% of its overall portfolio by the same year (Multilateral Development Banks, 2015).

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the part of public sector actors. While traditional development finance tools such as grants and loans may develop enabling conditions for private investment, they have not adequately addressed these challenges. Furthermore, grants and loans offer no systematic way to ensure public funds are being allocated efficiently and can be highly time-intensive and costly to administer and monitor (Ciplet, Mueller, & Roberts, 2010; World Bank Group, 2013). New climate finance instruments that work in tandem with market forces while making more efficient use of public resources are needed.

iii. The evolving role of carbon markets in mobilizing capital

Carbon finance – the monetization of emission reductions to finance mitigation actions – has demonstrated its potential to mobilize climate finance. By delegating part of national emission reduction targets to private firms via market mechanisms, governments create a private source of capital for the same subsidies they seek to deliver via policy instruments such as grants and feed-in tariffs. The Kyoto Protocol’s Clean Development Mechanism (CDM) has become the largest mitigation policy instrument under the UNFCCC, mobilizing over $400 billion (UNEP, 2017a, 2017b; UNFCCC, 1997). CDM activities have generated more than 1.7 billion issued certified emission reductions (CERs), and offer a theoretical mitigation potential of up to 10.7 billion CERs by 2020 and 18.7 billion CERs through 2030 (UNEP, 2017a, 2017b). Voluntary carbon standards such as the Gold Standard, VCS and Climate Action Reserve have also generated substantial mitigation pipelines.

However, carbon markets have suffered from low prices partly as a result of weak global mitigation ambition, and have therefore not lived up to their full potential as a major driver of low-carbon investment and substitute for public subsidies. The World Bank estimates that ‘an international (carbon) market could reduce the cost of delivering the emission reductions identified in the current INDCs by about a third by 2030’ (W ... ited above

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internationally recognized baseline and monitoring methodologies for measuring mitigation results in a large variety of sectors (UNFCCC, 2017b). As a result, the CDM offers a readily available, UNFCCC-approved monitoring, reporting and verification (MRV) toolkit for generating GHG-denominated result units (Mikolajczyk et al., 2016). Because CERs are issued outside the host country by a third party (the UNFCCC), the CDM provides a novel way for investors to support low-carbon investment in developing countries while minimizing delivery and currency risk. Moreover, CDM programmatic approaches have allowed for the efficient aggregation of projects and lower transaction costs (e.g. for distributed energy access models) (Figueres, 2006; Figueres & Streck, 2009). This experience offers a foundation upon which results-based climate finance tools can build to deliver mitigation impacts at scale.

iv. Linking climate finance and carbon finance

Deepening the integration of climate finance and carbon finance enhances the effectiveness and transparency of delivering mitigation results while also encouraging private investment (Michaelowa, 2012). Specifically, public climate finance and private carbon finance can mutually reinforce their respective strengths through competitive auctions for emission reductions units to be purchased and retired. Carbon market methodologies offer an internationally accepted set of tools to quantify emission reductions and a means to monitor, report and verify results. Using tons of CO_2e reductions as the currency of climate finance creates a single, transparent benchmark for measuring results. Two decades of experience with the CDM and other carbon market standards has increased familiarity within the private sector, including banks, with the notion of using carbon purchase contracts to underwrite project finance.

The World Bank's Carbon Initiative for Development, the PAF and the Forest Carbon Partnership Facility have all tested models whereby carbon credits are procured and then can ... erating net climate ... gistry has establish ... nt accounti ... ment has a stro ... blishes a potenti ... s and results-b ... its earliest days, th ... e auctions under its Private Sector Facility (GCF, 2013). The following section provides the theoretical underpinnings of these emerging ‘quantity-performance’ instruments.

III. The theory of auctioned price floors

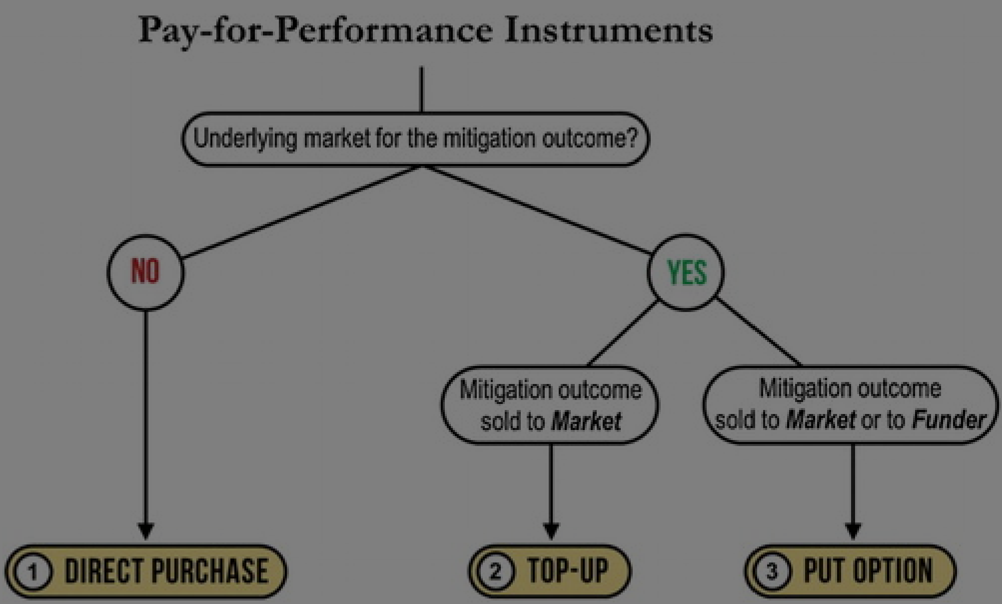
i. Pay-for-performance and quantity-performance instruments

‘Pay-for-performance’ mechanisms, also known as results-based finance, offer perhaps the most effective way of spending limited public funds to mobilize private capital for climate change mitigation (Ausubel, Cramton, Aperjis, & Hauser, 2014; Climate Focus & Ecofys, 2016; Pizer, 2011). Unlike input- or activity-based approaches, pay-for-performance mechanisms deliver funding only upon achievement of pre-defined and verified results, thus transferring risk from public donors to private service providers. Pay-for-performance instruments rely on clear and verifiable yardsticks for measuring results, which may be either quantitative (e.g. tons of carbon dioxide equivalent) or qualitative (e.g. successful completion of a mitigation project).

‘Quantity-performance’ instruments are a subset of pay-for-performance mechanisms that disburse finance for performance assessed in terms of quantities (Ghosh, Muller, Pizer, & Wagner, 2012). To date, public funders have adopted several variations on quantity-performance instruments. In the case of direct purchase agreements, a public funder contracts emission reductions at a fixed price directly from the project implementer. The public funder thus pays the incremental cost necessary to achieve a particular emission reduction. Perhaps the most advanced example of the direct purchase model is Australia’s Emission Reduction Fund, an AUD 2.55 billion concessional financing vehicle that supports domestic climate mitigation projects across a variety of sectors. The Fund purchases and cancels domestic Australian Carbon C … ernment of Australia … legal responsi … to sell ACCUs …

By co… wing holders to sell to … es at least a minimur… er offers a funder or to the market (e.g. World Bank Pilot Auction Facility). With top-up instruments, the funder pays the difference between the guaranteed price and the market price, with the project implementer always selling to the market (e.g. UK Contracts for Difference). The three mechanisms – direct purchase, put options and top-ups – can be understood as stages in the evolution of the role of the public subsidy, with concessional finance playing varying roles depending on the level of market development and private sector participation (Figure 1).

Figure 1. Typology of pay-for-performance instruments. Source: Climate Focus & Ecofys (2016).



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ii. Auctioned put option

The auctioned put option for emission reductions offers perhaps the most advanced – and flexible – pay-for-performance subsidy instrument (Ghosh et al., 2012). This instrument provides option holders with the right, but not the obligation, to sell future emission reductions to the funder at a predetermined price (the 'strike price'). The options … per emission reductio… rchase agreeme… to transfer owne… ays the strike … ucture.

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reductions. Through online auctions, private sector participants bid in multiple rounds by submitting a quantity of options demanded at a series of prices.[2] Auctions can be structured as either reverse auctions, in which the premium price is fixed and bidders bid down the strike price, or as forward auctions, in which the strike price is fixed and bidders bid up the premium price. In both cases, bidders drop out as the price per emission reduction (the strike price minus the premium) decreases, forcing private sector participants to underbid each other and thus maximizing the impact of funds. Other public auctions have produced similar results, e.g. at least 44 countries have held auctions in the electricity sector (Ecofys, 2016; IRENA, 2013; Milgrom, 2004).

Together, the put option as pay-for-performance instrument plus the auction as allocation tool address several barriers to climate finance (Table 1). The primary benefit to the private sector is reduced market risk, as the public fund guarantees a minimum price for future emission reductions. Furthermore, while carbon price instability has historically posed a major barrier for project developers seeking to raise capital, price floor contracts can be used as collateral by the private sector to raise up-front project finance, much as a wind developer can use a power purchase agreement from a creditworthy utility to raise debt. While paying an option premium itself requires capital resources unavailable to some developers, an auction open to all market participants enables the subsidy to be delivered in other ways. For example, commercial banks can purchase the options and package their subsidy value into the pricing of debt products, while technology suppliers can do the same via vendor financing.

Table 1. Advantages of the auctioned put option.

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While the put option offers several desirable features, there are clear trade-offs compared to the other quantity-performance instruments. First, if the carbon market does not deliver carbon prices that motivate investments, the put option relies on the ongoing availability of public funds; conversely, top-ups require an underlying private market. Second, both the put option and top-up approaches tend to favour mature technologies, whereas direct purchase contracts may be more applicable for early-stage technologies. Third, while the tradability of the options maximizes the probability of achieving results, it also creates the opportunity for speculative financial gain. Finally, as with any pay-for-performance instrument, all three instruments require project implementers to have sufficient access to other forms of finance, as well as the capacity to monitor, report and verify results. The following section explores how these theoretical advantages and barriers have played out in practice.

IV. Implementation and results of auctioned price floors

Initial evidence from the World Bank's Pilot Auction Facility for Methane and Climate Mitigation (PAF) and the United Kingdom's Contracts for Difference programme (CfD) indicates that auctioned put options and auctioned top-ups, respectively, offer effective models for maximizing the impact of public climate funds while also mitigating private sector risk and supporting market development.

i. Pilot auction facility

Developed by the World Bank Group and supported by funding from Germany, Sweden, Switzerland and the US, the PAF is a $53 million pilot programme designed to stimulate private investment in projects that reduce greenhouse gas emissions in developing countries. Through the issuance of tradable put options, technically structured as zero-
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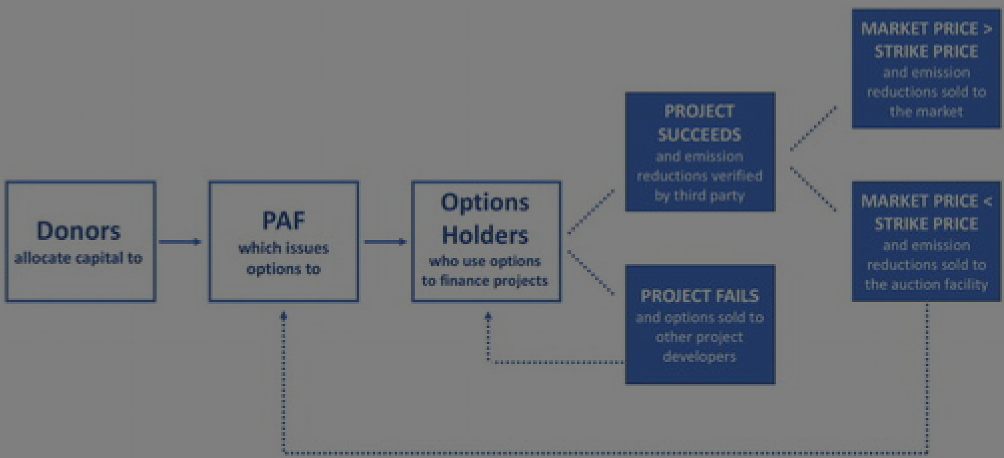
sector to invest in emission reductions, therefore achieving the highest volume of climate benefit per dollar (World Bank Group, 2015) (Figure 2).

Figure 2. Pilot auction facility model.



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Between 2015 and 2017, the PAF conducted three pilot auctions. The first, hosted in July 2015, allocated \$20.9 million in put options at a net price of \$2.10/tCO2e.[4] This auction focused on emission reductions from the solid waste, wastewater and agricultural waste sectors. To receive payment, option holders must present CERs under certain CDM methodologies. In its second auction of May 2016, the PAF allocated an additional \$20 million for emission reductions at a net price of \$2.09/tCO2e from these same sectors, while also expanding eligibility to the Gold Standard and Verified Carbon Standard (VCS). Finally, the third auction, hosted in January 2017, allocated \$13 million at a net price of \$1.80/tCO2e to projects that reduce nitrous oxide emissions from chemical and fertilizer plants (World Bank Group, 2015).

ii. Contracts for difference

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For each CfD ‘allocation round’ (auction), a budget is set for each pot and only technologies within the same pot will compete, which ensures that less mature technologies receive a certain level of support and are given the opportunity to come down the cost curve (Duke, 2002; Duke & Kammen, 1999; Lacerda & van den Bergh, 2014; Ueno, 2007). Unlike the PAF auctions, CfD relies on both administrative pricing and auctions to determine the strike price. Prior to an allocation round, the UK government establishes a ceiling price for each eligible technology and commissioning period. Applicants then submit bids, specifying the technology, capacity and desired strike price, and an auction is triggered if the value of contracts demanded exceeds the available budget (Onifade, 2016; UK BEIS, 2017a).

In total, the CfD and related programmes have signed 42 contracts for renewable energy production and have issued GBP 98 million as of the end of June 2017 for over 1000 MW of operating renewable projects (Low Carbon Contracts Company, 2017a, 2017b). The UK government announced in September 2017 that 11 new energy projects worth up to £176 million per year were successful in the latest auction (UK BEIS, 2017b). The competitive approach is generating savings for taxpayers and consumers with the cost of offshore wind projects now 50% lower than the first auction held in 2015 (UK BEIS, 2017c).

iii. Comparing the PAF and CfD

The CfD programme differs from the PAF in several ways. First, the CfD demonstrates the ability to apply top-up instruments for both established and less established technologies, while noting that the latter requires a higher level of price support. Second, the contracts under CfD are specific to individual projects and not tradable like put options. This increases the government’s risk of exposure to project failure. By contrast, because PAF options are tradeable, owners of failed projects can sell their PAFERNs ... bid auctions over the ... day, multiple ... , large-scale power p... ernment agen... e power price ex... difference back to t... cise their options i...

V. Lessons learned and considerations for policy makers

Building on PAF and CfD implementation, auctioned price floors have the potential to maximize the impact of public resources by revealing the minimum subsidy required for mitigation activities (IRENA, 2013; Klemperer, 2004). However, they also pose implementation challenges and risks. To complement the literature on renewable energy auctions (Cramton, 2009; IRENA, 2013; Klemperer, 2004; Lesser & Su, 2008; Maurer and Barroso 2011), this section provides a set of lessons learned and recommendations for governments and public finance institutions to appropriately target and design auctioned price floors. These considerations fall into three categories: (1) enabling emerging technologies and capital-intensive projects, (2) ensuring competitive auctions and (3) managing public and market risk.

i. Enabling emerging technologies and capital-intensive projects

The subsidy delivered by auctioned price floors will vary by technology and project development stage, with emerging technologies and capital-intensive projects likely demanding higher subsidies. While price floor mechanisms reduce revenue and market risk for projects, technologies in early stages of development often face technology, execution and other risks that may stymie deployment even with price floor support. Furthermore, auctions for early-stage technologies may not attract sufficient participation due to a potentially low number of active projects.

While the PAF focused on existing projects, targeting subsidies towards operating expenditures only, the CfD programme offers several lessons on how to overcome potential barriers when targeting emerging technologies or capital-intensive projects:

- Longer timelines for project and bid development: Policy makers should provide lengthy lead times before hosting auctions for new projects, and should provide clear g ... cipation.
- Reven ... ntensive projec ... anoff, Ho ... ng price floors ... etary risk for pro ... n of the contra ... budget

- Larger auction budgets: As a result of supporting larger capital costs and longer contractual periods, auctions for new and high-capital expenditure projects require substantially higher budgets than those supporting existing projects. For example, the CfD budget for just one year (600 million GBP) dwarfs that of the PAF's multi-year budget ($53 million). When defining auction budgets and scope, policy makers should look to balance goals of achieving immediate, low-cost emission reduction opportunities with longer term gains from large-scale technologies.

Finally, while not demonstrated by the CfD programme, policy makers targeting early-stage technologies may seek to blend results-based incentives with more traditional grants and loans, as demonstrated in a number of results-based climate finance programs in the energy and forestry sectors (World Bank Group, 2017a). Once technologies reach commercial readiness, they may then graduate to pure pay-for-performance support schemes.

ii. Managing public and market risk

From the perspective of the public sector, auctioned puts reduce delivery risk by ensuring that taxpayer monies are only disbursed for verified results. However, auctioned price floors pose challenges for public budgeting. In the case of auctioned put options, the public funder is uncertain about the share of options that will be exercised and therefore not sold to the market. This uncertainty creates an opportunity cost because these funds cannot be utilized elsewhere. In cases like the CfD, where the total liability of the public funder is uncertain because the commitment to top up varies with market conditions, policy makers may need to take the most pessimistic view of future markets and thereby over-budget (California Air Resources Board, 2017). To reduce the opportunity cost of reserving public funds, public entities could size the price floor programme budget based on probabilistic estimates, as is done with loan guarante

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emissions-reducing technologies and projects should graduate to either regulation or market-determined pricing to ensure achievement of mitigation goals at the lowest possible cost.

iii. Ensuring competitive auctions

Strategic auction design is one of the most important factors for increasing subsidy efficiency (Kreiss, Ehrhart, & Haufe, 2017). Key principles for effective auctions include the following:

- Setting the budget: The optimal auction budget will vary according to a funder's objectives. For example, the PAF targeted existing, and therefore relatively low-cost, methane and nitrous oxide reductions in an effort to capture maximum emission reductions in the near term. The CfD programme created distinct categories for less mature and more mature technologies, with separate budgets for each pool, thereby serving a diversification objective. Based on the auction objectives and scope, policy makers should set the auction budget based on the likely number of participants as well as technology costs, using market data (e.g. CDM data on abatement costs) and stakeholder interviews to gauge demand (UNEP, 2017a; World Bank, 2015).

- Maximizing participation: Perhaps the most critical factor to ensuring successful auctions is attracting sufficient participation, indicated by both the number of bidders as well as their aggregate demand. Each of the PAF auctions attracted a diverse set of bidders, ranging from large multinationals to small local businesses, and including both project developers and aggregators (World Bank Group, 2015; 13 Million World Bank Auction. Washington, D.C.: World Bank Group. Retrieved from https://www.pilotauctionfacility.org/content/third-auction-results World Bank Group, 2017b). According to experienced auction managers, auctions should aim to attract severa … mand may lead to … uncom … al., 2014).

- Av … to avoid both c … securing a relat … much cheap … around require that options, though tradeable, be exercisable only by the owners of underlying projects. Policy makers should carefully consider auction, trading and ownership rules during programme design to ensure programmatic efficiency is not hampered.

VI. Potential future applications

Initial real-world experiments with auctioned price floors indicate broad applicability for a large range of existing and early-stage technologies. In this section, we identify some promising opportunities in both international and domestic climate finance that could support efforts to achieve a 1.5°C warming limit.

i. International climate finance

The GCF is the largest source of concessional finance for mitigation and adaptation in the developing world. It faces both a challenge and an opportunity to allocate its initial $10.2 billion pledged resource base efficiently, not least to help countries move towards a 1.5°C warming limit. The GCF's initial funding activities have predominantly relied on grants and loans, which require time- and labour-intensive application processes and accreditation systems, and a lack of comparability in subsidy requests and provision, and an elaborate accreditation system for managing GCF resources. The GCF's 'Private Sector Facility' (PSF) – touted as one of the fund's innovative features – has not yet been implemented. It is not clear that this approach is scalable or efficient, and the GCF Board has been criticized for moving money too slowly (Darby, 2017; Gunther, 2015).

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While this programme could start with project-level support, as market mechanisms emerge under Article 6 of the Paris Agreement, the GCF could scale to back-stopping auctioned price floors for entire sectors. At that stage, the GCF could provide technical assistance to help countries put auctions in place, and provide a guarantee against countries exceeding their price floor support budgets.

Of the sectoral climate policy tools developed at the international level, 'jurisdictional' REDD+ has focused most closely on results-based financing.[5] Bilateral funding committed from Norway, Germany and others to support national or sub-national verified emission reductions from REDD+ represents an important opportunity to extend the auctioned price floor model. Put options issued by the GCF could also allow jurisdictions the opportunity to monetize REDD+ credits into compliance carbon markets, if and when they emerge. Stimulating the development of a supply of cost-effective REDD+ credits could have the added benefit of encouraging more ambitious compliance targets in industries that have the option to use offsets. In response to a recent GCF request for public inputs on results-based payments for REDD+, 6 of 14 inputs from GCF Board members suggested reverse auctioning as a possible tool (GCF, 2017).

Finally, auctioned price floors can harness market forces to reveal untapped mitigation opportunities across a variety of sectors, thus supporting the decarbonization that will need to happen throughout the global economy to meet a 1.5° target. By identifying projects with low costs, auctioned price floors can also help policy makers identify sectors and technologies that can transition to regulation. For example, the German Nitric Acid Climate Action Group (NACAG) incentivizes emission reduction projects in developing countries via a CDM methodology while also supporting the transition to national restrictions on nitrous oxide emissions as a part of countries' efforts to meet their NDCs from 2020 onwards (Carbon Pulse, 2015; NACAG, 2017).

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may be particularly appropriate for established technologies or if the availability of concessional finance has a high impact on achievable emission reductions; where private sector actors are able to finance capital costs given more certainty about revenues; and where established MRV methodologies are available to enable quantification and verification of emission reductions.

In California, an auctioned put or price floor mechanism is being considered to support investments under the Low Carbon Fuel Standard (LCFS), in an effort to make the value of LCFS credits (denominated in tons of CO_2e) more predictable. Investment in low-carbon fuels has declined substantially in recent years due to low global oil prices, making it difficult for oil-substituting transportation fuels to compete. To create greater certainty and support new investment, California is looking at a number of options for increasing low-carbon fuel incentives. Pavlenko, Searle, Malins, and El Takriti (2016) estimate a reverse auction-price floor programme applied to the California LCFS could motivate greater market entry of low-carbon fuels than a constant per-gallon price. Based on this analysis, the California Air Resources Board has identified price floor auctions as a leading option for a pilot financial mechanism to support renewable biogas projects (CARB, 2017).

In Brazil, price floor auctions have been proposed as a mechanism to avoid forest loss, the country's largest source of emissions. Brazil's Forest Code allows landowners the flexibility to comply by purchasing a 'CRA' (Environmental Reserve Quota). The potential oversupply in the CRA market is large – the Forest Code's targets could be achieved while still leaving a theoretical potential for legal clearing of 85 million hectares of forests (Soares-Filho et al., 2014). There is an opportunity for a range of public and private actors to buy and retire CRAs through auctions, thereby supporting government efforts to reach more ambitious targets for avoided deforestation. Soares-Filho et al. (2016) suggest an investment of US$ 8.4 ± 2.0 billion to purchase low-cost CRAs co[...] reduce CO_2 emission[...]arket to be oversup[...]ards, 2016).

In ac[...]nting their NDCs, [...] price floor approac[...]d China's CDM Fu[...]3 and N2O

VII. Conclusion

Achieving the 1.5°C target will require a rapid surge in both the volume and efficiency of climate finance. The traditional toolkit of public finance instruments has enabled some progress, but it is becoming clear from the early years of the GCF and other vehicles that grants and loans do not mobilize sufficient private investment, therefore failing to drive down mitigation costs. Such tools can enhance capacity in developing countries, support early-stage technologies and help overcome financing barriers, but are difficult to scale and face fundamental challenges in terms of allocating public funding in a fair and transparent manner. At the same time, a new generation of quantity-performance instruments is emerging with early results from pilots like the World Bank PAF and the UK's CfD programme, as well as Australia’s ERF.

Quantity-performance instruments put a direct value on GHG mitigation outcomes while harnessing the benefits of competition among private sector actors to lower the incremental costs of transitioning to low-carbon economies and leveraging private finance. As the PAF demonstrates, auctioned price floors can be particularly effective at capturing and encouraging immediate mitigation opportunities at risk due to low-carbon prices. At the same time, the ability to tailor auctions enables policy makers to provide direction on which low-cost technologies and geographies may transition towards regulatory approaches under NDCs (as proposed by NACAG), and which ones continue to play a role in crediting mechanisms as the new generation of Paris Agreement market mechanisms emerges.

To be clear, the mechanism described in this paper is not intended exclusively or even mainly to support offsetting activities, nor does it obviate the need for carbon pricing,
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decreases direct costs for taxpayers (World Bank Group, 2015) and for consumers in the case of sectoral schemes like the International Civil Aviation Organization's Global Market-Based Measure. It also deepens competition for mitigation capital across technologies. If implemented carefully and in concert with other policies, auctioned price floors can evolve into a central mechanism by which limited public funds are allocated to attract the scale and speed of private investment required to keep the 1.5°C goal within reach.

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Notes

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2. The auctions can be designed either a reverse auction, in which the premium price is fixed and bidders submit their demand at decreasing strike prices, or a forward auction, in which the strike price is fixed and bidders submit their demand at ascending premium prices. In both scenarios, the net price per emission reduction decreases over the course of the auction.

3. PAFERNs are a special type of World Bank bond. They do not pay interest, nor do they pay holders a traditional principal at maturity. Rather, PAFERN holders, upon delivering qualifying emission reductions, receive a redemption payment equal to the auction strike price multiplied by the quantity of emission reductions. The PAF selected this instrument because it is built on existing market infrastructure for issuing and trading World Bank bonds.

4. 'Net' here refers to the net benefit to the option holder, or the strike price minus the premium price.

5. 'Jurisdictional' approaches to REDD+ are designed to overcome the shortcomings of project-based approaches (including the potential for deforestation to 'leak' to other areas) by working across landscapes with multiple stakeholders for national and sub-national implementation. Support from Norway for Brazil's Amazon Fund is an example of donor funding for a jurisdictional REDD+ outcome at the national level.

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