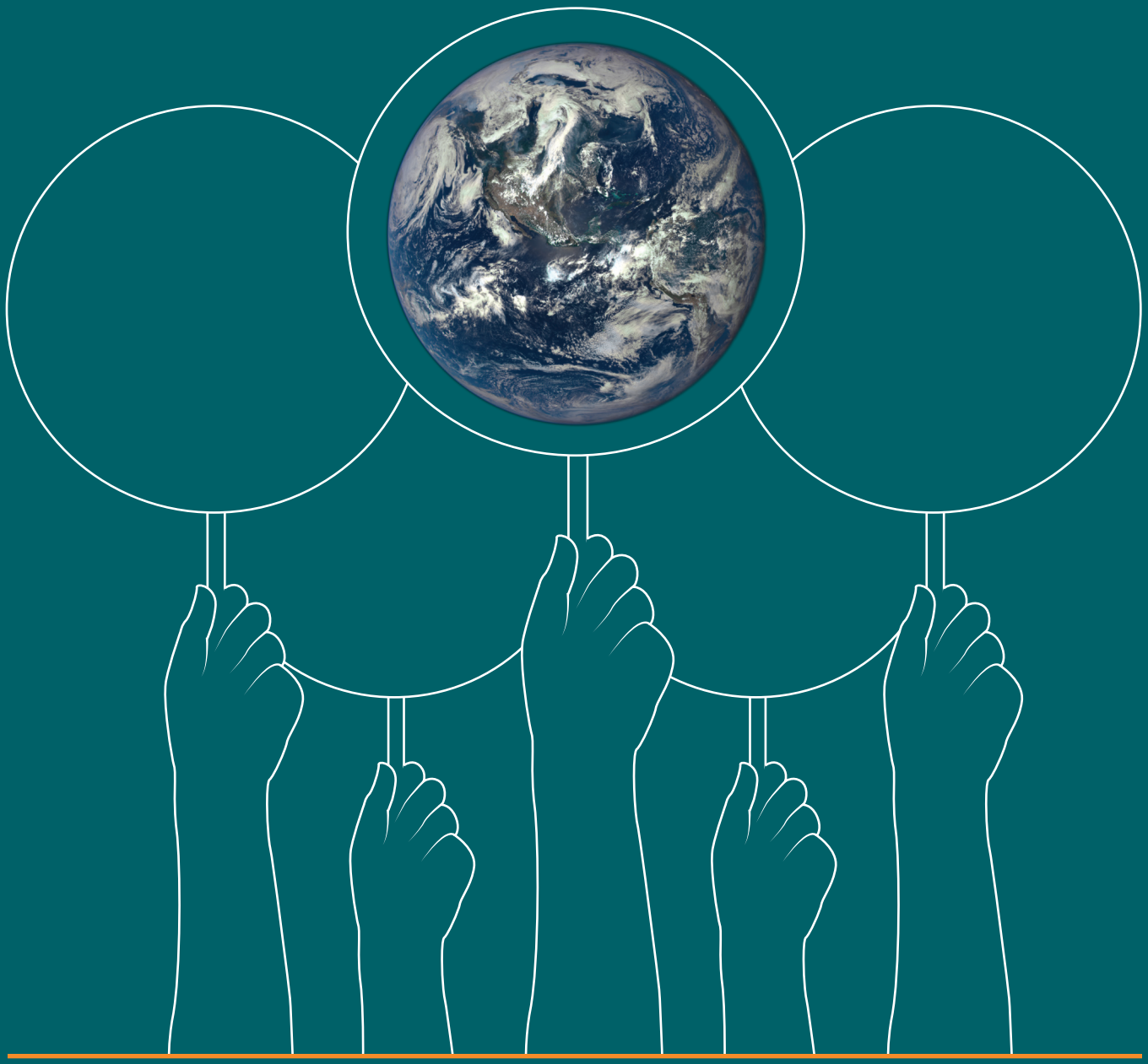
The Potential for Climate Auctions as a Mechanism for NDC Implementation



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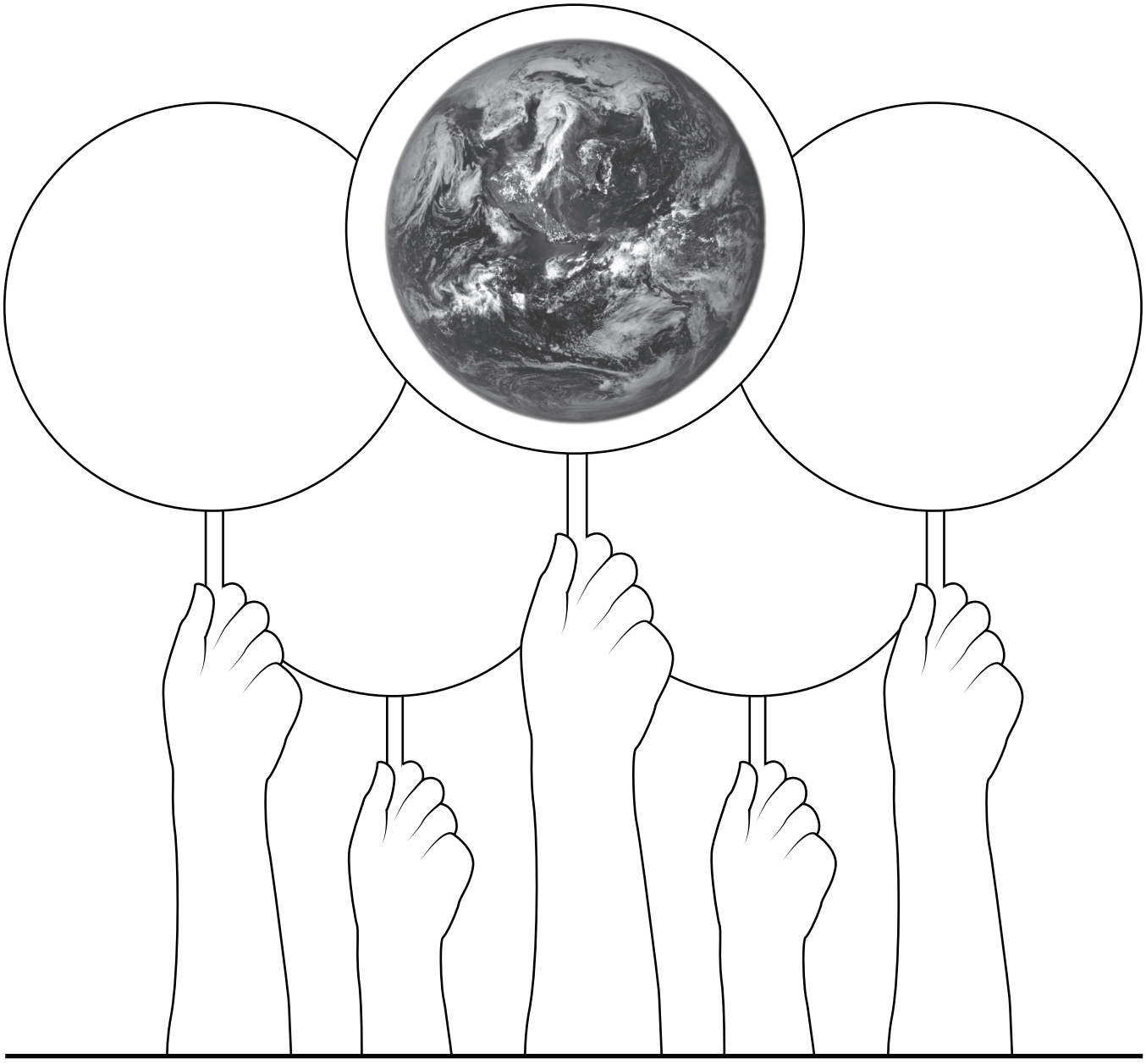

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EXECUTIVE SUMMARY

Climate auctions are an innovative public climate finance mechanism, with high potential to support nationally determined contribution (NDC) implementation through cost effectively leveraging private investment. The World Bank has developed the concept of *climate auctions* consisting of three essential elements (World Bank, 2017c):

1. **Products:** the sale of price guarantees for climate assets. Climate assets are (tradable) units that represent specific climate-outputs or outcomes, such as emission reductions, energy efficiency savings or renewable energy. The price guarantee usually takes the form of an option contract that give the owner the right, but not the obligation, to sell the climate asset in the future at the stated price;

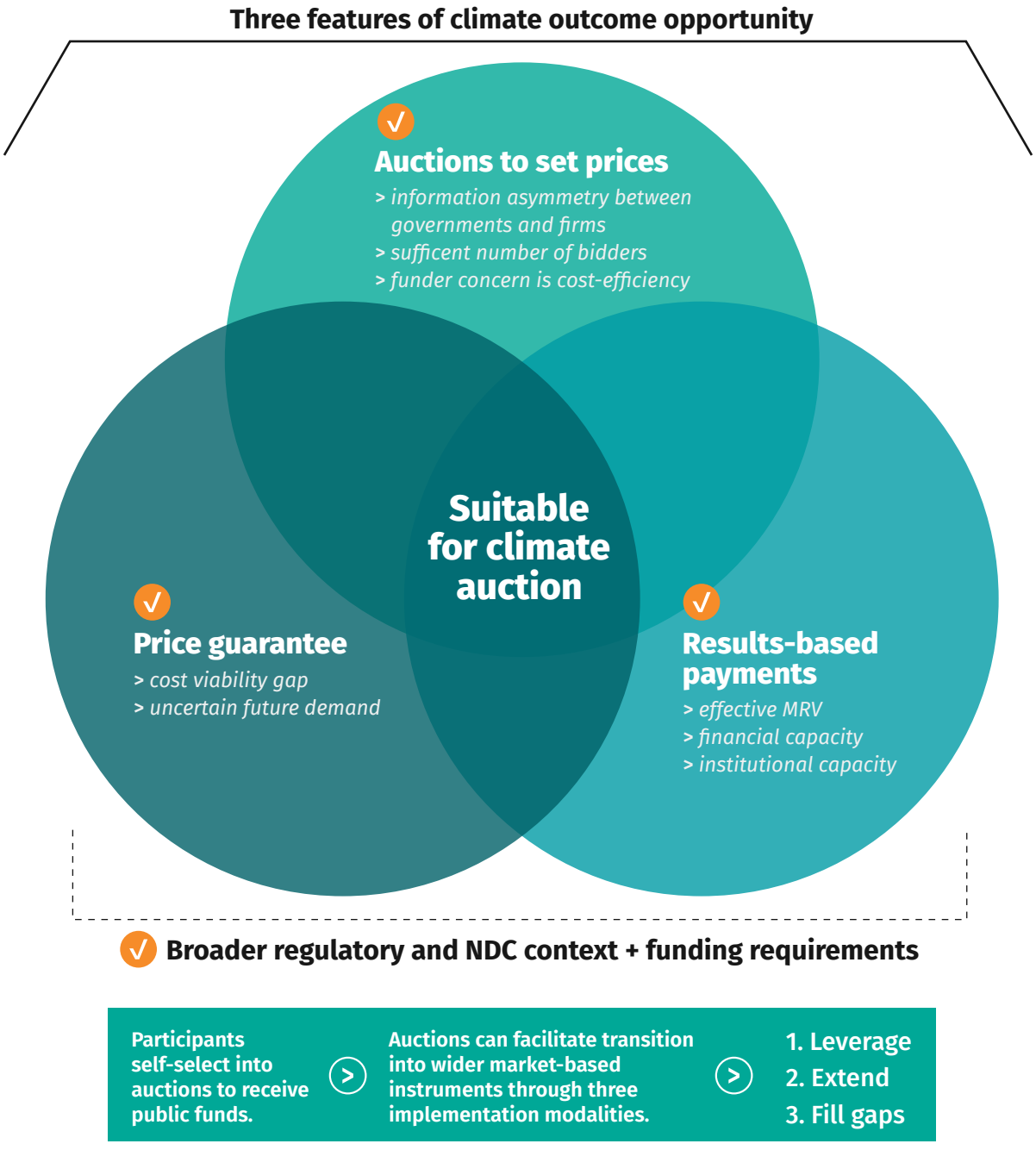
2. **Price formation:** the price paid for the guarantee is determined by an auction format where multiple bidders compete to own the contract; and

3. **Risk sharing:** the owner of the option contract is only allowed to make use of the fixed price guarantee if a third party verifies that the owner has satisfactorily delivered the climate asset. As such, climate auctions are a form of results-based climate finance (RBCF).

The Pilot Auction Facility (PAF), an example of a climate auction, has delivered cost-effective abatement. The PAF sold tradeable price guarantees, in the form of option contracts, to support abatement. To date, there have been three PAF auctions, with the first two focusing on methane abatement from landfills and the most recent auction focusing on nitrous oxide abatement from nitric acid production. Together, the three auctions have allocated US$54 million in climate finance to reduce 21 MtCO2e, with bidders paying US$13 million in premiums to acquire the options. To date, the net cost of the mechanism to the auction funders has been just over US$ 2/tCO2e. Existing studies on the PAF suggest there is potential to replicate the climate auctions model in other sectors and across other emissions sources and climate outcomes.

Climate auctions may be an attractive option for supporting cost-effective NDC implementation, as part of a transition towards the greater use of market-based instruments. The use of competitive

FIGURE 01 *The suitability of climate auctions depends on the features of the climate outcome opportunity and on the broader regulatory and NDC context (including funding requirements)*



bidding and the results-based nature of the auction model helps ensure that public resources are allocated efficiently and effectively, and allows firms to become increasingly familiar with responding to price signals to deliver abatement. At the same time, the continued use of public funds embedded in the model may enhance its political feasibility relative to carbon pricing measures, at least in the

short term. Over time, climate auctions can help build MRV capacity and an ecosystem of firms (project developers, consultants) well versed in understanding where there are climate outcome opportunities and what the costs may be, which may allow a transition towards more conventional carbon pricing instruments.

A climate outcome opportunity must satisfy three overarching conditions to be suitable for climate auctions. To successfully implement a climate auction, not only should the broader policy context be conducive to auctions, it is also necessary that they are applied in the right technical and economic context. Figure 1 details the three overarching conditions for climate outcome opportunities to be suitable for climate auctions, which are:

- they must be suitable for **using auctions to set prices**;
- they must be suitable for **results-based payments**; and
- they must be suitable for providing **price guarantees**.

Climate auctions can transition support mechanisms towards market-based instruments through three different implementation modalities. Climate auctions can be powerful instruments as they provide cost-effective abatement, remove a key commercial risk (price volatility) that project developers would otherwise face, and participant self-selection and competition means support flows to the most efficient firms. This report develops three implementation modalities through which climate auctions can support NDC implementation as countries look to increase their use of market-based instruments:

- **Leveraging:** delivers additional climate outcomes from existing market-based instruments; or
- **Extending:** delivers of climate outcomes from areas not currently covered by market-based instruments but where there is a near-term expectation that this can change; or
- **Gap filling:** delivers climate outcome targets identified in NDCs where no market can (yet) function, but where auctions might provide foundational experience to set the identified climate outcome opportunity on the path towards coverage under a market instrument.

01 INTRODUCTION

To mitigate climate change and put the world onto a 'well-below' 2°C pathway requires significant global action. Countries are beginning to step up to the challenge of climate change through the process of implementing their NDCs. These are bottom up voluntary commitments which come in a wide variety of forms: including commitments to reduce emissions by an absolute amount, commitments to reduce the emissions intensity of economic activity and commitments to reduce emissions relative to a business-as-usual (BAU) trajectory. Many countries have also formulated adaptation commitments. However, estimates suggest current NDC targets will result in a global mean temperature rise by 2100 of 3.2°C (CAT, 2017), significantly in excess of the Paris Agreement's goal of limiting global temperature rise to well below 2°C from pre-industrial levels. Moreover, at present, most governments have not introduced sufficient policies to reach even their current commitments (CAT, 2017). Substantial further action will be needed to reach a 2°C pathway, let alone come below it.

For countries to achieve, and go beyond, their NDC targets requires significant investment, particularly in emerging and developing countries. In just 21 emerging nations, on average US$ 1.6 trillion needs to be invested annually over 2016-2030 to meet their NDCs (IFC, 2016). To reach a '2°C pathway', around US$ 3.3 trillion needs to be invested in the energy system each year until 2030; this is around US$700 billion more investment required than under the BAU scenario (World Bank; Ecofys; and Vivid Economics, 2017). Annual renewable energy investment alone needs to exceed $560 billion (IEA & IRENA, 2017). There are further investment needs in the waste and agriculture sectors and to reduce industrial process emissions. These investment needs are heavily concentrated in emerging and developing countries. McCollum et al. (2013) estimates that about two-thirds of the required low-carbon investment will be needed in the developing world, particularly China, India, and Latin America.

There are large challenges in delivering this investment. Total global climate finance (private and public) in 2016 reached US$ 383 billion, with total renewable energy investment averaging just under US$ 305 billion in 2015/16 (Buchner et al., 2017) - only just over half of the US$ 560 billion estimated need for renewable energy investment in a 2°C pathway. A UNDP (2016) survey on NDC

implementation barriers suggests that the top need of countries is support for mobilising resources. This includes identifying public resources that can be used to meet NDC targets, introducing effective institutional mechanisms to distribute funds, developing capacity to help attract international financial support, and finding tools and approaches to help with private sector engagement.

Climate auctions are an innovative public climate finance mechanism, with high potential to support NDC implementation through limited use of public resources to cost effectively leverage increased private investment. This briefing note considers the role of climate auctions in more detail:

- **Section 2** discusses the World Bank's PAF model as an example of the climate auction model, illustrating some of its potential and initial lessons learnt
- **Section 3** illustrates that climate auctions can support NDC implementation by playing a transition role, taking account of the role of public resources in the model
- **Section 4** highlights that the climate auction model may be most effective in delivering climate outcomes when identified opportunities are suitable for auctions, results-based payments, and can benefit from price guarantees

02 THE ROLE OF AUCTIONS

Countries have already begun to harness the power of auctions to deliver cost effective climate outcomes. Auctions can support more cost-effective climate outcomes than command-and-control instruments by providing competition and flexibility as to who undertakes climate outcome opportunities and how: whoever finds an opportunity most attractive will be the most likely to win the auction. Auctions can further facilitate climate investment by auctioning products which make investments into low-carbon technologies more lucrative or less risky (Taschini, Fankhauser, & Hepburn, 2013).

Auctions in renewable energy generation demonstrate these benefits. The rise in auctions that allocate fixed price power purchase agreements to the lowest bidder have helped facilitate significant falls in the cost of renewable power and, more importantly, ensured that consumers and taxpayers capture the benefit of these cost reductions. The number of countries auctioning renewable energy contracts has increased from 6 in 2005 to 67 in 2016 (World Bank, 2017c). Between 2010 and 2016, global average prices for renewable power procured from auctions fell from US$250/MWh to US$50/MWh for solar and from US$90/MWh to US$45 MWh for wind (IRENA, 2017). South Africa's flagship Renewable Energy Independent Power Producers Procurement Programme (REIPPPP) used auctions to drive significant private sector investment into renewable power projects. Over 5 bid windows, the REIPPP incentivised the connection of over 6 GW of renewable capacity, through auctioning fixed price power purchase agreements (PPAs), and attracted US$ 13.2 billion of private sector investment (Mangondo, 2016).[1]

Auctions can expand beyond renewable energy to support a wide range of different projects or programmes that help achieve climate policy/NDC targets. The World Bank has developed the concept of *climate auctions* that consist of three essential elements (World Bank, 2017c):

1. **Products:** the sale of price guarantees for climate assets. Climate assets are (tradable) units representing quantified climate-outputs or outcomes, such as emission reductions, energy efficiency savings or renewable energy. The price guarantee usually takes the form of option contracts that give the holder of the option the

right, but not the obligation, to sell the climate asset in the future at the stated price;

2. **Price formation:** the price paid for the guarantee is determined in an auction format where multiple bidders compete to own the contract; and

3. **Risk sharing:** the owner of the option contract is only allowed to make use of the fixed price guarantee if a third party verifies that the owner has satisfactorily delivered the climate asset. As such, climate auctions are a form of RBCF.

Climate auctions are market-based instruments in the sense that agents compete in the auction format to win the price guarantee. This price guarantee should then facilitate investment by removing a key commercial risk (price volatility) that the firm would otherwise face. As noted above, they are also an example of RBCF as the firm holding the guarantee is only entitled its use when they have delivered, and verified the delivery of, the specified climate asset (World Bank; Ecofys; and Vivid Economics, 2017).

2.1 The PAF illustrates the benefits, and challenges, of auctions

The PAF provides insight into the benefits of climate auctions and the potential to extend the model into new sectors. The PAF shows how auctions can lead to cost-effective abatement and resource mobilisation. Additionally, the lessons learned from the PAF model suggest that there is potential to extend the auctions model into other sectors and sources of emissions and other climate outcomes.

The PAF initially used climate auctions to unlock methane emission reductions. The PAF emerged from the recommendations of a Methane Finance Study Group's (2013) report on 'Using Pay-for-Performance Mechanisms to Finance Methane Abatement', which an international group of experts convened at the request of the G8 to review innovative approaches to methane abatement. The Group recommended the use of an auction mechanism to sell tradeable put options that guarantee prices for abatement delivered from

BOX 01

MEANINGS OF KEY PAF TERMS

- PUT OPTION: a financial contract that gives the holder the right but not the obligation to sell assets to the auction funder at an agreed price
- STRIKE PRICE: the guaranteed price that the PAF pays per emission reduction
- PUT OPTION PREMIUM: the price paid by the auction winners to purchase the put option
- PAFERN: Pilot Auction Facility Emission Reduction Note, a World Bank issued, zero-coupon bond that delivers the put option
- REDEMPTION: Refers to redemption of the PAFERNs, which involves the payment of the strike price by the World Bank as issuer of the PAFERNs to PAFERN holders presenting eligible emission reductions
- MATURITY: the date on which the PAFERN holder can redeem the PAFERN
- DESCENDING CLOCK AUCTION: an auction in which the premium is announced, and the bidders iteratively bid down the strike price
- ASCENDING CLOCK AUCTION: an auction in which the strike price is announced, and the bidders iteratively bid up the put option premium
- ELIGIBILITY CRITERIA: requirements for how, when, and where emission reductions occur in order to qualify for redemption

methane projects. This aims to reduce the risk for project developers arising from potentially low future clean development mechanism (CDM) prices, thereby using public funds to unlock private investment. Box 1 provides a list of the meanings of key PAF terms (World Bank, 2015).

BOX 02

THE KEY RESULTS OF THE PAF DEMONSTRATE THE POWER AND FLEXIBILITY OF AUCTIONS

Each of the three auctions differed in design:

- **Auction 1** focused on methane emissions (CH4) from landfills. The put option premium was fixed, and participants bid on the strike price, in an multi-round descending clock auction (NERA, 2015).
- **Auction 2** also focused on CH4 from landfills but with a different auction design. The strike price and number of put options were fixed, but participants progressively bid a higher put option premium (NERA, 2016a).
- **Auction 3** focused on nitrous oxide emissions (N2O) from nitric acid production. As with round 1, bids were made on the strike price using a descending clock auction. Auction 3 was also partly designed to try and induce new investment. The auction was divided into a new segment, purely for new projects,[2] and an open segment without this restriction. The new segment auction took place first, and unspent budget from this auction was to supplement the open segment auction budget (NERA, 2016b). However, demand was insufficient to clear the market in the new segment auction, even at the highest (reserve) strike price of US$ 6/tCO2e (NERA, 2016b). No put options were purchased in the new segment and all of the budget transferred to the open segment (World Bank, 2017a).

The tradability of the auctioned options is a key feature of the PAF design. This allowed the winner of the auction to transfer the put option to another entity, who could then benefit from the fixed price, subject to the emission reductions of the second entity meeting eligibility criteria. This meant that, even if a winning bidder's project failed to realize emission reductions, the price guarantee might still be used by someone else, increasing the probability that emission reductions are achieved (Chee & LaCasse, 2017; Ecofys and Climate Focus, 2016). Tradability reduces the risk of a common problem in renewable power auctions, whereby prices are bid too low and bid winners cannot deliver their project based on these prices, resulting in the abandonment of the projects (Foresight, 2017).

There have been three PAF auctions to date, which together have allocated US$ 54 million in climate finance to reduce 21 MtCO2e, with bidders paying US$ 13 million in premiums to acquire the options. The auctions trialed two different auctions designs, and targeted two different pollutants (World Bank, 2017c). The PAF demonstrated that the climate auctions model could ensure fast disbursement, with the first auction taking place in July 2015 and the first redemption round occurring in November 2016 (World Bank, 2017d). Box 2 provides more details on each auction round.

The results suggest that climate auctions can deliver low-cost abatement while providing a benefit to project developers. The PAF put options redeem annually until 2020. The first redemption occurred in November 2016, when four projects delivered 1.3 million eligible CERs and were paid US$ 3.1 million in price guarantees (World Bank, 2017c). The second redemption took place in November 2017 when project owners received US$ 9.6 million from the sale of 3.4 million eligible

TABLE 01

The three PAF auction results all demonstrate cost effective abatement

Variable	Auction 1	Auction 2	Auction 3— new segment	Auction 3— open segment
Date	July 2015	May 2016	January 2017	January 2017
Emission reductions targeted	CH4	CH4	N2O	N2O
Strike price (price guarantee) (US$/tCO$_2$e)	2.4	3.5	-	2.1
Premium price (US$/ tCO$_2$e)	0.3	1.41	-	0.3
Net benefit	2.1	2.09	-	1.8
Volume of put options sold (MtCO2e)	8.7	5.7	0	6.2
Auction budget (US$ million)	25	20	New segment: 6	13 less spending in new segment
Number of bidders	28	21	0	13
Number of countries	17	12	0	9

CERs.[3] Around 95% of the options expiring in 2017 were redeemed; this high redemption rate may have been enabled by the tradability of options ensuring that the options ended up being owned by the project developers that valued them most (Hernandez & Arango, 2017). The abatement from the first redemption had a net cost to the funders of US$ 2.08/tCO$_2$e, falling to US$ 2.02/tCO$_2$e in the second round. The benefit to project developers is also clear as, in the absence of the PAF, they would probably have had to sell any emissions reductions at around US$ 0.5/tCO$_2$e. At the same time, the low prices were partly driven by the facility focused on reviving abatement from dormant projects, rather than stimulating new project abatement. The explicit effort to encourage new investment in round 3 was unsuccessful.

The different designs of the three PAF auctions provide lessons in terms of price discovery, bidders attracted and budget allocation efficiency. Some of the key design lessons learned from the PAF include:

» The format used in all three auctions provided participants with information from the previous rounds, which facilitated **price discovery** as bidders could incorporate historic information into their bidding strategy. The almost identical net benefits yielded between auction 1 and 2 is suggestive of efficient price discovery (Chee & LaCasse, 2017). Furthermore, bidding rules entailed that bidders could only make bids less than or equal to the volume of their bid in the previous round, which incentivised

truthful bidding and avoided the challenge of participants only placing serious bids at the last moment (so-called bid sniping) (Ausubel, Cramton, Aperjis, & Hauser, 2014).

» The model in auction 2 of fixing the strike price and bidding up the option premium (ascending clock design) deterred the entry of less capitalized bidders, possibly due to the higher upfront premium payment acting as a **barrier to entry** (Chee & LaCasse, 2017).

» On the other hand, the design of auction 1 (descending clock) implied a greater **risk of underspending the total auction budget**, as the number of put options for sale increased after each auction round as the strike price decreased. This risk is limited in an ascending clock auction where the number of put options for sale and their strike price remains constant in all rounds (Chee & LaCasse, 2017). This may have contributed to the different budget efficiencies observed in auctions 1 and 2 with an undersell in auction 1 of around US$ 4 million compared to virtually no underspend in auction 2. However, auction 3 also used a descending clock auction with virtually no budget underspend.

The PAF experience indicates a need to consider how to best incentivise new investment using climate auctions. As noted above, the attempt to incentivise new investment in auction 3 was not successful. There are a number of idiosyncratic factors related to the design of the PAF which may help to explain this, including a short marketing period and a relatively small auction budget. By contrast, other auction models have successfully incentivised new investment. For instance, the UK has developed a so-called Contract for Differences (CfD) model whereby renewable power producers bid for the price needed to make renewable power investments profitable (bound by a price ceiling) and the funder agrees to pay the variable 'top-up' difference between the auctioned price and the prevailing electricity price.[4] The CfD successfully incentivised new investment, with the latest auction in September 2017 procuring 11 new energy projects worth close to US$ 230 million (UK Department for Business Energy & Industrial Strategy, 2017). Comparing the two models, Bodnar et al. (2017) suggest that the CfD model incentivised investment because it allowed a sufficiently long timescale for project and bid development, provided revenue certainty over an extended period of time, and backed the auction with a large budget (US$780m compared to US$53m).[5]

2.2 Moving forward

Earlier studies suggest there is potential to replicate the climate auctions model in other sectors and across other emissions sources and climate outcomes. Ecofys and Climate Focus (2016) assess the suitability for the PAF model for extension into six non-methane emitting sectors using a range of criteria.[6] They find that CO_2 abatement projects in the energy and industry sectors are particularly well-suited to the climate auctions model, scoring highly on all assessment criteria. Other industrial gas projects and agriculture, forestry, and other land use (AFOLU) projects, especially forestry, are also found to be suitable, although the authors note potential concerns regarding the sustainable development impacts of some industrial gas projects, and the challenge of effective monitoring, reporting and verification (MRV) for climate outcomes in some AFOLU projects. By contrast, the study viewed transport and buildings sector projects as generally

less suitable for the model due to low price responsiveness, low applicability or high cost of current MRV processes, the wide dispersion of small emissions sources, and owner-operator differences. However, there may be an important exception for new energy efficiency options in the building sector, through exploiting alternative performance metrics with simpler MRV implications, such as the certified green building area or the number of efficient appliances (Ecofys and Climate Focus, 2016). Similarly, a quantitative analysis of the potential for using climate auctions in India's building sector suggests that creative thinking around auction design, especially bid product, eligibility criteria and performance metrics, could widen the role of the auctions model leading to emissions reductions and water, energy, and financial savings (Carbon Trust, 2018).

Some elements of the climate auction model remain untested. The PAF version of the climate auction model has been successful at reviving dormant investments rather than generating new investment. This reflects a more general concern that climate auctions, and other RBCF measures, may need to be paired with traditional upfront financial instruments, such as grants, to deliver transformative investments (World Bank, 2017d). Additionally, expanding into sectors where MRV practices are less well developed has yet to be fully tested.

There are also important questions about how climate auctions can be applied by countries addressing the challenges of NDC implementation. The PAF model supported the delivery of emission reductions from projects initially registered under the CDM, with the additional resources being provided through international climate finance. While helping to prove the climate auction concept, different questions arise when considering adapting the model to the context of domestic NDC implementation. This includes where resources might come from, recognising that many countries face constrained public resources, and that domestic (and any international complementary resources) may find it difficult to accommodate the uncertain levels of disbursement implied by the model. There are also further questions around how auctions can best work alongside other policies focused on NDC implementation.

To help address these remaining questions, the remainder of this paper focuses on two critical issues:

- What is the broader domestic policy context in which countries should consider using climate auctions?
- What are the conditions under which climate auctions are valuable and appropriate?

03 THE BROADER POLICY CONTEXT

This section assesses the policy context in which climate auctions might support the activities embedded within any country's NDC[7]. It explores when the broader policy and regulatory context, and its expected future trajectory, may be well-suited to climate auctions. It suggests that, within a broader policy transition towards the greater use and coverage of market-based instruments, climate auctions may be particularly helpful in **leveraging** the power of price signals in currently covered sectors, **extending** the reach of price signals to sectors on the verge of market inclusion, or **gap filling** to achieve discrete non-market policy objectives.[8] The broader policy context also needs to be one where there are sufficient public resources to use the auction model. Section 4 then explores the particular (economic) characteristics of activities within a country are the best candidates for using the climate auction model. Figure 2 summarises the structure of both sections.

Climate policies in many countries involve a gradual transition from domestic public funding to market based instruments. This entails a move from using public subsidies to support the delivery of climate assets to leveraging private funds by internalising the costs or benefits of climate outcomes. From a political economy perspective, the former is relatively easy to introduce, with clear beneficiaries and costs that are diffuse across a wide tax base. Exploiting these characteristics, subsidies can play a useful role in building familiarity with technologies and bringing down costs (World Bank, Ecofys, & Vivid Economics, 2016). Subsidies can also act as useful support policies in some countries, while they gradually begin implementing and enforcing stronger, market-based policies. However, subsidies are less efficient at reducing emissions than carbon pricing, as they do not encourage a demand-side response by end consumers, and there are often concerns about their long-term sustainability and scalability because their take up is often voluntary and they rely on limited public resources (Fischer, Newell, & Preonas, 2014).

From this perspective, climate auctions can be thought of as a policy instrument that ensures the efficient and effective use of public resources and incentivises self-selection:[9]

- Like 'standard' subsidies, auctions involve the continued use of public funds to support climate outcomes (through the publicly backed

FIGURE 02

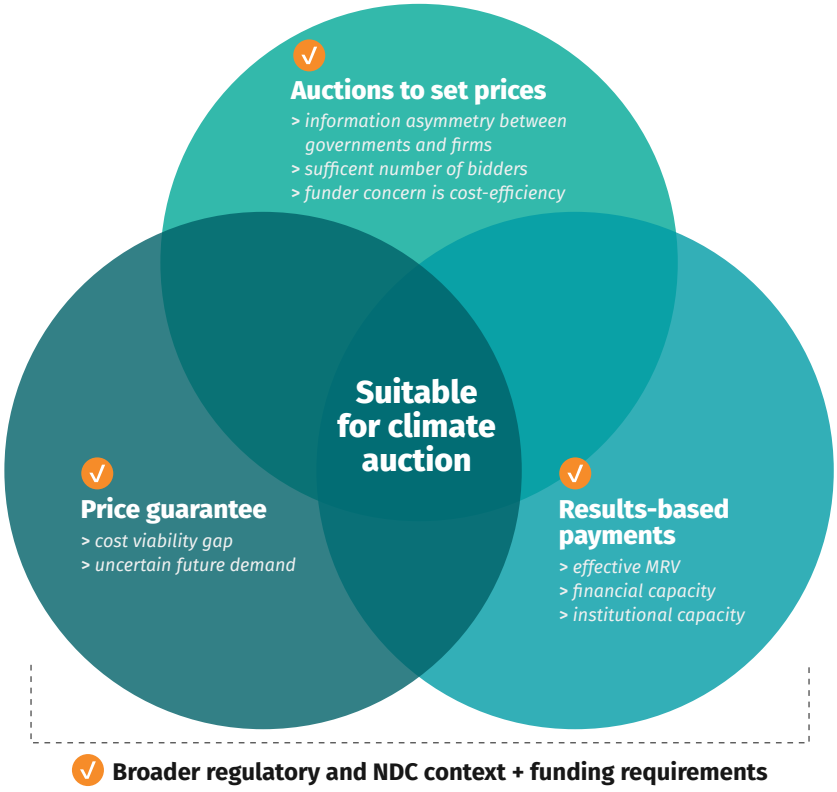
The suitability of climate auctions depends on the broader regulatory and policy context (including funding requirements) and the features of the climate outcome opportunity

Climate auctions act as transitionary climate policies through three modalities:

LEVERAGE
additional climate outcomes from existing market instruments

EXTEND
the reach of existing market instruments into new areas

FILL GAPS
to target discrete climate outcomes outside the scope of markets



price guarantee). However, the competitive allocation mechanism of the subsidy, and its results-based nature, helps ensure the efficient use of these public resources

» Like a carbon price instrument, auctions can facilitate the delivery of climate assets where it is cheapest, as it will be those who have access to the cheapest/most efficient processes who are most likely to win the auction, so long as they choose to participate.[10] Similarly, as with a carbon price, firms receive the financial benefits of the policy once they have successfully delivered the climate outcome (emission reduction or other).

This implies that climate auctions may have a particular role to play in supporting the progression towards a comprehensive suite of market-based instruments and climate markets within a country. The number of countries with carbon pricing mechanisms has grown rapidly in recent years. As of 2017, 42 countries are implementing or planning to implement some form of domestic carbon pricing mechanism, an almost threefold increase in three years (World Bank; Ecofys; and Vivid Economics, 2017; World Bank, 2014). However, this is far smaller than the number of countries that have identified interest in using domestic carbon pricing mechanisms. The World

Bank's Partnership for Market Readiness (PMR) and the International Carbon Action Partnership (ICAP) identify at least a further 23 additional countries that have made public announcements of considering carbon pricing mechanisms (ICAP, 2016; PMR, 2016). There are, however, a number of well-known political economy difficulties associated with moving from considering carbon pricing to committing to its implementation (Victor et al., 2015). Climate auctions may be able to play a valuable role in overcoming these barriers while helping demonstrate the cost effectiveness of market-based instruments. At the same time, they can help build MRV capacity, and build an ecosystem of firms (project developers, consultants) well-versed in understanding where there are climate outcome opportunities and what the costs may be.

There are three main ways in which climate auctions can act as transition tools to support NDC implementation. Figure 3 illustrates that the three climate auction modalities differ in terms of how they help transition current market instruments. They y-axis represents a binary threshold of whether climate opportunities are covered under a current market mechanism or not. The arrows reflect the different modalities' impact on transitioning climate outcome opportunities into markets:

- **Leveraging** delivers additional climate outcomes from existing market-based instruments, increasing the depth of current market instruments (reflected by the blue arrow becoming wider); or
- **Extending** delivers of climate outcomes from areas not currently covered by market-based instruments but where there is a near-term expectation that this can change, such that auction covered climate outcomes eventually become covered under existing market instruments; or
- **Gap filling** delivers climate outcome targets identified in NDCs where no market can (yet) function, but where auctions might provide foundational experience to set the identified climate outcome opportunity on a potential path towards coverage under a market instrument.

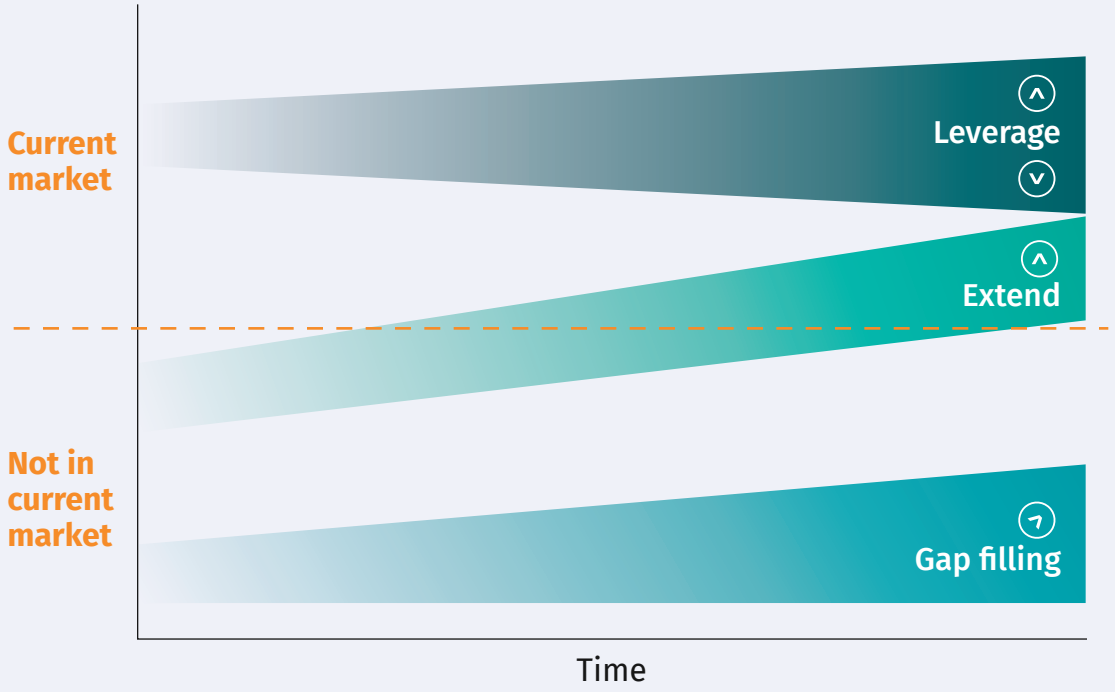
The following sections describe the three modalities. While much of the economics of the use of the model is consistent across the three options, they represent quite different roles for climate auctions from a policymaker perspective. For project developers, both the **Leverage** and **Extend** aim to prepare project developers for inclusion under future, or more stringent, markets. The **Gap** model, by contrast, aims to develop a fledgling ecosystem of project developers and achieve climate outcome targets independently. The analysis also draws on two case studies, from India and South Africa, to illustrate the potential application of the different climate auctions modalities. These case studies were selected on the basis of the interest of key stakeholders in the two countries and focus on sectors identified as being particularly well-suited for the climate auction model.

3.1 Leveraging additional climate outcomes

Climate auctions can leverage existing market-based instruments to unlock additional climate outcomes in sectors already covered by that instrument. Policymakers may wish to achieve additional climate outcomes whose cost is above

FIGURE 03

The three climate auction modalities help climate policy transition towards increased use of market mechanisms in different ways



the price in the existing market, for example to correct for additional market failures such as learning-by-doing effects that could reduce future costs. Climate auctions can target these specific opportunities and deliver additional climate outcomes without increasing the ambition of the entire market-based instrument.

In these cases, climate auctions can help realise additional climate outcomes, until the time when the existing market instrument can take over. This is the model of the first three PAF auctions, which unlocked methane and nitrous oxide abatement that were not incentivised by prevailing low CER prices. This model entails that climate auctions support the delivery of the additional climate outcomes temporarily, while technology costs fall or prices for the climate outcome rise. Box 3 summarises how climate auctions, applied in the context of India's Perform, Achieve, Trade (PAT) scheme, could leverage additional energy savings from thermal power producers.

Under the leverage model of climate auctions, there are important design features policymakers need to consider, including:[11]

- stipulated pricing rules; and
- the type of price guarantee offered.

The main auction pricing rule to consider is whether to use a uniform price auction or not. A uniform price auction offers the same price to all successful bidders while a discriminatory price auction would offer different price floors according to what firms reveal they need through the auction. The practical implications of which design leads to better financial outcomes for the auction funder

is an empirical question which depends on the particular context of the auction—for example, market uncertainty, number of participants, demand for the auction product (Monostori, 2014). With auctioning tradable products, however, uniform price auctions maximise environmental effectiveness compared to price discrimination auctions.[12]

Policymakers also need to decide whether to provide a price floor through put options (as in PAF model) or instead commit to paying a 'top-up' on the prevailing market price. Under the put option, bid winners receive the right, but not the obligation, to sell climate outcomes at the agreed strike price to the funder, who then removes purchased climate outcomes from the market. Under the top-up price guarantee, bid winners are required to sell climate outcomes into the market, but the auction funder commits to paying the difference between the agreed strike price and the prevailing market price. A project developer receives the same incentives under both types of price guarantee, however there are differences in terms of costs to the auction funder and general market impact, specifically:

» Top-ups may be cheaper for the auction funder

BOX 03

Climate auctions in India could leverage the impact of the Performa, Achieve, Trade (PAT) scheme to deliver additional energy efficiency improvements from thermal power producers

» **The Perform, Achieve, Trade (PAT) scheme is a market-based instrument designed to achieve energy efficiency improvements in energy intensive large industries and facilities. The scheme develops energy consumption reduction targets for facilities.** Facilities that consume more than their targets purchase energy savings certificates (EsCerts) from facilities who consume less than their target (or otherwise pay a penalty).

» **Climate auctions can help leverage additional energy efficiency from thermal power producers (TPPs) and deliver prioritised support based to projects delivering greater local air quality co benefits.** TPPs are the focus of PAT, yet they were the only sector not to surpass physical energy consumption reduction targets in the first cycle of PAT and the sector was a net purchaser of EsCerts. Using auctions in PAT to provide price guarantees for energy efficiency improvements would stimulate long-term energy efficiency investment by reducing project risk reflected in potential low future EsCert prices. As increasing the efficiency of TPPs may result in both lower GHG and other local air pollutant emissions, this would have significant local health co-benefits.

» **A segmented auction design with set-asides for projects with greater co-benefit values, would maximise the public benefit of climate auctions.** The local health co-benefits of energy efficiency improvements in TPPs closer to population-dense regions are greater than for TPPs in remote regions. As such, there exist differences in total project values from the perspective of the auction funder. Providing set-asides for these high-impact thermal power plants could provide prioritised support to more socially valuable energy efficiency improvements

» **Initial analysis suggests that there exists numerous potential sources of auction finance, and domestic institutions capable of implementing auctions.** India has a number of Funds which could potentially finance a climate auction, such as the Power System Development Fund (PSDF), the National Clean Energy Fund (NCEF), State Energy Conservation Fund (SECF) scheme, and the Partial Risk Guarantee Fund (PRGF). International development climate finance might also be sourced. Domestic institutions would likely play a significant role in implementing climate auctions: the Central Electricity Regulatory Commission (CERC), the Bureau of Energy Efficiency (BEE), the India Energy Exchange (IEX), and the Central Electricity Authority (CEA).

as they only pay the gap between the market price and the auctioned strike price. This helps maximise the use of auction funds as they only pay as much as is needed for climate markets to engage. However, the provision of a subsidy to climate assets that were previously too costly threatens to crowd out other climate assets and lead to a lower market price.

» The put option avoids the risk of crowding out as, if the option is used, funders fully purchase the climate outcome.[13] It may also be easier to ensure tradability through a put option model.[14]

3.2 Extending the reach of market-based instruments

Climate auctions can also support NDC implementation through helping extend existing market-based instruments into new sectors. Climate outcome opportunities can be excluded from market-based instruments for a range of reasons including concerns about the costs of delivering outcomes in that sector (similar to high-cost market segments under the Leverage model); difficulty in monitoring, reporting and verification (MRV) of climate assets in these sectors; or because of political economy challenges. In these cases, climate auctions can help extend the reach of the market-based instrument.

This model helps extend market-based instruments by facilitating early stage learning opportunities and preparing other sectors for market inclusion. The auctioned subsidies can help overcome early stage investment cost challenges; while self-selection and the RBCF characteristics of the model can help develop capacities for MRV practices and propagate this to other opportunities (within the targeted sector) (World Bank & Frankfurt School of Finance and Management, 2017). Over time, this may pave the way to integrate such climate outcome opportunities into the existing market-based instrument.[15] For example, Box 4 describes a case study exploring how the climate auctions model could extend the reach of South Africa's carbon tax.[16] Here, climate auctions in the waste sector could help stimulate abatement opportunities while the sector functions as an offset mechanism, and help prepare the sector for full inclusion under the tax in subsequent phases.

The key challenges and design considerations for the extend climate auction model are similar to those for the leverage model. Similar to the Leverage model, policymakers still need to decide whether to offer a uniform price or price discriminate, and must decide whether to offer price guarantees as a top-up or some form of put option. One additional consideration in this model surrounds the appropriate amount of information to provide to potential participants considering the extend model supports sectors without market experience. Distributing information before the auction, and revealing maximum information between auction rounds, can help increase the symmetry of information between auction participants which makes it more likely that the auction will be won by the participant who values the auctioned product most highly.

3.3 Filling a policy gap to deliver discrete climate outcomes

Climate auctions can also fill a policy gap by providing results-based incentives to encourage the efficient delivery of climate outcomes where there is no immediate expectation of

BOX 04

Climate auctions in South Africa could help extend the reach of the carbon tax to deliver additional mitigation from the waste sector

- **The upcoming carbon tax in South Africa plans to exclude the waste sector from direct coverage, until after the initial implementation phase.** This exclusion is because of administrative challenges faced by undertaking sector-wide MRV in these sectors (Republic of South Africa National Treasury, 2014). Instead, emission reductions from the waste sector will be targeted by allowing abatement from this sector to be sold to tax-liable entities as offsets. However, from 2022 onwards, the government plans to cover the waste by the tax (Republic of South Africa, 2017b).[17]
- **Climate auctions can help prepare the waste sector for inclusion under the carbon tax by alleviating the initial cost-viability gap, supporting early stage investment, and providing capacity building opportunities.** Due to the design of various tax allowances, the effective tax rate is likely to be below the marginal abatement cost of any waste sector mitigation measure, limiting the sector's attractiveness as a source of offsets. Auctioned price guarantees for abatement from landfill gas (LFG) waste sector projects could help support a fledgling industry by mitigating investor risks and build local capacity through learning-by-doing.
- **Several auction design amendments, relative to the PAF model, would help ensure the model takes account of sector characteristics.** Some of the potential changes to the original PAF model could include:
- a flexible auction budget to reduce the impact of potential low participation;
- the distribution of a project cost prospectus study to reduce information asymmetries between participants; and
- longer timeframes and larger budgets to incentivise new investment projects.
- **Local funds and institutions could both finance and administer the auctions.** The South African Green Fund or municipal infrastructure grants may be potential sources of auction funding, possibly paired with development finance institution or development bank funds. Two institutions would likely be capable of administering auctions with minimal capacity building requirements. The Independent Power Producers Procurement Programme (IPPPP) Office has experience in renewable auctions, while the Department of Environmental Affairs set up the South African Green Fund and has a national responsibility for waste and emission reductions.

using markets. Some NDC policy objectives relate to climate outcomes where there is no short-run prospect that they will be supported through the use of market-based instruments. For example, a country's NDC may have policy goals around afforestation, or improved climate resilience where there may be little domestic experience in using market based instruments. In these cases, climate auctions can ensure the efficient delivery of these outcomes by using a competitive bidding process among participants to identify the lowest cost providers. The auction would provide guaranteed future price purchase contracts between bidders and the auction funder, upon the delivery of the outcome. This can help support the efficient delivery of certain climate outcomes, although some non-market outcomes may be inherently more difficult to accurately measure.[18]

In this case, auctions act as a transformational tool. Previous World Bank analysis shows how RBCF can help to build a broader network of agents with the capacities to manage the risks associated with ex post remuneration of climate outcomes, develop

MRV processes, and trial experimental market designs (World Bank; Ecofys; and Vivid Economics, 2017). These apply equally to this version of the climate auction model; indeed, it is effectively an example of results-based climate finance where the quantum paid per result is determined through an auction rather than policymaker decree.

The design options under this climate auction model exclude top-up contracts, and the model implies different design complexities. The funder would always have to pay the full cost of the climate price guaranteed climate outcome, as there is no other underlying market. Funders can still decide whether to offer the same uniform price for all assets or to price discriminate. Due to the novelty of a market approach for opportunities under this model, there may be significant bidder uncertainty regarding cost trajectories to deliver climate outcomes. This necessitates that funders closely consider the type and amount of information revealed after each bidding round, the time elapsed between rounds, and the time between auctioning the asset and delivery of the climate asset. One option to ensure similar information levels is to undertake a comprehensive cost study and make it available to all potential bidders.

3.4 Climate auctions require additional public resources

A key component of the broader policy context is the initial availability of sufficient public resources which the auction model can then distribute efficiently to crowd-in private financing. In contrast to market based instruments like emission trading systems and carbon taxes, the climate auction model relies on public resources to underwrite price guarantees for delivered climate assets. This requires public money. In the PAF application of the climate auction model, developed country governments, specifically Germany, Sweden, Switzerland, and the United States, provided theses resources, with US$ 54 million in contributions over the first three auctions. Provided the availability of sufficient public resources, the climate auctions model is capable of allocating these revenues efficiently so as to leverage additional private resources.

The sustainability of climate outcomes supported by auctions relies on the government explicitly announcing the transitional intention of auctions. To help ensure the sustainability of supported outcomes and avoid the pitfalls of projects reliant on public funds, governments can make clear the finite timelines of support delivered through auctions and the intended transitional pathway into market instruments. This will help ensure that project developers understand the intended direction of future regulation. Transparency such as this could provide long-term signals that could both increase early participation in auctions, through highlighting first mover advantages, and clearly illustrate government's commitment to public fiduciary responsibility.

However, greater domestic public resources are being allocated to climate change. Ambition towards domestic climate action is growing around the world after the Paris Agreement. 197 countries have submitted NDCs, of which at least 87 countries, representing 65% of 2014 global GHG emissions,[19] indicate some form of unconditional climate action, largely implementable without foreign financial assistance (Strand, 2017; WRI, 2016).[20] In 2013,[21] estimates of domestic public climate finance rose to at least US$ 60 billion a year,[22] a significant increase from estimates of US$ 21 billion in 2011 (Buchner

BOX 05

A wider range of countries are using public resources to support NDC implementation

» **One model of raising public climate finance involves capturing the proceeds from existing market based instruments.** For example, Costa Rica uses the revenues from a fuel tax and a water surcharge imposed on landowners to finance its National Forest Financing Fund (FONAFIFO) (Faerron, 2016). FONAFIFO implements a Payments for Ecosystem Services (PPSA) programme, where landowners are compensated for planting and protecting trees, and is vital for the implementation of the country's REDD+ strategy (Bosquet, 2012). Similarly, India currently uses a portion of the Rs 400/tonne cess on coal to finance its National Clean Energy Fund (NCEF) which provides funding to research and innovative projects in clean energy technology. India also has several energy efficiency market-based instruments, from which some of the proceeds go into creating fiscal instruments (such as risk-sharing arrangements or seed capital) to leverage private investment (Jha, 2014). The design of South Africa's (upcoming) carbon tax includes a revenue recycling component, which may support certain climate projects (such as low carbon public transport and a solar water heater programme) (Hemraj, 2016).

» **Other countries have capitalized climate change funds using hypothecated portions of the general government budget.** For example, the Vietnam Environment Protection Fund (VEPF) receives an annual budget from the central government budget of US$ 24 million (Priambodo, Streiferdt, Tänzler, & Semmling, 2013).[23] The Indonesia Climate Change Trust Fund (ICCTF) is resourced by a combination of bilateral and multilateral donors and domestic public financing (Bird & Tilley, 2012) with the Government of Indonesia provided US$ 142 million to the ICCTF in 2016 (ICCTF, 2016b).[24] Annual ICCTF project financing in 2016 was US$ 34 million, with 62% going to seven land-based mitigation projects, 30% going to seven adaptation projects, and 8% going to three energy projects (ICCTF, 2016a). Mexico's Climate Change Fund, created in 2012, delivers finance to projects contributing to climate change mitigation and adaptation and is resourced from a range of sources, including federal grants, domestic or foreign donations, foreign government contributions, and contributions from international organisations (SEMARNAT, 2015).

et al., 2014; Buchner et al., 2011). Public domestic resources to address climate change tend to come from either the general government budget or hypothecated proceeds from other market-based instruments. Box 5 provides just a few examples of current domestic public climate funds.

As countries continue to increase committed domestic public resources to climate change, there is increasing potential for the application of the climate auctions model to use these public resources as efficiently as possible to help implement NDCs. Given the cost-effectiveness of abatement delivered by the PAF climate auction model, and considering the analysis of how climate auctions can be best applied in the broader policy context, there are likely to be numerous opportunities to move forward with the climate auction model using domestic resources. Where necessary, international mechanisms and resources can provide support, including risk mitigation instruments, to enhance credibility.

04

WHEN ARE AUCTIONS VALUABLE AND APPROPRIATE?

This section defines the conditions under which the use of each individual element of the climate auction model is appropriate, to identify where climate auctions may be valuable. In order to successfully implement a climate auction, it is not sufficient that the broader policy context is conducive to auctions, it is also necessary that the specific technical and economic characteristics of the activities associated with the creation of the climate asset are well-suited to auctions. To explore this, we consider the characteristics of opportunities that are well suited to each of the individual elements of the climate auction model; opportunities that have all or many of these of these characteristics are strong candidates for using the auction model.

Three key features define the climate auction model:

1. The price of the product sold is determined through an auction mechanism
2. The product sold is a price guarantee, backed, if necessary, by public funds
3. The price guarantee is results-based: it can only be used by a party that has successfully delivered the climate assets

4.1 Suitable for using auctions to set prices

There are three conditions under which auctions can be used and provide value:

1. **Auctions are valuable when there is significant difference in the amount of information on the costs and/or the performance of technologies.** If the prospective funders had a good understanding of the costs of the relevant technologies they could set the price by decree; if they knew which firms would be able to provide the climate assets, they could also select the participants. However, when neither of these conditions are satisfied then there is merit in using the competitive auction mechanism to identify the firm best able to provide the asset and the price at which they are willing to do this. As the renewables experience shows, the competition engendered by an auction can often result in significantly lower prices than expected,[25] increasing value for money for funders.

At the same time, auctions are more likely to be successful when the information between firms is relatively similar and certain; if there are large discrepancies firms may be reluctant to participate in the auction or be less aggressive in their bidding strategy, reducing the auction's effectiveness. The climate auction product (typically a futures contract) is only valuable if the strike price (or the price that it is agreed the funder will top up to) exceeds the future market price at the relevant point in time. This means that bidders' expectations about this future market price are an essential factor in determining their bidding strategy. There is a risk that the highest bidder will only win because they underestimate the future market price the most, resulting in the 'winner's curse'.[26] Taking this into account, rational bidders reduce their own bid, and collectively the market-clearing price that the auction can realize, downward (Krishna, 2009).[27] This effect will be smaller when all bidders know that they have broadly the same amount of information as all other bidders and that the possibility of suffering a winner's curse is correspondingly lower.

2. **The second condition is a sufficient number of well-informed and well-resourced participants, who can absorb the transaction cost of bidding, such that the auction is competitive.** A sufficient number of participants reduces the risk of collusion. There is often some trade-off between attracting sufficient bidders for competitiveness and avoiding collusion, and the risk of non-compliance, i.e. not delivering the climate asset, as the increased number of participants increases the probability that the winner of the auction is unable to then deliver the climate asset.[28] However, non-compliance is somewhat mitigated in the climate auction model in cases where the price guarantee is tradable.[29]

3. **The third condition is that the funder of the auction is primarily concerned about the cost of delivering outcomes.** The fundamental benefit of the climate auctions model is the ability to facilitate competition between participants on the price needed to deliver the outcome, and so to deliver climate outcomes at low cost. While multi-factors auctions can be designed to encourage competition across multiple variables (not just cost but also, potentially, co-benefits such as local air quality outcomes or jobs created) these types of auctions are significantly more complex and less common.[30] A more pragmatic way to target multiple climate outcomes may be to hold separate auctions for each different outcome.

Even if the conditions for the use of auctions are satisfied, auctions need to be designed sensitive to their context. There is a wealth of literature of how to carry out auctions, both the format (e.g. sealed or open, ascending or descending clock) and infrastructure (physical versus online or other forms). Crucially, this literature demonstrates that auction design needs to be sensitive to the number and capacity of participants, their information about the market, and the type of climate outcome.

4.2 Suitable for results-based payments

The second key feature of the climate auction model is that it provides a results-based payment. Rather than the winner of the auction immediately receiving a product, they are only entitled to benefit from the product if they

successfully deliver the agreed climate asset. This places more risk on the auction winner than if, for instance, it was competing for a grant to support the financing of a climate outcome project.

Placing greater risks on a climate asset project developer has both an advantage and a disadvantage. The advantage is that they face a stronger incentive to deliver the result (climate asset). This may increase the quantity or quality of that which can be delivered with a given amount of resources. The disadvantage is that it places additional risk on the owner of the options contract, who will require a higher reward (a higher minimum strike price) as compensation. This may reduce the amount of climate assets achieved with a given amount of funding. Consequently, the auction funders need to balance the possibility that the model increases the probability of achieving a set of results against the likelihood that the delivery of these results may be more expensive.

To balance this trade-off, there are three fundamental conditions that need to be satisfied to use a results-based payment:

1. **Effective measurement of the result.** To make a payment against a result, it is essential that it is easy and non-controversial to establish whether the result has been delivered. In the climate auction context, this means that there are well-established, robust MRV processes associated with the delivery of the climate asset. This process may rule out certain projects that have non measurable or non-verifiable benefits. MRV costs are likely to be more manageable in cases where there are relatively fewer actors involved, e.g. emission reduction from industry rather than emission reductions from individual households. Robust MRV proxies can also simplify measurement, for example standardised energy saving certifications might be translated to an estimated CO2e savings without requiring direct emissions MRV.

2. **Participants can absorb the delay between acting and receiving the results-based product.** This can be ensured in one of three ways, or through a combination of them. First, if there is a relatively short time period between the action needed to deliver the climate action and the receipt of the results-based payment then the additional risk faced by the bidders will be less. Second, if delivery of the climate asset requires relatively little up-front financing cost, then bidders will find it easier to manage the delay. Finally, it will be easier for substantial up-front financing costs to be absorbed if the bidders are able to access capital markets easily, or if the results-based mechanism targets larger, well-capitalized participants.

3. **Third, both funder and participants need to have sufficient institutional capacity to set up and respond to an RBF incentive** (ESMAP, 2013). For the funder, this relates to the ability to develop and monitor the instrument and ensure quick disbursement of resources when bidders deliver the agreed results. For bidders, this relates to the planning tools and managerial ability to map out the expected cash flows from an RBF instrument, and to react to the new incentive structure.

4.3 Suitable for providing price guarantees

The final feature of the climate auction model

is that the product received by the bid winner, if they successfully deliver the agreed climate outcome, is a price guarantee. The provision of this product, rather than for instance a lump-sum payment, helps to further identify where a climate auction model can be used. Two factors are particularly important:

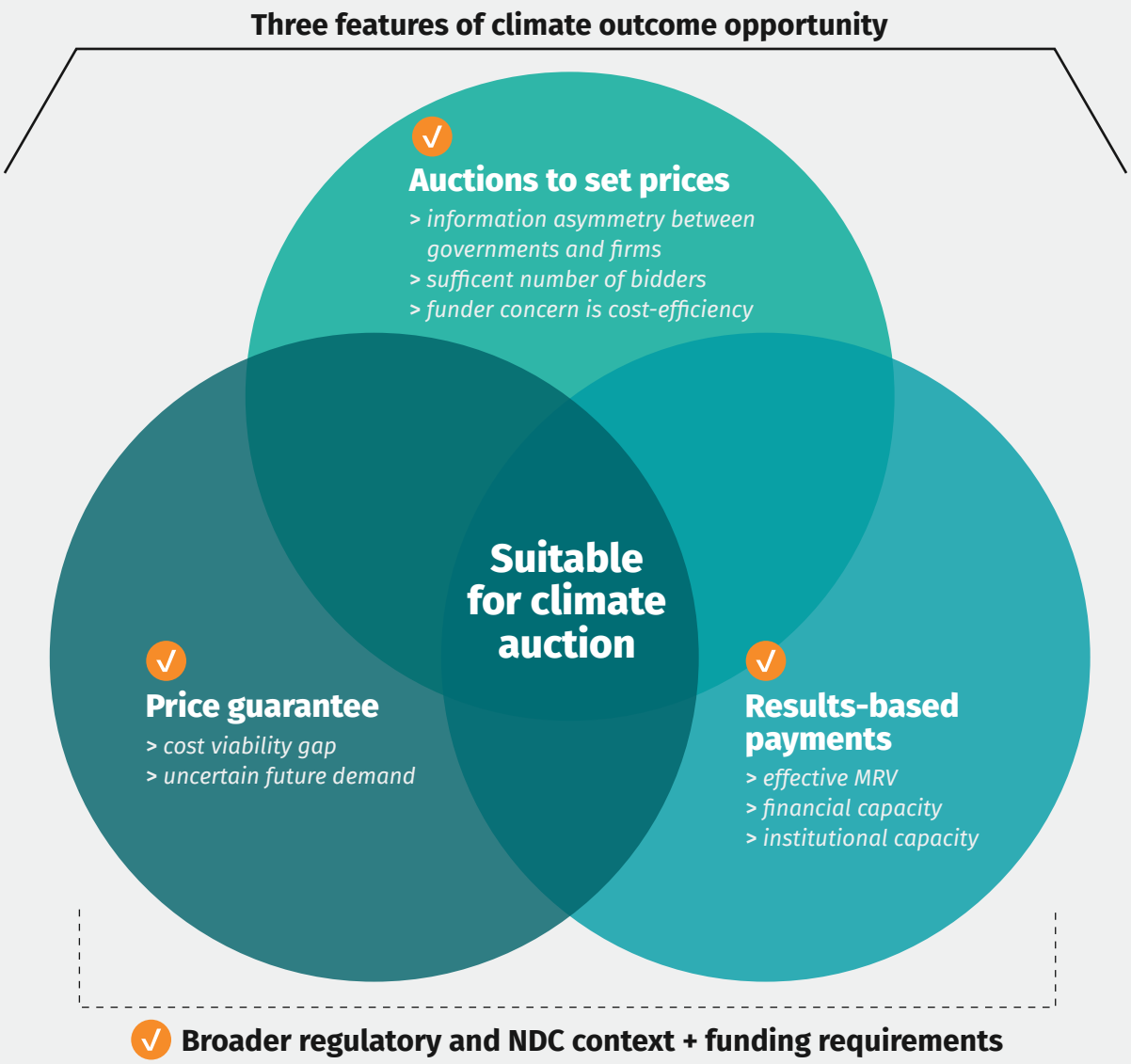
1. **Price guarantees are most useful where there is a possible cost viability gap.** The price guarantee gives confidence to the auction winner that a possible incremental cost gap will be filled. This is often the biggest barrier to delivering climate assets. However, in other cases, the barriers to delivering climate assets may be non-financial, such as informational, behavioral, bureaucratic, or transactional barriers, or split incentives that, for instance, make it difficult to incentivise energy efficiency improvements. In these cases, a price guarantee is unlikely to be effective, or could be expensive, and policymakers should first address these other barriers before implementing climate auctions.

2. **Price guarantees are most useful when bidders face uncertain future demand for the climate outcome.** By contrast, previous research suggests that if bidders face uncertainty related to the future trajectory of costs required to deliver the climate outcomes, price guarantees may not provide the revenue/profit stability that supports investment (Vivid Economics, 2010).

Figure 4 summarises the conditions under which climate auctions are most appropriate.

FIGURE 04

The suitability of climate auctions depends on the features of the climate outcome opportunity and on the broader regulatory and NDC context (including funding requirements)



Participants self-select into auctions to receive public funds. > **Auctions can facilitate transition into wider market-based instruments through three implementation modalities.** > **1. Leverage 2. Extend 3. Fill gaps**

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Endnotes

1. R194 billion, converted to US dollars using annual 2016 exchange rate of 14.7 ZAR/US (OANDA, 2017).
2. Projects having not purchased abatement technology before the date of the auction (Ausubel, Cramton, Hauser, & Aperjis, 2014; Chee & LaCasse, 2017).
3. Redemptions from auction 1 delivered 1.7 million metric tons of CO2e from CDM methane abatement projects in exchange for a payment of over US$ 3.9 million. Redemptions from Auction 2 delivered 1.4 million metric tons of CO2e from CDM, VCS, and GS methane abatement projects in exchange for a payment over US$ 4.9 million. Redemptions from Auction 3 delivered 290,000 metric tons of CO2e from a CDM nitrous oxide abatement project in exchange for a payment of US$ 609,000.
4. Under the CfD, if the market electricity price increases to above the predetermined auction price guarantee, then generators must pay the increment above the price guarantee back to the public funder.
5. The CfD budget is converted to US Dollars using the average annual exchange rate for 2017 (OANDA, 2017).
6. This analysis used seven assessment criteria: (i) price responsiveness of the targeted sector to a price guarantee; (ii) the availability of monitoring, reporting and verification (MRV) standards; (iii) sectoral abatement potential; (iv) abatement costs; (v) availability of existing projects; (vi) regulatory considerations; and (vii) sustainable development impacts (Ecofys and Climate Focus, 2016)
7. However, the rules and procedures developed in the wake of the Paris Agreement could affect the nature of using climate auctions and therefore the final versions (set for adoption in late 2018) should be considered before progressing any implementation of climate auctions towards NDC goals (Bodansky, O'Connor, & Rajamani, 2018).
8. Climate auctions are also capable of supporting the implementation of other policies such as feed-in-tariffs
9. While the leverage and extend modalities, developed below, are more immediate transitional mechanisms, the transition under the gap fill modality is more long-term and uncertain.
10. However, the voluntary nature of the auction-based model may serve to reduce cost-effectiveness if there are behavioral reasons why a firm that could financially benefit nonetheless choose not to participate.
11. These design considerations also apply to the extend model, discussed in Section 3.2 and, in part, to the gap model of Section 3.3.
12. This is because under price discrimination auctions, no one might trade with the lowest-value bid winner (highest premium or lowest strike price) should they fail to deliver.
13. Unless policymakers then choose to sell the climate asset.
14. While there is no theoretical reason for top-up price guarantees not to be tradeable, no previous climate auction has yet used tradeable top-up price guarantees (Bodnar et al., 2017)
15. There is a legitimate concern that providing subsidies for the delivery of climate assets may, rather than easing the transition to other market-based policies like carbon prices, make that transition more difficult, as participants resist gradual withdrawal of the subsidy. This risk can be diminished by clear pre-announcements of the intended transition and steadily reducing the resources provided through auctions over time. At the same time, the example of China illustrates how such a transition can be achieved (albeit not from an auction model): the Chinese industrial sector's experience with the CDM market had a significant influence on the Chinese government's decision to establish the seven regional pilot ETSs and contributed to the creation of the Chinese Certified Emissions Reductions (CCER) offset programme (Swartz, 2016).

Endnotes

16. In this example, climate auctions act as a leveraging model in the offset market, but an extending model in the carbon tax, as it prepares the waste sector for inclusion under the tax (similar to the influence of the CDM on the Chinese ETS).

17. Waste sites included will be those receiving 5 tonnes per day or a total capacity of 25,000 tonnes (Republic of South Africa, 2017a).

18. For example, there are a number of inter-related challenges to monitoring and evaluating adaptation outcomes, such as a lack of standardised methodologies, metrics and indicators; difficulty of identifying baselines; long timeframes; difficulty of attributing outcomes to specific interventions (Christiansen, Schaer, Larsen, & Naswa, 2016).

19. Excluding land-use change and forestry.

20. However, not all parties agree that achieving unconditional targets do not require foreign assistance.

21. Buchner et al. (2017) do not provide more recent estimates for global domestic public climate finance due to data limitations.

22. Based on a small number of countries

23. The VEPF also receives a portion of its financing from a charge on the sale of Certified Emissions Reductions (CERs) under the CDM programme which it manages, and from other environmental protection fees paid by firms for compliance.

24. Indonesian rupiah (IDR) converted to US dollars using annual 2016 exchange rate of 105.5 IDR/US$ (OANDA, 2017).

25. For example, UK prices for offshore wind procured through CfD auctions decreased by 47% over 2015-2017, yielding prices cheaper than nuclear power and natural gas power procurement (RenewableUK, 2017).

26. The resource curse is a form of adverse selection bias whereby, a bid winner is systematically more likely to win due to overestimating, rather than underestimating, a bid product's value (Milgrom, 2004).

27. To illustrate this with a real-world example, Hong & Shum (2002) show that the winner's curse significantly impaired government revenues from procurement auctions for highway- and bridge repair contracts in New Jersey.

28. This is highlighted by the experience in early Federal Communication Commission (FCC) spectrum auctions. The FCC offered lower down payments and attractive financing options for small firms (defined by low asset ownership and sales), and further allowed some licenses to be bought only by small firms. After winning, some small firms defaulted on their loans, leaving their part of the spectrum unused and resulting in loss for the FCC and consumers (Milgrom, 2004).

29. To nevertheless mitigate the risk of non-compliance, certain design choices can maximize expected compliance. As is standard in many procurements, the auction can specify a set of criteria that participating firms need to meet. PAF climate auctions, for example, specified a list of environmental, health and safety criteria (World Bank, 2015). These could be amended by other firm qualifiers, insofar as government bodies are able to identify compliance-relevant characteristics which are also likely to differ by country.

30. They also entail higher MRV costs as multiple outcomes must be monitored. Additionally some outcomes could possibly be difficult to accurately measure and verify, such as jobs created which, unless very specifically defined, can be ambiguous and open to gaming.

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