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Abstract

If global average temperature rise is to be limited to 2°C or even 1.5°C below pre-industrial levels this century, we require a paradigm shift in the way we value and exchange mitigations of Greenhouse Gas Emissions (GHGs). Positive carbon pricing shifts the focus from the cost of GHG emissions to the value of mitigating GHG emissions. We hereby propose a climate club governance arrangement based on Article 6 of the Paris Agreement as well as a robust accounting system to create a positive carbon pricing environment. It provides a starting point for modular, scalable and inclusive climate governance arrangements for environmental and social value creation.

1. Introduction

The net zero GHG emission requirement inherent in both the 2˚C and the 1.5˚C objectives of the Paris Agreement on Climate Change (PA) require a governance structure capable of incentivising mitigations of Greenhouse Gas (GHG) emissions at an international level while also providing individual countries (henceforth Parties) with the freedom to develop internal (national) approaches (e.g., carbon markets, Emission Trading Schemes (ETS), industrial strategies, Personal Carbon Allowances (PCAs)) according to Common But Differentiated Responsibilities and Respective Capabilities (CBDR-RC).

The governance solution proposed in this paper and described in detail in Stua (2017) *From the Paris Agreement to a Low-Carbon Bretton Woods* shifts the pricing of GHGs (carbon pricing) from a cost perspective based on GHG emissions to a value perspective based on the mitigation of GHG emissions (henceforth carbon) known as positive carbon pricing (PCP - Stua et al. 2016; Stua 2017). The basics for such a system to work are as follows:

- Assign value to carbon reductions by recognising atmospheric carbon-carrying capacity as an exhaustible natural resource
- Establish a timetable in which this exhaustible natural resource needs to be safeguarded
- Create demand for actions that protect this exhaustible natural resource

The PA provides a legal framework for establishing PCP. Article 2 of the PA (A2PA) requires Parities to limit global average temperature rise to 2°C/1.5°C below pre-industrial levels this century. The 2°C/1.5°C objective is the main objective of the PA and it provides the basis for recognising atmospheric carbon-carrying capacity as an exhaustible natural resource and the necessity of a net zero carbon level (henceforth Net Zero Carbon – NZC) in the second half this century. Recognising atmospheric carbon carrying capacity as an exhaustible natural resource requires the recognition of a global carbon budget (CarbonBrief 2018; Carbon Tracker 2018; IEA 2017; IPCC 2018). According to the IPCC (2018), the remaining carbon budget by the end of 2017 was 580GtCO_2 for a 50% probability of limiting warming to 1.5 ˚C, and 420GtCO_2 for a 66% probability.

Another precondition for PCP, the establishment of a timetable to safeguard the exhaustible natural resource, is also provided by the PA. Its Article 4 (A4PA) clarifies that 'each Party shall communicate a nationally determined contribution every five years' (UNFCCC 2015). Ambition for mitigating carbon emissions will be ratcheted up according to these binding updates every 5 years (Stua 2017).

Another precondition for PCP, demand for action to protect the exhaustible natural resource, is also inherent in the 2°C/1.5°C objective. In practical terms, demand for action is determined by the value (price) assigned to carbon emission mitigation (carbon price). Assigning value to the protection of this exhaustible natural resource equates to recognising carbon emission mitigation as a commodity, which enables measured, reported and verified carbon emission mitigation units (e.g. $1tCO_2e$) to be included in an international market pricing system and assigned a price (carbon pricing). The specific timetable in which the atmospheric carbon carrying capacity needs to be safeguarded combined with the fixed ceiling of the resource (i.e. <420/580$GtCO_2e$ 2011-2100) determine the price of carbon emission mitigation units traded in a PCP environment (Stua et al., 2016; Stua, 2017).

PCP shifts the emphasis from the *cost* of limiting an environmental externality (the cost of reducing carbon emissions to minimise impact on the non-exhaustible source of the atmosphere) towards the *value* of mitigating carbon emissions to protect an exhaustible natural resource (the atmospheric carbon carrying capacity). As part of a Low-Carbon Bretton Woods (Levi, 1991; Stua, 2017), commoditised units of measured, reported and verified carbon emission mitigation (e.g. $1tCO_2e$) can be established as a representative currency.

Given that this proposal satisfies the World Bank's METRIC requirements of Market integrity, Environmental integrity, Transparency, Recognising ambition, Inclusiveness and Cost-effectiveness (World Bank 2018), distributed ledgers such as Blockchain might enhance transparency, accountability and fungibility, to reduce transaction costs, and to provide a combined Measuring, Reporting and Verification (MRV) infrastructure. The tokenisation of carbon emission mitigation as interchangeable and fungible units of $1tCO_2e$ is of particular interest in this context.

2. A Climate Club for carbon governance

The carbon governance model we hereby propose has been developed on the basis of the PA and existing World Trade Organization (WTO) rules, as described in its General Agreement on Tariffs and Trade (GATT). The model involves the creation of a Climate Club based on Article 6 of the PA (A6PA) (Stua 2017; Falkner 2016; Das 2015; Keohane et al. 2015; Nordhaus 2015; Potoski 2015; Victor 2015; Stewart et al. 2013; Eckersley 2012; Weischer et al. 2012; Hale 2011 among others). We suggest a governance architecture similar to the international financial order established at the Bretton Woods Conference in 1944. Parties engaging with this proposed governance model form a Climate Club (CC) which provides the basis for a wide range of actors to engage.

The CC entails the establishment of a demand/supply system for climate-related services as well as exchange modalities. To this end, it aligns its members' mitigation ambitions with the PA's 2°C/1.5°C objectives described in A2PA, corresponding to a NZC emission level by 2070 at the latest. By adopting a NZC target in line with climate science, the CC recognises in the abovementioned *carbon budget* concept proposed by the IPCC (2018) an exhaustible natural resource according to GATT rules to be preserved by its members according to CC rules. The consumption of this budget produces carbon emissions. Its conservation produces carbon emission mitigations.

The CC requires the NZC target[1] to be distributed among CC members over time according to a set of 5-year timetables in accordance with the implementation tools described in A4PA. A4PA provides a timetable to safeguard the natural resource (the atmospheric carbon-carrying capacity) by ratcheting up carbon mitigation ambitions (implying that mitigation ambitions in each timetable are either equal to or higher than the previous one) through Parties' communication of Nationally Determined

[1] Here referring to the NZC aggregate target of CC members.

Contributions (NDCs). The CC's Plurilaterally Determined Contribution (PDC) extends the concept of Nationally Determined Contributions (NDC) introduced by A4PA.

CC members with per capita carbon emissions exceeding the CC average are assigned a share (quota) of the aggregate CC NZC target in each timetable through the application of a dynamic formula. Members registering per capita carbon emissions below the CC's average are exempt from mitigation quotas in the corresponding timetable.

The NZC target and its distribution among CC members over time represent the demand side (see 4.1) of the model and the international level of this proposed governance model. At (international) CC level, the demand side is established as a single and unified system. Individual CC members, on the other hand, are free to manage and distribute demand internally (i.e. geographical/sectoral distribution of the assigned quota, modalities of quota repayment etc.), which represents the Parties' (national) level of this proposed market solution.

The supply side (see 4.2) to satisfy such demand is provided by a single mechanism (the Climate Club Mechanism – CCM) to certify any measured, reported and verified mitigations of carbon emissions supplied within the CC as Certified Mitigation Outcomes (CMOs). The CCM certification system shall in principle apply to any form of mitigation, including reduction, avoidance and sequestration (sink). A CMO Bank (see Section 3) that manages the CCM and provides a centralised registry.

3. Certifying and depositing mitigations of carbon emission

Through CCM certification (and tokenisation), mitigations of carbon emissions are converted into entirely interchangeable private goods representing units of carbon emission mitigation (1tCO_2e). This enables the creation of a single registry for CMOs (such as a distributed ledger) to facilitate the overall operability of the PA.

Accumulation of carbon emission mitigation, certified through the CCM and issued as CMOs through the CMO Bank, represents the only means for CC members to demonstrate their success (or failure) in meeting their assigned quotas.[2] CC members maintain high degrees of freedom in establishing their internal (national) strategies, priorities and preferences for national CMO production (in line with the general rules established by the CCM).

Final CMO Deposit, which also resides in the CMO Bank, at the end of each 5-year timetable corresponds to CC members' individual stocktake. In between their issuance and deposit, CMOs can be subject to three use cases:

1. Unilateral production
2. Bilateral exchange
3. Multilateral exchange

Unilateral production implies that CC members submit mitigations of carbon emissions to the CCM for certification as CMOs and subsequently deposit them directly in the CMO Deposit to claim recognition for their mitigations of carbon emissions. This unilateral use fully satisfies the non-market exchange approach required by Paragraph 8 of A6PA to grant individual Parties (CC members) the greatest possible flexibility to create, manage and distribute demand internally.

[2] While not counting towards assigned quotas, non-certified mitigation holds a value thanks to the distribution formula (see section 4.1).

Bilateral exchange implies the direct exchange of CMOs between CC members, who submitted mitigations of carbon emissions to the CCM for certification as CMOs, and a third party. The third party is subsequently entitled to deposit the CMOs in the CMO Deposit to claim recognition for the mitigations of carbon emissions. This bilateral use fully satisfies the market exchange approach required by Paragraph 2 of A6PA involving the use of internationally transferred mitigation outcomes towards NDCs.

Multilateral exchange implies the free exchange of CMOs between actors before they are deposited in the CMO Deposit to claim recognition for mitigations of carbon emissions. This multilateral use fulfils the requirements of Paragraph 4 of A6PA which stipulates that mitigations of carbon emission can contribute towards NDCs by other Parties than the host Party.

Hybrid exchange approaches are facilitated through bilateral and multilateral CMO exchange. Combined with unilateral CMO production, the CC recognises multiple CMO exchange approaches among its members, including market, non-market and hybrid approaches. The CMO-based system will stimulate interlinking of various current and future exchange approaches as well as their convergence towards a single umbrella defined as an Inclusive Offsetting Scheme.

By implementing this system, CC members will keep their decarbonisation on track with PA objectives by banking an aggregate quantity of CMOs corresponding to the CC's PDC. The CMO Deposit might benefit from distributed ledgers such as Blockchain to help tokenise mitigations of carbon emissions through smart contracts.

4. Carbon Club requirements

The CC focuses on implementing a demand/supply system for carbon emission mitigations among its CC members. It requires the establishment of specific demand (4.1), supply (4.2) and exchange mechanisms (4.3) that, while guaranteeing homogeneity of the model, can also satisfy members' requirements regarding flexibility and adaptability to their needs and capabilities.

4.1 The demand side

The demand side will have to be aligned to a NZC target. This requires CC members to reduce the CC's overall carbon emissions to zero by 2070 at the latest. Taking into account CC carbon emissions at time zero (*t0*),[3] the resulting amount of carbon emissions (*Ct0*) will correspond to the overall CC's carbon emission mitigation target (henceforth *C*), hence becoming a single and common goal for its members. This target will then be distributed over time (following A4PA directions) and assigned to CC members, based upon the dynamic formula explained below.

This formula abides by the need 'to allow for higher ambition in their mitigation and adaptation actions and to promote sustainable development and environmental integrity'[4] for Parties voluntarily cooperating within the A6PA framework. Therefore, the here-proposed formula is aligned with the PA's and its A6PA's rules and principles which implies abiding by CBDR-RC criteria as well as transparency and environmental integrity requirements.[5]

In principle, CC members, following the rules contained in A4PA, can define time distribution a priori. Hence, overall target C will be organised in 5-year timetables ($t, t+1, \dots t+n$), with $t \leq t+1 \leq \dots t+n$. Each timetable in which a quota is assigned represents a 5-year period. According to A4PA, signatories to the PA are required to update their NDCs every 5 years. The idea behind this timetabling is that

[3] With *t0* corresponding to the CC's entry into force.

[4] A6PA, Paragraph 1.

[5] As specified in A6PA, Paragraph 2.

ambitions should be ratcheted up over time, especially given the current shortfall between NDC ambition and decarbonisation necessary to maintain a reasonable chance of limiting global average temperature rise in line with PA objectives (UN 2018).

With timetables corresponding to shares of *C* so that *Ct+Ct+1+…Ct+n = C*, quotas of each sub-target will be allocated to CC members through the application of the following dynamic formula (to be repeatedly used at the beginning of each new timeframe). The quota distribution system takes into account per capita emissions of each CC member as well as the CC's aggregate per capita emissions. The resulting values establish which members are responsible for which quota of the mitigation target corresponding to the given timetable. Only members with per capita emissions higher than the CC average will be assigned quotas.[6]

As assigned quotas do not correspond to direct shares of members' carbon emissions to be mitigated, both members with assigned quotas and members without them are still entitled to alter their individual emissions levels in each timeframe, with no pre-established limit or peak. As discussed below, any positive variation in CC aggregate emissions in a timeframe will be compensated in the following timeframe, through the adoption of the dynamic variations term *Vt*.

The following formula encapsulates the above by defining the mitigation target $MT_{j,t+1}$ (corresponding to the target assigned to timetable *t+1*) for any member *j* with per capita carbon emissions $PC_{j,t}$ greater than PCA_t at the time t:

$$MT_{j,t+1} = \underbrace{(C_{t+1} + V_t)}_{\text{total reductions}} \times \underbrace{\frac{(PC_{j,t} - PCA_t)P_{j,t}}{\sum_{i:PC_{i,t} > PCA_t} (PC_{i,t} - PCA_t)P_{i,t}}}_{\text{split among parties}}$$

where $PC_{j,t} = E_{j,t}/P_{j,t}$ is the member's per capita carbon emissions (current emissions divided by current population), PCA_t is total emissions of the CC divided by the total population of the entire CC. Mitigation target $MT_{j,t+1}$ for the next timetable is set at time t, the end of the previous period.

The fraction representing the second half of the formula can be understood to be member *j*'s portion of emissions above the CC threshold, divided by the sum of all such portions across the identified responsible members. It thus ensures the equitable distribution of the CC's target of $(C_{t+1} + V_t)$ among CC members with higher than average per capita emissions. The equity of the formula is further enhanced by the adopted net value of per capita emissions $(PC_{j,t} - PCA_t)$. This specifies that each member *j* is guaranteed a minimum level of per capita emissions corresponding to the CC aggregate.

The first half of the formula (the target itself) consists of two components: (i) the predetermined overall target C_{t+1} matching the CC's agreed emissions trajectory to limit temperature increase; and (ii) a dynamic 'variations' term V_t defined as follows:

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[6] In other words, with *PCA* corresponding to per capita emissions of the CC at the beginning of the timetable *t1*, and *PCX* corresponding to per capita emissions of CC member *X* at that same time: if *PCA* > *PCX*, then *X* is exempt from any quota for the duration of *t1*.

$$V_t = \max\left(0, \sum_{i:PC_{i,t} \leq PCA_t} \left(E_{i,t} - E_{t-1}\right)\right)$$

Based upon data collected through the public registries referred to in A4PA and information provided by the global stocktake referred to in A14PA, the variations term V_t represents a significant element of the overall formula and of the entire CC proposal. Its application in fact guarantees environmental integrity of the model embodied by the CC. In particular, V_t accumulates any overall emissions growth from CC members during the previous period. This amount is then automatically reallocated to the entire CC as part of the target for the following timetable

Changes in per capita emissions over time automatically alter the range of members with quotas and their relative quotas' magnitudes in successive timetables. This process implies that changes in per capita emissions, both at member and at aggregate levels, may move CC members from a non-binding to a binding mitigation condition or vice versa in the following timetable.[7]

With the establishment of general elements concerning CC target definition and distribution, CC members are free to internally distribute their quotas. In other words, each member can independently design rules determining whether and how they are assigned to specific sectors/areas/groups of stakeholder acting inside their domain and how to structure associated internal (national) markets.

4.2 The supply side

In principle, any form of carbon emission mitigation within the CC framework can be recognised as a means to fulfil assigned quotas, hence including mitigations of carbon emissions (typically associated *inter alia* with cleaner energy adoption and industrial innovation), avoidance of carbon emissions (typically associated *inter alia* with energy efficiency and shutting down highly polluting plants) and sinks of carbon emissions (typically associated *inter alia* with forest maintenance, reforestation and carbon capture and sequestration). Yet, to be used as tools to fulfil assigned quotas, such mitigations of carbon emissions will require certification as CMOs through the CCM and final retirement in the CMO Bank Deposit.[8]

Similar to already existing certification mechanisms (i.e. the Clean development Mechanism – CDM, the Gold Standard, etc.), the CCM will (at least initially) be a 'compensation chamber', where certifications resulting from other models applied by CC members will be 'weighted' and certified as CMOs (and vice versa). In other words, as shown in Figure 1, the CCM can function as an inclusive linking system for a multiplicity of certification standards, leading to their convergence towards a single system over time.

[7] Members may also accelerate their mitigation pathways voluntarily to counteract the move from a non-binding to a binding mitigation condition or to benefit from a decrease of quota linked to per capita variations, both in relative and absolute terms, over the course of a timetable.

[8] Measured in tons of carbon dioxide equivalent (tCO_2e).

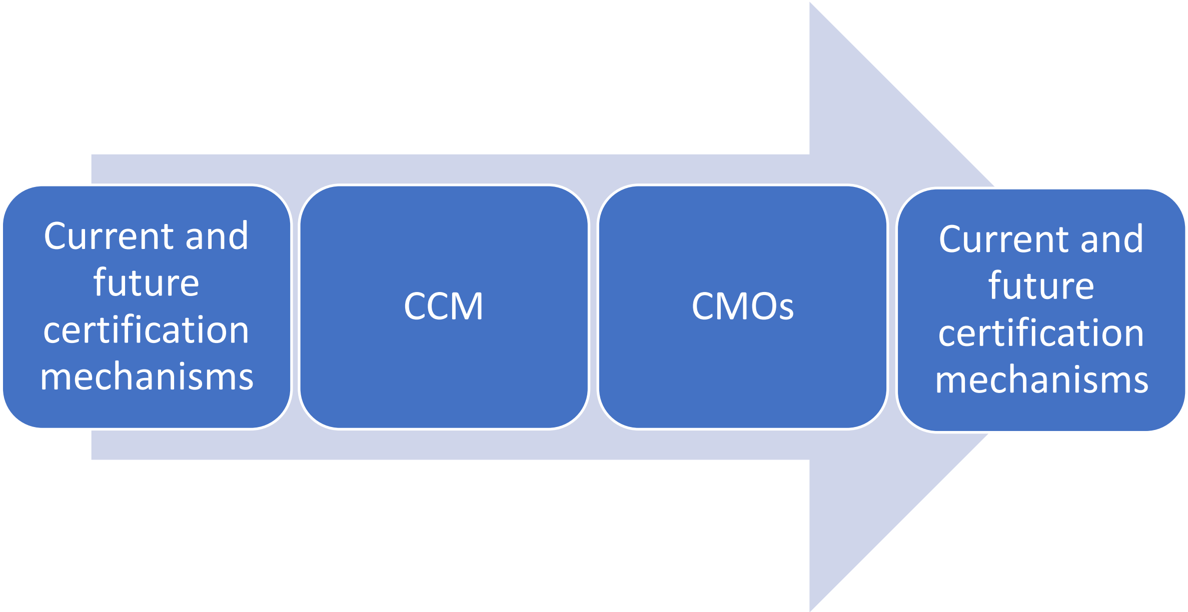

Figure 1: The Mechanism as multilateral linking system

Still, the CCM may be unable to capture all GHG emission mitigations from within the CC framework. This may depend on explicit decision by CC members,[9] technical limitations,[10] or the refusal partake[11]. Although such mitigations in carbon emission cannot be certified as CMOs and deposited in the CMO Deposit, they are still relevant within the distribution scheme envisaged by this CC model because they alter CC aggregate per capita emissions and those of its members, hence influencing quota sizes.

As a matter of fact, because any mitigation of carbon emissions happening within the geographical scope of CC members plays a role for the model, members and their stakeholders enjoy significant degrees of freedom and flexibility in adopting ad-hoc policies, strategies and actions, to combine mitigation with other benefits.

4.3 Exchange of Certified Mitigation Outcomes

With demand and supply fully defined, this CC model requires exchange approaches capable of guaranteeing CC effectiveness, transparency and efficiency, while granting members and respective stakeholders the freedom to adopt exchange approaches that most suit their needs and capabilities. With all demand resulting from a single, shared system distributed by the above-described formula, and all required supply certified under a single CC mechanism, each CMO holds a common value, equally recognised among CC members. As a consequence, any CMO, regardless of its geographical and/or sectoral origin, can in principle be exchanged among and within CC members. This implies that CMOs shall be exchanged under the Inclusive Offsetting System that encompasses any possible

[9] Some mitigation sources may be voluntarily excluded from those entitled to certification (as was the case with nuclear power under the Kyoto Protocol).

[10] Some mitigating actions may be too difficult or costly to certify.

[11] Suppliers may voluntarily decide to keep their mitigation outcomes outside the CCM to use them in other certification mechanisms.

exchange approach, including market, hybrid and non-market approaches.[12] Figure 2 summarises the entire demand/supply/exchange model envisaged for the CC and managed by the CMO Bank.

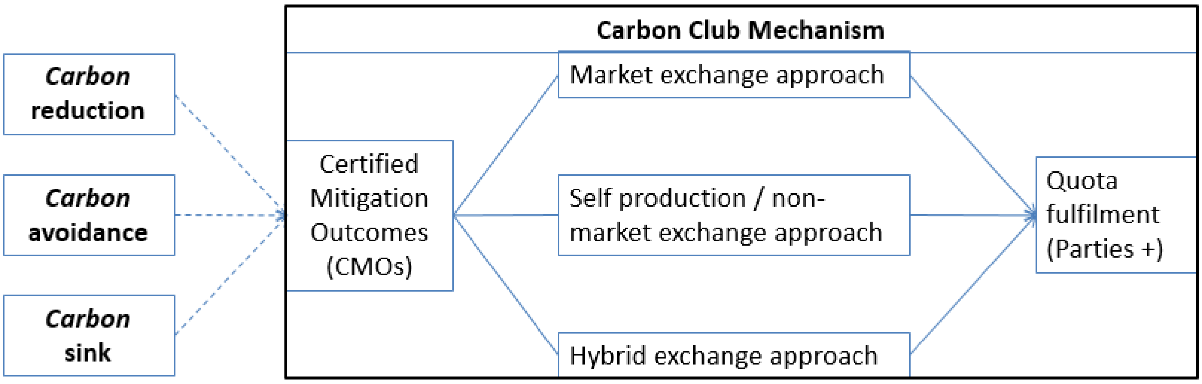

Figure 2: The Carbon Club mechanism (Inclusive Offsetting Scheme)

5. Positive carbon pricing

The atmosphere is commonly perceived as a non-exhaustible resource. Yet, by taking the 2°C/1.5°C atmospheric carbon emission carrying capacity (carbon budget) into account, the atmosphere can be interpreted as an exhaustible resource. Changing its composition by increasing GHG emissions represents its 'consumption', while mitigating carbon emissions represents its 'conservation'. Through its system of demand, supply and exchange of CMOs, the CC translates the 2°C/1.5°C atmospheric GHG carrying capacity into an exhaustible resource and quantified commodity, with CMOs translating mitigation (carbon budget conservation) into a private, excludable good/service within the CC. Therefore, CMOs represent units of carbon budget conservation. With mitigations of carbon emission converted into a private good within the CC, CMOs will be transformed into its sole, representative currency. The cost associated with mitigation within the CC is converted into CMOs, which hold a fixed exchange rate towards their commodity (mitigations of carbon emission). As a result, CMOs carry a value corresponding to PCP.

By supporting a wide range of approaches towards CMO exchange, both ETS and carbon taxation as well as PCAs may be implemented by CC members collectively or individually. Yet, instead of determining a fixed carbon price (mitigations of carbon emissions), CC carbon pricing relates to a fixed carbon budget, which has to be safeguarded within a time limit. Quotas within timetables represent fixed floor quantities of mitigation. Where carbon pricing in ETS and taxation depends on the cost of commodity consumption (carbon emissions), CC carbon pricing depends on the value of commodity conservation (mitigations of carbon mitigation). The CC transforms carbon pricing from the negative connotation of a liability into an asset whose value is based on the intrinsic value of carbon emission mitigation. PCP is the instrument to measure the intrinsic value of carbon emission mitigation as assets to offset the external cost of carbon emissions (Stua et al. 2016).

Once the value of CMOs has been expressed in terms of positive carbon pricing coupled with the CC model, measured, reported and verified carbon emission mitigation is transformed into a valuable financial asset. By establishing CMOs as the only recognised mitigation-related asset within its regime

[12] A limited summary of such approaches includes *inter alia*: (a) carbon markets and ETS for market approaches; (b) bilateral exchanges, carbon taxes and service-to-service agreements for hybrid approaches; and (c) self-production for non-market approaches

and by establishing a floor quantity of CMO demand through the application of the formula, the CC transforms CMOs from an asset into a currency used by its members.

CMOs would consequently become a representative currency for all CC members, similar to the role once played by the US$ in the Bretton Woods system. With mitigation representing the non-excludable benefit of the CC, and with opportunities to adopt border carbon adjustments, PCP and a representative currency amount to the key excludable benefits of the CC.

To sum up, a CC as described in this paper ensures multiple environmental, economic and social benefits for its members and stakeholders based upon the PA recognition of the value of voluntary carbon emission mitigation outcomes.[13] The combination of the CC's multiple benefits achievable through full CC implementation can lead to radical industrial innovation, market creation, societal change and environmental transformation, while deeply decarbonising the world.

6. Outlook

PCP through the application of the formula and the Low-Carbon Bretton Woods governance arrangements described in this paper provides a holistic yet simple metric to capture and measure economic, social and environmental (in)activities that benefit the environment. This stands in contrast to GDP, the main tool to determine the economic performance of a region since the Bretton Woods conference in 1944, which does not account for pollution and environmental damage in general. If the Low-Carbon Bretton Woods system was applied holistically, PCP would eventually replace GDP as the main tool to determine economic performance.

To ensure maximum inclusion and transparency, opportunities for tokenising carbon emission mitigations using distributed ledgers such as the Blockchain require exploration. In theory, CMOs can be transformed into a digital carbon currency to provide convenient, low-cost international access to CMOs as well as low-cost monitoring, reporting and verification of CMO supply, exchange and final accumulation as the only means of demonstrating Parties' success (or failure) in meeting their quotas.

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[13] Paragraph 108 of Section IV.

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