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Pricing of Verified Emission Reduction Units under Art. 6

Gaining a Better Understanding of Possible Scenarios

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Disclaimer

The views expressed in this report are solely the authors' and do not represent any official position of the commissioning agencies.

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Abbreviations

CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
EU ETS	European Emissions Trading System
IATA	International Air Transport Association
ICAO	International Civil Aviation Organization
IETA	International Emissions Trading Association
IMO	International Maritime Organization
ITMO	Internationally Transferred Mitigation Outcome
LDC	Least Developed Countries
MRV	Monitoring, Reporting and Verification
MSR	Market Stability Reserve
NDC	Nationally Determined Contribution
RBCF	Results-based climate finance
RGGI	Regional Greenhouse Gas Initiative
SIDS	Small Island Developing States
VCM	Voluntary carbon markets
VCS	Verified Carbon Standard
WCI	Western Climate Initiative

Executive Summary

The negotiation process for Article 6 of the Paris Agreement – namely cooperative approaches under Article 6.2 and market mechanisms under Article 6.4 – has so far produced few tangible results to clarify the framework under which Internationally Transferred Mitigation Outcomes (ITMOs) will be regulated post-2020. In this context, the price level of credits under Article 6 is highly uncertain and both private and public sector actors have limited visibility on how to structure their involvement in these future markets. This study seeks to provide a perspective on the key forces expected to drive carbon prices under Article 6. Building on a targeted literature review and a semi-quantitative analysis of ITMO generation costs and buyer's willingness to pay, select scenarios are presented to illustrate possible price evolutions.

Literature review - selected findings

The present study identifies four important streams of publicly available literature of relevance to better understanding how pricing may develop in these new markets. Firstly, data on price levels in existing compliance (e.g. EU emissions trading scheme) and voluntary carbon markets provides a frame of reference for transactions of emissions units. Secondly, the results from three economic modelling studies offer insights into potential carbon prices under scenarios where countries cooperatively implement their NDCs. Then thirdly, available estimates of carbon markets sizes illustrate possible demand volumes for future Art. 6 emission units. And finally, supply-side considerations, whereby the debated transition of Kyoto Protocol units over to Article 6 is likely to have greatest potential effect on price.

Past experiences reveal frequent issues of oversupply in carbon markets – maintaining prices at low levels – and a trend towards demand-constrained markets. This situation is likely to persist going forward, particularly as transition scenarios for Kyoto Protocol mechanisms may carry over significant volumes to post-2020 markets. In comparison to anticipated demand from the international aviation sector's global offsetting scheme CORSIA of 2.5-2.7 $GtCO_2e$ over the 2021-2035 period – expected to be one of the larger sources of demand – supply of CERS has been estimated by others to reach 15.6 $GtCO_2e$ by 2030 if all registered CDM activities are transitioned. The rules for the transitioning of CERs and CDM activities will therefore be a key factor governing carbon price evolution under Art. 6.

ITMO generation costs and buyers' willingness to pay

Building on our practical experience in carbon markets, we undertake a generalized, semi-quantitative analysis of ITMO cost elements. We identify four elements feeding into ITMO generation costs:

- Incremental costs of mitigation actions, including CAPEX and OPEX of the entities taking the mitigation action,
- Opportunity costs for the seller country in meeting its NDC,
- Transaction costs related to monitoring, reporting and verification (MRV) and the purchase and sale of ITMOs,
- Market premiums, including seller rents and premiums in respect of SDG co-benefits.

We find that the uncertainty surrounding corresponding adjustment is currently a key uncertainty factor in seller governments' analyses of their ITMO generation costs and, therefore, a major impediment to the rapid deployment of Article 6. This applies especially for prospective seller countries with single-year targets.

We conclude that it will become difficult for buyers to source ITMOs from new and truly additional mitigation activities at single-digit USD prices, given that seller countries' can be expected to retain their least-cost mitigation potentials and consider the potential opportunity costs related to ITMO transfers.

Conversely, we expect that the willingness of important buyer countries to pay for ITMOs will remain, until 2030, well below their domestic carbon price levels, because the purchase of ITMOs implies foregoing the co-benefits of domestic mitigation, for example regarding job creation and mitigation of air pollutants. Against the background of current carbon tax rates in Europe as well as latest forecasts for allowance prices in the EU ETS up to 2030, we hypothesize that 50 USD/t CO_2e could be an indicative upper limit for buyer's willingness to pay for ITMOs for some time.

Bringing together expected ITMO generation costs and buyer's willingness to pay, and considering our experience with Article 6 pilots to date, we expect a realistic band for actual ITMO transaction prices until 2030 to be 10 – 50 USD/t CO_2e, with 15 – 30 USD/t CO_2e as the likely range for most transactions in the next few years.

Identifying key drivers and illustrative scenarios

The study establishes a list of key drivers affecting ITMO prices up to 2030 and beyond. On the demand side until 2030, we see several drivers of similar importance, including: demand by Parties to offset emissions in their non-ETS sectors, whether CORSIA will require corresponding adjustments (and therefore purchase of ITMOs), as well as future demand trends in the voluntary market.

On the supply side over the same timeframe, we see three drivers as having a high potential relevance for ITMO pricing: the rules for the transitioning of both CERs and CDM activities, and the detailed rules for corresponding adjustment, as the latter will likely play a critical role in countries' readiness to sell ITMOs.

Given these multiple drivers, a multitude of scenarios for the development of Article 6 markets can be envisaged, which makes statements on expected ITMO prices highly speculative. In this context, Table S-1 identifies selected illustrative scenarios up to 2030 by combining different outcomes of selected key drivers.

Table S-1: Illustrative ITMO supply and demand scenarios up to 2030. CA = Corresponding Adjustment

		Low Supply	**High Supply**
		e.g.: - No transition of CERs - Limited transition of CDM projects - Ambitious NDCs - Strict corresponding adjustment rules strongly limit willingness to sell	e.g.: - Limited transition of CERs - Substantial transition of CDM projects - Less ambitious NDCs - Balanced corresponding adjustment rules raise readiness to sell
Low Demand	e.g.: - Little ITMO demand from Parties - Little ITMO demand from CORSIA (e.g., REDD+ accepted w/o CA) - Little ITMO demand from voluntary markets	Medium Scenario: 10 – 30 USD/t	Low Price Scenario: <10 USD/t
High Demand	e.g.: - Higher ITMO demand from Parties - ITMO demand from CORSIA (e.g., REDD+ not accepted) - ITMO demand from voluntary markets	High Price Scenario: >30 USD/t	Medium Scenario: 10 – 30 USD/t

Further areas of research

The detailed design of Article 6 markets is likely to have an important influence on ITMO prices. This includes the rules for corresponding adjustments as one of the most urgent aspects. Further tentative research questions remaining to be addressed and / or deepened include:

- Additionality tests to ensure environmental integrity and economic efficiency of Article 6, and their implications for ITMO prices;
- Link between crediting periods and ITMO prices;
- Treatment of sinks and permanence risks under Article 6, and implications for ITMO prices;
- Options for and merits of limiting seller rents through differentiated designs for offset programs under Article 6 (e.g., differentiated crediting periods and baselines);
- Differentiation between Articles 6.2 and 6.4 with respect to pricing;
- Pricing power and possible strategies of large buyers and sellers.

1 Background and objectives

The Paris Agreement establishes market mechanisms for international cooperation and trading of emission units for the period post-2020. While Article 6.2 provides a framework for bilateral cooperation among Parties to achieve their NDCs through trading of Internationally Transferred Mitigation Outcomes (ITMOs), Article 6.4 envisages a market mechanism overseen by the UN to promote climate action – quantified through Art. 6.4 emission units, so-called A6.4ER and in particular private sector involvement. As of October 2019, 186 Parties have ratified the Paris Agreement.

The effectiveness of these future markets at involving the private sector and generating meaningful mitigation activities – contributing to the achievement and enhancement of Nationally Determined Contributions (NDCs) – will be dependent to a large extent on the carbon price level. Prior experiences with carbon markets under the Kyoto Protocol and with existing compliance policies are testament to this: Secondary trading prices of Certified Emission Reductions (CERs) under the Clean Development Mechanism (CDM) plummeted in 2012. As a result, the CDM essentially ceased to stimulate new projects and market activities collapsed. Similarly, low prices under the EU's emissions trading system (EU-ETS) up until early 2018 provided little incentive for installations to direct investments towards the reduction in emissions. Behind these trends are supply and demand dynamics, market design aspects and policy drivers that play key roles in forming market prices.

In addition to its importance for private sector involvement, an understanding of potential price evolution under Article 6 is also highly relevant to governments and financing institutions looking to pilot activities ahead of 2020. Developing a clear perspective at present is made challenging by the extensive uncertainties still persisting in ongoing negotiation processes. A variety of contentious issues under both Art. 6.2 and 6.4 are delaying the adoption of modalities and procedures, leaving Article 6 as a "glaring gap" of the Paris Agreement Rulebook ahead of COP25 in Santiago.

The objective of the present short study is to identify drivers and possible scenarios for carbon prices under Article 6. In Section 2, publicly available studies on (i) pricing of emission units under Article 6 as well as (ii) directly relevant economic and policy considerations are discussed and a thematic categorization is introduced to identify relevant factors affecting prices. Section 3 then presents a simplified model of cost elements feeding into prices of ITMOs. Finally, Section 4 provides a qualitative assessment of illustrative price evolution scenarios and identifies further areas of research.

For simplification, emission units under Article 6 are referred interchangeably as "emission units" and "ITMO" throughout this study. Emissions units issued under Article 6.4 are also referred to as ITMOs, unless otherwise indicated.

2 Literature review

2.1 Overview

While literature specifically dedicated to pricing of emission units under Article 6 is presently limited to a handful of studies (see studies highlighted in italics in Table 1 below), a variety of publications are available addressing directly related issues. The literature list in Table 1 presents the most relevant studies identified on pricing, demand, supply, mitigation costs and carbon market design considerations critical to understanding how prices of emission units may evolve post-2020. These cover a mix of quantitative economic modelling exercises, technical analyses and conceptual policy papers from a variety of reputable private and public organizations.

Table 1: Chronological overview of relevant literature on pricing of Art. 6 emission units. Italics denote studies dealing with prices of Article 6 emissions units.

Author(s)	Date	Title	Relevant topics
Edmonds et al.	*09/2019*	*The economic potential of Article 6 of the Paris Agreement and implementation challenges*	*Market linkages, carbon price modelling post-2020, NDC ambition*
Michaelowa et al.	06/2019	Opportunities for mobilizing private climate finance through Article 6	Market linkages, supply & demand considerations,
Brescia et al.	06/2019	Transition pathways for the Clean Development Mechanism under Article 6 of the Paris Agreement. Options and implications for international negotiators	CER supply, CDM transition, demand for emission units
Lo Re et al.	06/2019	Markets negotiations under the Paris Agreement: a technical analysis of two unresolved issues	CER supply to 2020, CDM transition scenarios, demand for emission units post-2020 (e.g. CORSIA)
World Bank Group	06/2019	State and trends of carbon pricing 2019	Demand and supply of emission units, current carbon market prices
Kolos	04/2019	CORSIA offset supply - the importance of vintage in determining scheme's cost and environmental integrity	CER supply and demand under CORSIA
Warnecke et al.	03/2019	Robust eligibility criteria essential for new global scheme to offset aviation emissions	CER supply to 2020, mitigation costs, CORSIA demand for emission units

Piris-Cabezas et al.	*01/2019*	*Estimating the power of international carbon markets to increase global climate ambition*	*Market linkages, carbon price modelling post-2020 (supply/demand), NDC ambition*
IETA & PwC	2019	GHG market sentiment survey 2019	Expected carbon market prices, CDM transition
Greiner et al.	2019	Moving Towards Next Generation Carbon Markets: Observations from Article 6 Pilots	Pilot activities under Art. 6
World Bank Group	2019	Report of the High-Level Commission on Carbon Pricing and Competitiveness	Carbon pricing considerations
Mehling	12/2018	Governing cooperative approaches under the Paris Agreement	Market linkages, transaction costs
Schneider et al.	11/2018	Operationalising an 'overall mitigation in global emissions' under Article 6 of the Paris Agreement	Supply of emission units
Howard	04/2018	Incentivizing mitigation: using international carbon markets to raise ambition	Market linkages, NDC ambition
Piris-Cabezas et al.	*03/2018*	*Carbon prices under carbon market scenarios consistent with the Paris Agreement: Implications for the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)*	*Market linkages, carbon price modelling post-2020 (supply/demand), NDC ambition*
Fearnehough et al.	01/2018	Discussion paper: Marginal cost of CER supply and implications of demand sources	CER supply to 2020, mitigation costs, CORSIA demand for emission units
Hof et al.	03/2017	Global and regional abatement costs of Nationally Determined Contributions (NDCs) and of enhanced action to levels well below 2 °C and 1.5 °C	Market linkages

In the following sections, findings from this existing body of work are presented and common issues highlighted. This discussion is structured around four thematic areas:

1. **Current and forecasted carbon market price levels:** evolution of prices of emission units in existing compliance and voluntary carbon markets (e.g. EU-ETS, CDM, Verra/Verified Carbon Standard (VCS)).
2. **Macroeconomic views on market mechanisms under Art. 6:** Potential implications of market mechanisms in the Paris Agreement on global abatement costs and carbon prices.
3. **Future demand for Art. 6 emissions units**: demand for emissions units post-2020 under country NDCs, from the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), voluntary carbon markets (VCM), as well as compliance schemes.
4. **CDM transition and supply-side considerations**: Supply of CERs from the Kyoto era under Art. 6 and considerations of factors influencing supply of Art. 6 emission units.

2.2 Current and forecasted carbon market price levels

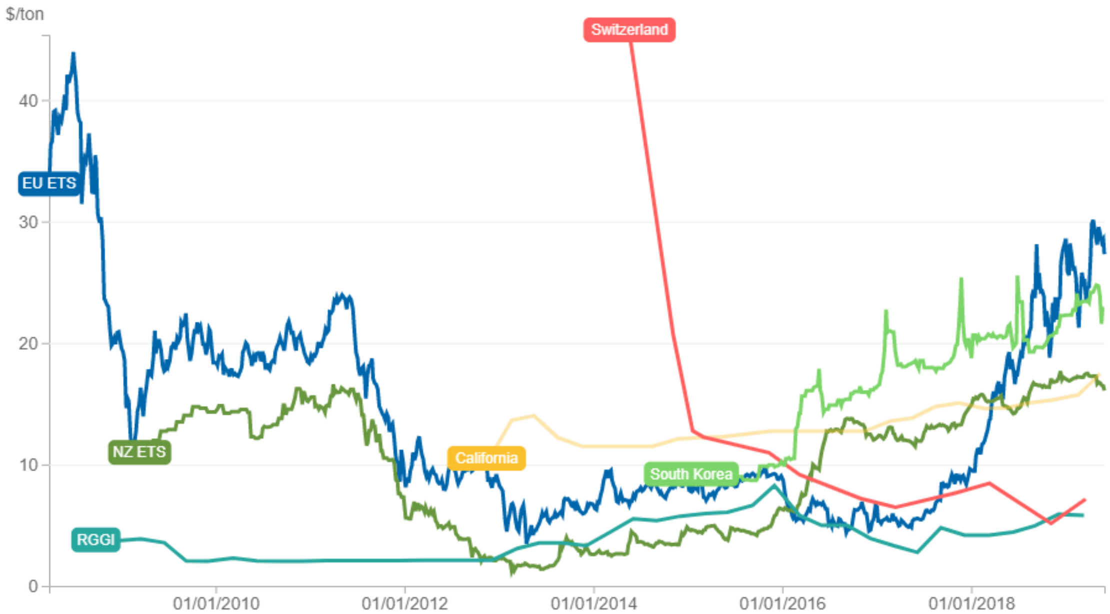
In its 2017 report, the High-Level Commission on Carbon Pricing concluded that global carbon pricing initiatives must reach levels of 40 US$/t$CO_2$ to 80 US$/t$CO_2$ by 2020 and 50 US$/t$CO_2$ to 100 US$/t$CO_2$ by 2030 in order to achieve the goals of the Paris Agreement (High-Level Commission on Carbon Pricing, 2017). In its 2019 report (High-Level Commission on Carbon Pricing, 2019), the Commission stressed that competitiveness impacts of such carbon prices would not be prohibitive. To date, these prices remain aspirational as the majority of operational carbon markets – whether compliance or voluntary – have exhibited prices well below those levels. A few noteworthy exceptions with prices already above 40 US$/t$CO_2$ include the carbon taxes in several Scandinavian countries and Switzerland as well as the Swiss domestic carbon offsetting scheme (World Bank Group, 2019a).

2.2.1 Cap & trade markets: Emissions trading systems

In compliance markets, prices for allowances in longstanding emissions trading systems have remained for the most part under 30 USD/tCO_2, albeit with the largest of these schemes (EU ETS) rebounding remarkably over the past 18 months – as a result of much-needed supply restrictions enabled by the Market Stability Reserve (MSR) – from multi-year lows of 6 USD/tCO_2 to a 10-year peak of 31 USD/tCO_2 in April 2019 (see Figure 1). Supply issues – mainly linked to systemic overallocation – have also been driving prices in other systems, such as the South Korean ETS, where allowance hoarding by installation operators is artificially restricting supply and driving up prices in an otherwise over-allocated market (Refinitiv, 2019), or the Swiss ETS, where market surplus has brought prices down since its entry into force.[1]

[1] Due to its small size, the Swiss ETS has also suffered from a lack of secondary trading with prices dictated by biannual auctions.

Figure 1: Carbon price evolution under regional and international emissions trading systems up until May 31st, 2019. Note: RGGI: Regional Greenhouse Gas Initiative (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont). Source: ICAP Allowance Price Exporter.



For the post-2020 phase, expectations from market observers point towards an increase in carbon price in all schemes. Results of the International Emissions Trading Association's (IETA) annual survey of industry stakeholders are summarized in Table 2 for both existing emissions trading systems and the anticipated Mexican and national Chinese ETS. Based on these estimates, the EU's system would continue demonstrating the highest average price over the period 2020-2030. To put these survey results into perspective, the anticipated price of 40.3 USD/tCO_2e EU ETS is well aligned with latest analyst forecasts for Phase 4 (2021-2030) of 40.5 USD/tCO_2e (Carbon Pulse, 2019).

*Table 2: Carbon price expectations (in USD/tCO_2e) for existing (EU, New Zealand, WCI, South Korea, RGGI) and anticipated (China, Mexico) emission trading systems over the period 2020-2030. Note: * WCI: Western Climate Initiative (California, Québec); ** RGGI: Regional Greenhouse Gas Initiative (Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont). Source: IETA & PwC (2019).*

Existing ETS					Anticipated ETS	
EU	N. Zealand	WCI*	S. Korea	RGGI**	China	Mexico
40.3	35.9	31.7	30.7	22.4	22.6	25.0

2.2.2 Baseline & credit markets: Offsetting schemes

Among operational offsetting schemes, the Kyoto Protocol's CDM is by far the largest. Yet, secondary market prices for Certified Emission Reductions (CERs) tumbled in 2011-2012 from around 15-17 USD/tCO_2 to well below 1 USD and have stabilized at about 0.20 USD/tCO_2 since. This collapse was driven by several factors, including a massive oversupply with CER and ERUs of often doubtful environmental integrity on the one hand and a refusal of the European Union to increase the quota for CER usage in its ETS post-2012 on the other.

In the primary market, however, Government and voluntary market buyers continued to pay prices well above the secondary market for selected projects of their choice, thereby underlining the value of the CDM as an instrument to deploy results-based finance, with a typical range of approx. 2 - 8 USD but only small traded volumes. Moreover, CERs from some countries (Colombia, South Korea) that can be used as offsets against the domestic carbon pricing instrument trade at prices close to the carbon tax rate (Colombia) or allowance price (South Korea), respectively.

The future of the CDM post-2020 is uncertain and its role within Art. 6 mechanisms is subject to much debate by negotiating parties. Whether CERs in vintages post-2020 will at all be issued under the Paris Agreement regime and what their price levels would be compared to ITMOs / A6.4ERs cannot be judged at present.

In parallel to compliance-based offsetting initiated in the Kyoto period, private sector demand for offsets has fostered a thriving voluntary market for carbon credits. Various programs exist that issue certificates for achieved emission reductions, with the two largest schemes being Verra's Voluntary Carbon Standard (VCS) and the Gold Standard. Pricing in this voluntary carbon market varies considerably. The World Bank Group's *State and Trends of Carbon Pricing 2019* reports a range of 0.1 USD/tCO_2e to just over 70 USD/tCO_2e for credits transacted in the first half of 2018, with approximately half of those transactions taking place at under 1 USD/tCO_2e (World Bank Group, 2019a). Many observers expect these prices to increase after 2020, given a noticeable increase in voluntary demand and the potential supply restrictions associated with host countries' NDCs.

Smaller markets – such as Switzerland's domestic compliance scheme – have enabled prices above most other offsetting schemes and transactions under this particular scheme regularly occur at around 100 USD/tCO_2e. However, this market is fairly peculiar with only one major buyer and prices are to a large extent policy-driven, as the penalty for non-compensation is set at 160 CHF/tCO_2e (approx. 163 USD/tCO_2e). The climate legislation in Switzerland for the period post-2020 is currently under revision and the proposal being debated would raise the penalty to 320 CHF/tCO_2e (approx. 327 USD/tCO_2e), thus paving the way for even higher domestic carbon credit prices.

2.3 Macroeconomic views on market mechanisms under Art. 6

Article 6 of the Paris Agreement is motivated by the idea that voluntary cooperative action among countries for the implementation of their mitigation objectives can lead to diverse benefits and efficiency gains. Indeed, enabling the transfers of mitigation outcomes is broadly reported in literature as leading to reduced costs since countries may take advantage of the different marginal abatement costs in other regions (Hof et al., 2017; Piris-Cabezas et al., 2018; Piris-Cabezas et al., 2019; Edmonds et al., 2019). These cost savings, in an ideal setting, could motivate greater ambition by reinvesting into further mitigation thereby aligning with the Paris Agreement's ratchet mechanism. Among submitted NDCs, 96 of these refer to using such international market mechanisms or carbon markets (World Bank Group, 2019a).

The direct impact on carbon prices of enabling market mechanisms in NDCs is modeled both by Piris-Cabezas et al. (2018, 2019) and Edmonds et al. (2019), the results of which are summarized in Table 3. In both cases, the authors assume fully cooperative implementation of countries' NDCs resulting in a uniform global carbon price. At current NDC ambition levels, prices simulated up to 2030 remain at a similar scale as those anticipated for existing carbon markets (see Table 2 in Section 2.2.1). Assuming the cost savings from cooperative implementation are then reinvested to enhance ambition, carbon prices would be foreseen to increase significantly (approx. 150-300%). If NDC ambition were to be raised even further to align with the Paris Agreement's 2°C pathway at the latest by 2030, prices modelled by Piris-Cabezas et al. (2019) rise to 31.6 – 55.2 USD/tCO_2 in 2030.

Table 3: Summary of carbon prices modeled by Edmonds et al. (2019) and Piris-Cabezas et al. (2018, 2019), including the effect of enhanced ambition achieved by reinvesting cost savings resulting from market linkages.

<table>
<tr><th rowspan="2">Publication</th><th colspan="3">Carbon prices</th><th rowspan="2">Key assumptions</th></tr>
<tr><th>2020</th><th>2030</th><th>2050</th></tr>
<tr><td rowspan="4">Edmonds et al. (2019)
(2015 US dollars)</td><td colspan="3">Current NDC ambition</td><td rowspan="4">Global shadow price of carbon assuming countries cooperatively implement their NDC goals (i.e. trading Art. 6 units).
(*) After 2030, decarbonization continues at same pace.</td></tr>
<tr><td>13 USD/tCO_2</td><td>38 USD/tCO_2</td><td>52 USD/tCO_2 (*)</td></tr>
<tr><td colspan="3">Enhanced NDC ambition</td></tr>
<tr><td>40 USD/tCO_2</td><td>65 USD/tCO_2</td><td>N/A</td></tr>
<tr><td rowspan="4">Piris-Cabezas et al. (2018) / Piris-Cabezas et al. (2019)</td><td colspan="3">Current NDC ambition</td><td rowspan="4">Carbon prices assuming a globally integrated carbon market where market actors fully anticipate future policies. Prices include the supply of emission reductions from REDD+.</td></tr>
<tr><td>7.4 USD/tCO_2</td><td>12 USD/tCO_2</td><td>N/A</td></tr>
<tr><td colspan="3">Enhanced NDC ambition</td></tr>
<tr><td>10.4 USD/tCO_2</td><td>16.9 USD/tCO_2</td><td>N/A</td></tr>
</table>

In practice, whether reduced costs actually translate into higher ambition is currently subject of debate. Mehling (2018) argues that such a link is not automatic and that the Rulebook for Article 6 must strike a balance between prescriptive guidance that promotes ambition and greater flexibility that would allow for a larger number of participants. Similarly, Howard (2018) finds that using markets to reduce abatement costs is not a guarantee of enhanced ambition and that the Rulebook must put in place a framework and safeguards to facilitate ambition-raising. The author also proposes approaches that countries may pursue when seeking to use carbon markets to raise ambition, such as generating new demand for emission units.

2.4 Future demand for Art. 6 emissions units

Demand for international emission units arises traditionally from either compliance or voluntary markets. Experiences to date with carbon markets – in particular compliance systems – frequently revealed systemic issues of oversupply (e.g. EU ETS, CDM). In these cases, markets tend to be demand-constrained and this situation is expected to persist in the near-term. Thus, understanding the dynamics of carbon markets and in particular demand for emission units within those systems is critical to forming a view of price evolution post-2020.

2.4.1 Compliance carbon pricing schemes

Compliance carbon markets present potential sources of demand for international emission units generated under Article 6 post-2020. Existing private sector compliance policies – such as emissions trading or carbon taxes – in some instances include an option for regulated entities to surrender international credits against compliance units. Such mechanisms are employed to the extent that the carbon price differential between both markets is to the advantage of the regulated entity – i.e. that international carbon credits prices are below the price in the compliance regime. Of the 57 carbon pricing initiatives identified by the World Bank's *State and Trends of Carbon Pricing 2019*, seven have current provisions enabling the use of international credits: Colombia carbon tax, EU ETS, Mexico carbon tax, Korea ETS, Slovenia carbon tax, and Switzerland ETS and carbon tax (World Bank Group, 2019a).

The EU ETS has historically been the largest source of demand for such units, accounting for 1.6 Gt up to 2020, while other systems have had a smaller impact. Installations participating in the EU ETS have been able to use international CDM and JI (Joint Implementation) credits for a share of their obligations since 2005, subject to quality and quantity restrictions (European Commission, n.d.). From 2021 onwards, the EU ETS no longer envisages the use of international credits thereby stripping a key source of demand for such units.

Other emissions trading systems – such as the Swiss and Korean ETS – have had a smaller impact on fostering demand to date and will continue playing only a minor role. The former allows the use of international credits in the current phase up to 2020 but not thereafter. In the latter, international credits have been authorized since 2018, however the relevant rules for the third phase (2021-2025) remain unclear. The Chinese provincial ETSs allow the use of offsets from Chinese CDM projects to a varying extent; most of them have a quantitative threshold and limit eligible credits geographically; some also have technology limitations. Total offset volumes traded in China to date reach 52 $MtCO_2e$ (Slater et al., 2018, p. 39). In comparison, cumulative trading of allowances up until May 2018 in the eight regional markets amounted to 222 $MtCO_2e$.

Domestic carbon taxes in several countries have evolved in recent years to include provisions for use of carbon credits, although these represent small demand volumes on a global scale. In Colombia, the tax allowed international credits in its first year (2017), restricting thereafter to only domestically generated units. Potential demand for Colombian domestic units in 2019 is estimated at approx. 50 $MtCO_2e$ (based on the aggregate emissions eligible to be offset)[2] whereas actual supply is constrained to a level far lower. South Africa implemented a carbon tax just recently (2019), which allows domestic offsets. Other relevant jurisdictions for future carbon offset demand include Chile, which implemented a carbon tax in 2017 but where rules for use of carbon credits remain uncertain.

2.4.2 Governments and intergovernmental institutions

A possibly major source of demand for mitigation outcomes is expected to come from the public sector and namely countries making use of international markets to achieve their NDCs. Among the 96 NDCs identified by the World Bank Group's *State and Trends of Carbon Pricing 2019* as referencing the use of international carbon pricing initiatives, eight so far mention an intention to use international credits to meet their NDCs: Canada, Japan, Liechtenstein, Monaco, New Zealand, Norway, South Korea and Switzerland (World Bank Group, 2019a). Piloting by several of these countries has been launched to test design options of these Article 6 activities (Greiner et al., 2019).

Other existing sources of demand come primarily from multilateral finance institutions (MFIs) and domestic finance institutions through results-based climate finance (RBCF). This type of finance is contingent on the actual achievement of emission reductions. Existing RBCF programs or funds have been implemented to purchase CERs based on well-defined eligibility criteria, thereby bridging the current lack of demand in this market (World Bank Group, 2019a). Examples of such programs include the World Bank's Pilot Auction Facility for Methane and Climate Change Mitigation (PAF) and the Swiss Climate Cent Foundation's Landfill Gas Program in Latin America. Recently, multiple RBCF programs have been announced in particular to support voluntary forestry initiatives (GCF, 2019; World Bank Group, 2019b). Based on the experiences till date and on similar mechanisms, finance institutions could possibly become important actors in creating demand under Article 6 (Michaelowa et al., 2019).

2.4.3 Aviation and shipping

The aviation sector's global carbon scheme, agreed by the International Civil Aviation Organization (ICAO) in 2016, will be launching its first compliance phase in 2021 for voluntary participation. Throughout the voluntary phases (2021-2026) and then ramping up with the mandatory phase (from 2027 onwards), aircraft operators in participating member states will be required to offset their emissions from international flights above 2020 levels. The actual emission units eligible for use under CORSIA are currently still under debate by ICAO's Technical Advisory Body (TAB) (see also Kolos 2018 for a general discussion of supply issues under CORSIA). To be approved, crediting programs must demonstrate that units comply with a set of eligibility criteria such as additionality, transparency, permanence and avoidance of double counting. 14 programs have submitted their candidacy. At the moment, it is therefore not predictable how this demand will be met, be it with CERs, Article 6 emissions units, voluntary carbon credits or other units.

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[2] Calculated by carbon consultancy AsoCarbono, based in Bogotá, Colombia (https://asocarbono.org/).

Various studies provide indications of the demand for offsets expected under CORSIA. Healy (2017) determine a range of 1.6 – 3.7 Gt over the period 2021-2035 for different sectoral growth scenarios. The key literature sources identified in this study reference offset demands over the same period of around 2.5-2.7 Gt (Fearnehough et al., 2018; Lo Re et al., 2019; Michaelowa et al., 2019; Piris-Cabezas et al., 2018). CORSIA therefore has the potential to become an important new source of demand for emission units post-2020. When put into perspective with current NDC ambition levels, CORSIA demand represents 3.3% of total reductions to be achieved (Piris-Cabezas et al., 2018).

The International Air Transport Association (IATA) references similar demand values of 2.5 Gt over the 2021-2035 timeframe (IATA, 2019). The industry group further estimates the overall cost this would represent for airline operators using an indicative price evolution from 8 USD/tCO_2e in 2021 up to 20 USD/tCO_2e in 2035.

The maritime sector, formally constituted through the International Maritime Organization (IMO), and still in the early stages of considering a price on carbon, could be a potential source of demand for international credits in the long-term. The IMO is exploring decarbonization pathways as it seeks to meet its 2050 targets of cutting shipping emissions by 50% compared to 2008 levels (IMO, 2018).

2.4.4 Voluntary carbon markets

In parallel to compliance-drive demand, voluntary carbon markets (VCM) are also currently a source of demand for international credits. Hamrick et al. (2018) provide an overview of issued and transacted offsets in the first quarter of 2018, amounting to 15.8 MtCO_2e and 18.7 MtCO_2e, respectively.

While the VCM has shown prices well above the 20 US-cents typical for recent secondary CER markets (see Section 2.2.2) and enabled the private sector to cost-effectively offset unavoidable emissions, its future under the Paris Agreement is unclear. An increasing array of private sector initiatives are encouraging corporations to set ambitious climate mitigation targets (e.g. Science-Based Targets Initiative) and disclose climate mitigation practices (e.g. CDP), which may be seen as potentially promoting greater demand, however the initiatives themselves tend to express reservations about the use of offsets for achieving abatement goals (SBTi, 2019).

There is also emerging debate whether the VCM’s current scope of activity can prevail in a context where “countries now have to prioritize fulfilment of their NDC targets, and therefore all mitigation actions run the risk of becoming appropriated by governments under compliance policy instruments” (Michaelowa et al., 2019). Among the contentious issues is the double counting risk between corporations claiming carbon neutrality and countries accounting the same emission reductions under their NDCs. In the view of the authors, this apparent conflict may likely be resolved by many voluntary buyers changing their claim to emphasize the financing of international emission reductions and contributions to host countries NDC (over-)achievement, rather than carbon neutrality in the traditional sense.

2.5 CDM transition and supply-side considerations

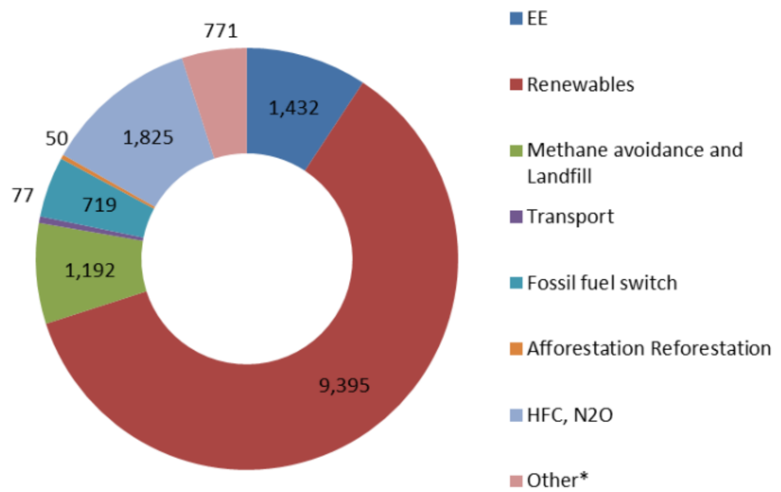
2.5.1 CER supply

The transition of Kyoto Protocol elements over to the Paris Agreement remains among the significant unresolved issues under Article 6. While not explicitly called for by the Paris Agreement (Lo Re et al., 2019), this transition is contentious given the legacy of Kyoto's still operational CDM mechanism.

From a pricing perspective of emission units post-2020, the transition of CDM units (CERs) plays a critical role. If fully transitioned over to Art. 6, the current vast supply of CERs could flood the market and, without any significant ramp up in demand to compensate, average transaction prices would likely be lower than in a market without such transitioning. Various studies have estimated the upper bound volume of CERs that could transition in such a scenario. Lo Re et al. (2019) reference figures of 819 million currently available CERs (representing approx. 40% of overall CERs issued until December 31st, 2018) and 4.7 billion CERs which could potentially be supplied until 2020, including from so-called "dormant" registered projects if market conditions become favorable. These projects are likely to remain in such a state until a time when anticipated earnings from CERs are foreseen as sufficient to warrant an investment in issuance fees. A guarantee that CDM units could be used post-2020 (e.g. under Article 6) and would be met with meaningful demand (e.g. CORSIA) could provide such a trigger.

Taking the supply assessment one step further, Brescia et al. (2019) estimate that overall CER supply until 2030 would reach 15.6 billion – assuming registered CDM projects are allowed to renew their crediting periods and continue generating CERs post-2020 without restriction (see Figure 2). When placed into relation with demand expected under CORSIA (2.5-2.7 billion over the 2021-2035 timeframe, see Section 2.4) – possibly one of the larger sources of demand for international credits post-2020 – the risk of oversupply becomes apparent. In contrast, the World Bank Group's *State and Trends of Carbon Pricing* reports that, from 2005 to first quarter 2018, the overall volume of credits issued in the voluntary carbon market is about 0.43 billion, thus well below available CER volumes.

Figure 2: Potential CER volume up to 2030 in the full transition scenario of Brescia et al. (2019).



Limited transition scenarios, designed by restricting eligible supply based on vintage year, host country, vulnerability, or technology sector have been studied and would be effective at significantly reducing CER volumes (Lo Re et al., 2019; Brescia et al., 2019; Fearnehough et al., 2018; Warnecke et al., 2019).

In addition to the direct negative effects of CER supply on carbon price, the design of the CDM transition scenario would also have relevant positive impacts on the post-2020 market. Transitioning the CDM mechanism would enhance trust from the private sector by sending a strong signal that efforts invested to date (in the CDM) are not worthless (Brescia et al., 2019). This would therefore help preserve knowledge and stimulate new mitigation activity.

2.5.2 Other notable supply considerations

Regardless of how legacy CDM units and mechanism will be transitioned under the Paris Agreement, an Art. 6-specific stream of international credits is expected to be generated through Articles 6.2 and 6.4. This is however dependent on the willingness of countries to host projects and generate emission reductions for international use. As opposed to the situation under the Kyoto regime, all parties have domestic mitigation commitments to achieve under the Paris Agreement. The supply of credits to an international carbon market will be particularly dependent on participation from large historical suppliers such as China and India – who together account for over two-thirds of registered CDM projects.

A key requirement of the Article 6.4 is that it must deliver “overall mitigation in global emissions”. While several approaches may be conceived to achieve this, Schneider et al. (2018) recommends automatic cancellation of “a portion of the emission reductions resulting from an activity credited under the Article 6.4 mechanism”. This would be equivalent to a special tax on Article 6 mitigation activities and, from a supply and demand perspective, the resulting effect would be a decrease in available supply and an ultimate increase in credit prices.

While overall price is the indicator used for assessing project economics, it must not be forgotten that in addition to covering project operating costs the price must also be sufficient to cover transaction costs under the scheme as well as other fees. Significant literature on project costs under the CDM is available and useful to consider in context of a future Art. 6.4 mechanism (EcoSecurities BV & CD4CDM, 2007; UNFCCC, 2013; UNFCCC 2010). Costs for consultants and verification vary considerably among project technology types (UNFCCC, 2013), however the Paris Agreement Rulebook has little direct influence on determining the level of these fees. Conversely, the Rulebook will play a role in defining UN fees – i.e. fees for registration, issuance and the levy on share of proceeds from Art. 6.4 activities – which project operators would incur.

From a voluntary market perspective, VCS recently published an updated version of the program’s Standard, which restricts the eligibility of various renewable energy project types to generate carbon credits in non-LDC countries (Verra, 2019). Driven by additionality concerns, these restrictions cover, among others, grid-connected electricity generation from wind, solar, geothermal, and hydro. Supply of VCS carbon credits from this technology sector – historically a large contributor to VCS supply – will thus be significantly reduced. Forestry projects are expected here to make up some of the supply loss.

3 ITMO generation costs and buyers' willingness to pay

3.1 Introduction

When reflecting on the drivers underlying ITMO prices, it is useful to bear in mind the twin nature of carbon offsetting transactions. For a buyer, procuring a carbon credit is in the narrow sense simply a *compliance instrument*, i.e. a cost-efficient but time-limited alternative to achieving the same emission reduction in its own operations or jurisdiction. For a seller, in contrast, the proceeds from the carbon credit sale are revenue from the sale of a new type of commodity. To trigger additional mitigation action, these proceeds must be high enough to make the mitigation action economically more attractive than the GHG-intensive business-as-usual scenario. In this sense, the carbon credit sales are comparable to a *subsidy* disbursed over several years, such as a feed-in tariff for grid-connected renewable energy sources, with the important distinction that the carbon credit revenues are market-driven and can entail significant rents for the seller in cases of competing demand.

Against this background, we identify below the key elements contributing to ITMO generation costs and sellers' resulting *willingness to accept* a given price, as well as key factors likely to influence buyers' *willingness to pay.* We use the example of a landfill gas to energy program in Mexico to illustrate our analysis with indicative numbers. For simplicity, we do not distinguish in this analysis between the macro-economic perspective of governments and the micro-economic perspective of the private-sector actors authorized by them to engage in ITMO transactions, unless indicated otherwise.

3.2 Seller's perspective: Breaking down ITMO generation costs

3.2.1 Overview of cost elements

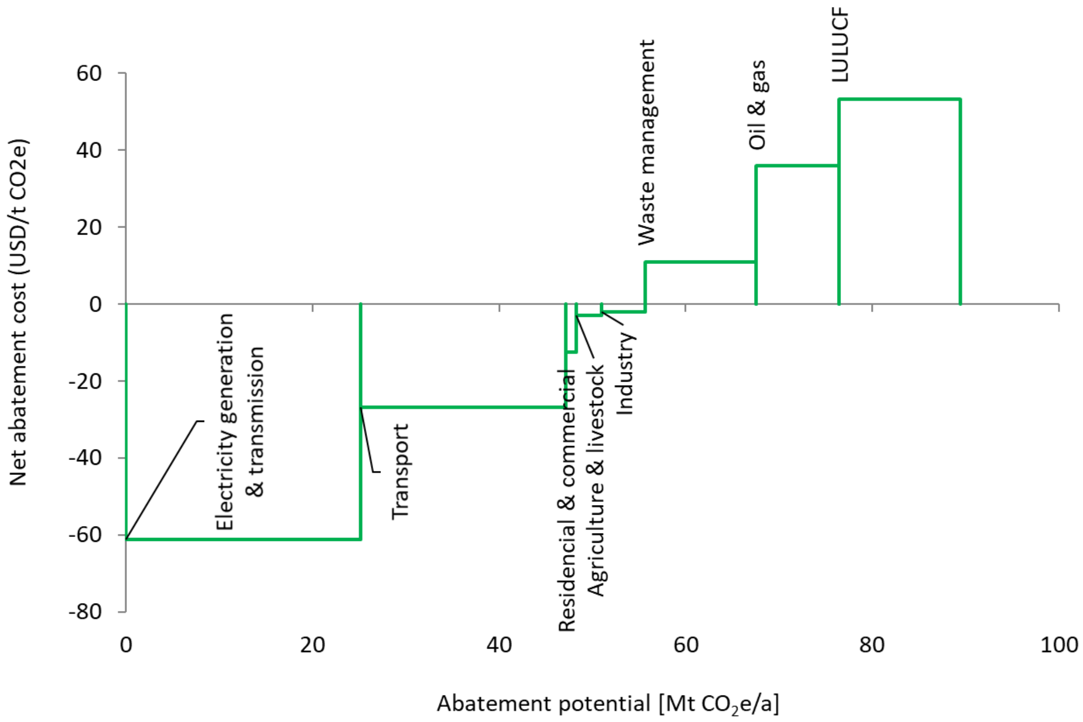
We distinguish four elements that feed into overall ITMO generation costs, and briefly discuss each of them below:

- *Incremental costs of mitigation actions*;
- *Opportunity costs* for the seller country in meeting its NDC. This cost component will depend on the detailed rules for corresponding adjustments, among other factors;
- *Carbon credit-related transaction costs*;
- *Market premiums*, including producer rents and premiums for ancillary benefits of GHG mitigation actions from a sustainable development perspective.

3.2.2 Incremental costs of mitigation actions

Incremental costs of mitigation actions include the capital costs (CAPEX), operating costs (OPEX) and risk premiums thereon required by the investors, always over and above those of the relevant business-as-usual course of action. The incremental costs of different mitigation actions are typically condensed in a marginal abatement cost (MAC) curve. For illustration, Figure 3 below shows such a curve for an initial set of mitigation actions, aggregated by sector, as assessed by INECC (2018) with a view to determining Mexico's least-cost path towards meeting the 2030 NDC.

Figure 3: Marginal abatement cost curve of Mexico to 2030. Source: Based on INECC (2018: 145)



Like many others, this example MAC curve shows a striking potential of mitigation action at negative costs, begging the question why these profitable potentials are not being exploited. Factors typically cited in response include the following:

- MAC curves tend to ignore barriers faced by micro-economic actors, such as incomplete information and split incentives;
- MAC curves tend to apply a low ("social") discount rate, thereby severely underestimating the actual premiums required by investors to balance project risks;
- MAC curves depend on numerous assumptions, for example regarding the costs of climate-friendly technologies as well as market prices for baseline fuels, which are all subject to considerable uncertainties.

Consequently, even abatement potentials with seemingly negative abatement costs may still be additional in the CDM sense. Nevertheless, it appears safe to assume that host countries will tend to direct Article 6 funds to abatement potentials with clearly positive abatement costs and reserve the lowest-hanging fruit as a target for their domestic climate policies. In the Mexican case used here as an example, this would mean that Article 6 funding could be preferentially directed to the waste management, oil & gas and LULUCF sectors, noting that the costs indicated for the latter two of 40-50 USD/t CO_2e are well above the typical price levels seen to date in international offsets markets.

For prospective buyers of ITMOs, MAC curves can be a useful starting point for identifying promising sectors for mitigation programs. However, the uncertainty inherent in such curves is significant, and we argue that reliable determination of incremental costs will generally require direct negotiation with the respective project owners.

3.2.3 Opportunity costs for host countries

From a seller country's perspective, an opportunity cost will arise if the transfer of ITMOs results in the need for that country to take other, more costly abatement action in order to meet its NDC. Referring to the MAC curve in Figure 3, for example, this could be the case in a scenario where Mexico allows its waste sector to sell ITMOs at a price of say 20 USD/t CO_2e (with a corresponding adjustment) and subsequently has to take additional action in the oil & gas or LULUCF sectors at 40 - 50 USD/t CO_2e, while the buyer would receive ITMOs at well below its domestic abatement cost. The level of the opportunity cost would thus depend on the cost differential between the Article 6 activity and the alternative abatement potentials available to the host country.

Clearly, such win-lose-scenarios must to be avoided when designing Article 6 activities. Instead, it is the authors' view that Article 6 activities should ideally help seller countries meet their current NDCs and strengthen the ambition of their future NDCs. While a detailed analysis of options for achieving such win-win-situations is beyond the scope of this study, we would like to point to the special role of single-year NDC targets in this context.

Prices for sale of ITMOs will strongly depend on the way corresponding adjustments are to be undertaken in the context of single year targets that have been chosen by most developing countries in their NDCs. Rules that require sellers to do corresponding adjustments at the same stringency as the buyers will lead to higher price requests from sellers as they have to “cover” their opportunity costs.[3] While single-year targets may be a transitory phenomenon on the way towards contingent multi-year targets, i.e. Kyoto-style assigned amounts, they may likely persist for LDCs and SIDS for quite some time.

Currently, various options for accounting of single year targets are under negotiation. Some would require sellers to make corresponding adjustments in the target year for ITMOs sold in respect of pre-target year emission reductions. In this case, a seller will have to take into account the opportunity cost for each ITMO and thus ask for a higher price than if he does not have to undertake a corresponding adjustment. In the experience of the authors, this can translate into a significant disincentive for seller governments to engage in Article 6 activities, because the cost of alternative mitigation options (and the political feasibility of harnessing them) is often uncertain.

Conversely, First Climate's view is that Article 6 activities can also facilitate the achievement of seller country single-year targets under favorable circumstances, while preserving environmental integrity. This is illustrated with an example in the following text box.

For the purpose of this pricing study, we conclude that the uncertainty surrounding corresponding adjustments rules is currently a key uncertainty factor in seller governments' analyses of their ITMO generation costs and, therefore, a major impediment to the rapid deployment of Article 6.

With respect to price expectations, we conclude that it will become difficult for buyers to source ITMOs from new and truly additional mitigation activities at single-digit USD prices, given that seller countries' can be expected to retain their least-cost mitigation potentials and consider the potential opportunity costs related to ITMO transfers.

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[3] The role of rules regarding use of ITMOs to meet single-year targets is addressed in Section 3.3.2.

Text box 1: Seller country opportunity costs in the case of corresponding adjustments: Illustrative scenarios

Single-year targets of prospective seller countries have been a cause of concern in the negotiations about corresponding adjustment rules. In the opinion of First Climate, however, Article 6 activities in countries with single-year targets can contribute to the cost-effective achievement of both the seller- and buyer country NDC, while preserving environmental integrity, even without the need of a corresponding adjustment for ITMOs transferred in respect of pre-target year emission reductions. This would be the case e.g. if the Article 6 activity starts early, its crediting period ends before the seller's NDC target year, and the projects underlying the Article 6 activity continue operating beyond the crediting period, during the seller's target year and thereafter.

In this scenario, environmental integrity of the ITMOs transferred in respect of pre-target year emissions reductions could be ensured by requiring that the crediting baseline (and additionality test) for the Article 6 activity is consistent with a path towards fulfilment of the NDC target.

Using the example of a landfill gas to energy program in Mexico, such a program would contribute fully towards Mexico's 2030 target if the crediting period for the program (and therefore ITMO transfers) ends well before 2030. This assumes that returns from electricity sales would be sufficient to cover the projects' operating costs after the end of the crediting period.

In contrast, the same program could deliver a negative contribution to Mexico's 2030 target, and thereby require Mexico to take additional action in other, more costly sectors, if the projects stopped operating at the end of the crediting period while international rules would force Mexico to make a corresponding adjustment in 2030 for ITMO's transferred prior to 2030.

In this equation, the risk of projects ceasing operation after the end of the crediting period is small or negligible for many project types, and therefore relatively easy to assess and control for seller governments. Whether the international rules will require corresponding adjustment for pre-target year transfers thus remains the key uncertainty and determinant of seller countries' opportunity costs.

3.2.4 Carbon-credit related transaction costs

In this study, we use the term transaction costs to denote all costs related to the monitoring, certification, sale and transfer of ITMOs and underlying emission reductions. Specifically, this includes the traditional costs for the registration, monitoring, reporting and verification of carbon offset projects, as well as the costs related to the negotiation, due diligence and execution of ITMO purchase and sale agreements (ERPAs).

To illustrate their order of magnitude, Table 4 breaks down the typical transaction costs of two landfill gas projects under the CDM, one small-scale and one large-scale. For these scenarios, we find that the typical transaction costs are in the range of 1-3 USD/t CO2e, i.e. one order of magnitude lower that the abatement costs and potential opportunity costs discussed in the previous sections.

As a caveat, we note that there may be high differences between different project types (for example if expensive equipment is required for the monitoring of emission reductions). In addition, the cost values shown here are higher than those typically cited for pure CDM transaction costs because the latter usually do not factor in costs for monitoring work and equipment as well as ERPA management. Finally, the actual transaction costs of Article 6 activities may differ from those known from the CDM.

Table 4: Indicative transaction costs for Article 6 projects, using LFG to energy as an example. Source: First Climate

Project Scale				**Small**		**Large**
ER Volume annual	t/a			20'000		100'000
Crediting period	a			7		7
ER Volume over crediting period	t			140'000		700'000
Transaction Costs		**All**	**Small**		**Large**	
			USD	**USD/a**	**USD**	**USD/a**
PDD	one-off		30'000	4'286	50'000	7'143
Validation	one-off		15'000	2'143	30'000	4'286
Monitoring	annual			10'000		30'000
Verification	annual			10'000		20'000
Issuance Fee - Administration	per ER	0.20		4'000		20'000
ERPA management incl. DD	per ER		1.00	28'000	0.30	30'000
Total				58'429		111'429
Total per CER - gross	USD/t CO2e			2.92		1.11
Issuance Fee - Adaptation	% of ER	2%				
Total per CER - net, rounded	**USD/t CO2e**	1		**3.00**		**1.10**

3.2.5 Market premiums

We use the term market premiums to denote the following:

- Producer rents earned by sellers of carbon credits if their ITMO generation cost (including minimum profits and risk premiums required) is less than the price offered by buyers; and
- Premiums offered by buyers in exchange for sustainability benefits associated with ITMOs, over and above the pure reduction in GHG emissions.

Strictly speaking, both are not a cost for the ITMO seller, but rather a premium as the term implies.

For sellers to earn meaningful producer rents would require a competitive market with a meaningful demand for ITMOs. As described elsewhere in this study in more detail, this currently appears rather unlikely to materialize until 2030, considering that only a handful of small and medium-sized Parties have stated an intent to procure ITMOs. CORSIA may eventually add to this demand in a scenario where the use of legacy CERs is limited.

A buyer's market also implies that it could be difficult for seller countries to charge meaningful premiums for ITMOs from projects with special sustainability benefits. A meaningful demand from the voluntary market could, in theory, change this, if voluntary buyers were to start competing with acquiring Parties for ITMOs. Recently, the authors have seen evidence of such competition, albeit still at a moderate level, for certain project types popular among voluntary buyers such as improved cook stoves.

However, voluntary carbon markets are currently going through a transition to adapt to the Paris world. While some voluntary buyers may insist on ITMO generation and transfer, others may be satisfied with just making a financial contribution towards host countries' NDC achievement, and therefore focus on other project types. On the other hand, the future supply and demand of the voluntary market are also currently evolving and subject to considerable uncertainty, as described in more detail in Section 2.4.4 of this study.

As an interim conclusion, based on the data available to date, we consider it rather unlikely that ITMO sellers could earn significant premiums or rents in the short term, and possibly up to 2030. This is a major difference to the heydays of the CDM where owners of certain project types with low abatement costs earned massive windfall profits.

Instead, current signs are pointing to a fragmented buyer's market where buyers can, at least for the next 3-5 years, continue to apply a "cost plus" approach to source ITMOs at the cost of generation plus a small premium. As mentioned above, the potential opportunity costs related to seller countries' own NDC achievement may prove to be the main uncertainty factor in the calculation of those ITMO generation costs in the near and medium term and lead host country governments to take a cautious approach towards ITMO transfers. Moreover, we note that this finding is subject to high uncertainty, the main drivers of which will be discussed in Section 4 below.

3.3 Buyer's perspective

3.3.1 Buyer's willingness to pay

If the cost of ITMO generation is one side of the equation determining market prices, the other side is the buyers' willingness to pay for those ITMOs.

Applying a conventional least-cost compliance logic, buyers would be expected to prefer the purchase of ITMOs as long as their price per tonne of CO_2 is lower than the cost of the marginal abatement potentials available at home. The carbon taxes in place in some European countries at or above 100 USD/t CO_2e (IMF 2019 p.3) are an indication of relatively high marginal abatement costs in the non-ETS sectors. This implies that the willingness to pay could reach the level of those taxes.

However, it is important to bear in mind the downsides – actual or perceived by the public – of using ITMOs as an instrument for compliance and ambition-raising. Specifically, if ITMOs displace domestic abatement action, co-benefits such as renewal of infrastructure, job creation and reductions in emissions of local air pollutants occur in the seller country rather than at home. In addition, critics often argue that offsetting merely serves to postpone inevitable abatement action at home, thereby increasing future compliance costs.

Against this background, we hypothesize that the actual willingness to pay of buyer countries will remain, until 2030, well below the tax levels referred to above, with 50 USD/t CO_2e as an indicative upper limit at least in the next few years.

Taken together with the double-digit ITMO generation costs discussed in the previous section and based on the authors’ experience with Article 6 pilots to date, we expect a realistic band for actual

ITMO transaction prices until 2030 to be 10 - 50 USD/t CO_2e, with 15 - 30 USD/t CO_2e as the likely range for most transactions in the next few years. Within this range, the quality of ITMOs, including aspects such as environmental integrity, additionality, local co-benefits and contribution to NDC (over-) achievement, are likely to influence the willingness to pay of many buyers.

3.3.2 Buyers with single year targets

Corresponding adjustment rules for buyer countries with single-year targets can have strong impacts on the quantity of ITMOs that needs to be acquired in order to have a specific quantity to be accounted by a buyer for its a single-year NDC. Demand will be higher if the buyer needs to apply an "averaging" or "linear" method for the entire NDC period than if the buyer just needs to cover the gap in the target year.

If buyer countries would not be obliged to buy ITMOs for the years preceding the target year, they would be heavily advantaged over buyer countries with multi-year targets and the environmental integrity of their NDC would be severely undermined. While a detailed discussion of this aspect is beyond the scope of this study[4], we note that the aggregate demand for ITMOs from buyer countries with single-year targets will strongly depend on the detailed accounting rules.

[4] See Perspectives' study on different accounting rule options for multi- and single years.

4 Synopsis and areas for further research

4.1 Summary of demand and supply estimates

Based upon the literature review in Section 2, Table 5 highlights key supply and demand figures for international carbon credits. These indicative figures shed light on the potential imbalance if Article 6 allows for the full transition of CDM units.

Table 5: Indicative supply and demand volumes relevant for Article 6.

		Volume	Source
Demand-side volumes			
Article 6	Fully cooperative scenario	**4.3 $GtCO_2e$** in 2030	Edmonds et al. (2019)
	Current NDC	0.23 $GtCO_2e$ in 2030	Authors' estimate[5]
CORSIA		**0.26 $GtCO_2e$** per year in 2nd Phase (2027-2035)	Fearnehough et al., 2018
Voluntary demand		**0.063 $GtCO_2e$** in 2018 (issued)[6] **0.075 $GtCO_2e$** in 2018 (transacted)[6]	Hamrick et al. (2018)
Compliance markets in various countries		**~0.1 $GtCO_2e$** in 2018	Extrapolation from Colombian (Asocarbono 2018) and Chinese values (Slater et al., 2018)
Supply-side volumes			
Article 6	Fully cooperative scenario	**4.3 $GtCO_2e$** in 2030	Edmonds et al. (2019)
CERs	Full transition of units	**4.7 $GtCO_2e$** up to 2020	Lo Re et al. (2019)
	Full transition of units + registered projects	**15.6 $GtCO_2e$** up to 2030	Brescia et al. (2019)

4.2 Summary of key drivers

Table 6 provides our synopsis of the key drivers affecting ITMO prices up to 2030 and beyond:

- On the **demand side until 2030**, we see several drivers of similar importance, including: demand by Parties to offset emissions in their non-ETS sectors, whether CORSIA will require corresponding adjustments (and therefore purchase of ITMOs), as well as future demand trends in the voluntary market. After 2025, in addition, the ratcheting-up of NDCs could further increase demand. While little demand for ITMOs is currently visible from the EU-ETS and North American ETS, it could potentially be forthcoming from the national Chinese ETS and Korean ETS and further ETS emerging in various jurisdictions. The importance of rules for using ITMOs

[5] Estimate assumes the following countries use ITMOs equal to 10% of their 1990 emissions in 2030: Canada, Japan, Liechtenstein, Monaco, New Zealand, Norway, South Korea, Switzerland. These countries mention an intention to use international credits to meet their NDC

[6] Extrapolated from Q1 figures for 2018.

towards single-year targets is currently difficult to assess. **After 2030**, all of these drivers have the potential to affect prices materially.

- On the **supply side until 2030**, we see three drivers as having a high potential relevance for ITMO pricing: the rules for the transitioning of CERs and CDM projects, and the detailed rules for corresponding adjustments, as the latter will likely play a critical role in countries' readiness to sell ITMOs. In contrast, we expect that the potential ratcheting-up of seller countries' NDCs will only affect supply after 2025. Equally, we expect that the relevance of transaction costs from UNFCCC regulations and of the detailed methodological rules for Article 6.4 will be low, or medium at most, for the supply until 2030. **After 2030**, the importance of CERs carried over from the Kyoto regime should diminish, and the ambition of seller country NDCs (along with corresponding adjustment rules) seem likely to become the key supply drivers.

Table 6: Overview of key price drivers for Article 6 emission units with qualitative rating (1. Low to 5. High) of their impact of carbon price. Question marks (?) indicate special uncertainty

Drivers	**Qualitative impact on price**	
	Relevance for price until 2030	**Relevance for price after 2030**
Demand-side drivers		
Ambition of NDCs in buyer countries	**3. Medium** (ratcheting-up after 2025)	**5. High**
Eligibility of ITMOs in domestic carbon pricing schemes (ETS, taxes)	**3. Medium** (unlikely in EU)	**5. High**
Use of ITMOs by Parties (Governments) for non-ETS sectors	**5. High**	**5. High**
CORSIA: Role of ITMOs / Need for corresponding adjustments	**4. Medium - high**	**5. High**
Voluntary market: Demand & preferences (e.g. purchase of ITMOs vs. financial contributions)	**2. Low-medium**	**4. Medium - high?**
Rules for ITMO used to meet single-year NDCs	**5. High**	**5. High**
Supply-side drivers		
Transition of CDM units to Article 6 / use to-wards NDCs	**5. High**	**2. Low - medium**
Transition of CDM activities to Article 6	**5. High**	**3. Medium**
Ambition increase of seller country NDCs	**2. Low - medium** (ratcheting up?)	**5. High**
Corresponding adjustment rules for single-year targets	**5. High**	**4. Medium-high**
Transaction costs: Fees, share of proceeds (OMGE), need for validation/verification	**1. Low**	**1. Low**
Buyer approaches (Art. 6.2) & UNFCCC rules on crediting periods, baselines, additionality, …	**4. Medium-high**	**4. Medium-high**

4.3 Illustrative scenarios

Given these multiple drivers, a multitude of scenarios for the development of Article 6 markets can be envisaged. This makes statements on expected ITMO prices highly speculative. For illustration, the following table combines different outcomes of selected key drivers on the demand- and supply side to identify low-, medium- and high price scenarios.

Table 7: Illustrative ITMO supply and demand scenarios until 2030. CA = Corresponding Adjustment

		Low Supply	**High Supply**
		e.g.: - No transition of CERs - Limited transition of CDM projects - Ambitious NDCs - Strict corresponding adjustment rules strongly limit willingness to sell	e.g.: - Limited transition of CERs - Substantial transition of CDM projects - Less ambitious NDCs - Rules not requiring corresponding adjustment for all units transferred raise readiness to sell
Low Demand	e.g.: - Little ITMO demand from Parties - Little ITMO demand from CORSIA (e.g., REDD+ accepted w/o CA) - Little ITMO demand from voluntary markets	Medium Scenario: 10 – 30 USD/t	Low Price Scenario: <10 USD/t
High Demand	e.g.: - Higher ITMO demand from Parties - ITMO demand from CORSIA (e.g., REDD+ not accepted) - ITMO demand from voluntary markets	High Price Scenario: >30 USD/t	Medium Scenario: 10 – 30 USD/t

The associated price ranges are only indicative, based on our expert judgement rather than robust modelling, and intended for illustration. In a nutshell, the message from Table 7 is the following:

- A **low-price scenario** with ITMO prices at up to 10 USD/t could result, for example, if demand for CORSIA is met mainly from carried-over CERs and REDD+ credits not requiring corresponding adjustments (see Kolos 2019). In addition, this scenario assumes that the traditional CDM host countries would be ready to sell ITMOs in light of rather unambitious NDCs coupled with absence of corresponding adjustments – essentially a continuation of the Kyoto world.

- A **high-price scenario** with ITMO prices above 30 USD/t, in contrast, could result if CORSIA results in a meaningful demand for ITMOs (due to an exclusion of CERs and REDD+) and / or if prospective seller countries restrain ITMO sales due high domestic ambition or requirement for corresponding adjustments rules for all ITMO sales.
- **Medium-price scenarios** are expected to result from different combinations, such as low demand with low supply or high demand and high supply. In the latter case, however, prices could be expected to increase noticeably once the supply from carried over CERs ceases.

4.4 Further areas of research

Of the various factors contributing to the uncertainty around future ITMO prices, the rules for corresponding adjustment is among the most urgent and important; however, this is currently being addressed in an ongoing study by Perspectives for the SEA.

More generally, the detailed design of Article 6 markets is likely to have an important influence on ITMO prices. Research questions remaining to be addressed and / or deepened in this context include:

- Additionality tests to ensure environmental integrity and economic efficiency of Article 6, and their implications for ITMO prices (see e.g. Michaelowa, Hermwille et al. 2019);
- Link between crediting periods and ITMO prices;
- Treatment of carbon sinks and permanence risks under Article 6, and implications for ITMO prices;
- Options and merits of minimizing seller rents through differentiated design rules for offset programs under Article 6;
- Differentiation between Articles 6.2 and 6.4 with respect to pricing;
- Pricing power and possible strategies of large buyers and seller.

5 References

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