The 'HCFC adder' in the Kigali Amendment baseline calculation

Risks to environmental integrity of the Paris Agreement

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LIST OF ABBREVIATIONS

A6.4ER	Article 6.4 Emission Reductions
A6.4M	Article 6.4 mechanism
A6TER	Article 6 Technical Expert Review
BAU	Business as usual
CARP	Centralized Accounting and Reporting Platform
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CFCs	Chlorofluorocarbons
CMA	Conference of the Parties serving as meeting of the Parties to the Paris Agreement
CO_2	Carbon Dioxide
COP	Conference of the Parties to the UNFCCC
CORSIA	Carbon Offsetting and Reduction Scheme for International Aviation
EIA	Environmental Investigation Agency
ETS	Emission Trading System
GCI	Green Cooling Initiative
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH
GWP	Global Warming Potential
HCFC	Hydrochlorofluorocarbon
HFC	Hydrofluorocarbons
HPMP	HCFC Phaseout Management Plan
IPCC	Intergovernmental Panel on Climate Change
ITMO	Internationally transferred mitigation outcome
KA	Kigali Amendment
LT-LEDS	Long term – Low emissions development strategies
LVC	Low Volume Consuming
MEA	Multilateral environmental agreement
MLF	Multilateral Fund
MP	Montreal Protocol
MRV	Measuring, reporting and verification
NAMA	Nationally Appropriate Mitigation Action
NDC	Nationally Determined Contribution
ODS	Ozone Depleting Substance
OMGE	Overall Mitigation in Global Emissions
PA	Paris Agreement
RAC	Refrigeration and air conditioning
RTF	Replenishment Task Force
SB	Supervisory Body
TACCC	Transparency, Accuracy, Consistency, Comparability, Completeness
TEAP	Technology and Economic Assessment Panel
UNFCCC	United Nations Framework Convention on Climate Change
VCM	Voluntary Carbon Market

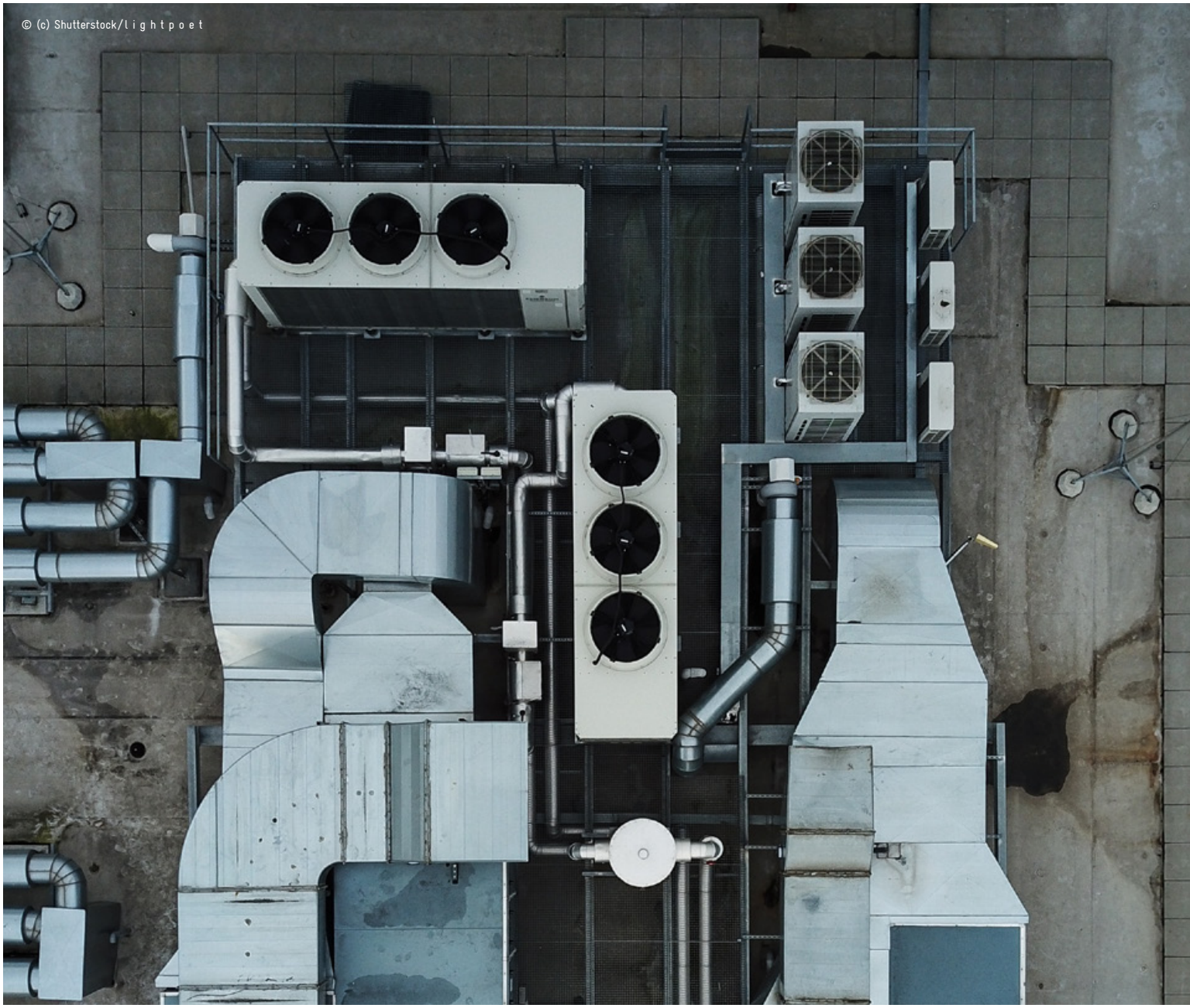
Executive Summary

The Kigali Amendment (KA) to the Montreal Protocol (MP) is the only multilateral environmental agreement (MEA) that includes a mandatory set of reduction targets for a key category of greenhouse gases (GHGs), hydrofluorocarbons (HFCs) that primarily serve as refrigerants. The baseline for these reduction targets will be set on the basis of the average HFC amount that is consumed now and in the immediate future. For most developing countries, the baseline period are the years 2020-22, with an exception for some countries with very high ambient temperatures (baseline period 2024–26). Activities that reduce HFCs in or before these baseline period years have a long-term mitigation benefit. Such activities could be mobilized through revenues from sale of emission credits through the international carbon markets under Art. 6 of the Paris Agreement (PA). The stringency of nationally determined contributions (NDCs) for GHG mitigation under the PA is highly relevant for the international carbon markets. If NDCs are not stringent but their targets are less ambitious than a business-as-usual (BAU) emissions path (thus creating 'hot air'), there is the risk that emissions credits do not reflect real reductions and actually lead to an increase in global emissions.

Baseline definitions for HFC emission levels under the KA, NDCs and Art. 6 differ. The former relates to production and consumption of HFCs, the latter two to HFC emissions. The link between these parameters can be made if one knows the temporal characteristics of HFC emissions occurring during the lifetime of refrigeration, air conditioning and cooling (RAC) equipment and at the point of its disposal. This means that there is a time lag between consumption and actual emissions that can reach over a decade.

A problematic feature of the KA baseline is the 'HCFC adder'. Developing countries (referred to as Article 5 countries under the Montreal Protocol) can add 65% of the HCFCs consumed in 2009-10 to the actual HFC consumption in the baseline period. The adder was brought into the KA negotiations because HCFC phase-out plans require developing countries to reduce consumption to 65% of 2009-10 values by 2020 and negotiators assumed countries would opt for this value. However, many Article 5 countries (for example Ghana, Kenya, Mexico, Namibia and the Seychelles), have reduced HCFC consumption much faster, some even to zero, due to financial support from the Multilateral Fund for the Implementation of the Montreal Protocol (MLF). The countries with a strong HCFC reduction therefore get a severely overestimated KA baseline. We have looked at the three countries Costa Rica, Seychelles and Vietnam and found an overestimate of over 80% for the Seychelles. For Costa Rica and Vietnam, the overestimate is much lower at 10-20%. With a rising BAU for HFC emissions, the overestimate vanishes for Costa Rica and Vietnam in the second half of the 2020s but persists in the Seychelles until 2040. We find that the situation is opaque for many countries that do not publish sufficiently disaggregated figures on installed RAC equipment and corresponding HFC consumption patterns, thus a concerted effort to collect and publish these data is essential.

In order to prevent generation of 'hot air', NDCs should be based on a realistic HFC BAU path. We therefore suggest that Article 5 countries do not apply the full HCFC adder to get the KA baseline but voluntarily only apply the adder to a percentage that is consistent with BAU. This allows to translate the KA baseline into NDC and Article 6 baselines under the PA.



1. Introduction

1.1 Background

In the context of climate change mitigation, the cooling sector has often been neglected and not considered in national climate targets and strategies, even though it holds a significant GHG reduction potential. Increasing ambient temperatures and seasonally extreme temperatures (Xu et al. 2020), a growing population, a trend for urbanization and finally rising incomes especially in developing countries will drive an increasing demand for refrigeration and air condition (RAC) devices in the next decades (GIZ 2016). As a result, emissions from HFCs which are used as refrigerants in cooling equipment and represent potent $GHGs_1$, are estimated to increase at a rate of 10–15% per year, resulting in a projected twenty-fold increase by 2050 (Sovacool et al. 2021). HFCs are widely used as a replacement for Ozone Depleting Substances (ODS), namely hydrochlorofluorocarbons (HCFCs) since the latter are currently being reduced under the MP. HCFCs shall be completely phased-out by developing countries until 2030 (UNEP 2020). Alternative solutions to high GWP HFCs, such as natural refrigerants, are already available. Through the implementation of the KA to the MP, which targets the reduction of HFC production and consumption, these low GWP solutions will increasingly be used. It is estimated that the KA can reduce global warming by up to 0.5°C (Birmpili 2018; Velders et al. 2017) and generate GHG emissions reductions of 210–460 billion t CO_2e through refrigerant replacement combined with energy efficiency improvements of cooling equipment by 2060 (Dreyfus et al. 2020). Purohit et al. (2018) calculate cumulative HFC emissions reductions for Asia by 22 billion t CO_2e over the period 2018 to 2050, 61% below business-as-usual. Höglund-Isaksson et al. (2017) calculate the marginal cost of meeting the KA targets as less than 60 €/t CO_2e throughout the period in all world regions, with marginal costs of HFC reduction for many solutions in industrial and commercial refrigeration as well as for residential ACs being negative. Given that most carbon pricing systems around the world until very recently reached values of less than 20 €/t CO_2e, and only in 2021 the threshold of 50 €/CO_2e, was reached by the EU emissions trading scheme (EU ETS), the more expensive mitigation options would not be mobilized by current carbon pricing.

However, since the first HFC reduction step of 10% under the KA will only take effect from 2029 for most developing countries, there is still the risk for a lock-in of high quantities of HFC emissions from production and consumption in the time up to that point as discussed in the following in this report. Purohit et al. (2018) stress that Asia could technically reduce 9 billion t CO_2e by 2050 from the KA baseline. According to the rules established by the KA, developing countries will calculate their HFC baseline emissions in CO_2e as the sum of two components:

1. the average annual HFC quantity consumed and produced during a 3-year baseline period (e.g., 2020–22 for most[2], 2024–26 for some countries)[3];
2. a default value of 65% of average HCFC production and consumption in the years 2009 and 2010 (KA Article 5c) for which we use the term 'HCFC adder' in this report (noting that this is not an official term under the KA). The argument to include the HCFC adder in the baseline was that countries would find it difficult to comply with the phase-down of HFC consumption while at the same time having to phase-out HCFCs under the MP (Laßmann et al. 2021).

High emission levels from HFC production and consumption until the reduction step in 2029 would not be in line with the mitigation pathway necessary to achieve the PA goal of limiting global warming to 'well below 2°C'. Purohit et al. (2018) assessed that full compliance with the KA would result in global HFC emission levels that are 87% lower than in the projected BAU scenario for the period 2018 to 2100, whereas the maximum technically possible emission reductions are considered about 10% higher with up to 97% reduction potential compared to BAU. A faster phase-down would not only avoid a significant quantity of emissions, but would also prevent the building and piling up of additional HFC

1 The global warming potential of HFCs ranges from several hundred to several thousand times that of CO_2.

2 Article 5 countries, Group 1: "Any Party that is a developing country and whose annual calculated level of consumption of the controlled substances in Annex A [Chlorofluorocarbons (CFCs) and halons] is less than 0.3 kilograms per capita on the date of the entry into force of the Protocol" (UN 1989)

3 Article 5 countries, Group 2: Bahrain, India, Iran, Iraq, Kuwait, Oman, Pakistan, Qatar, Saudi Arabia, UAE (UNEP Ozone Secretariat 2020b)

banks (IGSD 2018) Velders et al. (2014) estimate that with an earlier phase-out of HFCs in 2020, cumulative emissions of up to 146 $GtCO_2e$ could have been or could be mitigated in the period 2020–2050, plus an additional bank of approx. 39–64 $GtCO_2e$. Here, leapfrogging to sustainable cooling technologies that use low-GWP (natural) refrigerants is necessary to achieve both the KA and PA objectives. However, this requires a significant amount of funding which would exceed the funding available through the Multilateral Fund (MLF) of the MP. In order to estimate the funding requirement for the replenishment of the MLF, the Technology and Economic Assessment Panel (TEAP) was tasked by the Thirty-First Meeting of the Parties (MOP31) to assess the future costs of the HFC phase-down. The TEAP established a Replenishment Task Force (RTF) and submitted its report in May 2020. The indicative total costs for the HFC phase-down (consumption sector) of all Article 5 countries is forecasted to be USD 4.121 billion. The report also analyses opportunities for early activities focusing on high growth rates of HFCs, and particularly measures that aim to avoid the switch to high-GWP HFCs and the accumulation of high GWP banks – so called "close the tap" activities. But while costs for such measures like e.g., promoting the availability and accessibility of lower GWP technologies for end-users or equipment replacement programmes, are estimated at USD 10–65 million for the 2021–23 triennium, total forecasted funding requirement for the HFC consumption sector phase-down in the same period ranges between USD 58.2 and 292.7 million. For the subsequent triennia, costs are projected to increase to USD 801–942 million (2024–26) and 861–1063 million (2027–29). This includes both HCFC and HFC measures. So far, the budget of the MLF has usually been around USD 450–570 million per triennium, so is likely to be insufficient unless increased substantially (TEAP 2020). The Environmental Investigation Agency (EIA), in a comment to the TEAP report, argues that more funding is needed to promote leapfrogging to low and zero GWP solutions and to avoid the transition to mid GWP HFCs (EIA 2020).

With the exception of a proposal for an HFC reduction financing facility by Cseh (2018), no suggestion has been made internationally how to generate this financing. Michaelowa et al. (2019a) thus propose crediting HFC mitigation activities in the RAC sector through the international carbon market under Article 6 of the PA before the implementation of the KA begins, thereby lowering the baseline HFC production and consumption from which the KA phase-down schedule is calculated. Article 6 has stringent rules for safeguarding environmental integrity[4] so only activities that go beyond business as usual will qualify. Economically attractive activities will not be able to do so (Michaelowa et al. 2019b). Through the tightening of the KA phase-down path, this would generate long term GHG emission reductions. Moreover, KA obligations on reducing HFC production and consumption should be considered in the RAC-sector emission reference scenarios of NDCs[5] that countries need to submit as Parties to the PA. By lowering the crediting baselines below KA and NDC commitments, early market-based cooperation under Article 6 of the PA would thus 'raise ambition' in NDC implementation. However, this can only be the case if the original HFC consumption and production baseline levels for the KA reference level are conservatively estimated. Otherwise, environmental integrity of HFC reduction-based emission credits would be compromised (Michaelowa et al. 2019a). While some observers fear that the prospects of generating emission credits through Article 6 could lead to an artificial inflation of HFC consumption and production patterns before the baseline period these fears are unfounded. Firstly, Art. 6 activities would ideally be implemented prior to or during the baseline period years which determine the baseline level for the HFC phase-down. Most Article 5 countries (Group 1) are already in this period (2020–22). Hence, increase of consumption and production would have had

4 Environmental integrity is a key principle for Article 6 market mechanisms. This means that any emission reduction generated by an Article 6 activity must be additional to what is already being done or planned to be implemented and cannot lead to a higher overall level in emissions.

5 The Paris Agreement (Article 4, paragraph 2) requires each Party to "prepare, communicate and maintain successive nationally determined contributions (NDCs) that it intends to achieve. Parties shall pursue domestic mitigation measures, with the aim of achieving the objectives of such contributions." (UNFCCC 2015). These NDCs shall contribute to the collective achievement of the long-term targets of the Paris Agreement. Every five years, Parties need to communicate new or updated NDCs which showcase a progression in ambition levels.

to happen in the past. The MLF funding cut-off dates for production facilities in 2020 and for Group 2 Parties in 2024 have similar impacts.

1.2 The role of baselines for international climate policy

In climate policies that aim to mobilize emission reductions, mitigation is often defined with respect to a 'baseline'. A baseline can be set in different ways, inter alia:

1. Through projection of a likely scenario of emission development in the future, e.g., through the definition of a likely 'business-as-usual' (BAU) scenario (whereby definitions of BAU can vary widely), in continuation of a historical emission trend, in projection of average performance of technologies and techniques in a sector or in projection of best available performance of technologies or techniques in a sector.
2. Through projection of an emission pathway necessary to move from the current level of emissions to achieve a target level of emissions/ a cap.

The difference between observed emission levels and the calculated reference level, determined by the 'baseline' or cap, is then defined, and quantified as emission reduction.

A 'baseline' can also be calculated for other parameters than emissions, e.g., HFC consumption and production, in the same manner.

1.3 Objectives

This study discusses approaches to baseline-setting used by the KA under the MP and the PA under the United Nations Framework Convention on Climate Change (UNFCCC). It elaborates the effect of the 'HCFC adder' on the KA baseline and illustrates it with country-specific examples. It provides policy recommendations how to deal with potential risks of the 'HCFC adder' on environmental integrity of NDCs and international carbon markets under the PA, while pursuing the aim to positively influence countries' ambitions in GHG mitigation by applying a harmonized approach to the compliance with both multilateral agreements.

The three following types of 'baselines' are:

The baseline expressing fixed HFC production and consumption levels plus HCFC adder (converted in CO_2e according to the GWP of the different HFCs and HCFCs) under the KA that determines the KA phase-down pathway for each Article 5 country. We will refer to this as 'KA baseline', while it is rather a step-wise lowering of a cap in production and consumption of HFCs. Text box 2 provides further information on the HCFC adder.

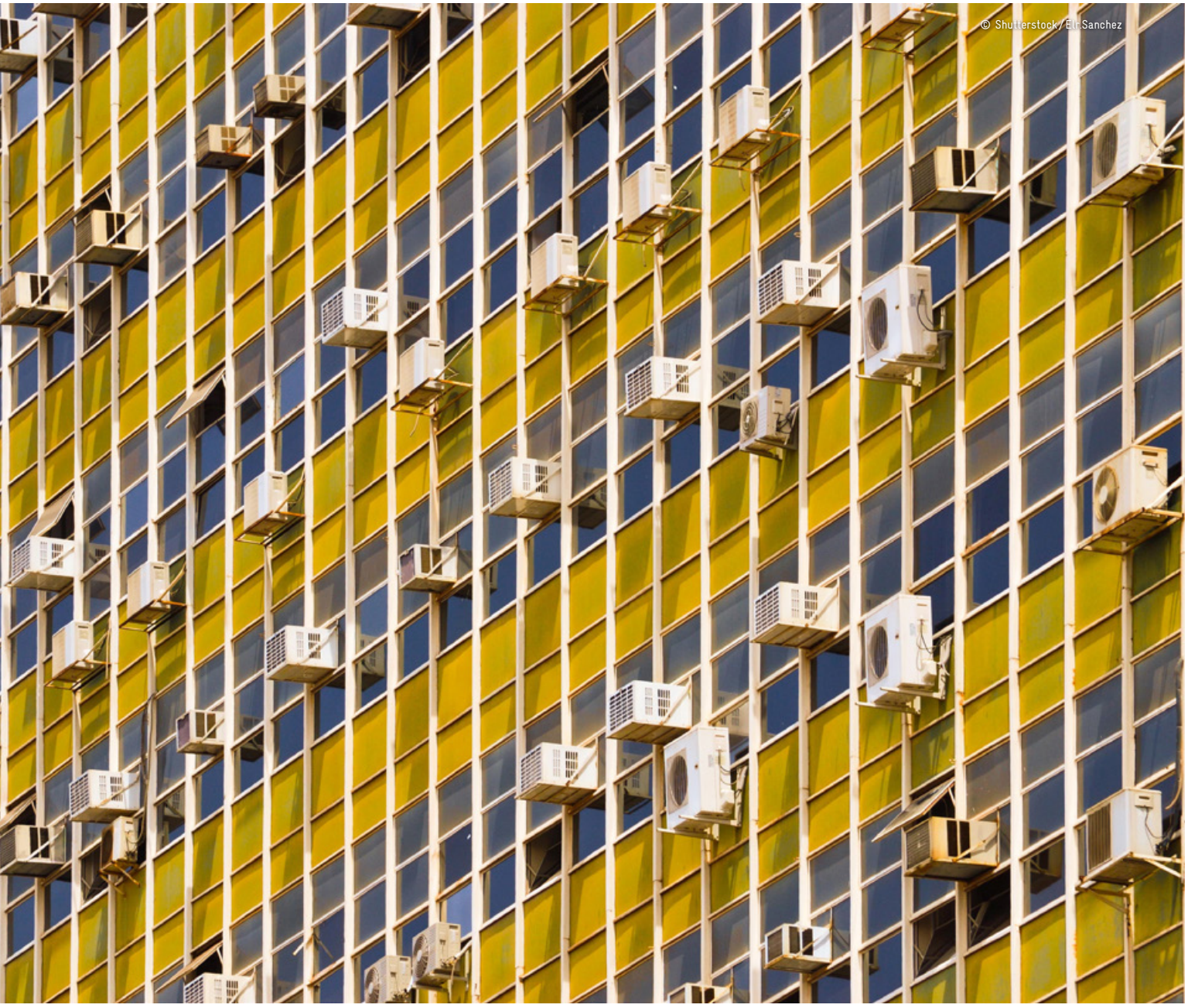
1. The GHG emission baseline over a certain period against which Parties of the PA set their NDC targets for the economy and/or specific sectors. We will refer to this as 'NDC reference scenario'.
2. The crediting baseline applied in market-based cooperation under Article 6 of the PA that serves as reference from which emissions of an Article 6 activity are deducted to calculate the amount of emissions credits (in tCO_2e) available for transfers on carbon markets. This crediting baseline must safeguard environmental integrity and contribute to ambition in mitigation as per the principles of Article 6 of the PA. We refer to this as 'Article 6 baseline'.
3. Our approach is to use the KA baseline as upper limit to the NDC reference scenario and ensure that the Article 6 baseline is not set on the basis of an overly high NDC reference scenario, as this would not be in line with the requirements of environmental integrity.

An initial assessment of the CO_2e level of reported HFC consumption, undertaken as part of the Green Cooling Initiative (GCI) project Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH showed a very important role for the 'HCFC adder' for many developing countries, namely Costa Rica, Indonesia, Iran and Vietnam (Laßmann et al. 2021, Michaelowa 2020). For some countries, this adder leads to KA baseline levels that are massively higher than projected levels of HFC consumption.

In this study, we therefore undertake an in-depth assessment of Art. 5 country group HFC consumption paths and estimated KA baseline levels. This includes the assessment and quantification of HFC consumption and emissions patterns of several countries including the effect of the HCFC adder on KA baseline setting; the analysis of reasons for KA baselines levels that are massively higher

than projected levels of HFC consumption; and finally, the identification of characteristics of countries that show this effect.

Based on the results of the assessment, implications on NDC reference scenarios and Article 6 baselines are drawn. Finally, the study analyses and discusses how Art. 6 cooperation and robust baseline-setting therein can serve to both, an increase in ambition of NDCs through robust NDC reference scenarios and the HFC phase down under the KA.



2. Two international regimes addressing HFCs

As explained in the introduction to this paper, both the UNFCCC and the PA (the "climate regime") as well as the MP through its KA ("the ozone regime") address mitigation of HFC emissions. Both regimes are closely intertwined as most ODS also have a GWP, so that action under the ozone regime has repercussions for climate action. Still, both multilateral environmental agreements (MEA) have their own focus: the MP aims to introduce control measures for production and consumption of gases, while the UNFCCC focusses on reducing their emissions (UNEP Ozone Secretariat 2016). Therefore, regulatory measures under both regimes are not having the same scope. It thus becomes critical to ensure synchronising action under these two regimes to ensure that they achieve climate change mitigation.

2.1 Bottom-up vs. top-down definition of commitments

The MP first established regulations to reduce production and consumption of ODS based on a 'start and strengthen' model that began with actions for certain ODS, namely chlorofluorocarbons (CFCs) and expanded on to further ODS. Decisions by the Parties on regulations often were taken in consideration of scientific and technological information provided by the TEAP, its Technical Option Committees (TOCs) and the Scientific Assessment Panel (SAP). While the schedules for phase-out or phase-down of ODS were imposed, each Party can decide on the instruments on how to meet these goals (Roberts 2018). Thereby, the compliance obligations imposed to its Parties are informed by the globally available and technical feasible options. The obligations are underpinned by incentives for ratification, particularly trade measures that restrict the trade between Parties and Non-parties, and compliance systems. In addition, developing countries can access funding from the MLF to cover the marginal costs of compliance. Funding guidelines of the MLF are negotiated by Parties.

With the adoption of the KA in 2016, the MP extended its scope to also control the reduction of HFCs internationally. The KA entered into force in 2019 and as of February 2021 has been ratified by 113 parties (UN Treaty Collection 2021).

Table 1: Overview of KA HFC phase-down schedule

	Art. 5 Group 1	Art. 5 Group 2
Baseline years	2020 – 2022	2024 – 2026
Baseline calculation	Average production and consumption of HFCs in 2020-2022 + 65% of HCFC baseline	Try to restri Average production and consumption of HFCs in 2024–2026 + 65% of HCFC baseline
Freeze year	2024	2028
Reduction Step 1	2029 – 10%	2032 – 10%
Reduction Step 2	2035 – 30%	2037 – 20%
Reduction Step 3	2040 – 50%	2042 – 30%
Reduction Step 4	2045 – 80%	2047 – 85%

Source: authors' own elaboration based on UNEP 2020

For most Article 5 (developing) countries[6], the phase-down of HFCs will start with a freeze of consumption in 2024, followed by reduction steps of 10% in 2029, 30% in 2035 and 50% in 2040. The final target is to achieve 80% reduction of HFC consumption compared to baseline levels in 2045 (UNEP 2020). Thereby, the KA imposes a top-down, harmonised mitigation pathway to different groups of Parties, while respecting national "start" conditions through the calculation of the baseline.

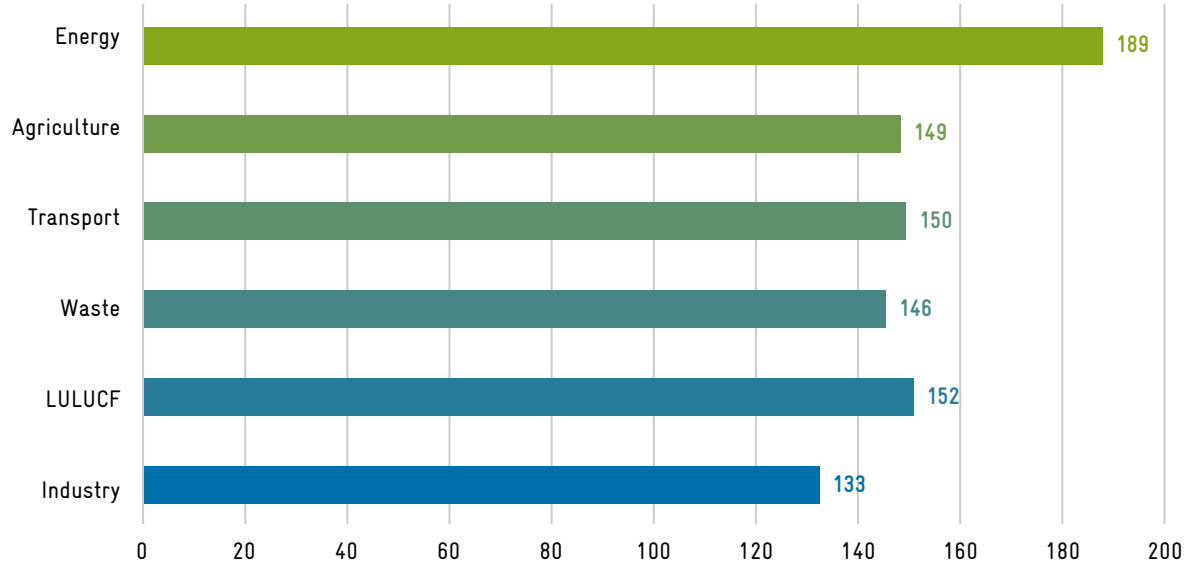
The KA contains two central incentives for ratification: First, Parties agreed to introduce mandatory national HFC import and export licensing systems by January 1, 2019, covering all virgin, recovered, recycled, and reclaimed HFCs and mixtures containing them. Secondly, on January 1, 2033 a ban on trade with non-Parties will enter into force (UNEP nD; Roberts 2017, Michaelowa et al. 2019a).

HFCs are also part of the basket of GHGs under the UNFCCC and thereby also under the PA and must be reported upon by the Parties to these agreements. The PA enshrines three collective commitments of its Parties in its Article 2 (UNFCCC 2015):

1. Holding the increase in global average temperature to well below 2°C, while pursuing efforts to limit global warming to 1.5°C above preindustrial levels.
2. Increasing the ability to adapt to the adverse impacts of climate change.
3. Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development.

The PA, in contrast to the Kyoto Protocol (KP), does not establish top-down defined mitigation targets but Parties put forward mitigation commitments through NDCs based on their own assessment of mitigation opportunities in their economic sectors. In implementing their NDCs, Parties are free to choose the measures, policies, and regulations to achieve these commitments. Developed country Parties must take the lead in mitigation efforts and provide support to developing country Parties through capacity-building, technology development and transfer and climate finance, the so-called "means of implementation". International finance for achievement of NDCs can be mobilized through the channels of climate finance and through voluntary cooperation in international

Figure 1: Sectors covered by NDC mitigation targets (as of April 2021)



Source: IGES (2021)

6 Article 5 group 1 parties; for Article 5 group 2 parties freeze will start in 2028 and the first reduction step of 10% will take place in 2032.

Table 2: Overview of RAC sector inclusion in selected countries

Country	HFC included in NDC	RAC sector mentioned	Comments
Colombia	Y	Y	Reduction of GHG emissions from the use of ODS HFC substitutes Introduction of environmentally friendly refrigerators to the market Refrigeration waste management Reduction of energy consumption in AC by 40%
Costa Rica	Y	Y	Costa Rica confirms the commitments established in the KA to phase down HFCs and promote low GWP refrigerants. By 2030 Costa Rica will have developed and/or updated energy efficiency standards and regulations for end-use technologies (including, but not limited to, refrigeration and air-conditioning)
Ghana	Y	Y	Green Cooling Africa Initiative - Abatement of fluorinated-gases (HCFC-22 and HFC-410a) from stationery ACs
Kenya	Y	N	
Mexico	Y	Y	National Cooling Strategy, as part of the compliance with the KA, which promotes HFC reduction actions
Namibia	N	N	
Senegal	Y	Y	Includes commitments under the KA to phase down HFCs by 80% in 2045 With the help of the international community, outside of the MP, the phase-down may be accelerated under the KA
Seychelles	N	Y	New Regulations on the use of air-conditioning, target of 20% energy savings in the service sector New Building Code for household dwellings (features natural ventilation, roof insulation, etc., target of 50% energy savings on fans & air-conditioning in households by 2035
Thailand	Y	N	
Tunisia	N	N	
Vietnam	Y	Y	Reducing consumption of HFCs

Y = yes; N = no

Source: authors

carbon markets (see chapter 3.3). Over time, all NDCs should progress towards economy wide emission reduction commitments relating to all GHGs, as well as an increase in carbon sinks.

Parties must submit information to enhance the clarity, transparency and understanding of their NDCs and regularly report on progress made in implementation and robustly account for the achievements of the targets put forward. While there is a Compliance Committee, the process under the PA is to be "facilitative" and "non-punitive" in nature. Every five years, in a global stocktaking process, Parties will assess whether the implementation of NDCs and the ambition levels expressed therein are sufficient to meet the long-term objectives. Parties are also invited to submit long-term strategies that provide the long-term horizon on NDCs. Parties' NDC updates are then to be informed by the outcome of these processes. Baselines and reference levels for mitigation action under the PA are therefore informed by national assessments of emission levels and mitigation assessments, but also assessments of the International Panel on Climate Change (IPCC) on the emission levels and mitigation efforts necessary to achieve the PA's long-term targets (UNFCCC 2021a).

In the first round, HFCs were neglected by many countries and accordingly not included in NDCs. According to the IGES NDC database (2021), 86 NDCs submitted to the UNFCCC contain HFCs in their scope and 133 Parties embed the industry sector in their targets (where HFC emissions from refrigerants are usually reported).

Currently, countries are in the process to prepare their updated NDCs which offers the opportunity to integrate the sector with its mitigation potential and appropriate mitigation measures. The following table gives an overview of the coverage of HFC and/or the RAC sector in the NDCs of the countries that are included in the assessment of HFC emissions paths in chapter 4 of this study.

Potential mitigation measures in the RAC sector range from interventions at the activity level such as replacement programmes for a specific technology or application to the sectoral and policy level, for instance through the introduction of specific policy instruments to promote the use of low GWP refrigerants (e.g., a staggered tax system).

Some countries already benefit from the experience of on-going activities, for instance a NAMA for the domestic refrigeration sector which is currently being implemented in Colombia and targets the production line conversion of domestic manufacturers combined with a replacement programme for old, inefficient and climate damaging appliances at the household level (NAMA Facility 2020). Costa Rica runs a pilot for the installation of energy efficient split air conditions that use natural refrigerants (propane) to demonstrate the feasibility of the technology and, at the same time, train technicians in the proper handling of such equipment (GIZ 2020b). In the context of these projects, countries have defined own methodologies to estimate GHG emissions reductions from the substitutions of the HFCs.

2.2 Market-based instruments as tool for implementation

While the MP can be characterized as a "top-down" MEA that relies on command-and-control instruments, directly regulating production and consumptions levels of HFCs, the PA can be characterized as a "bottom-up" regime based on transparency and accountability on mitigation action to enable achievement of collective targets. However, in implementing the commitments of Parties under both regimes, governments can choose between different policy instruments to support the adoption of low-carbon technologies:

Market-based instruments have proven to be a tool to help governments identify cost-effective mitigation options in their country, by providing a monetary incentive for private sector action. Thereby, market-based instruments have also proven useful to overcome challenges of asymmetric information, as usually it is the private sector with the best understanding of mitigation potentials in economic sub-sectors but access to this information is challenging for the public authorities. International market-based collaboration is a tool to channel private and public finance investments from countries with comparatively high marginal abatement costs (typically industrialized countries) in countries with comparatively lower marginal abatement costs but higher barriers in adoption of low-carbon technologies, which is mostly developing countries. Thereby, and in the context of robust rules that

Table 3: The "toolbox" to drive GHG mitigation action and MP implementation

Regulation	Adress behavioral barriers: misaligned incentives, behavioral inertia, etc.
	E.g., efficiency standards, building codes, technology standards
Information	Address non-market barriers relating to lack of information, capacity gaps.
	E.g., product labelling, information campaigns, education policies, etc.
Subsidies and strategic investments	Address technological innovation and systemic long-term change.
	E.g., R&D subsidies, direct support for low-carbon technologies, public infrastructure investments, urban planning, etc.
Market-based instruments	Address barriers related to the relative price of products and services on the market; provides an economic incentive to market players to reduce pollution.
	E.g., direct carbon pricing instruments in climate policy (carbon tax, cap-and-trade systems, baseline-and-credit instruments); quota or allowance trading in ODS and HFC management policy.

Source: authors

safeguard environmental integrity, international market-based cooperation lowers the cost for reaching mitigation commitments for all Parties involved.

Market-based instruments are also employed by Parties to comply with MP commitments. Quota systems that allow for trading between importers and consumers are a known instrument under the MP; they have been used as HCFC phase-out policy instruments in Australia and the US. Trading of quotas helps avoiding the "first come-first serve" approach of quota allocation, which prevents new importers to enter the market and may lead to corruption (UNEP 2012).

One example for a HFC quota and trading system is the EU's F-gas regulation. While HFCs are not covered by the EU-ETS, the EU has imposed a system of annual quotas that are allocated to producers and importers. The quantities in quotas are being gradually reduced as this "has been identified as the most effective and cost-efficient way of reducing emissions of those substances" (EU 2014, paragraph 14). These quotas are transferrable and are traded on the market "to maintain the flexibility on the market" (EU 2014, paragraph 19). The price of HFCs is strongly affected by the reduction in quotas. Prices peaked in 2018 due to scarcity created in the quota system but have decreased since as more climate-friendly alternatives to high GWP HFCs become available. Quota-induced carbon prices were significantly higher than EU ETS allowance prices before 2019, reaching peak values of around 40 €/t CO_2e. The high prices on high GWP HFCs until 2018 increased the relative cost-attractiveness of natural alternatives such as CO_2, ammonia, and propane (European Commission 2020).

This market-based instrument is complemented by further regulations, in particular import and export licenses (as mandated by the MP and labelling requirements (European Commission nD). A similar approach is undertaken by Australia since 2018 (Australian Government nD).

Tradeable quotas for HFC imports establish indirectly a carbon price for these substances. In addition, governments adopt regional, national, and subnational

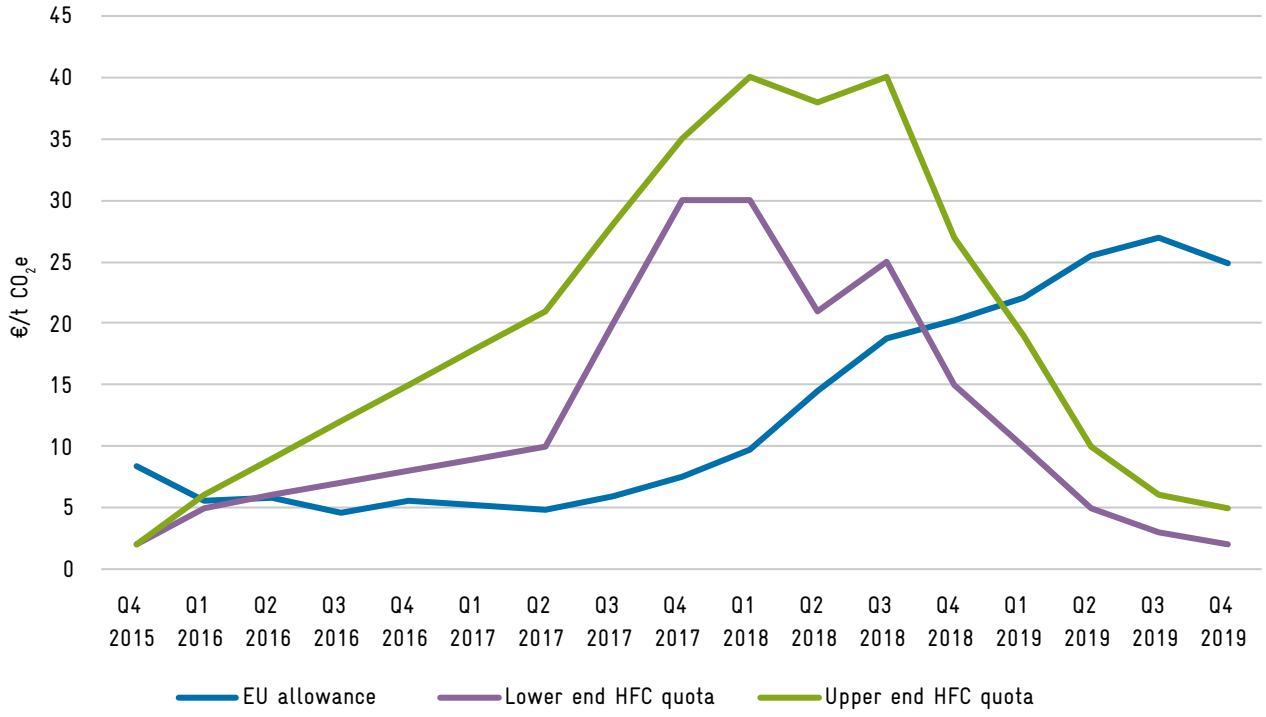
Text box 1: The history of HFC-23 mitigation under the CDM

The CDM, established under the KP of the UNFCCC was a pioneer baseline-and-credit mechanism that mobilised finance for generating Certified Emission Reductions (CERs) in developing countries that could be used in industrialised countries for compliance with their KP mitigation targets, that were defined top-down as a carbon budget. There are several methodologies under the CDM that can be used to generate credits for the mitigation of HFC emissions. The most prominent- and controversial- activity under the CDM on HFC mitigation was on decomposing fluoroform (HFC-23) waste streams formed as by-product in the production process of HCFC-22. While some climate policy specialists had stated for several years that HFC-23 reduction would be relatively straightforward and low-cost, there was no incentive to do so in developing countries. The approval of methodology AM0001 by the CDM EB in 2003 led to a high private sector interest in this activity type in China and India. However, the massive amount of CERs that could be generated at relatively low cost brought a perverse incentive to increase production of HCFC-22 to just generate CERs for HFC-23 decomposition and give away the HCFC-22 for free. Therefore, the CDM EB revised the methodology, limiting the use of the methodology to plants that had operated for at least three years before the end of 2004. In the context of persistent criticism from NGOs, the methodology was revised a second time with no possibility to generate credits for increased HCFC-22 production. However, after the EU prohibited their use from 2013 onwards, CERs from HFC-23 projects became a "nonsalable" commodity. Under the KA, destruction of HFC-23 will become mandatory as practicable to an extent of 99.99%, based on the experience gained and methodologies developed under the UNFCCC. The CDM acted as a search engine for mitigation opportunities that are now taken up by regulation under the KA (see a detailed discussion in Michaelowa et al. 2019a).

direct carbon pricing instruments, mostly taxes and emission trading systems in their efforts to comply with UNFCCC and PA commitments. Furthermore, there are international carbon pricing initiatives, for instance the Carbon Offsetting and Reduction Scheme in International Aviation (CORSIA). Also, carbon credits are transferred internationally and used for compliance, voluntary offsetting purposes or results-based climate finance (World Bank 2020). The best-known international crediting mechanism is the Clean Development Mechanism (CDM), established by the KP. This mechanism also mobilized finance for large-scale and small-scale HFC mitigation measures in developing countries (see Text box 1). From 2005 to 2011, the CDM experienced a "gold rush period" mostly due to demand from the EU ETS, followed by a slump in prices after compliance demand faltered in the second commitment period of the KP and concerns over environmental integrity and sustainable development benefits of the activities undertaken in the mechanism hampered voluntary demand. Under the PA's Article 6, there is new impetus for international market-based cooperation, which includes both linkages of ETS across jurisdictions and international transfers of carbon credits (World Bank 2020, Michaelowa et al. 2020a).

In the following, we discuss further how international market-based cooperation can be designed as a useful tool for HFC mitigation under both regimes and mobilize finance for mitigation in developing countries.

Figure 2: Prices for EU HFC quotas and EU ETS allowances (€/t CO_2e)



Data sources: EU allowances: ICAP (2021); HFC quotas: European Commission (2020), p. 8.

3. Potential synergies between the Paris Agreement and the Kigali Amendment

Ideally, to maximize ambition and synergies between the two regimes countries would develop and follow an integrated approach to reduce HFC emissions. If countries are not able to finance these measures through domestic means, funding can be mobilized through the MLF (for compliance with KA phase-down) or climate finance sources to go beyond (e.g., the Green Climate Fund). In addition, international finance, from both public and private sources, can be mobilized through the exploitation of Art. 6 market-based approaches under the PA. Concerted action to comply with obligations under both regimes offers significant benefits in mitigation ambition and economic development in the host countries. However, one must consider significant and fundamental differences in the underlying regulatory and procedural framework of the two agreements.

3.1 Synchronising accounting under both regimes

Whereas under the UNFCCC, Parties report on and consider the full set of HFC emissions occurring during the lifecycle of a cooling device, i.e., from production, operation (in-use) and end-of-life respectively disposal of the equipment, the KA only considers the production and consumption of HFCs without looking at the point in time when these HFCs are emitted. Consequently, the KA mandates Parties to control and report HFC production and consumption mainly derived from the quantity of produced, imported, and exported substances which is then translated into CO_2e by using the corresponding value of the global warming potentials (GWPs). Translating these different approaches to estimate emission levels in corresponding methods recommended by the 2006 Intergovernmental Panel on Climate Change (IPCC) guidelines for National GHG Inventories, one can differentiate potential and actual emissions. The IPCC guidelines suggest four different approaches that reflect and estimate emissions at various levels of aggregation:

GHG inventories in the RAC sector in developing countries often apply the concept developed and outlined in the Handbook for Nationally Appropriate Mitigation Actions (NAMA[7]) in the RAC sector (GIZ 2014) which is mainly based on the IPCC 2006 guidelines, and more specifically the Tier 2 emission factor approach for the

Table 4: Overview of IPCC 2006 Tiers and approaches relevant for HFCs

	Emission factor approach (a)	Mass-balance approach (b)
Tier 2 (emission estimation at a dis-aggregated level)	Data on chemical sales and usage pattern by sub-application [country-specific or globally/regionally derived] Emission factors by sub-application [country-specific or default]	Data on chemical sales by sub-application [country-specific or globally/regionally derived] Data on historic and current equipment sales adjusted for import/export by sub-application [country-specific or globally/regionally derived]
Tier 1 (emission estimation at an aggregated level)	Data on chemical sales by application [country-specific or globally/regionally derived] Emission factors by application [country specific or (composite) default]	Data on chemical sales by application [country-specific or globally/regionally derived] Data on historic and current equipment sales adjusted for import/export by application [country-specific or globally/regionally derived]

Source: IPCC (2006)

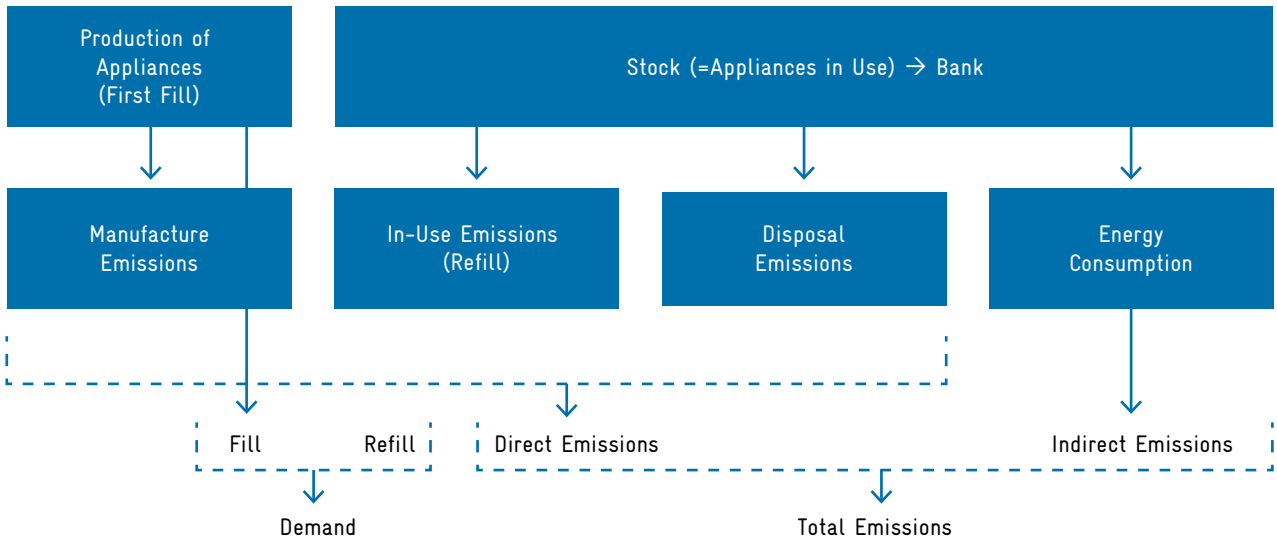
7 Parties to the UNFCCC agreed at COP18 that developing countries will engage in NAMAs in the context of sustainable development. NAMAs refer to any action that reduces emissions in developing countries prepared under the umbrella of a national government initiative. AMAs are supported and enabled by technology, financing, and capacity-building and are aimed at achieving a reduction in emissions relative to 'business as usual' emissions in 2020 (UNFCCC 2021b).

RAC sector[8] (IPCC 2006). This means that historic and future emissions are modelled based on stock and market/production data (number of appliances/units). Emissions are estimated via emission factors during manufacturing, use and disposal of the appliances. The following figure provides an overview of data and information that are required for and included in the calculation.

The approaches under UNFCCC, i.e., Tier 1 and Tier 2, take into account a time lag between the consumption of HFC refrigerants and emissions. HFC emissions occur mostly through leakage in equipment over time and importantly, at the point of disposal of equipment. For instance, residential air conditioners need to be serviced with refrigerant regularly (see Figure 5). Household refrigerators, on the other hand, are rarely re-filled during their lifetime. Here it can be assumed that a large proportion of the refrigerant-related emissions are released at the end of life if they are not disposed of properly (Figure 4). The KA only accounts for the consumption in the specific year, e.g., filled into specific equipment. This means that, in the PA context, actual HFC emissions are accounted for and reported, whereas, under the KA framework, production and consumption would equal potential emissions. The longer the lifetime of equipment, the bigger the time difference in potential and actual emissions, meaning that with each additional year of operation of an appliance the time gap between the potential emissions which are accounted for due to the initial filling of the equipment and the larger part of the actual emissions which occur at the end of the equipment's lifetime is widening. This leads to the fact that emission levels cannot be directly compared and aligned. The following two figures show the difference between potential and actual emissions using the two concrete examples mentioned before – a domestic refrigerator and a split air conditioner.

Also, the coverage of GHGs in the RAC sector differs between both regimes. Parties' commitments under the UNFCCC only relate to 'gases not controlled by the MP'. Before the adoption of the KA, HFCs were only included in the basket of GHGs under the UNFCCC (alongside CO_2, CH_4, N_2O, PFCs and SF_6). With the adoption of the KA there is now an overlap. Also, the PA does not adhere to this clear demarcation anymore and no longer references that it only extends to 'gases not controlled by the MP'.

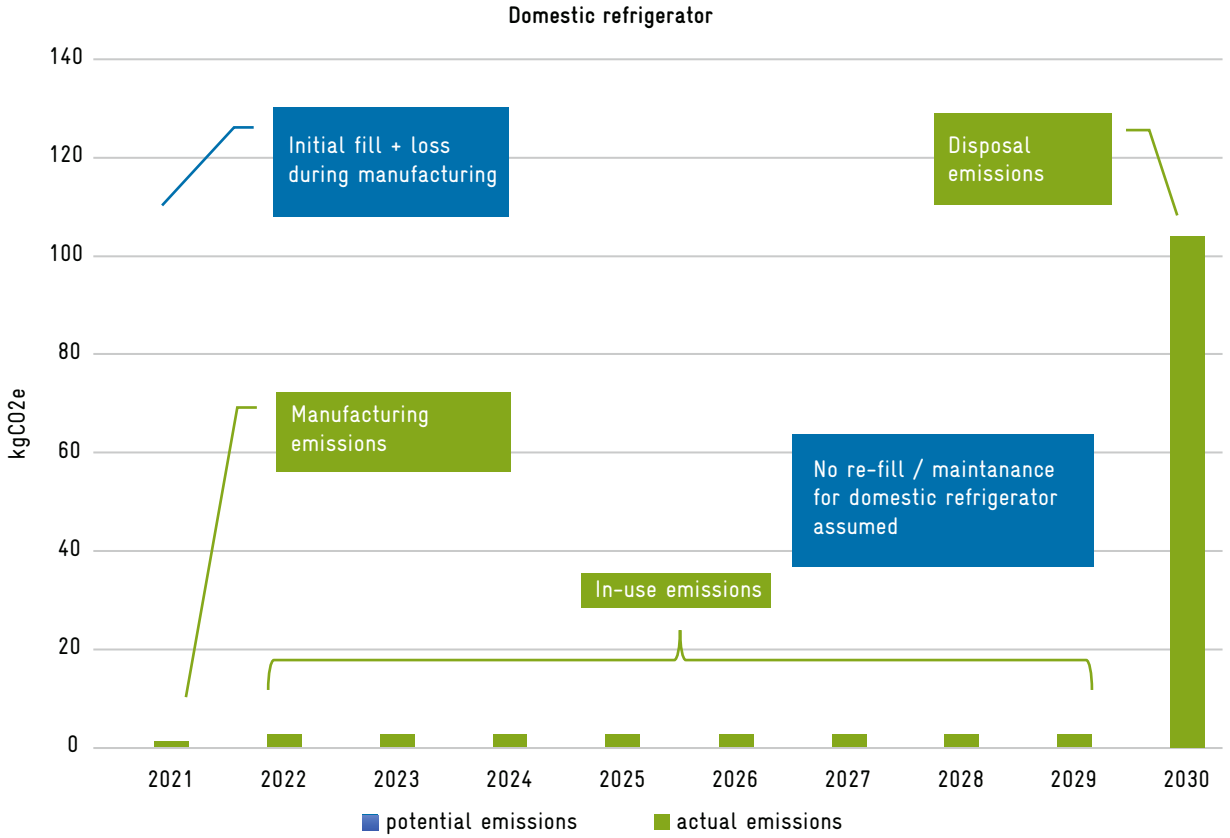
Figure 3: Schematic overview of emission factor approach to calculate HFC emissions



Source: GIZ (2020)

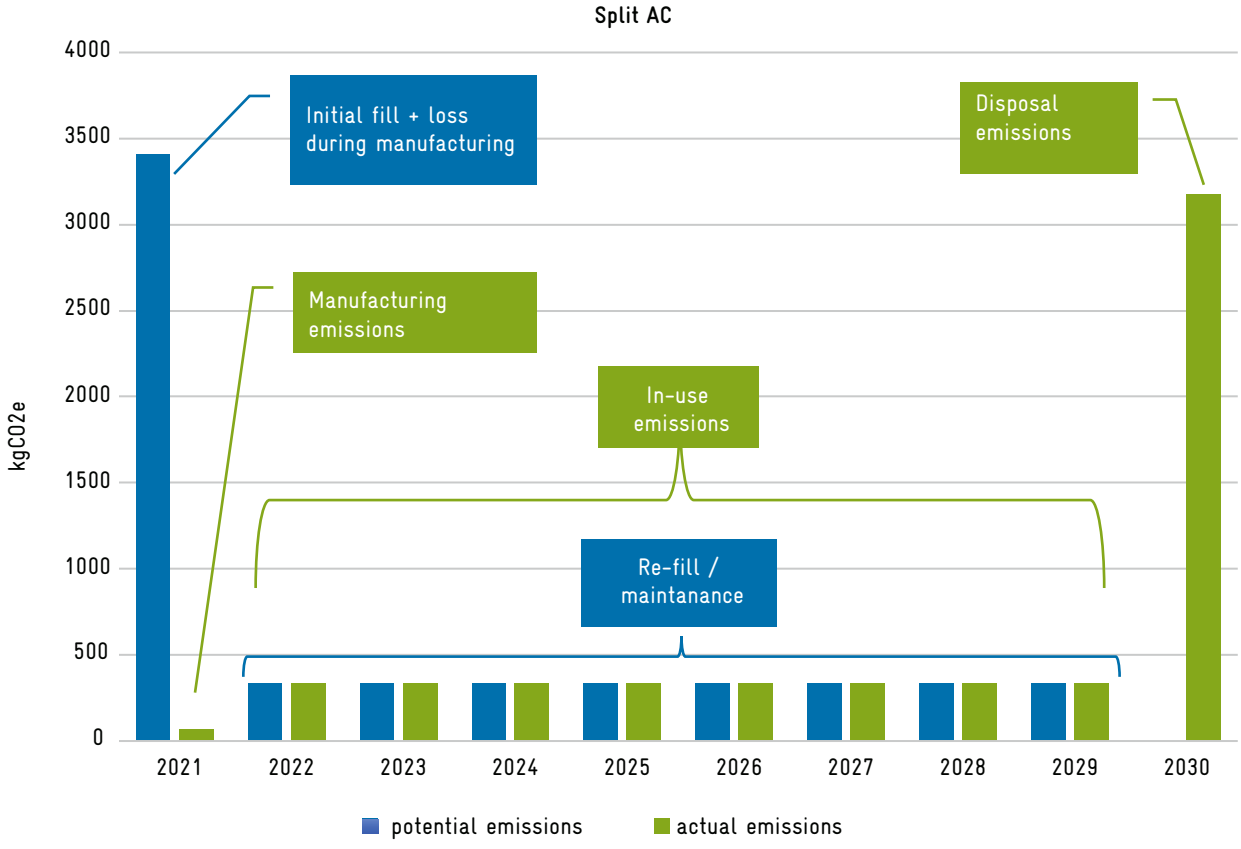
8 The 2006 IPCC guidelines generally provide advice on estimation methods for emissions by sources and removals by sinks at three levels of detail, ranging from the default method (tier 1) to the most detailed method (tier 3). Decision trees guide Parties in the selection of the tier to use for estimating a specific category. For 'key categories' (categories with a significant influence on overall emissions), the IPCC guidelines usually require the use of a tier 2 or 3 approach to estimate emissions.

Figure 4: Potential vs. actual emissions of a domestic refrigerator



Source: authors

Figure 5: Potential vs. actual emissions of a split AC



Source: authors

Text box 2: The 'HCFC adder' under the Kigali Amendment

The 'HCFC adder' under the Kigali Amendment

For the determination of the HFC baseline, the KA states in Article 5 that "each Party operating under paragraph 1 of this Article, for the purposes of calculating its consumption [production] baseline under Article 2J, shall be entitled to use the average of its calculated levels of consumption [production] of Annex F [HFCs] controlled substances for the years 2020, 2021 and 2022, plus sixty-five per cent of its baseline consumption [production] of Annex C, Group I [HCFCs], controlled substances as set out in paragraph 8 ter of this Article." (UN 2016).

According to participants in the KA negotiations, the reason why the value of 65% of the original HCFC baseline (2009-2010) was chosen is due to the HCFC phase-out schedule of Article 5 countries. This stipulates that the Parties should have reduced their HCFC consumption by 35% in 2020, hence can consume 65% of the baseline level. But since this specific value of the HCFC adder was probably more of a political decision and technical circumstances played less of a role in the KA negotiations, the concrete impact of the HCFC adder respectively its potential effects on the HFC baseline may not have been sufficiently considered (see chapter 4.3).

However, it is not clear how reduction of HCFC emissions, which is covered only by the MP, can be taken into account in countries' NDCs. Many HCFCs are GHGs and their most common replacement, the 'business as usual' (BAU) would be HFCs, also GHGs. Therefore, it makes sense to also consider HCFC consumption when calculating NDC reference scenarios for the RAC sector, also to understand implications of the HCFC phase-out on the HFC consumption levels and the need to introduce low-GHG alternatives to both groups of gases.

This is particularly relevant for mitigation activities that target disposal-related ODS emissions of cooling equipment. While this would both target HFC and HCFC emissions, under the PA, accounting and reporting requirements would first relate to HFC emissions. But since the PA, as a bottom-up regime, allows for a wide range of targets and related indicators, a potential solution could be the inclusion of all ODS or their replacements that are also GHGs in countries' NDCs and corresponding reporting. However, the link to quantified GHG targets needs to be clarified to fulfil the general principles for reporting and review under the UNFCCC, the so called TACCC principles (transparency, accuracy, consistency, comparability, completeness). Those are important to guarantee the comparability of emissions and removals among Parties which, in the end, is crucial for any transfer of mitigation outcomes. The next chapter provides further explanation.

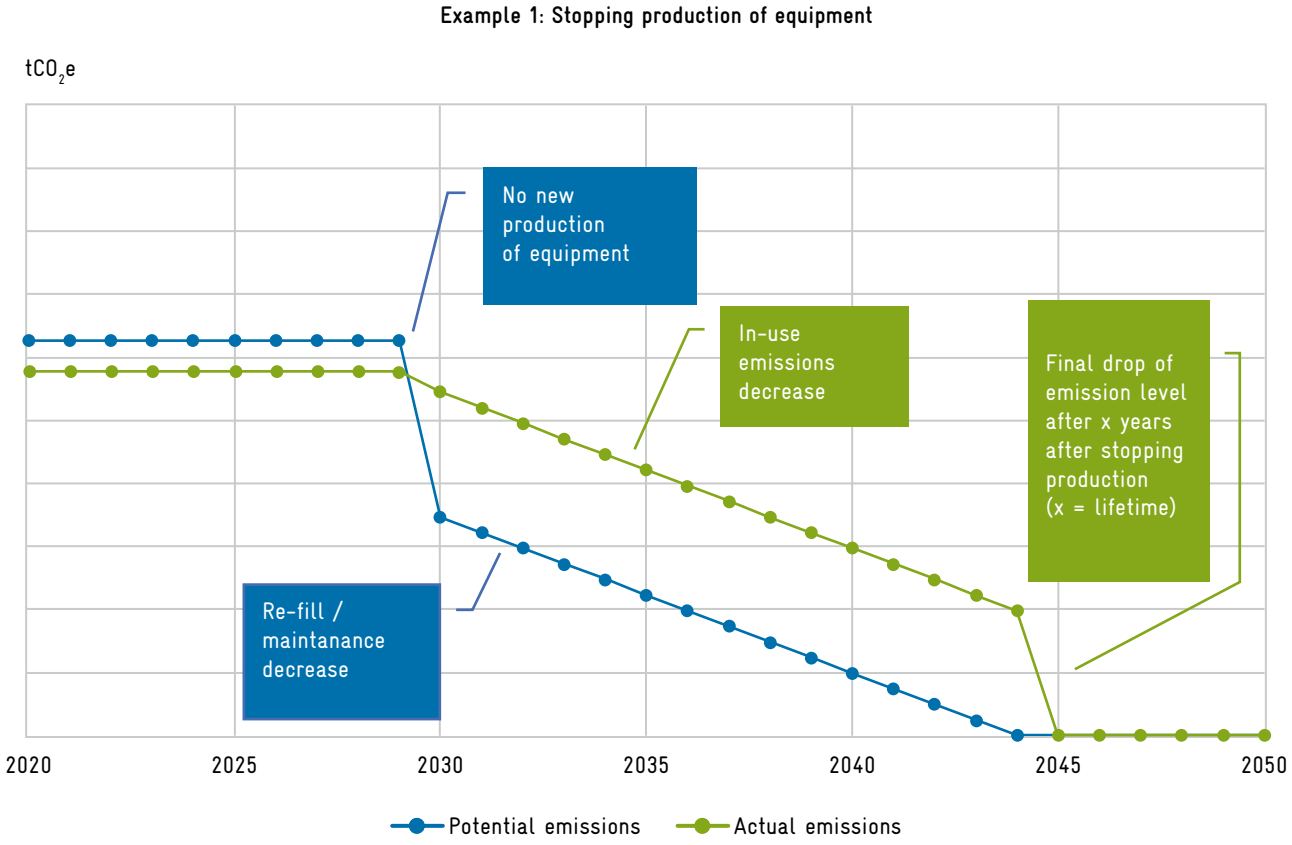
3.2 Synchronising baseline-setting

Another pivotal factor for synchronizing the two regimes is the determination of both the KA baseline and the NDC reference scenario. According to Article 5 of the KA text, developing countries shall use the average HFC consumption (or production) for the period 2020–2022[9] plus a default value of 65% of the HCFC baseline (2009–2010) to calculate its KA baseline for the HFC phase-down (KA Article 5c). However, a preliminary analysis of expected HFC emission paths and the potential KA baseline of various countries found that, in some cases, this 'HCFC adder' to this baseline might lead to an overestimated HFC baseline (Laßmann et al. 2021). A potential reason for such an excessive HCFC proportion in the Kigali baseline could lie in an accelerated phase-out of HCFCs. Hence, actual HCFC consumption levels in the base years for the HFC baseline under the KA (2020–2022 or 2024–2026) do not match the anticipated reduction of HCFC consumption.

Following a synchronized approach, a country should ideally consider the KA baseline in developing its NDC baseline to ensure coherence between both systems and to safeguard additionality of RAC mitigation actions. Hence, the implications of an excessive HCFC adder need to be carefully considered in the context of NDC reference scenarios and even more so, when determining crediting baselines or ETS caps in market-based cooperation under

9 For Article 5 group 2 countries, baseline years are 2024–2026.

Figure 6: Potential vs. actual emissions at sub-sectoral level – example 1



Source: authors

Article 6. Chapter 4 of this study provides an in-depth assessment of the effects of the HCFC adder using various country examples. Furthermore, the difference in accounting approaches (potential vs. actual emissions whose timing can differ by decades) means that the KA baseline cannot be directly translated into actual emissions. The following graphs illustrate the time lag between actual and potential emissions based on two fictitious examples.

Example 1 (Figure 6) shows the effect on actual and potential emissions for the case that a country stops producing the equipment with a certain HFC refrigerant in 2030. The consumption of refrigerant and thus the potential emissions decrease much more than the actual emissions directly after stopping the production. This is based on the fact that to calculate potential emissions, the majority of emissions are attributed to the production and filling of the appliances.

Example 2 (Figure 7) illustrates the difference of potential and actual emission for a measure that supports the (partial) replacement of HFC refrigerant in the sales of new equipment by a low-GWP alternative. The main drop of potential emissions happens at the time of substituting the refrigerant during manufacturing of the equipment. For the actual emissions, the main reduction only occurs years or decades later, once the equipment reaches the end of its lifetime. We assume that the overall stock of equipment remains the same, i.e., equipment reaching the end of its lifetime is replaced by new equipment.

Therefore, in order to derive a NDC reference scenario for the RAC sector to be included in a country's NDC, further modelling based on equipment sales and stock and specific parameters (such as equipment lifetimes and related emission factors, see Table 4) is required.

3.3 Mobilizing revenue for HFC mitigation under Article 6 of the PA

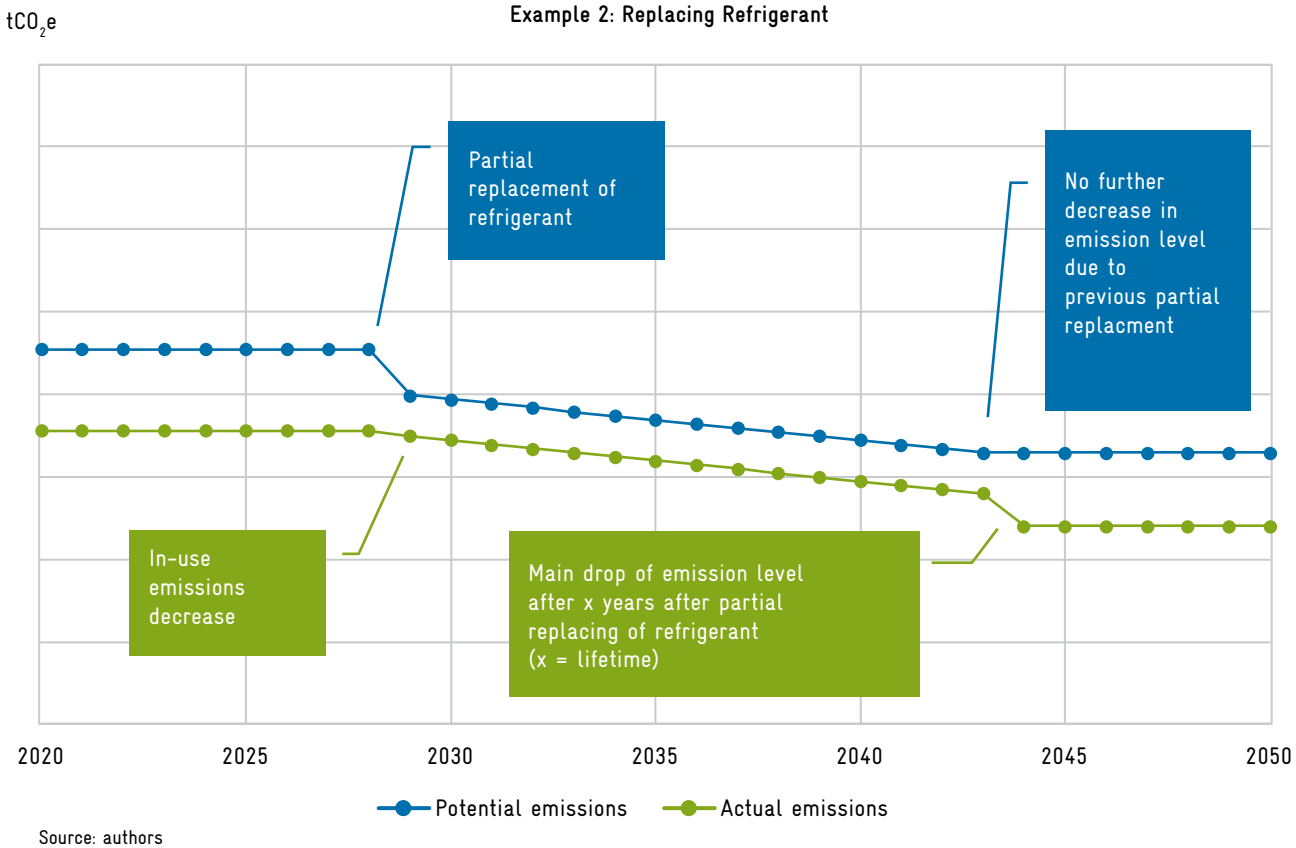
Article 6 of the PA recognizes voluntary cooperation that includes both market-based and non-market approaches to allow for higher ambition in mitigation and adaptation as well as promote sustainable development and environmental integrity. Article 6 sets the guardrails for market-based cooperative approaches among Parties, establishes a baseline-and-credit mechanism under the authority of the Conference of the Parties serving as meeting of the Parties to the PA (CMA) and defines a framework to promote non-market approaches to sustainable development. Negotiations to operationalize Article 6 are still ongoing. While an agreement could not be reached at the 24th and 25th Conference of the Parties to the UNFCCC (COP), negotiations are expected to conclude at COP26 in Glasgow in November 2021 (Michaelowa et al. 2020a). In the following, the opportunities Article 6 will offer for Parties to engage in carbon market activities will be described based on the status of negotiations after COP25.

3.3.1 Cooperative approaches under Article 6.2

Cooperative approaches are enshrined in Article 6.2 and can take very different forms of market-based cooperation, such as international trading of parts of country's emission budgets defined in NDCs, linking Emissions Trading Systems (ETS) and transfers of credits from a baseline-and-crediting mechanism. Thereby, Article 6.2 offers a large degree of freedom to Parties so they can tailor their cooperation to national circumstances to fit them with their NDC achievement. All of these different approaches have in common that they lead to a transfer of mitigation outcomes, and thereby involve 'Internationally transferred mitigation outcomes' (ITMOs). Mitigation outcomes must be 'real, verified and additional' and cannot lead to higher levels of global emissions. They are attributed to the country (host) and year (vintage) in which they occur.

Cooperative approaches require a strong government involvement and degree of oversight on the integrity of cooperative approaches resulting in higher transaction costs

Figure 7: Potential vs. actual emissions at sub-sectoral level – example 1



Source: authors

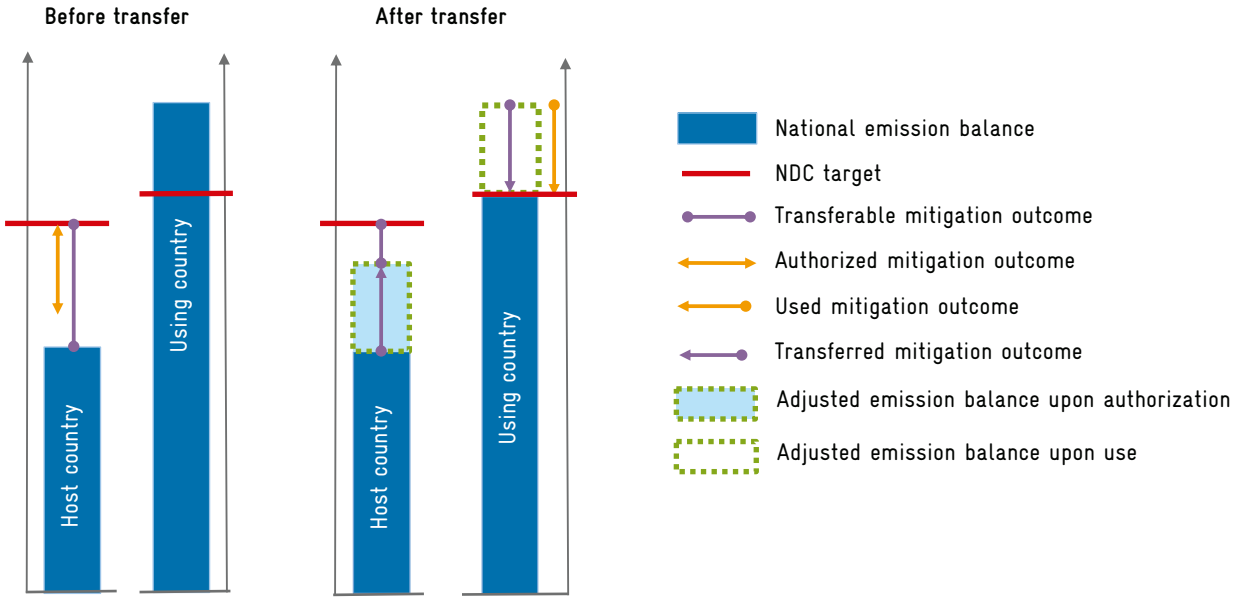
for the Parties. A group of countries has committed to the San José Principles, constituting a first "club of countries" that will certainly be followed by others, setting further guardrails for Article 6.2 cooperative approaches[10]. In the context of the Article 6 negotiations, the CMA is currently elaborating a guidance for these cooperative approaches on safeguarding environmental integrity.

Environmental integrity must be ensured both in the underlying mitigation activities and the creation of ITMOs as well as through robust accounting for ITMO transfers, to ensure that double counting is avoided. Double counting of the same mitigation outcome includes among other things double issuance of credits for the same mitigation activity and accounting for the same mitigation outcomes towards more than one mitigation target (between two NDCs, between NDCs and other international compliance regimes, etc.). Double counting is to be prevented through transparency, unique identifiers of ITMOs and through so-called 'corresponding adjustments'. These are made to the emission balance of sources and sinks covered by NDCs (most likely calculated based on IPCC guidelines) at the time of transfer on the seller's side. If the buyer is a Party to the PA, it applies a corresponding adjustment at the time of 'use' and 'retires' the ITMO in the PA context. Other users of ITMOs cancel the ITMOs in national or international registries to avoid double counting with NDCs (Ahonen et al. 2020, Michaelowa et al 2020b).

To ensure transparency, the guidance establishes reporting requirements for Parties on both the cooperative approach and on the accounting rules for ITMO transfers in the context of NDC implementation and achievement.

According to the draft texts subject to negotiations under the CMA, Parties must submit an initial report, annual information, and regular reports on information related to ITMOs and cooperative approaches. The reports specify the accounting methodologies and list authorizations and transfers (see report module 2, chap. 5). The information will be stored in a Centralized Accounting and Reporting Platform (CARP). The information submitted by Parties

Figure 8: Corresponding adjustments to emission balances – the principle



Source: authors

10 The San José Principles for High Ambition and Integrity in International Carbon Markets are promoted by a coalition of Parties, spearheaded by Costa Rica, that support a list of minimum requirements for Article 6.2 cooperative approaches to be adopted by the CMA (Costa Rica 2019).

in their reports will be reviewed by an Article 6 technical expert review (A6TER) for consistency with the guidance. In doing so, the reporting and review under Article 6.2 will be linked to and partly take place under the reporting and review cycle of the Article 13 'Enhanced Transparency Framework' (ETF). It is important to note that robust accounting of host Parties also extends to cases where the ITMO is not used by another Party to the PA but for 'other purposes', e.g., CORSIA or the voluntary carbon market (VCM). However, details on the link to these 'other uses', i.e., other non-UNFCCC regimes on carbon markets are not yet fully clear (Michaelowa et al. 2020b).

Currently, negotiations on the Article 6.2 guidance are already well advanced. However, 'nothing is agreed until everything is agreed' in UNFCCC negotiations. Mainly, three 'crunch issues' remain to be decided:

- Whether mitigation achieved in sectors or regarding gases not covered by / 'outside' of the NDC can be transferred out of the host country, and whether the host country then must undertake a corresponding adjustment (Michaelowa et al. 2020b).
- Whether leveraging finance for adaptation through cooperative approaches should be mandatory.
- Whether cancelling a share of ITMOs for overall mitigation in global emissions (OMGE) should be mandatory

(Michaelowa et al. 2020a).

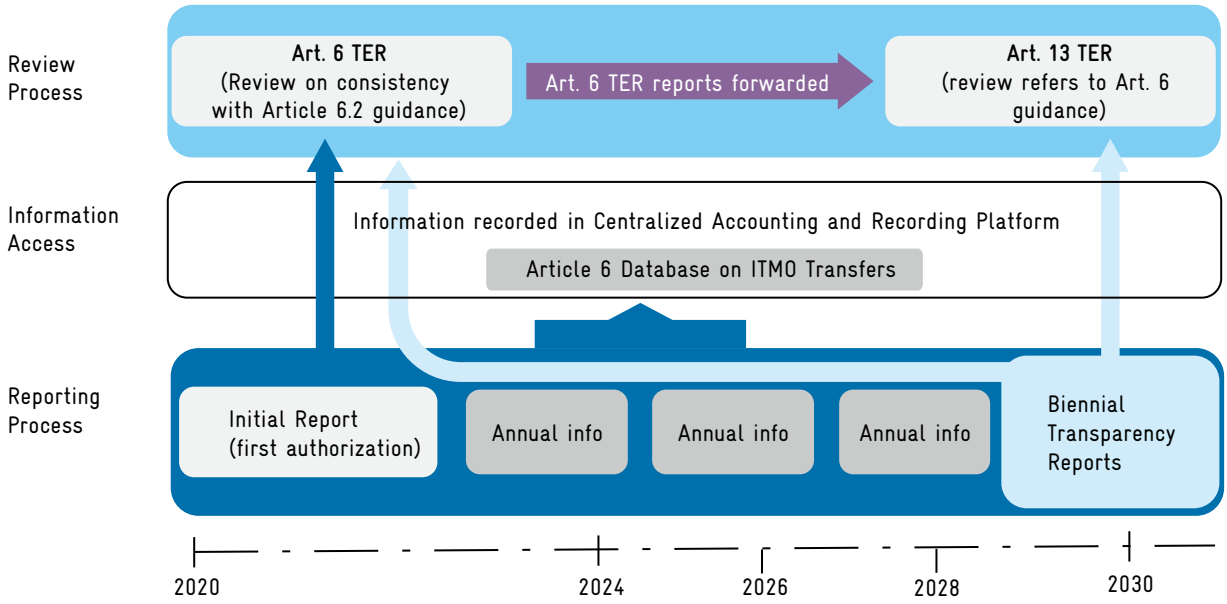
3.3.2 The Article 6.4 mechanism

Next to cooperative approaches, the PA establishes an Article 6.4 mechanism (A6.4M) that will credit Article 6.4 Emission Reductions (A6.4ERs) for mitigation achieved by activities authorized by host countries according to approved methodologies. The A6.4M will leverage finance for adaptation and aims to deliver OMGE through the cancellation of a certain share of issued A6.4ERs. The A6.4M will be the successor to the Clean Development Mechanism (CDM) established by the Kyoto Protocol.

The A6.4M will be overseen by a Supervisory Body (SB) – an entity which is placed under the authority of the CMA. It will approve eligible baseline and monitoring methodologies as well as methodological tools such as additionality tests. Activities will be registered upon validation by a designated operational entity (DOE) as well as approval by the host country.

The A6.4ERs can also be used on the VCM and are likely to be accepted under CORSIA. Non-Party stakeholders,

Figure 9: Reporting and review under Article 6 of the PA



Source: Michaelowa et al. (2020a), p.11

such as the private sector, can engage as project developers, auditors, investors or ITMO buyers under the A6.4M. In addition, countries with lower domestic capacities can adopt this approach enabling them to oversee methodologies as it would be needed in cooperative approaches.

A6.4ERs authorized for transfer towards another Party or for other (international) mitigation purposes will be considered ITMOs and participating Parties must respect the Article 6.2 guidance. Activities under Article 6.4. include projects, programmes, and potentially approaches on other scales (e.g., jurisdictional, or sectoral crediting approaches) if they are approved by the SB. Currently, Parties are still negotiating the rules, modalities, and procedures of this mechanism under the CMA. Further remaining crunch issues in this regard are:

- Whether Certified Emission Reductions (CERs) issued for mitigation achieved prior to 2020 by the CDM will be made eligible for use and accounting towards post-2020 NDC targets.
- The future rules on baseline setting and additionality determination under the A6.4M and in what regard they will have to differ from the CDM to respect the new context of the PA.

(Michaelowa et al. 2020a).

3.3.3 Supply-side perspective of engaging in carbon markets

While accounting under the PA mostly only refers to the achievement of NDCs, domestic and international carbon markets as well as compliance-related and voluntary uses of mitigation outcomes (carbon credits or emission allowances) become increasingly interconnected. This is showcased by several examples at an international scale, such as the recognition of domestically achieved CERs to reduce carbon tax liabilities in Colombia and South Africa, and the recognition of independent standards (e.g., Gold Standard, Verra), which are so far mostly used on the VCM, in CORSIA.

From a supply side perspective, host countries can strategically engage in market-based cooperation to help them mobilize finance for additional mitigation, while the introduction of new technologies will lower abatement costs in the longer term.

From a theoretical perspective, benefits for the host country can be maximized through a well thought through 'division of labour' of policy instruments.

Domestic regulation or other measures are most suitable for the lowest or negative cost options as well as for measures that cannot be applied on carbon markets due to the impossibility to quantify the mitigation potential or because the mitigation impact comes with a time lag. This applies to information instruments such as eco-labels or awareness-raising campaigns or capacity building activities (such as for instance training of RAC technicians for the proper handling of low GWP refrigerants). Noteworthy, market-based measures must always be coupled with non-market instruments to stimulate technological development, wider behavioural change, and public acceptance of mitigation measures.

Domestic carbon markets or other carbon pricing instruments can incentivize low-cost abatement options and strengthen measuring, reporting and verification (MRV) of emissions and emission reductions in sectors covered. Domestic carbon markets can play an important role in achieving unconditional NDC targets. Host countries should promote engagement of their private sector and engage themselves in international market-based cooperation to finance mitigation additional to their unconditional commitments that tackles the middle- and high-cost abatement options. To raise ambition in mitigation, in line with the PA, the profits obtained, and costs reduced should enable the host country to increase its mitigation targets and strengthen its domestic measures.

Public or international climate finance should complement revenues from the sale of ITMOs for high-abatement cost action not suitable for market-based cooperation (e.g., the establishment of a proper end-of-life management system including collection and destruction of ODS / high GWP refrigerants) and for research and development of low-emission technologies.

International and national climate finance also serves to scale up mitigation activities across a wide range of different sectors. This includes the possibility to blending different climate finance instruments with international carbon market mechanisms.

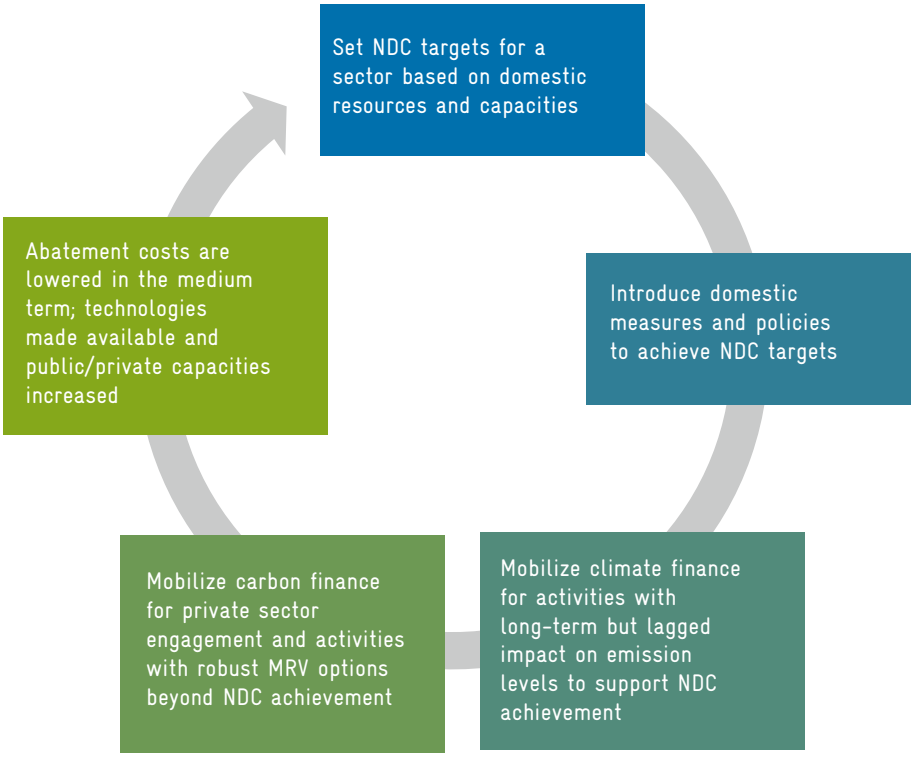
In sum, it can be said that Article 6 cooperation, if cleverly designed, contributes to the reduction of emissions in the host country and to their NDC achievement while also incentivizing a higher mitigation ambition by showing low-cost mitigation potential and thereby making future NDCs more stringent than would have been the case otherwise.

It should be noted that marginal abatement costs are not constant – rather they shift over time. Consequently, high-cost mitigation activities will become less expensive with their wide-spread adoption and implementation in a sector (and in the context of increasing carbon prices) – a phenomenon which is also called "running up the marginal abatement cost ladder". As a result, after a certain period, activities formerly financed by international carbon markets can be either mandated by domestic regulation or financed through domestic market mechanisms. International carbon finance can then be channelled to support new 'first-of-its kind' technologies or innovative measures, that may or may not have been developed with the support of public or climate finance.

Carbon finance can generate mitigation from activities implemented at different levels of aggregation, ranging from a single project activity, over a programme that bundles similar activities implemented in different places (e.g., the market introduction and rollout of a specific technology that uses natural refrigerants), measures that affect an entire sector or jurisdiction as well as through policy instruments such as emission trading systems, carbon taxes or regulations (e.g. levies or import taxes on refrigerants with high(er) GWP values).

In the context of baseline-and-credit mechanisms, credits generated can be transacted on the VCM, used for compliance under CORSIA, or made eligible for use ETS or other domestic schemes (e.g., against a tax). They can also be used by another government for compliance under the PA.

Figure 10: The 'division of labour' and NDC cycle from a host country perspective



Source: authors

3.4 Art. 6 key principles for HFC reduction activities

International carbon markets depend on trust in the environmental integrity of the emission units traded. While there is no internationally recognized definition of environmental integrity, there is a shared understanding that it means at least that an activity shall not lead to a higher overall level in emissions. In the context of the PA, one could interpret environmental integrity be fulfilled when a mitigation activity contributes to the fulfilment of its long-term targets. This means that mitigation measures realized through the use of carbon credits ideally lead to a more ambitious NDC in the next round and thus, support the 'ratcheting up' mechanism of the PA which strives to boost ambition over time. Nevertheless, ensuring environmental integrity is a prerequisite for cranking up ambition (Ahonen et al. 2020, Michaelowa et al. 2020a), and apart from accounting rules, environmental integrity must be therefore safeguarded in the design of mitigation activities. In the context of baseline-and-credit mechanisms, additionality determination and the setting of a crediting baseline at a level that does not overestimate emissions are key steps to ensure the environmental integrity of an activity. The following chapters briefly outline the concepts of additionality and baseline setting. Further and more detailed information on these aspects and how they could be applied in the context of Art. 6 activities in the RAC sector are provided in Michaelowa et al. (2021b).

3.4.1 Additionality

An activity that is credited mitigation for transfers on carbon markets must respect the principles of additionality, meaning that the mitigation activity generates mitigation additional to what would otherwise have occurred (Michaelowa et al. 2019b). The determination of additionality has various aspects. First, activities are only additional if they are not mandated by national policies and laws – so-called regulatory additionality. Second, financial additionality, i.e., that an activity is not commercially viable, i.e., having negative abatement costs, is also crucial in achieving environmental integrity. However, many observers have stressed that activities that in monetary terms are profitable may face non-monetary barriers, e.g., that tenants in rented apartments have no possibility to influence the choice of the air conditioners by the landlord, who has an incentive to choose cheap equipment that has low energy efficiency. Additionality assessment will have to assess which barriers are prohibitive and which ones are not. Moreover, in the context of international carbon markets, mitigation activities must be additional to unconditional NDC targets. Here, a differentiation between policies mobilizing the mitigation needed for the unconditional NDC target and those policies aiming for mitigation contributing to the conditional target seems to be required. Also, the expectation of planned policies should be considered, as the anticipation of policies may induce behavioural change. At the end, there remains a strong link between these 'aspects' of additionality and it should be kept in mind that the additionality determination also varies according to the different levels of aggregation and the type of activities. However, 20 years of experience with additionality testing under international carbon market mechanisms have led to a large body of experience which is being tapped under Article 6.

If the principle of additionality is not respected, incentives for domestic action are reduced or even eliminated, as ITMO prices would be driven downwards by a high supply of ITMOs from profitable (negative cost) mitigation interventions. This means that instead of engaging in domestic mitigation action, it would become cheaper to acquire ITMOs. Also, the mitigation outcome would not represent a "real" mitigation and overall emissions would increase (Ahonen et al. 2020).

3.4.2 Baseline setting

Crediting baselines set the reference level against which the volume of mitigation achieved is calculated. They are therefore crucial to safeguard environmental integrity (Ahonen et al. 2020). Baselines for emission reductions need to be based on a conservative and robust reference scenario which ideally is calculated by accurate and up-to-date data, considering uncertainties.

As per the status of negotiations on Article 6, crediting baselines must be set below a business-as-usual scenario. That means that not everything which is better than the continuation of BAU can be credited and sold as a carbon credit. Carbon crediting shall already assume that there will be the implementation of meaningful mitigation action. This is meant to ensure higher ambition in carbon markets and the exclusion of mitigation activities that do not represent a significant improvement of emission levels.

Ideally, baselines are based on a conservative benchmark or a credibly conservative projection of emissions for activities where benchmarks cannot be defined. This is the case in sectors with very heterogeneous technologies or heterogeneous application of technologies, for instance industrial chillers. In addition, key parameters that determine the baseline emissions, e.g., assumed Gross Domestic Product (GDP) growth, could be made "dynamic". In this case, they would be estimated ex ante based on projections that consider technological and economic developments. The actual value is then calculated *ex post*, once it is known, before credits are issued. However, this approach would reflect a trade-off between the certainty for investors and environmental integrity, which could be reduced by conservative defaults.

Parameters (such as in-use and end-of-life emission factors) can be standardized to lower transaction costs. Also, baselines can be standardized to reflect emission levels at higher levels of aggregation. Consequently, there are differences in baseline setting at different levels of aggregation (Michaelowa et al. 2021a) which will be assessed in a separate study on the methodological requirements for MRV and accounting.

3.4.3 Linking additionality determination and baseline setting to NDCs

In the PA context, environmental integrity is also closely connected to the NDC targets and their ambition as they become a key reference point for market-based cooperation. Against this backdrop, there is a strong need to safeguard NDC achievement, meaning that the transfer of mitigation outcomes does not jeopardize NDC achievement of the host country. Thus, it must be ensured that the host country does not sell its lower cost mitigation options ('low hanging fruits') given that the requirement to apply a corresponding adjustment to the emission balance would then require the host country to take measures costlier than the mitigation sold to still meet its NDC targets. Beyond incorporating the achievement of NDCs in additionality determination and baseline setting, host countries can adopt further measures to protect their NDC achievement when authorizing transfers on international carbon markets. These measures could for instance be:

- An 'in-kind' taxation on ITMOs, meaning that the host country retains a share of mitigation outcomes permanently or provisionally until it accounts for its NDC.
- A monetary taxation, retaining a share of revenue, linked to the opportunity costs of corresponding adjustments. The revenues raised can then be reinvested to mobilize additional mitigation for NDC achievement.
- Shorter crediting periods, ensuring that a mitigation activity only generates credits for the international carbon market for a period lower than the technical lifetime of the activity, before being integrated in domestic measures.

At the end, different solutions may be suitable in different country contexts and at different levels of aggregation.

As mentioned before, there is also a need to protect carbon markets from 'hot air', which is the case when NDC target is less stringent than the BAU development of national emissions (Ahonen et al. 2020). As a result, these 'inflated' NDC reference scenarios would lead to overstated baseline levels and enable the sale of credits from non-additional activities. If such 'hot air' is traded, (transferred to other countries) then total global emissions increase as a result, undermining environmental integrity (Michaelowa et al. 2020a).

There is still a limited degree of understanding how to link additionality testing and baseline setting with NDCs, Long term – Low emissions development strategies (LT-LEDS) and the achievement of the long-term target of the PA. Most importantly, there is still a lack of common understanding about the key question of 'where does the ambition come from?'– through limiting the mitigation that is available for crediting and use through carbon markets or through increasing the ambition in national targets and policy instruments to achieve them. In contrast to the CDM, most Parties agree that in the future, baselines and additionality tests will have to consider policies and regulations in the host country and any mitigation credited will have to be additional to the mitigation mobilized by domestic measures. Also 'ambition' levels will be different for countries considering the common but differentiated responsibilities and respective capacities under the UNFCCC (Michaelowa et al. 2021a).

4. HFC emissions paths and the relevance of the HCFC adder

Harmonizing KA baselines, NDC reference scenarios and Article 6 crediting baselines is a crucial step in achieving a concerted mitigation action in the RAC sector that serves to advance compliance with both multilateral regimes. Therefore, this chapter describes current and future developments in HFC consumption paths on which all three forms of 'baselines' will be based. For the analysis, we focus on HFC consumption, whereby the KA for the phase-down of HFCs takes both consumption and production into account. Special attention is thereby given to the relevance of the HFCF adder in KA baselines. As KA baselines, NDC reference scenarios and Article 6 crediting baselines for the RAC sector will be different from country to country, this chapter looks at a sample of countries in Africa, Asia, and Latin America: Colombia, Costa Rica, Ghana, Kenya, Mexico, Namibia, Senegal, Seychelles, Thailand, Tunisia and Vietnam.

4.1 HFC baseline-setting prior to KA commitments

KA baselines will only be calculated in the future once consumption levels in the reference years have been reported (2023 for Art. 5 Group 1 and 2027 for Group 2). However, in this study the authors estimate expected KA baseline levels as to conceptualize how to harmonize KA and PA action. PA implementation starts from 1 January 2021 onwards, so current HFC emission levels are already relevant for Parties' RAC sector mitigation efforts.

For the assessment of HFC emission patterns and the impact of the HCFC adder on KA baselines, the authors extracted existing data on projected HFC consumption from GHG inventories of the RAC sector of the selected countries. To project potential HFC consumption paths (expressed in CO_2e) up to 2030 and the impact of the HCFC adder, the authors use estimates on potential emissions based on annual consumption of the different HFCs.

Table 5: Overview of data sources for assessment of future HFC emissions patterns and KA baselines

Country	RAC GHG Inventory	HPMP documents
Colombia	X	X
Costa Rica	X	X
Ghana	X	X
Kenya	X	X
Mexico	X	X
Namibia	X	X
Senegal	-	X
Seychelles	X	X
Thailand	(X)[1]	X
Tunisia	X	X
Vietnam	X	X

Source: authors

11 Data collection carried out in 2013, but GHG inventory has not been developed.

In addition to the GHG inventories, documents on the national HCFC Phaseout Management Plans (HPMPs) provided the necessary data to define the HCFC adder to future KA baselines. For this purpose, the HCFC baseline (2009 – 2010) was used and converted into CO_2e emissions using the corresponding GWP values of the refrigerants. This allows to estimate the expected KA baseline and the effect of the HCFC adder. In addition, officially reported data on HCFC consumption permitted assumptions to be made in cases where the distribution of HCFCs and HFCs amongst current and projected stock of RAC technologies was not clear from the inventories. The following table provides an overview of the data basis available for each country assessed. Annex 1 provides further details.

4.2 KA baseline stringency for Costa Rica, Seychelles and Vietnam

We now want to find out where the HCFC adder leads to an inflated HFC consumption baseline and for how much time. As described in the previous chapter, for all countries listed above (except for Senegal), comprehensive GHG inventories for the RAC sector were the basis for the analysis of expected HFC consumption paths expressed in CO_2e until 2030. These projections of potential HFC emissions levels under the BAU scenario reflect the countries' commitments under the MP to phase-out HCFCs until 2030. However, some documents did not provide the required data for an in-depth assessment, namely the inventories and data collection reports for Tunisia and Thailand. For Senegal, HFC data was not available. Therefore, it was not possible to include Senegal, Tunisia, and Thailand in the assessment. Besides, for further countries (Colombia, Ghana, Kenya, and Namibia), the RAC GHG inventories did not provide the HFC data at a disaggregated level. For this reason, no analysis of the HCFC adder effect on the Kigali baseline can be carried out for these countries for the time being. Besides, it is worth mentioning that the assessment is based on modelled and not actual data.

The following table provides an overview of the results of the analysis.

The analysis of the projected potential HFC emissions levels (based on consumption), the Kigali baselines derived from these projections and the effects of the HCFC adder shows that all three assessed countries will start with an overestimated baseline in 2024 compared to a BAU scenario. The difference ranges between 9% and 84% for the first year of the HFC consumption freeze and, in the case of Seychelles remains above 0% until 2040. This means that in the Seychelles, the Kigali baseline remains above the projected BAU HFC emission levels for the entire first decade of the KA implementation period (see Figure 11). However, with the first reduction step in 2029 the baseline falls below the BAU scenario in the other two countries. The figure below illustrates the difference between the BAU HFC emission paths (based on consumption levels) and the KA baseline and phase-down schedule in relation to the BAU scenario (in %). A positive percentage figure (i.e., the part above the horizontal axis) corresponds to the fact that the BAU emissions level is below the KA baseline. Hence, the latter is overestimated and generates 'hot air'. Only if the difference is negative, i.e., if the lines in the graphics fall below the horizontal axis, the KA baseline is lower than the projected BAU scenarios and therefore stringent.

The graphs clearly show that, for Costa Rica and Vietnam, the KA baseline becomes stringent from the year 2025 onwards. The Seychelles seems to be an exceptional case where the HCFC adder leads to a massively inflated KA baseline which almost doubles the BAU HFC consumption levels and will only move below BAU in 2040 (see Figure 12).

Costa Rica, on the other hand, is an example for the HCFC adder having only a temporary impact where the Kigali baseline becomes stringent between 2025 and 2026 (see Figure 13).

4.3 Potential reasons for overestimated KA baselines levels

There might be several reasons for an overestimated KA baseline, as already indicated in chapter 4.2. While our sample is very small, we do not see any geographical or level of development related reason, nor a clear relationship between HFC consumption projections and the level of the HCFC adder. However, the analysis of the officially reported HCFC consumption for the last five years (2015 – 2019) clearly shows that countries with an advanced HCFC phase-out process tend to have an overestimated KA baseline compared to parties that still

Table 6: Overview of assessment results of HFC emission paths and Kigali baselines until 2030

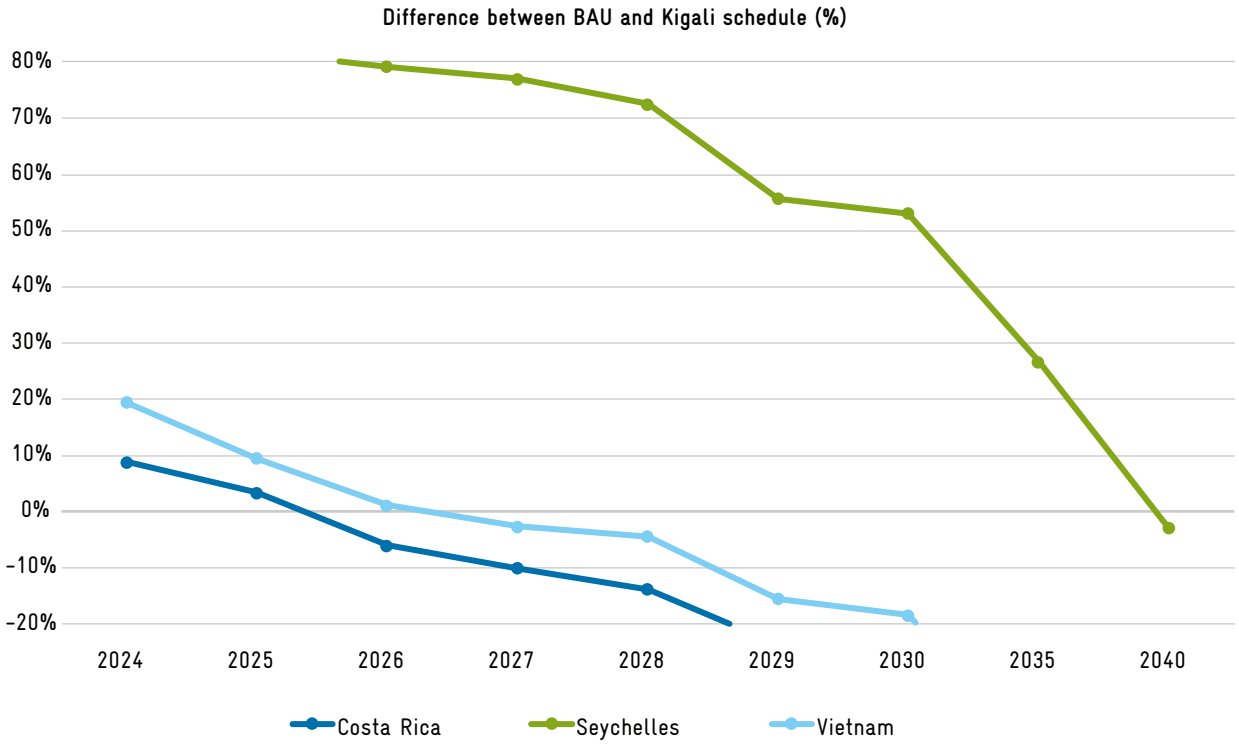
Country	Projected HFC emissions in 2020–2030 (in $MtCO_2e$)											
		2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Costa Rica	HFC - BAU	0.75	0.80	0.85	0.90	0.95	1.00	1.10	1.15	1.20	1.22	1.25
	HCFC adder					0.23	0.23	0.23	0.23	0.23	0.23	0.23
	KA baseline/ schedule					1.03	1.03	1.03	1.03	1.03	0.93	0.93
	Difference KA / BAU (%)					**9%**	**3%**	**-6%**	**-10%**	**-14%**	**-24%**	**-26%**
Seychelles	HFC - BAU	0.029	0.030	0.030	0.031	0.031	0.032	0.032	0.033	0.034	0.033	0.034
	HCFC adder					0.029	0.029	0.029	0.029	0.029	0.027	0.027
	KA baseline/ schedule					0.058	0.058	0.058	0.058	0.058	0.052	0.052
	Difference KA / BAU (%)					**84%**	**82%**	**79%**	**77%**	**73%**	**56%**	**53%**
Vietnam	HFC - BAU	9.00	9.50	10.00	10.50	11.00	12.00	13.00	13.50	13.75	14.00	14.50
	HCFC adder					3.64	3.64	3.64	3.64	3.64	3.64	3.64
	KA baseline/ schedule					13.14	13.14	13.14	13.14	13.14	11.83	11.83
	Difference KA / BAU (%)					**19%**	**10%**	**1%**	**-3%**	**-4%**	**-15%**	**-18%**

Source: authors

have a higher HCFC consumption. Table 7 lists the results for the assessed countries, with those countries in italic font for which we could assess the degree of KA baseline overestimation.

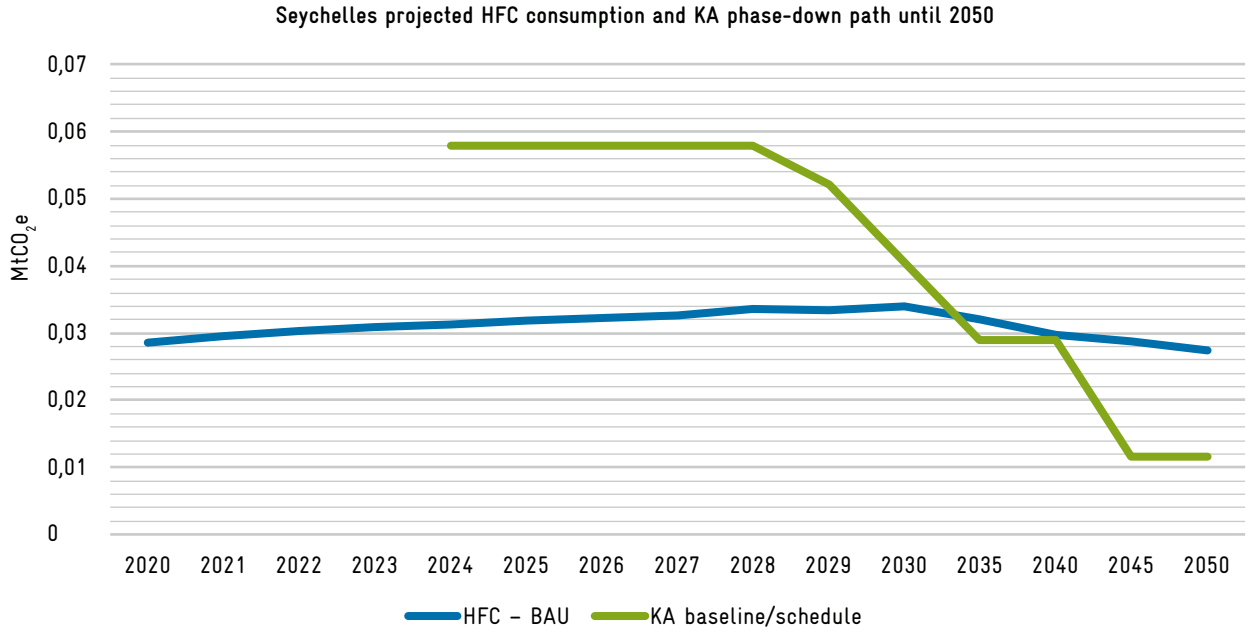
For 2019, Colombia, Costa Rica and Vietnam reported relatively high consumption levels in comparison to the other countries. Vietnam claimed the largest amount of HCFC consumption at 89% of baseline levels. These parties also belong to the group of assessed countries whose KA baselines become stringent rather quickly after the freeze of HFC consumption in 2024. In contrast, it can be presumed that for countries that reached comparatively low HCFC consumption levels during the last years, the HCFC adder is potentially oversized and thus has a greater impact on the KA baseline. This leads to a scenario where the BAU consumption levels are below the KA baseline for the initial several years. The Seychelles for example have been one of the frontrunners within the Article 5 group in terms of an accelerated HCFC phase-out and established a ban on HCFC-based equipment and gas in 2018 (GIZ 2019). The measures implemented during HPMP stage I finally lead to zero consumption in 2019. The Seychelles show similar ambitions in their updated NDC, as they completely waive

Figure 11: Difference between BAU HFC consumption levels and KA schedule



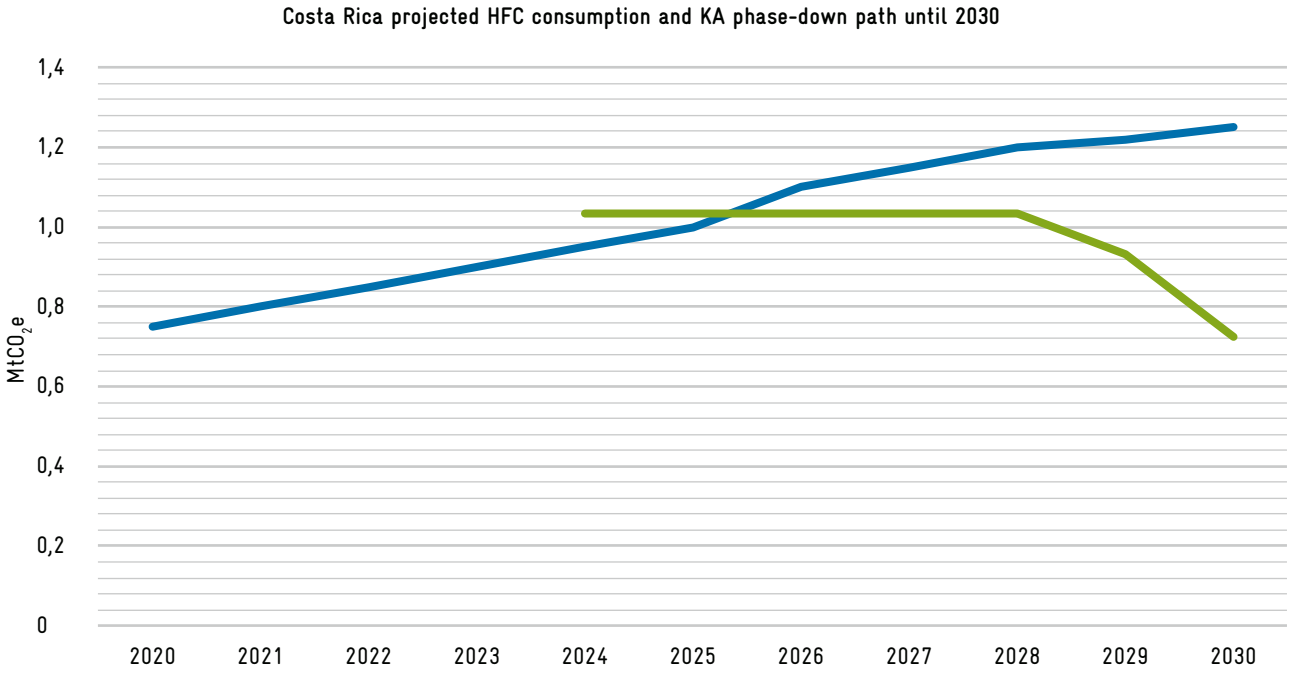
Source: authors

Figure 12: Seychelles projected HFC consumption and KA phase-down path until 2050



Source: authors, based on GIZ 2020

Figure 13: Costa Rica projected HFC consumption and KA phase-down path until 2030



Source: authors, based on GIZ 2020

Table 7: Overview of HCFC consumption (ODP tonnes) in % of HCFC baseline (2009-2010) for the period 2015 – 2019

Country	Baseline 2009 – 2010 (ODP tonnes)	Consumption in % of baseline				
		2015 (%)	2016 (%)	2017 (%)	2018 (%)	2019 (%)
Colombia	225.5	73%	61%	66%	35%	36%
Costa Rica	14.08	78%	77%	72%	63%	45%
Ghana	57.25	36%	32%	34%	31%	30%
Kenya	52.15	40%	29%	11%	9%	12%
Mexico	1148.8	57%	45%	36%	28%	20%
Namibia	8.4	64%	45%	32%	20%	9%
Seychelles	1.40	24%	24%	24%	5%	0%
Vietnam	221.21	87%	88%	89%	88%	89%

Source: authors, based on UNEP 2020

the inclusion of the HCFC share for their RAC sector targets. By doing so, the NDC reference scenario is lower than the Seychelles' commitments under the KA and thus provides a good basis for activities in the context of Art. 6 cooperation.

The TEAP of the MP has assessed and listed the current status of HPMPs (approved and planned[12]) according to the related targets (TEAP 2020). By January 2020, 143 Article 5 countries had obtained approval and funding for the implementation of stage I HPMPs, which shall implement the 2013 and 2015 HCFC MP control measures (freeze in 2013 and 10% reduction in 2015). But the assessment reveals that the HPMP stages, which were used to align with the MP reduction targets, and the actual associated reduction targets differ greatly between countries. Of the total of approved stage I HPMPs, there are eight countries that aim to achieve 100% reduction (among them the Seychelles). This variation is evident, particularly in stage II HPMPs, where many countries target reduction of HCFC consumption beyond the mandatory 35% in 2020 and some even complete phase-out. According to the TEAP assessment from 2020, the cumulative HCFC reductions achieved by Article 5 countries reached 63% of baseline levels of all approved HPMPs (TEAP 2020). Therefore, it can be stated that the HCFC adder does not reflect current real HCFC consumption and, in those cases where HCFC consumption has been phased out already, excessively increases the KA baseline compared to actual HCFC and HFC levels. EIA, when commenting the results of the TEAP Replenishment Task Force Report, note that there is a "need for an adjustment of the HFC phase-down" (EIA 2020). They argue that there was high uncertainty on both, future HCFC and HFC consumption and production levels, when the Kigali Amendment was adopted in 2016. But in the meantime, more information and data became available which now reveal that the HCFC component of the HFC baseline is too high. The Replenishment Task Force Report includes projections for the BAU scenario until 2050 and the estimated HFC baseline for all Article 5 countries. The figures are validated by applying a bottom-up model and a growth rate approach. According to the projections, the baseline for Article 5 Group 1 countries surpasses the BAU scenario at least until 2026. This would mean that no action to reduce HFCs would be required for those Parties until that time (EIA 2020, TEAP 2020).

Three of the assessed countries, Costa Rica, Namibia and Seychelles, belong to the so-called low volume consuming countries (LVCs), whose calculated level of HCFC consumption is less than 360 t per year (ExCom 1995, para. 19 (a)). These countries usually do not have (large) RAC equipment producers, and consumption of refrigerants is limited to the servicing sector. Projects that promote an accelerated phase-out of HCFC consumption in LVC countries and which have a strong national commitment are considered on a case-by-case basis (ExCom 2010, para 198 f). These parties mainly receive support to e.g., strengthen and expand awareness and training programmes and establish regulatory and legislative measures. The fact that those countries only need to address relatively small amounts of HCFCs could be one reason why Seychelles and Namibia are well advanced with their HCFC phase-out. On the other hand, Mexico is a large consumer and HCFC producer country, but also already well advanced with its HPMP.

4.4 Implications for baseline setting under the PA

If due to the HCFC adder, the KA baselines do not reflect realistic potential HFC emission paths and hence, are constantly above a credible HFC consumption BAU scenario for several years if not decades, these should not be translated into a sector wide actual NDC emission reference scenario nor used as basis for crediting in Article 6 baselines. If 'inflated' by the HCFC adder, the KA baseline will not incentivize any mitigation action in the respective

12 "Planned" means the HPMP is not yet approved but is included in the consolidated Business Plan.

country, generating 'hot air[13]' which may result in an overall increase of global emissions. NDC targets at the minimum shall be defined as a reduction from a credible emission BAU scenario, otherwise they cannot contribute to the achievement of the PA, but rather contribute to an increase in global emissions. More problematic, if a country has a credible NDC target for its entire economy, a 'hot air' RAC-sector baseline would increase the burden for achievement of the NDC targets on other sectors and thereby actors. A country willing to achieve its NDC has a clear interest in setting sector targets below a credible BAU pathway.

If a 'hot air' KA baseline, translated into an actual emission reference scenario would be applied as a crediting baseline or used to determine a cap of a (linked) ETS under Article 6, this would be inconsistent with the Article 6 principles of international cooperation. As shown in Figure 10, if a country simply translates a possibly overstated KA potential emission baseline, including a 'full' HCFC adder of 65%, into actual emission RAC-sector targets, this will generate 'hot air'.

As per the status of negotiations, Article 6.2 cooperative approaches and the A6.4M to deliver on 'real and additional' mitigation outcomes and to ensure this inter alia through robust and conservative baseline setting (Michaelowa et al. 2020a). Protecting carbon markets from 'hot air' is crucial to protect the reputation of international market-based cooperation and thereby, a potentially important source of revenue for many developing countries and important instrument in achieving PA objectives.

Therefore, safeguards are necessary to ensure that countries do not consciously or inadvertently translate 'hot air' KA baselines in their NDCs and potentially even crediting baselines or caps of linked ETS in Article 6 market-based cooperation. In a step-by-step manner, countries should:

1. Collect robust and recent data on RAC sector ODS and GHG emissions and project a credible BAU pathway of actual emissions in absence of KA and PA, in line with conservative assumptions on energy efficiency improvements, technological change, improved management and disposal of equipment, etc.
2. Have a good understanding of the expected KA phase-down path and the expected impact of the HCFC adder on potential emissions in the reporting years and on actual emissions over time.
3. Derive the NDC reference scenario for the RAC sector from the same data. The HCFC adder should be calculated in a 'Paris-aligned' manner to avoid 'hot air'. This means the HCFC adder should be recalculated based on ex ante realistic assumption of and adjusted for ex-post observed HCFC consumption levels during the base years for the KA baseline (e.g., 2020 – 2022), see Michaelowa et al (forthcoming).
4. Define NDC targets against these actual emission reference scenarios to ensure KA implementation but also reflect 'highest possible ambition'.
5. For activities to be implemented in market-based cooperation, undertake an activity-specific additionality test which for instance combines an investment test and a barrier analysis, and set a baseline based on RAC sector data which fulfils Article 6 requirements of environmental integrity, while incorporating a contribution to KA commitments and NDC targets.

With these safeguards in place, all three forms of 'baselines' (KA, NDC and Article 6) can be harmonized and calculated in reference to each other leading to an overall reinforcement of ambition. A credible reference scenario is a precondition for good planning of mitigation policies and efficient disbursement of limited funds. A country should understand whether its KA baseline, translated into expected actual emissions, would already set the country on a pathway below a credible BAU actual emissions scenario. Ideally, the country would only consider the

13 'Hot air' is a term coined in the UNFCCC context for fictitious mitigation claimed against overestimated baselines, originally applied to countries in transition like Russia and Ukraine whose emissions fell massively due to the economic transition in the 1990s while their emissions target under the Kyoto Protocol was just a stabilization of emissions. 'Hot air' is especially problematic if mitigation credits or allowances generated by claiming the difference between the overestimated baseline and the real business as usual emissions path are traded on the carbon market and used by other governments or private sector buyers to claim achievement of their mitigation target. In a worst-case scenario, trading hot air results in an overall emission increase because no real mitigation took place in the host country and the buyer claims to have offset real emissions. This happened when Russia and Ukraine sold hundreds of millions of emission credits through the Joint Implementation market mechanism under the Kyoto Protocol in 2012 – 2013, which eroded trust in market-based cooperation (Kollmuss et al. 2015).

optional 'HCFC' adder to the extent it requires it to ensure KA compliance. This would mean, re-assessing the likely (ex-ante) or observed (ex-post) HCFC consumption levels in the KA baseline years and adjusting the HCFC adder to just cover the real 2020 HCFC use respectively (with 65% as highest value, and zero if HCFC emissions have reached zero in 2020).

If this is the case, this stringent KA baseline translated into actual emissions, setting the country on a downward ambition path, can be considered in the NDC reference scenario for the RAC sector, as it constitutes a credible BAU scenario, meaning the scenario of emission levels in the absence of the PA. Also, MLF funding will be available for the achievement of KA compliance, if needed. Additional mitigation, beyond the translated KA baseline, can then be tackled inter alia by climate finance and finance through market-based cooperation. If the KA baseline includes 'hot air', the country can be sure that with a credible NDC reference scenario (i.e., more stringent than the KA baseline) and achievement of NDC targets, it secures KA 'overachievement' while also promoting environmental integrity and ensuring it remains a credible partner in international market-based cooperation.

5. Main findings and conclusions

Art. 6 may help to leverage climate finance resources for faster KA implementation: International carbon markets can play an important role to reduce emissions of HFCs which are potent GHGs beyond the commitments undertaken under the KA to the MP. Both the KA as well as the PA under the UNFCCC address HFCs in terms of their GWP. The two multilateral environmental agreements require definitions of baselines against which reductions are specified. The KA baseline which is defined in terms or production and consumption or HFCs must be translated into projections of actual emissions over time to be converted into a PA compatible baseline, determined in emission units. This requires a good understanding of the lifetime of cooling equipment and the respective emissions profiles from servicing and end of use disposal. Once this is done, the baseline for the NDC of a country under the PA can be specified. This baseline serves as key backdrop for setting baselines for generating emissions credits ('crediting baselines') under the international carbon market mechanisms of Art. 6 of the PA, linked to specific mitigation activities.

While the KA baseline has been formally fixed through the phase-down schedule of the KA and is mandatory for Parties to the KA, PA baselines are developed in a bottom-up fashion, applying generic principles of environmental integrity and transparency. While still being under negotiation, an NDC baseline is generally understood as reflecting and going beyond the BAU path of emissions, while an Article 6 crediting baseline should be set both below the NDC reference level and below a credible BAU. Setting the latter baselines should be done in a way that the KA commitment can be met and that the contribution of the RAC sector is 'fair' with regards to the different sectoral contributions to the NDC target. If an NDC or crediting baseline is overestimated, it will lead to 'hot air' which means that emissions credits issued against such a baseline are fictitious and lead to an increase of global emissions.

The KA baseline for A5 countries consists of two components, HFC consumption during a period in the 2020s, and an 'HCFC adder' which is equal to 65% of HCFC emissions during a past baseline period (2009 – 2010). The HCFC adder is due to the requirement that A5 countries should reduce HCFC consumption by 2020 to 65% of the baseline value. However, many A5 countries have reduced HCFC consumption much more strongly, some even to zero. An assessment of Costa Rica, Seychelles and Vietnam shows that applying the HCFC adder leads to a significant overestimate of the KA baseline compared to a BAU path, reaching over 80% in the case of the Seychelles. While the KA baseline falls below BAU in the second half of the 2020s for Costa Rica and Vietnam, for the Seychelles it remains above BAU until about 2040. Unfortunately, lack of data makes it impossible to do similar calculations for other countries so we call for a concerted effort under the KA to calculate baseline levels and BAU for all countries. Thereby, the KA phase-down pathway alone may not result in additional emission reductions below a business-as-usual scenario in all countries. Therefore, RAC sector mitigation efforts under the PA should go beyond the KA commitments of Parties. To satisfy NDC reference scenarios, countries should not include the "full" HCFC adder in their NDC reference scenarios- if that leads to inflated baseline levels – but be based on a downward-adjusted HCFC adder which is derived from the actual HCFC consumption levels achieved in 2020 – 2022, and subsequently adjusted as per the continuation of the HCFC phase-out. In any case, NDC reference scenarios should be the lower of (a) the country's KA commitments or (b) a conservative emissions pathway.

How to set a reference level for voluntary market-based cooperation in the RAC sector in the Paris Agreement context, with the objective of raising ambition in both regimes, is discussed further in Michaelowa et al. (2021b).

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Annex

Table 8: Data sources for assessment of HFC emission patterns and HCFC baselines

Country	RAC GHG Inventory Source	HFCF baseline Source
Colombia	GIZ 2017a	ExCom 2019a
Costa Rica	GIZ 2019b	ExCom 2019b
Ghana	GIZ 2018a	ExCom 2018b
Kenya	MoEF 2020	ExCom 2012
Mexico	GIZ 2014	ExCom 2018a
Namibia	GIZ 2017b	ExCom 2017
Senegal	-	ExCom 2020
Seychelles	GIZ 2020a	ExCom 2015
Thailand	BMC 2013	ExCom 2018c
Tunisia	GIZ 2018b	ExCom 2016
Vietnam	GIZ 2019a	ExCom 2019c

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