Applying Article 6 in the Cooling sector

Graph 1: This wide spread in HCFC reductions achieved (HPMPs) reflects firstly the spread of political power of the National Ozone Offices in Min. of Env., secondly spread of cooperation with industry and thirdly spread of help from Montreal P. implementing agencies. Türkiye is the best success case as a mayor appliances manufacturing country that effectively replaces HCFC and HFC with laws nonetheless, and Turkish OEMs continue to beat their competitor OEMs (in all brands from expensive Siemens to cheapest Sharp). The universally correct conclusion is the technologies (compressors) required are all available and do not imply significant cost. Whereas Vietnam, Tunisia and South Africa suffer from manufacturer OEMs and MNCs with little regard for environmental policy concerns.

Countries without manufacturing but rising HFC consumption are influenced by cheap importers' interests. But Cuba, Namibia, Cabo Verde, Maledives or Philippines prove the opposite is just as possible, opting for HCFC and HFC – free appliances although in these cases for various idiosyncratic motives.

The Montreal P. legacy is a complex outcome also due to its funding rules, based on "eligible consumption" and "eligible cost", often based on averages between all countries, hiding cost differences between countries and thus poor outcomes in some and effective outcomes in others.

The following 4 tables illustrate NDCs and Montreal P HPMPs published, grouped with the most typical aspects.

Table 1: Continued HCFC-22 imports (because poor HPMPs) and rising HFC imports

	South Africa	Cambodia	Tunisia	Vietnam	Sri Lanka	Uruguay	Senegal	Oman
in NDC	No. HFC in NIR	Yes. Nat. cooling plan: MEPS AC refr	Yes. HFC 4.6m tCO2e in'30. Nat. cool. plan	Yes. No target. Nat. cooling plan	No. en.eff. target Nat. cooling plan	No	Yes. HFC 801kt '35. MEPS. HCFC phaseout'30	No. additional MEPS
MP HPMP	HCFC st.I '19 46%[1] ban'14, '16. non-eligible co. to HFC. 4RRR	HCFC st.I '19 72% ban'20. 141b to HC self-funded. 22AC im 30k	HCFCst.I in'20 90%. 141b: 67t to HFO	HCFCst.II 64% 141b: 148to. nonA5 AC self-funded. 4 AC co. to 32	HCFC st.II '19 71% ban'16. 200 AC units to 32. 9RRR only 1to 22	HCFC st.III, '19 60%. 59t 141b to HFO ongoing	HCFC st.II 141b ban'23, 2nd hand HCFC ban'24.no RRR	HCFC st.III '20 52%. Mandat. recovery and leak detection
ODS credits	VCS2509							
Conversions in manufacturing	Bumbo, Harvey to HFC Whirlpool self-f and Arcelik funded to HC			Hoa Phat, Midea, Nagakawa, REE with KCEP fin several wait	Customs data problems, st.II deferred	Imports in '19 58% 22, 21%134a		Al Kawthar Risk of non-compliance

Table 2: Countries with successful HPMPs and major HFC reductions (bottom-left)

	Türkiye	Namibia	Mauritius	Maledives	Philippines	Botswana	Rwanda	Cuba
in NDC	no	Yes. 31kt CO2e disposal AC, refrig conditional	no	no	no	no	Yes. HFC 28kt CO2e. Kigali phase-down conditional	no
MP HPMP	HCFC st.I. '19 2%. HCFC ban'18 imp only for AC exp to A5	HCFC st.I 141b ban'13. HCFC ban '25. subsidy HC importers	HCFC st.I in'19 60%. HCFC AC imp ban in'13	HCFC st.I fisheries R-438 100% HCFC phaseout'20	HCFC st.II HCFC AC ban'22. All to 32. 141b ban '15	HCFC st.II 141b ban'21. HCFC ban'24 3RRR centres	HCFC st.II in '20 36%. HCFC AC ban '15	HCFC st.II '19 37% HCFC ban '15. 141b ban '16 HFO pb

[1] Percentage of baseline HCFC consumption = remaining reductions to achieve

Table 3: Successful HPMP but rapidly increasing HFC imports (bottom-right)

	Kiribati	Sudan	Mozambique	Kenya	Gambia	Surinam	Fiji
in NDC	no	no	no	yes	Yes. HFC 804kt '30	no	no
MP HPMP		HCFC st.III demo 80 ACs on HC. Manuf HFC AC to HC. 141b ban '20	HCFC st.I in'18 46%. HCFC ban'20	HCFC st.II in'19 38%. ban'21. Demo HC chiller	HCFC st.II in'19 13% Demo 200 AC HC	HCFC st.I customs data uncertain	HCFC st.II '20 37% 142 ban '21. 2nd hand ban'23. KIP HFC invent.

Table 4: Poor HPMP record but reducing HFC imports (upper left)

	Niger	Ghana	Mali	Ethiopia	Laos	Paraguay	Benin	Dom.Rep.
in NDC	No. energy efficiency refrigeration mentioned	Yes. 3874 kt '30. 4.3mt '50 Nat. cool. plan new MEPS,lab	Yes. HCFC HFC phaseout	Yes. No target. Nat. cooling plan	no	Yes. 260 kt. HFC phasedown Kigali	No	Yes. No target. HFC phasedown Kigali
HPMP	HCFC st.I in'20 63%. AC, refrig all HFC	HCFC st.I R406 10k AC to HC. 70% '30. KCEP AC retrofitting	HCFC st.I in'19 61%. on-hold	HCFC st.II in'20 62% HCFCequip ban'24	HCFC st.II in'19 56% HCFCequip ban '23	HCFC st.II HCFC AC ban'15. 141b ban'24. RRR train	HCFC st.I '20 57%. MEPS '20 reduced HCFC AC to 30%	HCFC st.III '19 74%. NH3 pilots. HCFCequip ban'17 KIP
		VCS1752						VCS2449

In total nine countries cite a HFC quantitative target in their NDC (like Table 1) and 55 countries mention the cooling sector in their NDC. Among the nine countries none propose a target more ambitious than the Kigali HFC phase-down schedule (not even Costa Rica). In other words, the existing NDCs referring to Kigali A. declare the targets to be conditional although Kigali A. implies MLF funding, so the NDC targets for HFCs all invite Art.6 funding overlapping with MLF funding.
Most of those nine countries have also published a National Cooling Plan including new or improved MEPS, which underlines that these governments are struggling with the urgency of increasing GHG emissions from cooling.
Those countries with major HFC reductions (Table 2 and 4) have all imposed bans on AC equipment with HCFC early, in 2013, 2015 or 2018. The HCFC reduction success is the direct impact but there appears to be an indirect effect that also reduces their HFC consumption. In other words, the HCFC ban signaled to importers and manufacturers that they should also replace HFC anticipating likewise regulatory initiatives for these gases. This is underlined by the fact that those countries with poor HPMPs (Table 4), where HCFC is still 56 or 74% of the HCFC baseline, have also announced import bans for equipment with HCFCs in 2017, 2023 or 2024 (Ghana being the most famous of them for banning 2nd hand refrigerators into Accra).

Overall this clearly indicates that countries with rising emissions or with ineffective past efforts tend to include cooling in their NDC efforts. An indication that producing an NDC is itself a policy opportunity. However, the uncertainties about the forces at work prevent them from proposing more ambitious goals than Kigali phase-down to attract conditional funding.

The overlap between Paris A. and Kigali A. has been increasing in strength (HPMPs started at the concentrated parts) and will continue to do so when HPMP work only on Air-conditioner servicing until 2030.

Montreal Protocol legacy and Article 6

Art.6.4 stresses ambition over time, BAT, aligning with Paris temperature goal and avoiding lock-in. These four issues are very salient in the Montreal Protocol legacy. Further HCFC and HFC reductions in Türkiye require a high benchmark, whereas in Tunisia, even a modest benchmark would create strong incentives for Tunisian Air-conditioner companies. Montreal legacy presents very different national circumstances.

Hypothesis I: Designated National Authorities (DNA) are the weakest part of CDM
Hypothesis II: Art.6 requires much additional capacity and policy from DNAs
Hypothesis III: Supervisory Body will not be able to address the Montreal legacy and their regulations after the next CMA (Sharm el-Sheikh) will not include any cooling related guidance.

If Hypothesis I is correct, Art.6 principles within the Montreal legacy are an extreme challenge for DNAs. As an example, consider the question whether BAT refrigerant is propane or one of the HFOs where commercial interests, doubts about environmental fate of chemicals and thermodynamic efficiency differences are evidently irresolvable in the Montreal P. expert community since 10 years, (TEAP) and in the Paris A. SBSTA forum just as likely to be so.

Hypothesis IV: voluntary carbon market actors will remain the only cooling sector actors. It is an open field where the first movers will be particularly influential.

Table 1: South Africa, Cambodia, Tunisia, Vietnam, Sri Lanka or Uruguay are the countries with the highest need (consumption remaining, up-left in the graph)) and the most active governments. In these countries, sales of new refrigerators and Air-conditioners that leapfrog HFCs can be credited to contribute to achieve their NDC target. Esp. before 2030, as a support for their slow HCFC phase-out (struggling with poor maintenance of HCFC-22 Air-conditioners) AND reducing their rapidly rising HFC consumptions.

Observation 1: Most active governments are addressing HCFC-22 and HCFC-141b with different regulations but the low price of these chemicals (a third of the alternatives) diminishes the regulations' impact. Senegal and Sri Lanka's weak regulations show that they will not force cheap appliances out of the market. Paying for a few thousand demonstration units (AC and refrigerators) will not change the market. Some of the non-eligible manufacturers of refrigerators or Air-conditioners (no funds from MLF) in the Table 1 countries choose HFCs (but not Whirlpool), others Hydrocarbons or simply wait. All of these countries have National Cooling Plans and are developing additional MEPS.

Observation 2: What distinguishes effective regulations (Table 2 countries) from weaker ones (Table 1 countries) is banning HCFC-22 Air-conditioners, even when the ban lies in the future (Namibia and Botswana). Türkiye shows that such a ban can work also in a major appliance manufacturing country, although in that case Türkiye's goal is

to comply with the EU's F-gas directive to assure exports while at the same time allowing cheap exports (with HCFC-22) to Article 5 countries. Mercantilism is at work in both directions.

Observation 3: While some countries introduce new labels against HCFC-141b (all produced in China) used for refrigerators and other foam, the majority of regulations address Air-conditioners (and thus HCFC-22) in all countries. Nonetheless, the replacement of HCFC creates increasing HFC consumption both in refrigerators and in Air-conditioners. The main difference between refrigerators and Air-conditioners is that in the latter it is mainly a price problem, HCFC-22 Air-conditioners are cheaper. While for refrigerators, the choice for Hydrocarbons instead of HCFC or HFCs is not motivated by a price differential (of the gases, perhaps prices for compressors are more influential). Cheaper and less efficient refrigerators defend their market share against higher-priced brands, no matter which is the refrigerant or which is the blowing agent.

Observation 4: Both to the left and to the right are smaller countries and larger countries around the middle. A plausible explanation is that smaller countries tend to be dominated by one or two importers of Airconditioners and these decide which brand offers them more attractive conditions.

In sum, the negative "barter" trade-off between HCFC and HFC is getting stronger, i.e. reducing HCFC-22 further (less Air-conditioners with it) has increased HFC (more Air-conditioners with R-404 and R-410) to the tune of 70% HFC consumption increase and more 2018-2020 in some cases. This invites the question, how to define a baseline combination that links a reduction of HCFC and a reduction of HFC, to achieve with sales of Air-conditioners with Hydrocarbons (non-HFC and non-HCFC) ?

Market Share Baseline Components Definition

There is no physical relation at all between HCFC and HFC, their link is in the choices made when Air-conditioners are sold. Whereas the sales choice involves an energy efficiency level "hardwired" into the Air-conditioner model. The obvious solution is this a baseline with three components.

Countries without bans can use a voluntary market baseline that reflects current market shares of refrigerants, both for new sales as for replacing (and recovering) old units. The basis would be a large sample of sales, for instance in mayor cities. In countries without bans, the phase-out schedule for HCFC and the phase-down schedule for HFCs would be the time limit for credits. HCFCs replaced get voluntary credits, for HFCs replaced ITMOs. An HCFC baseline works in parallel to an HFC baseline, each can rise or fall. The HFC one would be more influential because of the higher GWP. When a country reaches the HCFC consumption level for 2025 (bold black line in graph), no more credits are possible because these would surpass what is legally allowed. The consumption level reflects all HCFCs so it includes different usages (but AC dominates HCFC usage everywhere). The crediting contributes to reducing consumption (ambition level of GHG reduction) and the baseline can be dynamic, calculated ex-post with the market share of the HFC to be replaced (not HCFC as it is not a Paris A. gas). This baseline would reflect

the high GWP of HCFC-22 and of HFC-404 (or 410) and add price incentive to prefer Hydrocarbons (R600 and R290). It concerns HCFC-22 as refrigerant in Air-conditioners and puts those with HFCs (404 and 410) at a disadvantage. Such as baseline can be derived for refrigerators and for Air-conditioners. Voluntary credits reflect the HCFC market shares. Most countries are in this case as they are above the black line.

Baseline attribute 1: reflects all appliances of a type entering a country, not a boundary around single units Baseline attribute 2: market share of HCFC and HFC are independent (for HFC appear in the national inventory),

This following equation reflects the change in market share of nonHFC,nonHCFC appliances which comprises Air-conditioners with Hydrocarbons (potentially also HFO). ThisΔ% reflects a gain in Low-GWP AC as it reflects the loss of AC with HCFC-22 and HFC-410. Multiplied with the absolute change in sales units Hydrocarbon AC minus change in sales HFC-410 AC and multiplied with the GHG reduction per Air-conditioner.

$$\Delta\%nonHFC,nonHCFC\,appliances\times(\Delta salesHC-\Delta salesHFC)\times\frac{avr.charge kg_{HFC}\times GWP_{HFC}}{avr.charge kg_{HC}\times GWP_{HC}}=\text{Refrigerant-in-use}$$

The first term is market share and the second only the change in HFC sales because Article 6 concerns only HFC. The similar operation for HCFC would apply to voluntary credits.

$$\Delta\%nonHFC,nonHCFC\,appliances\times(\Delta salesHC-\Delta salesHCFC)\times\frac{avr.charge kg_{HCFC}\times GWP_{HCFC}}{avr.charge kg_{HC}\times GWP_{HC}}=\text{Refrigerant-in-use}$$

These 2 equations apply while the stage I HPMP are completed, while the HCFC phase-out schedule is not surpassed and while the Kigali HFC funding is not yet available.

Observation 5: 46 among Article 5 countries have Minimum Energy Performance Standards (MEPS) for ACs. Almost all of these efficiency classes allow to define an ambition level either among all models on offer or less often, an ambition level among actual sales. The energy baseline would combine easily with a refrigerant baseline (as is the case in existing CDM methodologies). The refrigerant baseline reflects bans and where the ban lies in the future the credits from refrigerant would disappear then. In a few countries the MEPS recently introduced have contributed to reduce HCFC AC market share but this does not affect the accuracy of a baseline.

■ pentane, butane, propane or any HFO

HFC-32

HFC-227ea, 245fa or 365mfc

55 Länder sind schon unter 32,5% (2025), d.h. bekommen weniger hohe HFC baselines und brauchen keine HPMPs mehr. 70 brauchen noch HPMP impacts.

22 ODP 0.055 141b ODP 0.11

Reported HFC consumptions and baselines

		HPMP	2020 cons HCFC-141b	HCFC	2020 % on baseline 88/8 AnII
Afghanistan					26
Albania					52
Algeria					63
Angola	67.5% 2025	8836	4		58
Antigua					0
Argentina		8439			31
Armenia		8638	0		31
Bahamas		8837	0		
Bahrain		8838	90		
Bangladesh		8123			64
Barbados					24
Belize		8719	0		
Benin		8720	0		57
Bhutan					0
Bolivia		8721	0		33
Bosnien					30
Botswana		8640	0		0
Brazil		8839 8641	0	45% in'21	34
Brunei		8642	0		60
Burkina		8643	0		22
Burundi					0
Cabo Verde		8840 8644	0		0
Cambodia		8321			45
Cameroon		8841	0		37
Chad		8723	0		63
Chile		8842	0		31
China		8843	28,976		55
Colombia		8844	357		28
Comores		8724	0		100
Congo		8845	0		63
Cook Isl					0
Costa Rica		8445			28

Cote d'Ivoire					65
Cuba		8645	0	0% in'30	
DPKorea					82
Djibouti		8846	0		57
DominicanR		8646	0		57
Ecuador		8647	6.7 ban '20		57
Egypt		8847	0		
El Salvador		8726	0 HPMP II		24
Equat Guinea					16
Eritrea					55
Eswatini		8649	0		24
Ethiopia		8848	0		62
Fiji		8849	0		37
Gabon		8727			51
Gambia		8651	0 AC		13
Georgia		8850	0		
Ghana	67% below t	8450			28
Grenada					25
Guatemala		8652	4.19 ban'21		48
Guinea					8
Guyana					50
Haiti					0
Honduras		8653	0 ban'17		36
India		8654	3459 ban'15 not complied		18
Indonesia		8851	220		47
Iran		8655	9.5		43
Jamaica		8656	0		31
Jordan					35
Kenya		8657	0		12
Kiribati					0
Kuwait		8852	380		61
Kyrgyzstan					0
Laos		8658	0 ban '23		61
Lebanon		8659	139.8		48
Lesotho		8731			14
Liberia					30
Madagascar					22
Malawi					31
Malaysia		8853	227		44
Maldives		7640			2
Mali		8330			50
Marshall Isl					0
Mauritius		8660	0		25
Mexico		8145			10
Micronesia					50
Moldova		8861	0		

Mongolia		8661	0		47
Montenegro					13
Morocco		8854	104		
Mozambiqu		8333			
Myanmar		8662	0		80
Namibia		7937			8
Nauru					0
Nepal		8663	0		36
Nicaragua		8664	0		40
Niger		8855	0		63
Nigeria		8856	485		48
Niue					0
N Macedonia		8857	0		22
Oman		8858	0		51
Pakistan		8859	763	Ban ‘26	49
Palau					0
Papua N Guinea		8732	0		
Panama		8668	0		46
Paraguay		8733	3		61
Peru		7938			46
Philippines		8048			31
Qatar		8860	385		65
Rwanda		8672	0		41
Saint Lucia		8736	0		0
St.Vincent		8673	0	Ban ‘25	0
Samoa					0
Sao Tome					5
Saudi Arabia					60
Senegal		8862	0	Ban ‘30	36
Serbia					63
Seychelles					0
Sierra Leone		8737	0		35
Singapore					35
Somalia		8863	0		24
S.Africa		8336			30
Sri Lanka		8674	0		62
Sudan		8864	0		20
Suriname		8149			30
Syria		8676	0		61
Tanzania		8739	0		59
Thailand		8269			38
Timor-Leste					40
Togo		8738	0		55
Trinidad		8677	0		32
Tunisia	43% below				57
Turkey		8461		100% ‘25	0.3

Turkmenistan		8678	0		56
Tuvalu					0
Uganda		8679	0	Ban'30	50
UAE					63
Uruquay		8680	0 St.III		48
Vanuatu					0
Venezuela					0
Vietnam		8740	148		64
Zambia		8681	0		44
Zimbabwe		8682	0		35

Afghanistan				
Albania				
Angola	67.5% 2025	4 tons 141b		
Antigua				
Argentina				
Armenia				
Bangladesh				
Barbados				
Benin				
Bhutan				
Bolivia				
Botswana				
Brazil				
Brunei				
Burkina				
Burundi				
Cabo Verde				
Cambodia				
Cameroon				
Chad				
Chile				
Colombia				
Comores				
Cook Isl				
Costa Rica				
Cote d'Ivoire				
DPKorea				
Djibouti				
Dominican R				
Ecuador				
Equat Guinea				
Eswatini				

Ethiopia				
Fiji				
Gabon				
Ghana	67% below t			
Grenada				
Guatemala				
Guinea				
Guyana				
Haiti				
Honduras				
India				
Jordan				
Kenya				
Kiribati				
Kyrgyzstan				
Laos				
Lebanon				
Lesotho				
Liberia				
Madagascar				
Malawi				
Malaysia				
Maldives				
Mali				
Marshall Isl				
Mauritius				
Mexico				
Micronesia				
Montenegro				
Namibia				
Nauru				
Nicaragua				
Niger				
Nigeria				
Niue				
N Macedonia				
Oman				
Pakistan				
Palau				
Panama				
Paraguay				
Peru				
Philippines				
Qatar				
Rwanda				
Saint Lucia				
St.Vincent				
Samoa				
Sao Tome				

Senegal				
Serbia				
Seychelles				
Sierra Leone				
Somalia				
S.Africa				
Sri Lanka				
Sudan				
Suriname				
Syria				
Timor-Leste				
Togo				
Trinidad				
Tunisia	43% below			
Turkey				
Turkmenistan				
Tuvalu				
Uganda				
Tanzania				
Uruquay				
Vanuatu				
Venezuela				
Vietnam				
Zambia				
Zimbabwe				

All Refrigerant Management Plans (RMP) for CFCs in the Servicing Sector					
Algeria			Laos	LVC	16,900
Angola	LVC	700,000	Lebanon	LVC	52,000
Antigua	LVC	124,000	Lesotho	LVC	56,000
Argentina		454,000	Macedonia	LVC	270,000
Bahamas	LVC	194,775	Madagascar	LVC	25,000
Bahrain	LVC	239,151	Malawi	LVC	106,000
Bangladesh		271,148	Malaysia		1,614,000
Barbados	LVC	164,688	Mali	LVC	176,000
Belize	LVC	144,384	Mauritius	LVC	170,500
Bolivia	LVC	216,000	Mexico		1,176,000
Brazil		170,820	Moldova	LVC	329,000
Burkina	LVC	230,000	Mongolia	LVC	149,000

Burundi	LVC	171,205	Morocco		53,000
Cameroon	LVC		Mozambique	LVC	145,000
CAR	LVC		Namibia	LVC	137,000
Chad	LVC	226,761	Nepal	LVC	156,000
Chile		336,000	Niger	LVC	137,000
China		1,129,364	Oman	LVC	49,000
Colombia		1,017,000	Panama	LVC	200,000
Congo	LVC	262,000	Paraguay	LVC	290,295
Costa Rica	LVC	451,693	Peru	LVC	365,000
Cote D'Ivoire	LVC	115,000	Philippines		925,000
Croatia	LVC	376,281	Qatar	LVC	89,000
Cuba		362,233	Saint Vincent	LVC	40,000
Dominican R		839,000	Samoa	LVC	86,000
El Salvador	LVC	442,000	Senegal	LVC	250,000
Ethiopia	LVC	65,255	Seychelles	LVC	25,000
Fiji	LVC	161,000	Sri Lanka	LVC	522,000
Gabon	LVC	244,122	Sudan	LVC	339,614
Gambia	LVC	75,000	Syria	LVC	700,718
Georgia	LVC	172,000	Tanzania	LVC	36,000
Ghana	LVC	623,000	Thailand		637,000
Granada	LVC	62,000	Trinidad	LVC	393,000
Guatemala	LVC	427,000	Tunisia		333,000
Guinea	LVC	127,000	Turkey		587,000
Guyana	LVC	138,000	Uganda	LVC	75,000
Honduras	LVC	245,000	Uruguay	LVC	450,000
India		12,000	Venezuela		1,913,000
Indonesia		275,000	Vietnam		543,000
Iran		183,000	Yemen	LVC	86,917
Jamaica	LVC	289,000	Zambia	LVC	131,000
Jordan		353,000	Zimbabwe		351,000
Kenya	LVC	87,000			
Korea DP		130,000	Sum total:	27,125,000	
Kuwait		624,000	88 countries		
Kyrgyzstan	LVC	9,170			