POLICY RECOMMENDATIONS ON THE PROPOSAL FOR AN F-GAS REGULATION

The COM proposal for a new F-Gas Regulation, released in November 2012,[1] contains the basic elements required to tackle HFC emissions but lacks ambition and advances an incomplete regulatory framework. Parliament and the Council should ensure specific policies targeting critical moments during the lifetime of HFC-based equipment – before use (bans), during use (containment) and end of use (recovery) – supported with strong reductions in bulk HFCs allowed to be placed on the market (also referred to as "quantitative limits" or "phase-down").

CONSTRUCTING A SUCCESSFUL REGULATORY FRAMEWORK

While the phase-down is an important tool, by itself it will not be successful. It is just one of a package of measures needed to achieve our climate objectives. But if over-allocation can be avoided, a phase-down that limits the amount of HFCs that may be placed on the market can play a crucial role in supporting other measures by limiting the amount of HFCs available for first fill and refill, in particular:

BANS by promoting the uptake of alternatives in advance of the ban;

CONTAINMENT by encouraging tighter systems and leakage control; and

RECOVERY by incentivising reclamation and recycling.

A phase-down is important for encouraging the transition to alternatives in areas where bans are not feasible because alternatives are not expected to fully penetrate the market. It can also generate revenue to cover Member State costs associated with implementation by allocating HFC quotas at a cost.

However a phase-down is not a substitute for the other measures. Only containment measures establish mandatory leakage checks or maximum leakage rates; only recovery measures mandate recovery or producer responsibility schemes; only bans ensure HFC-based equipment is no longer placed on the market in a sector when no longer necessary. For these reasons, a phase-down is a critical part of a package of measures but a substitute for none.

The Environmental Investigation Agency (EIA), the European Environmental Bureau (EEB), World Wide Fund for Nature (WWF), and Climate Action Network Europe (CAN-E) therefore propose the following revisions to the COM proposal and rationale.

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Overview

The centre-piece of the COM proposal is a phase-down with discrete bans in pre-charged and hermetically sealed equipment.[2] Despite clear evidence of the technical and economic feasibility of additional bans in other subsectors, and the clear legislative mandate to include them, these bans were excluded.[3] This exclusion represents a *dramatic* departure from the successful regulatory framework applied to ozone-depleting substances (ODS Regulation) – the predecessor gases used in these same sectors – where a phase-down was coupled with robust bans in refrigeration, air-conditioning and foams when CFC or HCFC-based products and equipment were no longer needed.[4] The same successful regulatory approach must be restored here.

Introduce Additional Bans and Preserve Existing Ones

Safe, energy-efficient and cost-effective alternatives to HFCs are on the market today.[5] When those alternatives can fully meet market demand for any given application, new equipment using HFCs should be banned in that subsector. Bans "lock-in" benefits in subsectors capable of transitioning and that is what the original F-Gas Regulation envisioned would be proposed during this revision (see Annex I).[6] Although the leaked proposal circulated in inter-services consultation included bans in commercial and industrial refrigeration on this basis, the final COM proposal excluded them, due to HFC industry pressure not merit. We urge their reintroduction here.

The *Impact Assessment* and *Preparatory Study* identified when bans can be adopted using the concept of "penetration rates."[7] Penetration rate is defined as "the maximum market potential of a technical choice (i.e. abatement option) to replace new products or equipment relying upon HFCs in a particular sector."[8] It incorporates safety concerns and cost constraints while also factoring in the availability of materials and components, system complexity and know-how.[9] It also ensures, as its basic guiding principle, that abatement options (alternatives) achieve "*at least the same level of efficiency as the existing refrigerants.*"[10] This latter consideration is significant because it ensures that indirect greenhouse gas (GHG) emissions from energy consumption are always equal or less in the case of alternatives.

The presumption should be strongly in favor of inclusion in the list of bans in Annex III when penetration rates reach close to 100% for any given subsector. In addition, since penetration rates are conservative assessments, they serve as the latest date for which a prohibition should take effect. Earlier action is advised under the precautionary principle, bedrock law in the Lisbon Treaty.[11]

When alternatives have the potential to meet market demand in a subsector, bans should be introduced. Unless bans are included as part of the package of measures, new HFC-based equipment will continue to be placed on the market in subsectors that should have fully transitioned to alternatives, locking in HFC infrastructure for decades into the future, creating chronic market uncertainty, and undermining the uptake of alternatives. Bans also ensure that if sectors transition to alternatives earlier than expected, this does not enable other sectors to lag behind, thus ensuring each sector does its fair share while preserving limited HFC quotas for those sectors that really need them. In addition, clear market signals with concrete timeframes for companies and investors *in each subsector* are needed to ensure proper planning and investment in production facilities to transition fully to alternatives. Allowing HFC-based equipment when it is no longer necessary also places unnecessary reliance on containment and recovery measures that are not only expensive but suffer from well-known compliance and enforcement problems, further burdening Member States. There is no substitute to bans, and the opportunity to strengthen Europe's position as a leader in providing alternatives will be squandered without them.

The *Impact Assessment* and *Preparatory Study* contain an abundance of information – corroborated by industry, Member State and Commission studies – that is summarised in the following tables:

TABLE 1: PENETRATION RATES OF ALTERNATIVES FOR EACH SUBSECTOR
Preparatory Study / Impact Assessment

Sector	Subsector	Maximum Penetration Rate of Alternatives		
		2015	2020	2030
Domestic Refrigeration	Refrigerators/Freezers[12]	100%	100%	100%
Commercial Refrigeration	Stand-Alone Systems (Hermetic Units)[13]	70%	125%†	145%
	Condensing Units[14]	36%	100%	190%
	Centralized Systems[15]	46%	125%†	300%
Industrial Refrigeration	Small Industrial Equipment[16]	60%	70%*	95%
	Large Industrial Equipment[17]	60%	70%*	95%
Transport Refrigeration	Refrigerated Vans[18]	6%	100%	165%
	Refrigerated Trucks[19]	32.5%	65%	125%†
	Fishing Vessels[20]	70%	90%	95%
Mobile Air Conditioning	Cargo Ship AC[21]	71%	100%	180%
	Rail Vehicle AC[22]	5%	25%	60%
	Passenger Ship AC[23]	1%	20%	90%
Stationary Air Conditioning	Moveable Systems[24]	31%	100%	150%
	Split Systems[25]	31%	105%	125%
	Multi-Split/VRF System[26]	36%	90%	190%†
	Rooftop Systems[27]	36%	100%	215%
	Chillers (Displacement) [28]	41%	100%	180%
	Centrifugal Chillers[29]	6%	45%	130%†
	Heat Pumps[30]	51%	110%	260%
Fire Protection	Fire Prot. HFC-23[31]	100%	100%	100%
	Fire Prot. HFC-227ea[32]	70%	80%	90%
Aerosol	Aerosol (sans metered dose inhalers) [33]	25%	95%	95%
Foams	XPS with HFC-134a[34]	120%†	190%	190%
	XPS with HFC-152a[35]	130%†	200%	200%
	PU Spray Foam[36]	150%†	200%	200%
	Other PU[37]	125%†	195%	195%

Notes: * For industrial refrigeration, bans are feasible by 2020 with capacity greater than 100 kw.[38]
† Bans may be adopted earlier because penetration rates exceed 100% on this date.

TABLE 2: COMPARISON OF FEASIBILITY OF BANS AND LOW-GWP ALTERNATIVES IN REFRIGERATION

Preparatory Study / Impact Assessment and *SKM Enviros Report*

Sector	*Preparatory Study / Impact Assessment*		*SKM Enviros Report*		
	Subsector	Market Penetration 100%	Subsector		Very Low GWP GWP <10[39]
Domestic Refrigeration	Refrigerators/Freezers[40]	2015	Refrigerators[41]	MT	🟢
			Freezers[42]	LT	🟢
Commercial Refrigeration	Stand-Alone Systems[43]	2018†	Hermetic Units (medium temp)[44]	MT	🟢
			Hermetic Units (low temp)[45]	LT	🟢
	Condensing Units[46]	2020	Single Condensing Units (MT)[47]	MT	🟢
			Single Condensing Units (LT)[48]	LT	🔴
	Centralized Systems[49]	2019†	Multi-pack Centralised Systems (MT)[50]	MT	🟢
			Multi-pack Centralised Systems (LT)[51]	LT	🟢
Transport Refrigeration	Refrigerated Vans[52]	2020	Vans and Light Trucks[54]	LT & MT	🟢
	Refrigerated Trucks[53]	2026†	Large Trucks and Iso-Containers[55]	LT & MT	🟢
Industrial Refrigeration	Small Industrial Equipment (above 100kW) [56]	2020*	Small DX LT (low temp)[58]	LT	🟡
			Small DX MT (medium temp)[59]	MT	🟢
			Medium DX LT (low temp)[60]	LT	🟡
			Medium DX MT (medium temp)[61]	MT	🟡
			Large DX LT (low temp)[62]	LT	🟢
	Large Industrial Equipment [57]	2020*	Large DX MT (medium temp)[63]	MT	🟢
			Medium-size Industrial Chillers MT[64]	MT	🟢
			Large Industrial Chillers MT[65]	MT	🟢
			Large Flooded LT (low temp)[66]	LT	🟢
			Large Flooded MT (medium temp)[67]	MT	🟢

Notes: 🟢 = Suitable for application, according to *SKM Enviros Report*.[68]

🟡 = Technically feasible but other options usually preferable in terms of capital cost and / or energy efficiency, according to *SKM Enviros Report*, although no thresholds are provided for this determination.[69]

🔴 = Not suitable on safety, efficiency or cost grounds, according to *SKM Enviros Report*.[70]

† = Penetration rates exceed 100% at dates given by *Preparatory Study* (100% occurs earlier assuming linear penetration of alternatives).[71]

* = Penetration rates reach 100% in industrial refrigeration with capacity greater than 100 kw by 2020.[72]

TABLE 3: COMPARISON OF FEASIBILITY OF BANS AND LOW-GWP ALTERNATIVES IN AIR CONDITIONING
Preparatory Study / Impact Assessment versus SKM Enviros Report

Sector	*Preparatory Study / Impact Assessment*		*SKM Enviros Report*	
	Subsector	**Penetration Rate 100%**	**Subsector**	**Very Low GWP GWP <10**[73]
Stationary Air Conditioning	Moveable Systems[74]	2020	Small portable units, cooling only (air-to-air)[75]	🟢
			Small split systems, cooling only (air-to-air)[79]	🟡‡
			Small split systems, heating & cooling (air-to-air)[80]	🟡‡
	Split Systems[76]	2020	Medium split systems, cooling only (air-to-air)[81]	🔴*
			Medium split systems heating & cooling (air-to-air)[82]	🔴*
	Rooftop Systems[77]	2020	Large split systems, cooling only (air-to-air)[83]	🔴*
			Large split systems heating & cooling (air-to-air)[84]	🔴*
			Packaged systems, cooling only (air-to-air)[85]	🔴*
			Packaged systems, heating & cooling (air-to-air)[86]	🔴*
	Multi-Split/VRF System[78]	2021†	VRF systems, cooling only (air-to-air)[87]	🔴*
			VRF systems, heating & cooling (air-to-air)[88]	🔴*
			Small - cooling only (scroll/screw, air-cooled)[90]	🟡‡
			Medium - cooling only (scroll/screw, air-cooled)[91]	🟢
			Large - cooling only (screw, air-cooled)[92]	🟢
	Chillers (Displacement)[89]	2020	Small - cooling only (scroll/screw, water-cooled)[93]	🟡‡
			Medium - cooling only (scroll/screw, water-cooled)[94]	🟢
			Small - reversible heating/cooling, air-source, hydronic[95]	🟡‡
			Medium - reversible heating/cooling, air-source, hydronic[96]	🟢
	Centrifugal Chillers[97]	2027†	Large - cooling only (centrifugal, water-cooled)[98]	🟢
	Heat Pumps[99]	2020	Domestic - heat only, air-source, hydronic[100]	🟡‡
			Small - heat only, air-source, hydronic[101]	🟢
Mobile Air Conditioning	Rail Vehicle AC	---	Buses, trains[102]	🟢

Notes: 🟢 = Suitable for application, according to the *SKM Enviros Report*.[103]
🟡 = Technically feasible but other options usually preferable in terms of capital cost and / or energy efficiency, according to the *SKM Enviros Report*, although no thresholds are provided for this determination.[104]
🔴 = Not suitable on safety, efficiency or cost grounds, according to the *SKM Enviros Report*.[105]
† = Penetration rates exceed 100% at dates given by *Preparatory Study* (100% occurs earlier assuming linear penetration of alternatives).[106]
‡ = Traffic light determination excludes hydrocarbon-based alternatives from consideration (other studies have found them technically feasible).[107]
* = This conclusion conflicts with the findings in other studies and current practices, in particular discounting the suitability of hydrocarbons and CO_2.[108]

The COM proposal does not follow the clear findings in the *Impact Assessment* and *Preparatory Study*. Annex III should be amended to:

1. **Introduce bans on new HFC-based equipment in commercial and industrial refrigeration**. Bans in refrigeration are supported by an unparalleled body of technical evidence,[109] and an abundance of real-world experiences.[110] These bans were originally included in the draft proposal circulated in inter-services consultation but HFC-industry pressure resulted in their removal. The *Impact Assessment* and *Preparatory Study* show that alternatives are cost-effective and achieve clear reductions in HFC emissions, with penetration rates (except in a small sub-sector of industrial refrigeration) reaching 100% in 2020 and sometimes earlier – see Table 2.[111] Given the clear energy-efficiency gains from alternatives, bans also reduce indirect GHG emissions.[112]

2. **Introduce bans in foams starting in 2015**. Foams can have long lifetimes of up to 50 years, with the *Impact Assessment* indicating that "a lack of public intervention today would result in higher emissions up to several decades into the future,"[113] especially as increasing insulation operations are undertaken to save energy in new and existing buildings. The *Impact Assessment* and *Preparatory Study* show that alternatives are cost-effective and achieve clear reductions in HFC emissions, with penetration rates reaching 100% in 2015.[114] In addition, it is costly and difficult to recover F-gases from foam products. A March 2012 report commissioned by DG Climate demonstrated that no end-of-life recovery measures were possible within €50 per t/CO_2-eq. whereas a phase-out of HFC use in XPS and PU spray foams generates substantial emission reductions at reasonable cost-effectiveness.[115]

3. **Introduce bans in technical aerosols starting in 2020**. The *Impact Assessment* and *Preparatory Study* show that alternatives to technical aerosols are cost-effective and achieve clear reductions in HFC emissions, with penetration rates reaching close to 100% in 2020.[116]

4. **Introduce bans in stationary air-conditioning when penetration rates reach 100%**. Bans in stationary air-conditioning are supported by a significant body of technical evidence.[117] This sector is also the fastest growing source of emissions. The *Impact Assessment* and *Preparatory Study* show that alternatives are cost-effective and achieve clear reductions in HFC emissions, with penetration rates reaching 100% in 2020 or earlier in all subsectors (single-split, rooftop, displacement chillers) except multi-split/VRF systems and centrifugal chillers, which will require a little more time.[118] It should be noted that the EPEE-funded *SKM Enviros Report*, which contends that there are no suitable very low-GWP (<10) alternatives (red dots in Table 3) in mid-size air conditioning systems, dismisses hydrocarbon and CO_2-based alternatives, although other studies demonstrate they are feasible.[119] Given that improvements in energy efficiency are inherent in technology generation, and alternative technologies are much earlier in the innovation curve than HFC technologies, energy efficiency gains can be expected in the future. New bans for this sector should be included in Annex III, coupled with a review clause before 2020 as an additional measure to ensure no adverse impacts on energy efficiency while not compromising the transition to alternatives.

5. **Introduce bans in refrigerated vans, trucks and trailers**. The *Impact Assessment* and *Preparatory Study* show that bans are cost-effective and achieve clear reductions in HFC emissions in transport refrigeration, with penetration rates reaching 100% in 2020 for refrigerated vans and over 100% in 2030 for refrigerated trucks and trailers.[120]

6. **Introduce bans in cargo ship air-conditioning**. The *Impact Assessment* and *Preparatory Study* show that bans are cost-effective and achieve clear reductions in HFC emissions in cargo ship air-conditioning, with penetration rates reaching 100% in 2020.[121]

7. **Delete Article 9(2)**. This provision, which automatically exempts products and equipment when certain findings on lifecycle CO_2 emissions are made under Directive 2009/125/EC, should be deleted for several reasons. It creates a significant loophole, placing undue reliance on lifecycle analyses that suffer from a lack of transparency and discount other sources of GHG emissions, such as those from production; it further politicises the ecodesign decision-making process; and it undermines the market certainty provide by bans. Further, the COM proposal already allows for discrete derogations based on lifecycle GHG emissions to be granted by the Commission, rendering this provision redundant.

Although the COM proposal requires significant revision to ensure a successful regulatory framework, the bans that were included should not be discarded but also strengthened:

8. **Preserve the service ban in Article 11 and re-introduce an earlier start date**. Article 11 in the COM proposal prohibits the use of HFCs or HFC blends with GWP >2,500 in the servicing and maintenance of refrigeration equipment with a charge sizes 5 tonnes CO_2-eq or more from 1 January 2020. This will ban the use of HFC-404A, an HFC blend (GWP 3,922) that is extensively used in refrigeration equipment across the EU and responsible for the largest proportion of HFC emissions. According to the EPEE-funded *SKM Enviros Report*, HFC-404A consumption in refrigeration represents 44% of GWP-weighted consumption of refrigerants in 2010.[122] The *SKM Enviros Report* analysed a scenario where 50-75% of existing stationary refrigeration systems (commercial and industrial) was retrofilled with lower-GWP refrigerants during 2014-2017 and all new systems avoided the use of HFC-404A during 2015-2019, demonstrating deep cuts in HFC demand.[123] Indeed, the *SKM Enviros Report* even acknowledges that an earlier start and faster move away from HFC-404A is technically feasible.[124] The draft proposal circulated in inter-services recommended a 2018 start date for the service ban, which was pushed back to 2020 in the COM proposal for unknown reasons. The start date of the service ban should be moved to 2016 or earlier. There may be some concerns regarding the economic feasibility of retrofilling smaller stationary refrigeration systems and transport refrigeration systems. These can be addressed by increasing the current 5 tonne CO_2-eq threshold to around 40 tonnes CO_2-eq, which would effectively exempt these systems and ensure that operators will not be required to change equipment before end-of-life. The charge threshold should be expressed in kilogrammes of refrigerant which for 40 tonnes CO2-eq equates to around 11kg. For smaller systems, the use of recycled or reclaimed HFC-404A should be mandatory shortly after the servicing ban comes into place (e.g. 2017), to ensure a market for the refrigerant that has been taken out of the larger systems, and to avoid unnecessary continued production of virgin HFC-404A. In support of the service ban, and until a full ban on fluorinated greenhouse gases can be introduced for commercial and industrial refrigeration, a ban on new refrigeration equipment with a GWP >2,500 should be introduced starting in 2016. New refrigeration equipment with a charge size equivalent or less than 11 kg can be placed on the market with HFCs having a GWP >2,500 only if the refrigerant is reclaimed or recycled.

9. **Preserve the bans in hermetically sealed equipment in Annex III.** The COM proposal includes bans on hermetically sealed domestic and commercial refrigerators and freezers and moveable room air-conditioning appliances, which are sealed during manufacture and not reopened for charging so considered leak-proof. These bans are needed not only to ensure transition to alternatives in these sectors, but also to preserve the integrity of the phase-down mechanism as these products are imported in significant quantities.[125]

10. **Preserve the pre-charged ban in Article 12 to ensure the phase-down functions.** The pre-charged ban is needed to preserve "the integrity of the phase-down mechanism" since the phase-down is based on bulk quantities, i.e. HFCs destined for first fill and refill that have not yet been charged in equipment.[126] The pre-charged ban is critical for the phase-down for several additional reasons: (i) the phase-down is based on reported data, meaning importers of pre-charged equipment did not report under the original F-Gas Regulation so no concrete information exists for phase-down schedule or allocation purposes; (ii) the high number of importers and ports of entry considerably complicates enforcement and compliance and also incentivises mislabeling and illegal trade; (iii) loopholes that would encourage pre-charging abroad or moving production outside the EU to avoid the phase-down are avoided; and (iv) pre-charged equipment is packaged in standard sizes, meaning that it is not always tailored to the specific application for which it will be used, resulting in the inefficient use of resources and reduced energy efficiency in comparison to equipment charged on site. The pre-charged ban is a placeholder to ensure the phase-down works until the impacted subsectors can actually be subject to full HFC bans – regardless whether charged in the EU or abroad – which can occur shortly thereafter according to *Impact Assessment* and *Preparatory Study*.

CASE STUDY: LOBBYING FOR MID-GWP HFCS AND HFC BLENDS

American and Japanese chemical companies—including Daikin, Dupont and Honeywell—offer a range of mid-GWP HFC options designed to prolong reliance on HFC-based equipment which could potentially thwart a transition to alternatives often produced by smaller European companies that invested in the green economy.

Some examples of these new chemicals include:

Honeywell's HFC-407F (GWP 1,850): used to replace HFC-404A (GWP 3,922) in refrigeration.

Daikin's HFC-32 (GWP 675): produced for stationary air-conditioning and to make HFC blends.

DuPont and ***Honeywell***'s HFC-1234yf (GWP 4) and HFC-1234ze (GWP 7): used with high-GWP HFCs to create new mid-GWP HFC blends (GWP 600-800) for refrigeration.

These chemical companies are lobbying heavily for a phase-down structured to facilitate their market dominance – one that allows unfettered access to mid-GWP HFCs and HFC blends in the future (more relaxed phase-down steps and a significant "tail" after 2030). Including bans limits the ability of these chemical companies to manipulate the phase-down schedule in their favour, while bans are essential for smaller European companies because they provide *clear market signals with concrete timeframes for companies and investors in each subsector*, spurring the necessary planning and capital investments to achieve scale of production and meet market demand.

ADJUST THE PHASE-DOWN SCHEDULE

It is vital that the phase-down is as robust as possible. This requires, in the first place, that it does not over-allocate HFC quotas. Once over-allocation is avoided, a phase-down can play a crucial role in supporting the other measures – bans, containment, and recovery – while also complementing them in areas left unaddressed, as described above. It also sends an economy-wide signal that HFC use is unsustainable, one that has tremendous implications at the international level. But these are all premised on the phase-down avoiding over-allocation.

The COM proposal advancing a phase-down without reasonable bans will have several unintended consequences. **First**, it will ensure the continued market dominance by American and Japanese multinationals at the expense of smaller European enterprises. This is because, unlike other GHGs, HFCs have considerable differences in GWP (from 4 to 14,800) and the phase-down is CO_2-weighted. As a result, any downward pressure can be reduced or eliminated by using HFCs or HFC blends with slightly lower GWPs. This continued market dominance of HFC-based equipment is the single greatest threat to transitioning to truly climate-friendly alternatives and positioning smaller European enterprises as global leaders. **Second**, it creates chronic market uncertainty. Alternatives providers are left to divine the future marketplace and speculate whether HFC-based equipment will continue to occupy disproportionate market share, resulting in inaction across all subsectors. Again, this serves to penalise smaller European enterprises that rely on outside investment and have less room to manoeuvre than their larger competitors. In contrast, bans send clear market signals with concrete timeframes for companies and investors in each subsector, spurring the necessary planning and capital investments to achieve scale of production and meet market demand. **Third**, it will encourage long-term reliance on expensive and difficult containment and recovery measures, given equipment lifetimes are 10-30 years. The most important measure to overcome the unintended consequences stemming from the current proposal is to include additional bans in Annex III.

In addition to the inclusion of bans, the following improvements to the phase-down are needed:

1. **Adjust downward the HFC baseline to account for historical noncompliance embedded in reported data**. Proposed Annex V calculates the HFC baseline as the "annual average of the total quantity produced and imported into the EU during the period from 2008 to 2011."[127] This contrasts with the *Preparatory Study*, which relied on a bottom-up approach in the *AnaFgas* model developed specifically for this revision to calculate actual HFC demand for new and existing equipment based on current and future HFC infrastructure.[128] The switch to reported data, in which even the *Impact Assessment* acknowledges

overestimation is possible,[129] serves to inflate the HFC baseline, and locks in historical noncompliance with containment and recovery (thus rewarding poor implementation).[130] To the extent reported data is used, it should be adjusted to reflect what would have been achieved under full compliance.

2. **Amend phase-down steps before 2020 to avoid deliberate over-allocation**. There is no need for the first two phase-down steps in 2016 and 2018 to deliberately over-allocate HFCs by 10% and 5%, respectively, as the *Impact Assessment* explicitly admits: "[t]he first two phase-down steps are designed to be above the calculated [quantities] in order to grant more flexibility to ensure that companies have sufficient time to adapt."[131] The fact that the baseline already over-allocates exacerbates this over-allocation in the first two phase-down steps, and will significantly impact the transition to alternatives before 2020. The reductions steps must be downward adjusted so that the reduction step in 2016 is 83% (not 93%) and the reduction step in 2018 is 58% (not 63%).

3. **Amend phase-down steps after 2020 to take account of the service ban.** The *SKM Enviros Report* found that HFC-404A, which is used only in refrigeration, represents 46% of HFC emissions during the period 2015-2020.[132] It therefore identified "excellent potential for early emission reductions via a policy that will encourage the move away from HFC-404A," in particular the retrofill of existing equipment with medium-GWP refrigerants.[133] Phasing out HFC-404A therefore will have a significant impact on CO_2-weighted demand after the start date (2020 in the current proposal) but the phase-down steps in the current proposal did not consider this impact.[134] While initially the service ban will increase demand for HFCs as systems are refilled with the lower-GWP refrigerants, the proposed phase-down schedule can accommodate this. Demand will then swiftly decrease once all systems comply with the ban and overall a significant decrease is expected. In addition, the service ban can take place in 2016 or earlier, with smaller systems exempted through increasing the threshold. The short-term additional demand for HFCs can also be reduced through mandatory use of recycled and reclaimed refrigerant by the smaller systems.

4. **Require allocation fees to access HFC quotas**. HFC quotas are grandfathered at no cost.[135] The only other option explored by the Commission was an auction, which was rejected because of the small number of actors and administrative burden.[136] In addition, an auction would likely yield very low prices, as occurred in the EU Emissions Trading Scheme (ETS), due to HFC over-allocation described above. However grandfathering violates the polluter pays principle, bedrock EU law in the Lisbon Treaty.[137] A better approach is to require payment of fixed allocation fees, which is administratively simple and will secure a revenue stream to compensate Member States for costs associated with training and certification,[138] collection of emissions data,[139] and enforcement and mitigate disproportionate regional impacts among Member States.

STRENGTHEN CONTAINMENT AND RECOVERY

Containment is required to reduce leakage once HFC-based equipment is placed on the market. At the time of adoption of the original F-Gas Regulation, the effectiveness of containment was largely unknown. The Commission imagined that containment measures would result in EU-wide leakage rates of 5.5%, something which now seems hopelessly ambitious.[140] Recovery is required once HFC-based equipment is placed on the market, meaning HFCs will need to be reclaimed, recycled or destroyed. Given the lifetimes of HFC-based equipment, the full implications of recovery have yet to be felt. But experiences with ozone-depleting substances confirm it is burdensome and expensive. Containment and recovery suffer from well-known compliance and enforcement problems, and tend to shift significant costs to Member States and taxpayers, rather than the HFC producers thus allowing the polluter to avoid paying.

The following revisions to containment and recovery measures are needed:

1. **Outline precautionary measures to be taken to prevent leakage**. The original F-Gas Regulation required operators to take "*all measures which are technically feasible and do not entail disproportionate cost*." That language was discarded because it created too much uncertainty, compounded by the fact that the original F-Gas Regulation did not state what it considered to be "*technically feasible*" or

"*disproportionate cost*." The Commission proposal now requires operators of HFC-based equipment to "*take precautions to prevent their unintentional release."* However, the proposal does not include an annex of precautionary measures or delegate to the Commission the task of detailing them. From a legal perspective, these unclear obligations are effectively inoperative.

2. **Include maximum leakage rates for each sector**. Maximum leakage rates, an important backstop to unabated leakage, already exist in some Member States, namely Germany, Belgium and Luxembourg.[141] From both a compliance and enforcement perspective, maximum leakage rates provide clear benchmarks that set out impermissible limits and allow violations to be pursued. Findings in the *Preparatory Study* support this conclusion on maximum leakage rates: "[f]rom a legal point of view, the establishment of maximum leakage rates would lead to clear identification of leaks and hence provide an additional tool for control and enforcement of containment measures resulting in F-gas emission reductions."[142] The *Preparatory Study* also notes that maximum leakage rates are already set out in several sectors by international and European standards.[143] It does caution, however, that "the choice of maximum leakage rates would need to be supported by experiences on best practices and determination of such rates." Opponents of maximum leakage rates make two main arguments against their inclusion. First, they argue that including maximum leakage rates will result in operators only taking precautionary measures to reduce leakage up to the maximum leakage rate and no more. This argument is disingenuous since maximum leakage rates can exist *without prejudice* to the overall obligation to "take precautions to prevent their unintentional release." Second, they argue that maximum leakage rates depend on the subsector in question. This argument has merit; subsector specific maximum leakage rates should be adopted to account for the particularities of each subsector in question and ensure best practices. Either subsector specific maximum leakage rates should be included in the Regulation or the Commission should adopt them through delegated or implementing acts.

3. **Extend containment to maritime sector**. The *Impact Assessment* and *Preparatory Study* show that extending containment to maritime is cost-effective and achieves reductions in HFC emissions.[144] The Commission declined to extend to maritime because at the time it was considering a separate instrument to address GHG emissions in the maritime sector, however that instrument is no longer under consideration or forthcoming.[145]

4. **Require Member States to adopt producer responsibility schemes to promote recovery**. Several Member States have adopted producer responsibility schemes, including take-back schemes in Sweden and Germany[146] and a deposit-refund scheme in Denmark.[147] These serve to internalise the costs of HFC recovery into the prices of new HFC-based equipment, and promote compliance. In the *Impact Assessment*, producer responsibility schemes are discarded "because no generic scheme seems to be universally applicable" and national circumstances make it "preferabl[e] to be implemented at MS level and not at EU level."[148] This is true, but in order to promote cost-effective recovery and ensure a level playing field while taking into account national circumstances, Member States should be required to adopt their own producer responsibility schemes for equipment outside the scope of the WEEE Directive. In addition, the *Impact Assessment* acknowledges that "[r]ecovery of F-gases from foams is rather costly."[149] Mandatory recovery measures therefore exclude foams, and only require recovery "to the extent that it is practicable."[150] The lifetime of foams can reach 50 years with significant emissions only occurring thereafter, a point too far into the future for a traditional producer responsibility scheme. Therefore, not only should bans on foams enter as soon as possible – starting in 2015 as previously discussed – but Member States should adopt specific measures on producer responsibility for their recovery in consideration of their unique attributes.

5. **Require mandatory reporting to competent authorities to improve enforcement.** There is no uniform requirement for operators and certified personnel to forward records to competent authorities, only to maintain them.[151] This increases the administrative burden of enforcement and results in differential treatment across the Member States. Operators and certified personnel should be required to submit records to competent authorities with summaries of compliance for inclusion in a central electronic database. To ensure harmonised enforcement and compliance, the Commission should adopt detailed rules on the nature and frequency of checks by national authorities, as required by other EU legislation.[152]

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ANNEX I

LEGISLATIVE MANDATE

In light of the omission of bans, Parliament and Council include a revision clause in the original F-Gas Regulation.[153] In order to achieve climate objectives and commitments, the original F-Gas Regulation acknowledges that prohibitions in other subsectors may be necessary. It states in Recital 10 that:

> The placing on the market of the products and equipment containing fluorinated greenhouse gases as listed in Annex II is detrimental to the objectives and commitments of the Community and its Member States with regard to climate change and it is therefore necessary to restrict the placing on the market of these products and equipment as regards the Community. This could also be the case concerning other applications containing fluorinated greenhouse gases and therefore the need for an extension of Annex II should be reviewed, taking account of the environmental benefits, the technical feasibility and cost effectiveness.[154]

This is the justification for the revision clause, found in Article 10(2)(j):

> [A]ssess whether the inclusion of further products and equipment containing fluorinated greenhouse gases in Annex II is technically feasible and cost-effective, taking account of energy-efficiency, and, if appropriate, make proposals to amend Annex II in order to include such further products and equipment.[155]

The three criteria the Commission were to assess were: (i) technical feasibility, (ii) cost effectiveness, and (iii) energy efficiency. Technical feasibility means that, as a technical matter, if a ban on marketing HFC technologies in certain subsectors is to be included, alternative technologies must be available in that same subsector to fulfill the same function. Cost-effectiveness requires consideration of the costs in both absolute terms and in CO_2 equivalence relative to the status quo, i.e. allowing HFC technologies to be placed on the market but subject to existing containment and recovery measures. Energy efficiency, which is to be taken into account, requires consideration of whether equivalent energy savings can be achieved by alternative technologies to current HFC technologies on the market. This is the justification for the *Preparatory Study* to only consider as alternatives those technologies achieving equal or greater energy efficiency when determining penetration rates. It should be noted that the *Impact Assessment* and *Preparatory Study* also considered additional factors, including safety, availability of materials and components, and system complexity and know-how when determining penetration rates.

It may not always be the case that technical feasibility and cost-effectiveness are demonstrated. And when that happens, the Commission must balance various interests in determining the "appropriate" course of action. But when it is the case that each criterion is met for any given subsector, and energy efficiency is equal or greater, the presumption should be strongly in favour of a ban when penetration rates reach 100% – indeed inter-institutional cooperation on legislative and regulatory matters requires it.

ANNEX II

SUMMARY OF UBA REPORT

In June 2011, the German Federal Environment Agency (UBA) released a 262-page report titled *Avoiding Fluorinated Greenhouse Gases: Prospects for Phasing Out*. Based on an extensive literature and technical review, it assesses "whether the use of halogen-free substances or process is technically and economically possible and ecologically desirable."[156] It finds that "because of their high [GWP] and their persistence, fluorinated gases should be dispensed with where the use of halogen-free substances and/or processes is possible from a technical and safety point of view and does not result in environmentally harmful situations."[157] The report represented UBA's "contribution to the discussion about measures at European and international level."[158]

The UBA Report reaffirms that HFC technologies can be replaced with non-HFC alternatives:

Sector	Subsector	Substitution Options in New Equipment
Domestic Refrigeration	Refrigerators / Freezers / Tumble Dryers	Isobutane
Commercial Refrigeration	Plug-In Appliances	Isobutane, Propene, Propane, CO_2, NH_3
	Condensing Unit Systems	
	Centralised Systems	
Industrial Refrigeration	Food Processing	Propane, Isobutane, NH_3, NH_3/CO_2
	Chemical / Pharmaceutical	
	Coldstores	
	Sports and Leisure Facilities	
	Metal Industry	
	Industrial Heat Pumps	CO_2
Stationary Air Conditioning	Room Air Conditioners	H_2O, NH_3, Hydrocarbons, NH_3/Dimethylether
	Building Air Conditioners / Chillers	
	Domestic Heat Pumps	Propane, CO_2
Fire Protection	Fire Extinguishing Agents	CO_2, N_2, Argon
Aerosols	Technical Sprays	Propane, Isobutane, CO_2, N_2
	Freezer Sprays	
	Compressed Air Sprays	
	Other Technical Sprays	
	Medicinal Sprays	Powder Inhalers
Foams	Rigid Foams for Thermal Insulation (XPS, PUR)	CO_2, CO_2/Ethanol, Pentane
	Flexible PUR Foams	CO_2
	Integral PUR Foams	CO_2, Pentane
	Caulking Foams	290, Butane, DME

In addition to identifying substitution options, the UBA report offers an in-depth qualitative analysis of each subsector, including energy efficiency and cost-effectiveness, before providing its conclusions.[159] For example, when discussing industrial heat pumps, after listing industry practices and alternatives already in use, UBA then delivers its policy conclusion:

> In view of the considerable advances made in the development of industrial heat pumps with natural refrigerants, it is possible to dispense with systems using HFCs. The advantage of HFC-free systems lies not only in the substitution of the refrigerant, but also in the much improved energy yield of CO_2 systems in heat-pump mode. The resulting additional capital costs are thus more than made good by reduced operating costs. If operators want to avoid capital costs despite the short payback period, there is the possibility of 'heat contracting,' which is offered by system manufacturers.[160]

The UBA Report supports including bans under the criteria set out in the legislative mandate. Indeed, UBA finds that "[h]alogen-free alternatives can be used as substitutes for fluorinated greenhouse gases (HFCs, PFCs, and SF_6) in nearly all fields of application."[161]

ANNEX III

TABLE 4: ANNUAL GHG EMISSION REDUCTIONS IN 2030 FROM INTRODUCTION OF BANS
Preparatory Study / Impact Assessment

Sector	Subsector	Penetration Rate 100%	Annual GHG Emission Reductions (kt CO_2-eq in 2030)‡
Domestic Refrigeration	Refrigerators/Freezers[162]	2015	12
Commercial Refrigeration	Stand-Alone Systems (Hermetic Units)[163]	before 2020†	147
	Condensing Units[164]	2020	2,849
	Centralized Systems[165]	before 2020†	12,055
Industrial Refrigeration	Small Industrial Equip.[166]	2020*	67
	Large Industrial Equip.[167]	2020*	202
Transport Refrigeration	Refrigerated Vans[168]	2020	421
	Refrigerated Trucks[169]	before 2030†	322
	Fishing Vessels[170]	(exception needed)	27
Mobile Air Conditioning	Cargo Ship AC[171]	2020	232
	Rail Vehicle AC[172]	(exception needed)	16
	Passenger Ship AC[173]	(exception needed)	97
Stationary Air Conditioning	Moveable Systems[174]	2020	2,781
	Split Systems[175]	2020	22,970
	Multi-Split/VRF System[176]	before 2025†	2,172
	Rooftop Systems[177]	2020	573
	Chillers (Displacement)[178]	2020	1,989
	Centrifugal Chillers[179]	before 2030†	9
	Heat Pumps[180]	2020	1,356
Fire Protection	Fire Prot. HFC-23[181]	2015	961
	Fire Prot. HFC-227ea[182]	(exception needed)	167
Aerosol	Aerosol (sans non-medical)[183]	(exception needed)	3,637
Foams	XPS with HFC-134a[184]	2015	1,553
	XPS with HFC-152a[185]	2015	460
	PU Spray Foam[186]	2015	1,369
	Other PU[187]	2015	587

Notes:
* For industrial refrigeration, bans are feasible by 2020 with capacity greater than 100 kw.[188]
† Since penetration rates exceed 100% on the date given, according to *Preparatory Study*, a ban is feasible prior to that date assuming linear penetration of alternatives.[189]
‡ Annual GHG emission reductions are conservative estimates due to: (i) assuming full implementation of containment and recovery (unrealistic leakage rates); and (ii) omitting indirect GHG emission reductions (from reduced energy consumption). Actual GHG emission reductions from bans will be higher.

[1] Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643.

[2] Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643, Articles 12, 13-16 and Annexes III, V-VI.

[3] Regulation (EC) No 842/2006 of the European Parliament and of the Council on Certain Fluorinated Gases, 17 May 2006, Off. J. Eur. Union L 161/1-10 [also referred to as "Original F-Gas Regulation"], Article 10(2)(j); *see also* Joint NGO Submission During Public Consultation, *Prohibiting HFC Technologies in the European Union: Obligations in the F-Gas Regulation* (14 December 2011), pp. 4-5 *available at* http://www.eia-international.org/joint-ngo-submission-during-public-consultation-on-the-f-gas-regulation.

[4] Regulation (EC) No 2037/2000 of the European Parliament and of the Council of 29 June 2000 on substances that deplete the ozone layer OJ L 244 29 September 2000, Articles 4-5; *see also* Regulation (EC) No 1005/2009 of the European Parliament and of the Council of 16 September 2009 on substances that deplete the ozone layer OJ L 286 31 October 2009.

[5] *See e.g.* Öko-Recherche *et al.*, *Preparatory Study for a Review of Regulation (EC) No 842/2006 on Certain Fluorinated Greenhouse Gases, Final Report* (September 2011)(hereinafter "*Preparatory Study*"); Umweltbundesamt, *Avoiding Fluorinated Greenhouse Gases: Prospects for Phasing Out* (June 2011, English Version) (hereinafter "*UBA Report*"); Bio Intelligence Service, *Preparatory Study for Eco-design Requirements of EuPs, Lot 1: Refrigerating and Freezing Equipment: Service Cabinets, Blast Cabinets, Walk-in Cold Rooms, Industrial Process Chillers, Water Dispensers, Ice-Makers, Dessert and Beverage Machines, Minibars, Wine Storage Appliances and Package Condensing Units*, (Final Report May 2011); Armines, *Sustainable Industrial Policy – Building on the Ecodesign Directive – Energy-Using Product Group Analysis/2, Lot 6: Air-Conditioning and Ventilation Systems: Air Conditioning Systems* (Final Report, 25 July 2012; Corrected Final Report, 5 September 2012); Shecco, *Guide 2012: Natural Refrigerants Market Growth for Europe* (2012).

[6] Regulation (EC) No 842/2006 of the European Parliament and of the Council on Certain Fluorinated Gases, 17 May 2006, Off. J. Eur. Union L 161/1-10, Article 10(2)(j); see also Joint NGO Submission During Public Consultation, *Prohibiting HFC Technologies in the European Union: Obligations in the F-Gas Regulation* (14 December 2011), pp. 4-5 *available at* http://www.eia-international.org/joint-ngo-submission-during-public-consultation-on-the-f-gas-regulation.

[7] *Impact Assessment*, pp. 243-248; *Preparatory Study*, pp. 195-199.

[8] *Impact Assessment*, p. 243; *see also Preparatory Study*, p. 195.

[9] *Impact Assessment*, pp. 244-246; *see also Preparatory Study*, pp. 195-198.

[10] *Impact Assessment*, pp. 243-245; *see also Preparatory Study*, pp. 196-197.

[11] *See* Lisbon Treaty, Article 191(2).

[12] *Preparatory Study*, Annex V, p. 244.

[13] *Preparatory Study*, Annex V, p. 245.

[14] *Preparatory Study*, Annex V, p. 246.

[15] *Preparatory Study*, Annex V, p. 247.

[16] *Preparatory Study*, Annex V, p. 248.

[17] *Preparatory Study*, Annex V, p. 249.

[18] *Preparatory Study*, Annex V, p. 250.

[19] *Preparatory Study*, Annex V, p. 251.

[20] *Preparatory Study*, Annex V, p. 252.

[21] *Preparatory Study*, Annex V, p. 260.

[22] *Preparatory Study*, Annex V, p. 262.

[23] *Preparatory Study*, Annex V, p. 261.

[24] *Preparatory Study*, Annex V, p. 253.

[25] *Preparatory Study*, Annex V, p. 254.

[26] *Preparatory Study*, Annex V, p. 255.

[27] *Preparatory Study*, Annex V, p. 256.

[28] *Preparatory Study*, Annex V, p. 257.

[29] *Preparatory Study*, Annex V, p. 258.

[30] *Preparatory Study*, Annex V, p. 259.

[31] *Preparatory Study*, Annex V, p. 264.

[32] *Preparatory Study*, Annex V, p. 263.

[33] *Preparatory Study*, Annex V, p. 265.

[34] *Preparatory Study*, Annex V, p. 266.

[35] *Preparatory Study*, Annex V, p. 267.

[36] *Preparatory Study*, Annex V, p. 268.

[37] *Preparatory Study*, Annex V, p. 269.

[38] European Commission, *Impact Assessment: Review of Regulation (EC) No 842/2006 on certain fluorinated greenhouse gases* (Commission Staff Working Paper), SWD(2012)0364, p. 173 *citing* Umweltbundesamt, *Avoiding Fluorinated Greenhouse Gases: Prospects for Phasing Out* (June 2011, English Version).

[39] SKM Enviros, *Phase Down of HFC Consumption in the EU – Assessment of Implications for the RAC Sector* (Final Report, Version 11, September 2012) [hereinafter "*SKM Enviros Report*"], p. 35; *see also* SKM Enviros, *Phase Down of HFC Consumption in the EU – Assessment of Implications for the RAC Sector* (Draft Version 3, July 2012), pp. 31-32 (earlier version includes complete traffic light analysis, not included in final version, with more favorable conclusions for alternative technologies due to the inclusion of hydrocarbon-based alternatives available in 2012).

[40] *Impact Assessment*, p. 115; *Preparatory Study*, Annex V, p. 244.

[41] *SKM Enviros Report*, p. 77.

[42] *SKM Enviros Report*, p. 78.

[43] *Impact Assessment*, p. 115; *Preparatory Study*, Annex V, p. 245.

[44] *SKM Enviros Report*, p. 79.

[45] *SKM Enviros Report*, p. 80.

[46] *Impact Assessment*, p. 115; *Preparatory Study*, Annex V, p. 246.

[47] *SKM Enviros Report*, p. 81.

[48] *SKM Enviros Report*, p. 82.

[49] *Impact Assessment*, p. 115; *Preparatory Study*, Annex V, p. 247.

[50] *SKM Enviros Report*, p. 83.

[51] *SKM Enviros Report*, p. 84.

[52] *Impact Assessment,* p. 118; *Preparatory Study*, Annex V, p. 250.

[53] *Impact Assessment*, p. 120; *Preparatory Study*, Annex V, p. 251.

[54] *SKM Enviros Report*, p. 85.

[55] *SKM Enviros Report*, p. 86.

[56] *Impact Assessment*, p. 116; *Preparatory Study*, Annex V, p. 248.

[57] *Impact Assessment*, p. 116; *Preparatory Study*, Annex V, p. 249.

[58] *SKM Enviros Report*, p. 87.

[59] *SKM Enviros Report*, p. 88.

[60] *SKM Enviros Report*, p. 89.

[61] *SKM Enviros Report*, p. 90.

[62] *SKM Enviros Report*, p. 91.

[63] *SKM Enviros Report*, p. 92.

[64] *SKM Enviros Report*, p. 93.

[65] *SKM Enviros Report*, p. 94.

[66] *SKM Enviros Report*, p. 95.

[67] *SKM Enviros Report*, p. 96.

[68] *SKM Enviros Report*, p. 35.

[69] *SKM Enviros Report*, p. 35.

[70] *SKM Enviros Report*, p. 35; *see generally Preparatory Study*; *UBA Report*; Bio Intelligence Service, *Preparatory Study for Eco-design Requirements of EuPs, Lot 1: Refrigerating and Freezing Equipment: Service Cabinets, Blast Cabinets, Walk-in Cold Rooms, Industrial Process Chillers, Water Dispensers, Ice-Makers, Dessert and Beverage Machines, Minibars, Wine Storage Appliances and Package Condensing Units*, (Final Report May 2011); Shecco, *Guide 2012: Natural Refrigerants Market Growth for Europe* (2012).

[71] *Preparatory Study*, Annex V, pp. 244-272.

[72] *Impact Assessment*, p. 173 *citing* Umweltbundesamt, *Avoiding Fluorinated Greenhouse Gases: Prospects for Phasing Out* (June 2011, English Version).

[73] *SKM Enviros Report*, p. 35; *see also* SKM Enviros, *Phase Down of HFC Consumption in the EU – Assessment of Implications for the RAC Sector* (Draft Version 3, July 2012), pp. 31-32 (includes complete traffic light analysis not included in final version with more favorable conclusions for alternative technologies due to the inclusion of hydrocarbon-based alternatives available in 2012).

[74] *Impact Assessment*, p. 116; *Preparatory Study*, Annex V, p. 253.

[75] *SKM Enviros Report*, p. 97.

[76] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 254 and Annex VI, p. 307 (includes reversible heat pumps).

[77] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 256 and Annex VI, p. 308 (includes reversible heat pumps).

[78] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 255 and Annex IV, pp. 307-308 (includes reversible heat pumps).

[79] *SKM Enviros Report*, p. 98.

[80] *SKM Enviros Report*, p. 99.

[81] *SKM Enviros Report*, p. 100.

[82] *SKM Enviros Report*, p. 101.

[83] *SKM Enviros Report*, p. 102.

[84] *SKM Enviros Report*, p. 103.

[85] *SKM Enviros Report*, p. 104.

[86] *SKM Enviros Report*, p. 105.

[87] *SKM Enviros Report*, p. 106.

[88] *SKM Enviros Report*, p. 107.

[89] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 257 (includes reversible cycle mode).

[90] *SKM Enviros Report*, p. 108.

[91] *SKM Enviros Report*, p. 109.

[92] *SKM Enviros Report*, p. 110.

93 *SKM Enviros Report*, p. 111.

94 *SKM Enviros Report*, p. 112.

95 *SKM Enviros Report*, p. 113.

96 *SKM Enviros Report*, p. 114.

97 *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 258.

98 *SKM Enviros Report*, p. 115.

99 *Impact Assessment*, p. 118; *Preparatory Study*, Annex V, p. 259 and Annex VI, p. 309 (heat pumps defined as heating only; reversible air conditioners containing heat pumps are covered by the relevant air-conditioning subsector).

100 *SKM Enviros Report*, p. 116.

101 *SKM Enviros Report*, p. 117.

102 *SKM Enviros Report*, p. 119.

103 *SKM Enviros Report*, p. 35.

104 *SKM Enviros Report*, p. 35; *see also* SKM Enviros, *Phase Down of HFC Consumption in the EU – Assessment of Implications for the RAC Sector* (Draft Version 3, July 2012), pp. 31-32 (earlier version includes complete traffic light analysis, not included in final version, with more favorable conclusions for alternative technologies due to the inclusion of hydrocarbon-based alternatives available in 2012); *see generally Preparatory Study*; *Impact Assessment*.

105 *SKM Enviros Report*, p. 35; *see also* SKM Enviros, *Phase Down of HFC Consumption in the EU – Assessment of Implications for the RAC Sector* (Draft Version 3, July 2012), pp. 31-32 (earlier version includes complete traffic light analysis, not included in final version, with more favorable conclusions for alternative technologies due to the inclusion of hydrocarbon-based alternatives available in 2012); *see generally*; Armines, *Sustainable Industrial Policy – Building on the Ecodesign Directive – Energy-Using Product Group Analysis/2, Lot 6: Air-Conditioning and Ventilation Systems: Air Conditioning Systems* (Final Report, 25 July 2012; Corrected Final Report, 5 September 2012); Shecco, *Guide 2012: Natural Refrigerants Market Growth for Europe* (2012).

106 *Preparatory Study*, Annex V, pp. 244-272.

107 *Compare SKM Enviros Report*, pp. 98, 99, 108, 111, 114, 116 (hydrocarbon-based alternatives not included market sub-sector profiles) *with* SKM Enviros, *Phase Down of HFC Consumption in the EU – Assessment of Implications for the RAC Sector* (Draft Version 3, July 2012), pp. 94, 95, 104, 107, 110, 112 (hydrocarbon-based alternatives included in market sub-sector profiles); *see also* Öko-Recherche *et al.*, *Preparatory Study for a Review of Regulation (EC) No 842/2006 on Certain Fluorinated Greenhouse Gases, Final Report* (September 2011)(hereinafter "*Preparatory Study*"); Umweltbundesamt, *Avoiding Fluorinated Greenhouse Gases: Prospects for Phasing Out* (June 2011, English Version) (hereinafter "*UBA Report*").

108 *Compare SKM Enviros Report with Preparatory Study*; *UBA Report*; SKM Enviros, *Phase Down of HFC Consumption in the EU – Assessment of Implications for the RAC Sector* (Draft Version 3, July 2012), pp. 31-32 (earlier version includes complete traffic light analysis, not included in final version, with more favorable conclusions for alternative technologies due to the inclusion of hydrocarbon-based alternatives available in 2012); *see generally*; Armines, *Sustainable Industrial Policy – Building on the Ecodesign Directive – Energy-Using Product Group Analysis/2, Lot 6: Air-Conditioning and Ventilation Systems: Air Conditioning Systems* (Final Report, 25 July 2012; Corrected Final Report, 5 September 2012); Shecco, *Guide 2012: Natural Refrigerants Market Growth for Europe* (2012).

109 *See e.g. Preparatory Study*; *UBA Report*; Bio Intelligence Service, *Preparatory Study for Eco-design Requirements of EuPs, Lot 1: Refrigerating and Freezing Equipment: Service Cabinets, Blast Cabinets, Walk-in Cold Rooms, Industrial Process Chillers, Water Dispensers, Ice-Makers, Dessert and Beverage Machines, Minibars, Wine Storage Appliances and Package Condensing Units*, (Final Report May 2011); Shecco, *Guide 2012: Natural Refrigerants Market Growth for Europe* (2012).

110 Environmental Investigation Agency, *Chilling Facts IV: HFC-Free Cooling Goes Mainstream* (July 2012).

111 *Impact Assessment*, pp. 115-116 (bans reduce 12 ktCO_2eq at 1 €/tCO_2eq in domestic refrigeration; 147 ktCO_2eq at -0.8 €/tCO_2eq in commercial hermitic systems; 2,849 ktCO_2eq at 1.2 €/tCO_2eq in condensing units; and 12,055 ktCO_2eq at 23.7 €/tCO_2eq in centralised systems); *Preparatory Study*, pp. 264, 292-294 and Annex V, pp. 244-249.

112 Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, […](2012) XXX draft, Annex IV (bans on "refrigerators and freezers for commercial use (hermitically sealed systems)" in 2017, "other refrigeration and freezing systems for commercial use" in 2020, and "industrial refrigeration and freezers capacity > 100kw" in 2020).

113 *Impact Assessment*, p. 9.

114 *Impact Assessment*, pp. 113-114 (ban of HFC-152a in XPS foam blowing reduces 460 ktCO_2eq at -1.6 €/tCO_2eq; ban of HFC 134-a in XPS foam blowing reduces 1,553 ktCO_2eq at 1.0 €/tCO_2eq; ban of HFCs in PU spray foam blowing reduces 1,369 ktCO_2eq at 61.6 €/tCO_2eq; ban of HFC in other PU spray foam blowing reduces 587 ktCO_2eq at 3.5 €/tCO_2eq although a minor exemption may be needed for discrete applications since penetration rate in 2015 is only 95%); *Preparatory Study*, pp. 260-261, 290 and Annex V, pp. 266-269.

115 SKM Enviros, *Further Assessment of Policy Options for the Management and destruction of Banks of ODS and F-gases in the EU* (Final Report, Revised Version 2, March 2012) *available at* http://ec.europa.eu/clima/policies/ozone/research/docs/ods_f-gas_destruction_report_2012_en.pdf

116 *Impact Assessment*, p. 112 (ban of HFCs in technical aerosols reduces 3,637 ktCO_2eq at 10 €/tCO_2eq); *Preparatory Study*, pp. 260-261 and Annex V, p. 265.

117 *See e.g. Preparatory Study*; *UBA Report*; Armines, *Sustainable Industrial Policy – Building on the Ecodesign Directive – Energy-Using Product Group Analysis/2, Lot 6: Air-Conditioning and Ventilation Systems: Air Conditioning Systems* (Final Report, 25 July 2012; Corrected Final Report, 5 September 2012); Shecco, *Guide 2012: Natural Refrigerants Market Growth for Europe* (2012).

118 *Impact Assessment*, pp. 117-118 (bans reduce 22,970 ktCO_2eq at 19 €/tCO_2eq in single split; 2,172 ktCO_2eq at 13.1 €/tCO_2eq in multi split; 573 ktCO_2eq at 8.2 €/tCO_2eq in rooftop systems; 1,989 ktCO_2eq at 5.9 €/tCO_2eq in displacement chillers; 9 ktCO_2eq at 7.5 €/tCO_2eq in centrifugal chillers; and heat pumps, sometimes placed in this sector, have penetration rates reaching 100% in 2020 and a ban reduces 1,356 ktCO_2eq but alternatives are not considered cost-effective at 130.2 €/tCO_2eq); *Preparatory Study*, pp. 264, 292-294 and Annex V, pp. 253-259.

119 *Preparatory Study*, pp. 264, 292-294 and Annex V, pp. 253-259; *UBA Report*, pp. 81-85 (citing several different technologies that have been used in recent years).

[120] *Impact Assessment*, pp. 118 and 120 (bans reduce 421 ktCO_2eq at 45.1 €/tCO_2eq in refrigerated vans; and 322 ktCO_2eq at 2.6 €/tCO_2eq in refrigerated trucks and trailers); *Preparatory Study*, 264, 292-294 and Annex V, pp. 250-251.

[121] *Impact Assessment*, p. 119 (bans reduce 232 ktCO_2eq at 16.7 €/tCO_2eq in cargo ship air-conditioning); *Preparatory Study*, pp. 264, 292-294 and Annex V, p. 260.

[122] *SKM Enviros Report*, p. 20.

[123] *SKM Enviros Report*, pp. 60-63.

[124] *SKM Enviros Report*, p. 62.

[125] *Impact Assessment*, pp. 141-142.

[126] *Impact Assessment*, pp. 141-142.

[127] Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643, Annex V.

[128] *Impact Assessment*, Annex X, pp 156-163; *see also Preparatory Study*, pp. 9-30.

[129] *Impact Assessment*, Annex X, pp 157 (concluding that reporting system is still relatively new and an overestimation is possible).

[130] *See generally Preparatory Study*, pp. 104-126 (review of the application of containment and recovery measures).

[131] *Impact Assessment*, Annex X, pp 159-160; *see also* Commission Proposal for Revised F-Gas Regulation, Annex V.

[132] *SKM Enviros Report*, pp. 60-63.

[133] *SKM Enviros Report*, p. 62.

[134] *See* Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643, Annex X

[135] Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643, Articles 14-15 and Annex VI; *Impact Assessment*, Annex X, pp. 165-166.

[136] *Impact Assessment*, Annex X, pp. 164-165.

[137] *See* Lisbon Treaty, Article 191(2).

[138] Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643, Article 8.

[139] Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643, Article 18.

[140] *See* Institute for European Environmental Policy, *Is STEK as good as reported? – Uncertainties in the concept underlying the proposed European Regulation of fluorinated gases*, 14 June 2005, pp. 7, 41.

[141] *Preparatory Study*, p. 256.

[142] *Preparatory Study*, p. 256.

[143] *Preparatory Study*, pp. 256-257.

[144] *Impact Assessment*, pp. 108-109 (inclusion in containment and recovery reduces 273 ktCO_2eq at 10.5 €/tCO_2eq in refrigerated cargo ships, 405 ktCO_2eq at 8.5 €/tCO_2eq in refrigerated passenger ships, and 360 ktCO_2eq at 0.5 €/tCO_2eq in fishing vessels); *Preparatory Study*, p. 293.

[145] *Impact Assessment*, p. 109; *Preparatory Study*, p. 293; *see also* European Commission, *Joint Statement on Emissions from Shipping* (1 October 2012)(statement from Commissioner Kallas and Commissioner Hedegaard announcing no new legislation).

[146] *Preparatory Study*, p. 50.

[147] *Preparatory Study*, pp. 52-53.

[148] *Impact Assessment*, pp. 103 and 110.

[149] *Impact Assessment*, p. 10.

[150] Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643, Article 7.

[151] Proposal for a Regulation of the European Parliament and of the Council on fluorinated greenhouse gases, COM(2012)0643, Article 5.

[152] Regulation (EU) No 995/2010 of the European Parliament and of the Council of 20 October 2010 laying down the obligations of operators who place timber and timber products on the market, OJ L 295 12.11.2010.

[153] Regulation (EC) No 842/2006 of the European Parliament and of the Council on Certain Fluorinated Gases, 17 May 2006, Off. J. Eur. Union L 161/1-10, Article 10(2)(j).

[154] Regulation (EC) No 842/2006 of the European Parliament and of the Council on Certain Fluorinated Gases, 17 May 2006, Off. J. Eur. Union L 161/1-10, Recital 10.

[155] Regulation (EC) No 842/2006 of the European Parliament and of the Council on Certain Fluorinated Gases, 17 May 2006, Off. J. Eur. Union L 161/1-10, Article 10(2)(j).

[156] Umweltbundesamt, *Avoiding Fluorinated Greenhouse Gases: Prospects for Phasing Out* (June 2011, English Version) [hereinafter "UBA Report"], p. 3.

[157] *UBA Report*, p. 24.

[158] *UBA Report*, Foreward.

[159] *See e.g. UBA Report*, pp. 37-244.

[160] *UBA Report*, p. 71.

[161] *UBA Report*, p. 245.

[162] *Impact Assessment*, p. 115; *Preparatory Study*, Annex V, p. 244.

[163] *Impact Assessment*, p. 115; *Preparatory Study*, Annex V, p. 245.

[164] *Impact Assessment*, p. 115; *Preparatory Study*, Annex V, p. 246.

[165] *Impact Assessment*, p. 115; *Preparatory Study*, Annex V, p. 247.

[166] *Impact Assessment*, p. 116; *Preparatory Study*, Annex V, p. 248.

[167] *Impact Assessment*, p. 116; *Preparatory Study*, Annex V, p. 249.

[168] *Impact Assessment*, p. 118; *Preparatory Study*, Annex V, p. 250.

[169] *Impact Assessment*, p. 120; *Preparatory Study*, Annex V, p. 251.

[170] *Impact Assessment*, p. 118; *Preparatory Study*, Annex V, p. 252.

[171] *Impact Assessment*, p. 119; *Preparatory Study*, Annex V, p. 260.

[172] *Impact Assessment*, p. 120; *Preparatory Study*, Annex V, p. 262.

[173] *Impact Assessment*, p. 120; *Preparatory Study*, Annex V, p. 261.

[174] *Impact Assessment*, p. 116; *Preparatory Study*, Annex V, p. 253.

[175] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 254.

[176] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 255.

[177] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 256.

[178] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 257.

[179] *Impact Assessment*, p. 117; *Preparatory Study*, Annex V, p. 258.

[180] *Impact Assessment*, p. 118; *Preparatory Study*, Annex V, p. 259.

[181] *Impact Assessment*, p. 120; *Preparatory Study*, Annex V, p. 264.

[182] *Impact Assessment*, p. 121; *Preparatory Study*, Annex V, p. 263.

[183] *Impact Assessment*, p. 112; *Preparatory Study*, Annex V, p. 265.

[184] *Impact Assessment*, p. 113; *Preparatory Study*, Annex V, p. 266.

[185] *Impact Assessment*, p. 113; *Preparatory Study*, Annex V, p. 267.

[186] *Impact Assessment*, p. 113; *Preparatory Study*, Annex V, p. 268.

[187] *Impact Assessment*, p. 114; *Preparatory Study*, Annex V, p. 269.

[188] *Impact Assessment*, p. 173 *citing* Umweltbundesamt, *Avoiding Fluorinated Greenhouse Gases: Prospects for Phasing Out* (June 2011, English Version)

[189] *Preparatory Study*, Annex V, pp. 244-272.