

Chapter 1: The HFC Phase-Down

I. How the HFC Phase-Down Works

The HFC phase-down is a progressive reduction of HFCs measured in CO₂-equivalence (CO₂e) made available on the EU market each year, starting in 2015 and running through 2030 and beyond.⁽⁵⁾ Producers and importers are allocated annual quotas of HFCs (hereinafter referred to as “HFC quotas”) that are progressively reduced according to a reduction schedule.

A. Reduction Schedule

From 2015 onwards, the total sum of the HFC quotas allocated to producers and importers cannot exceed the “maximum quantity” calculated for that calendar year.⁽⁶⁾ The maximum quantity of HFC quotas available in 2015 corresponds to 100% of the annual average demand during 2009-2012, approximately 182.5 million tonnes (Mt) CO₂e,⁽⁷⁾ which is also referred to as the “baseline.” The maximum quantity or baseline is thereafter reduced by 7% in 2016, 37% in 2018, 55% in 2021, 69% in 2024, 76% in 2027 and 79% in 2030.⁽⁸⁾

The HFC phase-down is actually more stringent than it initially appears for those sectors that fall within its scope. This is because the maximum quantity of HFC quotas available on the market is adjusted downward from 2018 onwards to remove HFC quotas in exempt uses, estimated at approximately 8.5 Mt CO₂e each year.⁽⁹⁾ This makes the burden on non-exempt uses higher than it first appears (see Table 1 and Figure 1).

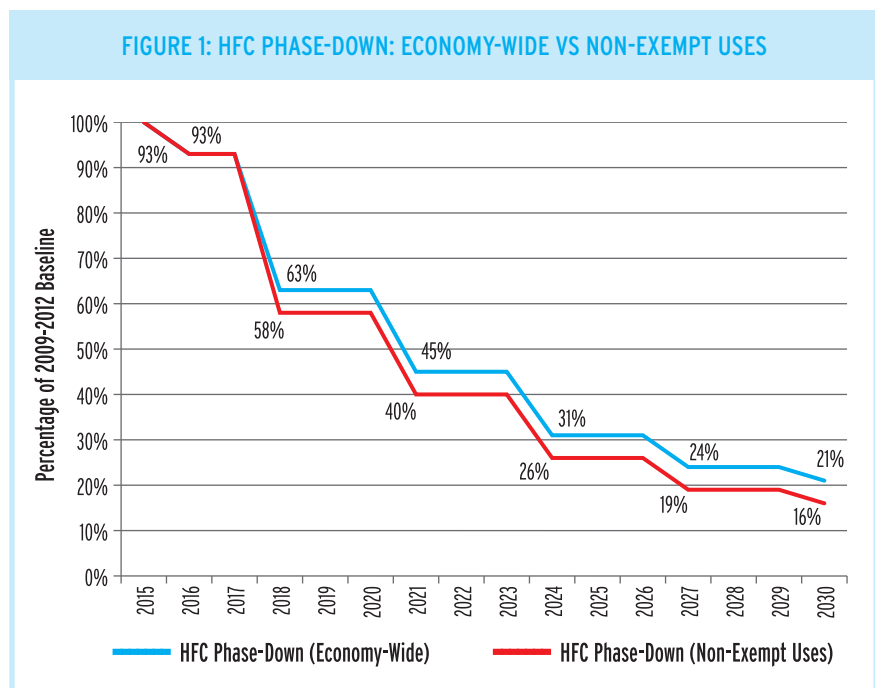
TABLE 1:
Comparison of Maximum
Quantity of HFC Quotas Available
Economy-Wide and to
Non-Exempt Uses

Years	HFC Phase-Down Schedule	
	Economy-Wide	Non-Exempt Uses
2015	100%	100%
2016-17	93%	93%
2018-20	63%	58%
2021-23	45%	40%
2024-26	31%	26%
2027-29	24%	19%
2030	21%	16%

“PRODUCERS” are companies that manufacture HFCs in the European Union. Producers place HFCs on the European market when they supply them to third parties or use them internally for their own account.

“IMPORTERS” are companies that import HFCs manufactured outside the European Union. Importers place HFCs on the European market upon release by customs for free circulation.

FIGURE 1: HFC PHASE-DOWN: ECONOMY-WIDE VS NON-EXEMPT USES



In total, the HFC phase-down will reduce cumulative HFC emissions by 1.5 gigatonnes (Gt) CO₂e by 2030 and 5 Gt CO₂e by 2050.⁽¹⁰⁾

The HFC phase-down will compel a near-complete transition away from HFCs in new equipment in almost all sectors by 2030. The remaining HFC consumption available from 2030 onward is expected to be used for servicing the installed base and in certain discrete applications where no alternatives exist. Decisions on the post-2030 reduction schedule will be made well before 2030.⁽¹¹⁾

B. Carbon Dioxide Equivalence

The HFC phase-down is defined in terms of (CO₂e). The metric tonnage of HFCs that may be placed on the European market therefore depends on the global warming potential (GWP) of the HFC or blend in question.

For example, an importer with 10 Mt CO₂e of HFC quotas can only place 2.5 tonnes of HFC-404A on the European market that year. See Table 2 for other examples.

HFC or Blend	Global Warming Potential	Quantity of HFC Equivalent to 10 Mt CO ₂ e (tonnes)
HFC-23	14,800	0.6
HFC-404A	3,922	2.5
HFC-227ea	3,220	3.1
HFC-410A	2,088	4.7
HFC-407C	1,824	5.4
HFC-134a	1,430	6.9
HFC-32	675	14.8
HFC-152a	124	80.6

TABLE 2:
Implications of Global Warming Potential under HFC Quota System

Unsaturated HFCs, sometimes referred to as hydrofluoroolefins (HFOs), such as HFC-1234yf, HFC-1234ze and HFC-1336mzz, do not require HFC quotas as they are contained in Annex II of the EU F-Gas Regulation.⁽¹²⁾

C. Scope and Exemptions

The HFC phase-down operates economy-wide across the European Union. All stationary and mobile sectors in every EU Member State compete for the same pool of HFC quotas unless exempt. The HFC phase-down applies to bulk quantities of virgin HFCs, regardless whether produced within or outside the European Union. From 2017 onwards, all HFCs imported in pre-charged products and equipment are also included. Recycled and reclaimed HFCs are excluded from the scope of the HFC phase-down.

There are certain limited exemptions to the HFC phase-down. For example, it does not apply to producers and importers placing less than 100 tonnes CO₂e of HFCs on the EU market in any given calendar year.⁽¹³⁾ This equates to, for example, 69 kilogrammes of HFC-134a. The HFC phase-down also exempts HFCs used for the following purposes, assuming they are properly labelled:⁽¹⁴⁾

- quantities imported for destruction;
 - feedstock applications;
 - military equipment;
 - quantities exported out of the European Union;
 - certain semiconductor applications;
 - metered dose inhalers.⁽¹⁵⁾
- } Must be “supplied directly,” i.e. cannot be via third parties in the HFC supply chain.

HFCs purchased in bulk by a European manufacturer and subsequently placed in pre-charged equipment that is then exported outside the European Union are not exempt from the HFC phase-down.⁽¹⁶⁾

In addition to the exemptions above, following a substantiated request by an EU Member State, the European Commission may “exceptionally” authorise a time-limited exemption for up to four years for specific applications or categories of products or equipment where alternatives are unavailable or cannot be used for technical or safety reasons, or where a sufficient HFC supply cannot be ensured without entailing disproportionate costs.⁽¹⁷⁾ Given its exceptional nature, it is not expected that this exemption will be used.

II. Origins of the HFC Phase-Down

The HFC phase-down was based on the *AnaFgas* model developed for European Commission’s *Preparatory Study* for the EU F-Gas Regulation which, among other things, mapped out annual HFC demand in the European Union for each year from 2015 to 2030.⁽¹⁸⁾ HFC demand consists of first fills in new equipment and refills in installed equipment.⁽¹⁹⁾ Underpinning the *AnaFgas* model are two assumptions: penetration of low-GWP technologies in new equipment where technically and economically feasible, and full implementation of containment and recovery measures. These assumptions have important implications on HFC quota availability and HFC prices in the future.⁽²⁰⁾

A. Penetration of Low-GWP Technologies

The HFC phase-down assumes near-perfect market penetration of low-GWP technologies in new equipment.⁽²¹⁾ This means that whenever a low-GWP technology can technically be installed instead of an HFC technology, it is assumed to have been installed and no HFC quotas for first fill or refills are needed for that piece of equipment.

The commercial refrigeration sector underscores the impact of this assumption. With respect to new centralised systems, approximately 19,000 medium-temperature and 18,000 low-temperature systems were installed in 2010, and annual new systems are expected to remain roughly the same for each year through 2030.⁽²²⁾ Table 3 shows the expected market penetration of low-GWP technologies in these new centralised systems (as a percentage of all new equipment in this sector), which not only highlights the need for a prompt transition but also speaks to the risks associated with delayed action.⁽²³⁾

Table 3:
Penetration of Low-GWP
Technologies in New
Centralised Systems

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
New Centralised Systems	46%	61%	77%	93%	100%											

According to the *AnaFgas* model, 46% of all new multipack centralised refrigeration systems installed in 2015 should be relying on low-GWP technologies.⁽²⁴⁾ This increases to 100% in 2019, i.e. from 2019 onward all new multipack centralised systems should be relying on low-GWP technologies. The phase-down therefore assumes that HFC quotas are not required for these systems, neither for first fill or refill during their 12-year average lifetime. This means that any new HFC-based centralised refrigeration system installed in 2020, for example, will consume HFC quotas that were not anticipated. All other sectors and EU Member States are impacted by misguided technology choices.

The pace of market penetration of low-GWP technologies in new condensing units and stand-alone refrigeration systems are similar, with 100% of new systems expected to utilise low-GWP technologies by 2020.

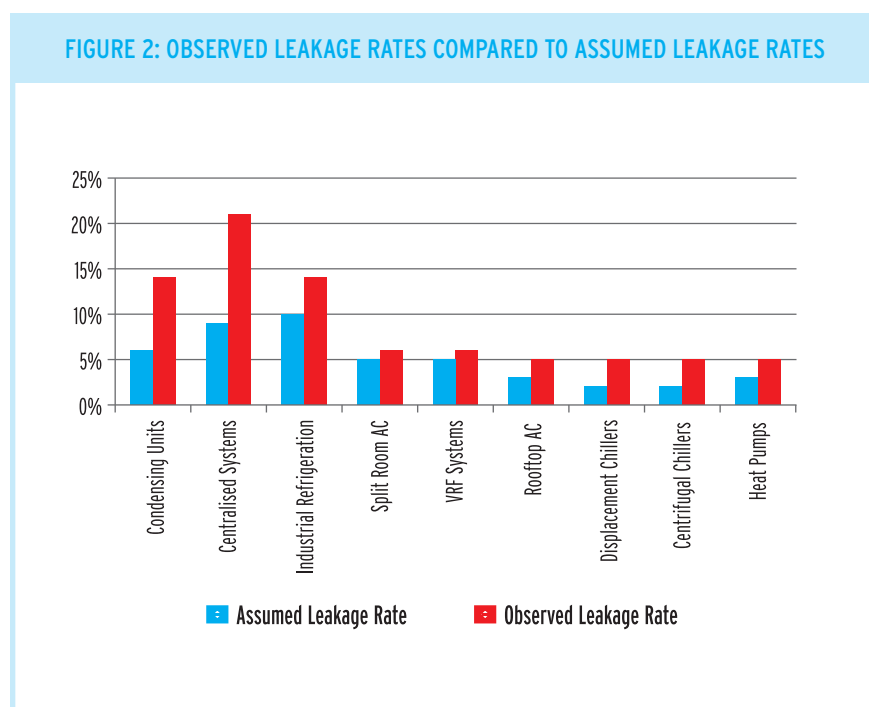
Supermarkets and other cold food chain retailers may wonder, given the above, why the bans in this sector do not take effect earlier. In fact, the European Commission's *Preparatory Study* recommended banning all new HFC technologies with a GWP higher than 150 in this sector from 2020,⁽²⁵⁾ a recommendation which was supported by the European Parliament⁽²⁶⁾ and many EU Member States. Most policymakers recognised that bans, identified as the most effective measure in the 2006 EU F-Gas Regulation,⁽²⁷⁾ were essential signposts that would prevent unnecessary reliance on HFCs in new equipment when no longer needed. During the negotiations, however, a blocking minority of EU Member States succeeded in weakening bans in some of the key sectors, including refrigeration. This means that the European market will need to shift in these sectors without these clear market signals. A slower transition than originally envisaged will exacerbate HFC quota shortages and cause HFC prices to skyrocket, with disproportionate impacts on small- and medium-sized enterprises (SMEs).

Operators and consumers should make every effort to make a quick transition away from HFCs to avoid paying excessive costs for unnecessary HFCs in the future.

B. Full Implementation of Containment and Recovery Provisions

The HFC phase-down also assumes full implementation of containment and recovery provisions.⁽²⁸⁾ This means operators and contractors are assumed to take all precautionary measures to reduce leakage during use of the equipment and ensure recovery at its end of life. For this to happen, there must be the widespread adoption of best practices by operators and contractors, something that seems unlikely to occur in the near-term without further intervention given the historical "low degree of overall compliance" with these provisions.⁽²⁹⁾

To date, containment provisions have not resulted in significant reductions in observed leakage rates. In order for observed leakage rates to match assumed leakage rates, significant improvements are required, shown in Figure 2.



Until leakage rates are reduced, the installed base of HFC technologies will consume more HFC quotas during servicing and maintenance than anticipated. This will have knock-on impacts on HFC quota availability and HFC prices.

The same holds true with recovery provisions. The HFC phase-down assumes 16% reclamation at end-of-life with the remaining 84% being emitted or destroyed.⁽³⁰⁾ While 16% reclamation seems reasonable, historical recovery rates indicate otherwise. The European Commission’s *Preparatory Study* found that 12 EU Member States did not even have reclamation facilities and, among those that did, low levels of reclamation and recycling were still found.⁽³¹⁾ Recycling and reclamation are important safety valves for the HFC phase-down and increased recovery rates will be critical to its success.

National authorities should consider adopting maximum leakage rates and minimum precautionary measures to reduce leakage and mandatory producer responsibility schemes to promote recovery, as some EU Member States have already done.⁽³²⁾ This would facilitate the creation of a national recycling and reclamation market while minimising impacts within their borders.

III. What the HFC Phase-Down Means

The HFC phase-down is intended to induce HFC quota shortages that will in turn increase HFC prices, making high-GWP HFC technologies less attractive from a cost perspective. In addition, given the assumptions underpinning the *AnaFgas* model, market opportunities will be limited for mid-GWP HFCs and blends in 2018 and beyond. Indeed, these lower-GWP HFCs are supposed to be leapfrogged in favour of truly low-GWP technologies, and their use, at least in new equipment, will only serve to exacerbate HFC quota shortages and HFC prices across the European Union.

A. Early HFC Quota Shortages

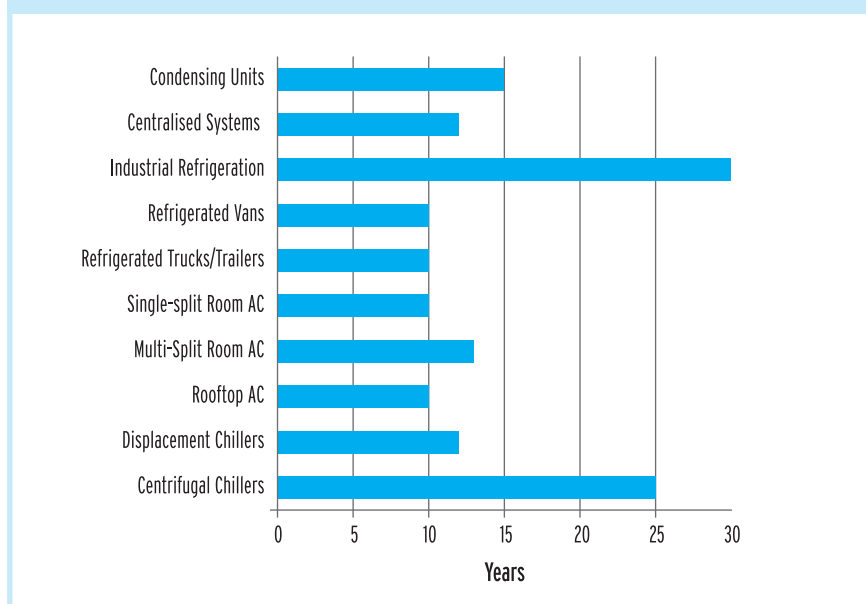
A confluence of factors beginning in 2017, not all of which were fully factored into the *AnaFgas* model, will likely reduce available HFC quotas across the European Union more quickly than anticipated by many operators and consumers. These are outlined in Table 4.

Table 4:
Factors Impacting
Availability of HFC Quotas

Year	Factor	Impact on HFC Supply or Demand
2017	Pre-Charged Equipment	Importers of pre-charged equipment must secure HFC quotas from 2017 onwards, increasing HFC demand by 13% with no corresponding increase in HFC quotas ⁽³³⁾
2018	Exempt Uses	HFC quotas for exempt uses are subtracted from the maximum quantity of HFC quotas in 2018 onwards - approximately 8.5 Mt CO ₂ e per year-tightening the HFC phase-down further ⁽³⁴⁾
2018	HFC Phase-Down Step	37% reduction from the baseline in 2018 ⁽³⁵⁾
2020	Service Ban	The service ban enters into effect in 2020. This is expected to increase HFC demand by a total of 45 to 70 Mt CO ₂ e during the years immediately before and after, although it will later result in additional reduction ⁽³⁶⁾
2021	HFC Phase-Down Step	55% reduction from the baseline in 2021 ⁽³⁷⁾

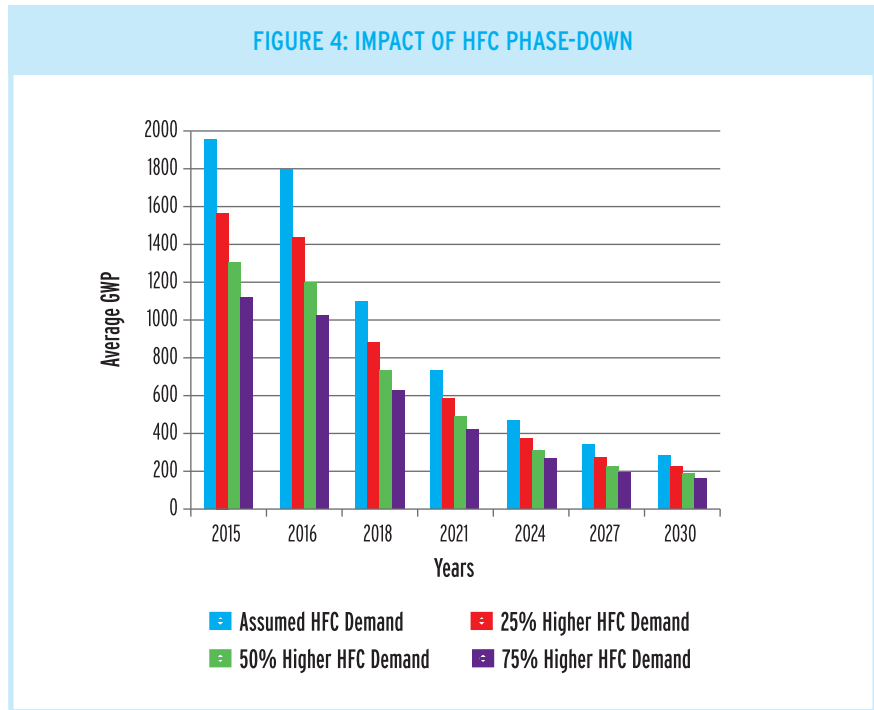
The first significant HFC quota shortages will be felt in late-2017 as pre-charged equipment is included within the scope of the HFC phase-down and stockpiles from previous years are depleted. In 2018, with the exclusion of exempt uses (8.5 Mt CO₂e), the second reduction step (37%), and early compliance with the service ban, HFC quota shortages will begin in earnest. At this time, operators and consumers that have not already taken action may find themselves behind the curve, in particular those with newly installed equipment relying on mid- or high-GWP HFCs whose average lifetimes can be expected to extend well into the HFC phase-down (see Figure 3).

FIGURE 3: AVERAGE LIFETIME OF CERTAIN HFC-BASED PRODUCTS AND EQUIPMENT



B. Implications of a Slower Transition to Low-GWP Technologies in the Early Years

A slower transition to low-GWP technologies than originally envisaged in the *AnaFgas* model will increase HFC demand, which in turn will exacerbate HFC quota shortages and make the HFC phase-down more burdensome in future years. This can be demonstrated, rather simply, by calculating the average GWP of HFCs that would be compatible with the annual HFC demand (in metric tonnes of HFC refrigerant) and available HFC quotas (in CO₂e) under various scenarios. Figure 4 shows the impact that a 25%, 50% and 75% increase in HFC demand higher than the amount assumed in the *AnaFgas* model would have on average GWP during the HFC phase-down.



If little action is taken to adopt low-GWP technologies early on, the average GWP of HFCs is dramatically reduced, with implications on the availability of HFCs to service existing equipment, underscoring the risk associated with unnecessarily locking in HFC technologies. Companies and consumers should exercise the utmost caution to avoid being saddled with unusable assets or skyrocketing costs.

The implication is clear. Companies and national authorities should take early concrete action to move away from HFCs or risk being behind the curve, competing for an ever-decreasing supply of HFC quotas that will increase costs during service and maintenance and possibly result in early retirement of equipment due to HFC quota shortages.

C. HFC Price Premium

Simple economics dictates that when demand outpaces supply, price increases. The same holds true for HFC quotas, which the European Commission acknowledges “have a clear monetary value.”⁽³⁸⁾ This price increase for HFCs, unrelated to any increase in manufacturing costs of the fluorochemicals themselves, is referred to as the “HFC price premium.”

Producers and importers, by virtue of being title holder to HFC quotas allowing them to place certain quantities on the European market, are the indisputable beneficiaries of the HFC price premium. The German Federal Environment Agency (UBA) has calculated the potential HFC price premium (see Figure 5) under conditions that approximate the HFC phase-down.⁽³⁹⁾

Since HFC quotas are grandfathered to a small number of producers and importers at no cost, i.e. given out for free, the HFC price premium represents a windfall profit for these companies in the billions of euros annually (see Figure 6).

In other words, free grandfathering will result in a significant transfer of wealth – approximately €32 billion from 2015 through 2030 – from European operators and consumers to mostly multinational HFC producers and importers.

WHO GETS HFCS FROM PRODUCERS AND IMPORTERS?
WHOEVER IS PREPARED TO PAY THE HIGHEST PRICE!

FIGURE 5: HFC PRICE PREMIUM

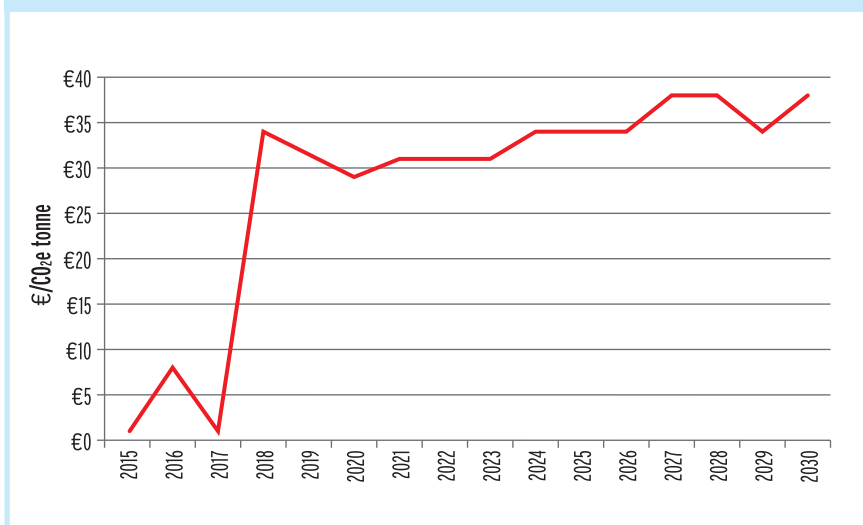
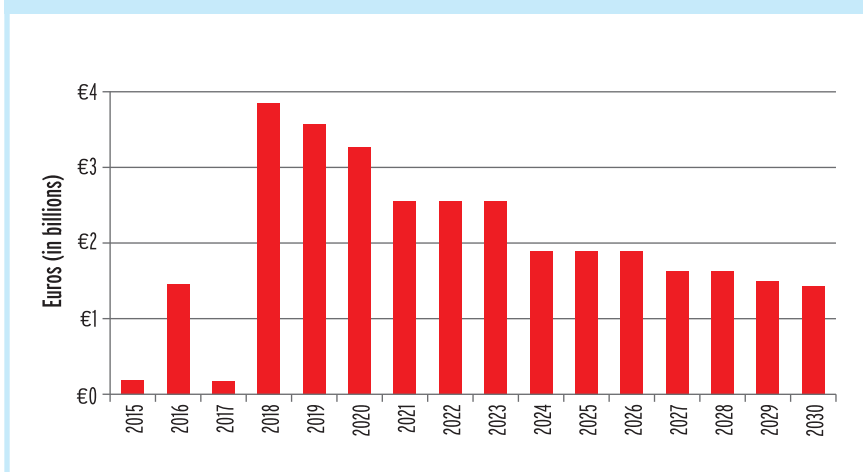


FIGURE 6: ANNUAL WINDFALL PROFITS TO PRODUCERS AND IMPORTERS



Short of early retirement or capital abandonment, operators and consumers with HFC technologies are locked into paying the HFC price premium. For example, current prices for HFC-134a are around €15-30 per kilogramme (kg), depending on whether wholesale or retail. At an HFC price premium of €30 per CO₂e tonne, each kg of HFC-134a increases by €43 so that the total price for HFC-134a would be €58-73 per kg. The HFC price premium should therefore be factored into the purchase of new products and equipment, in particular when calculating annual costs related to servicing and maintenance in the future. Once factored in, HFC-free technologies are the clear choice from an economic perspective.

The estimates on the HFC price premium, however, do not capture the full picture. Other factors related to the nature of the HFC market could drive up the HFC price premium further, in particular:

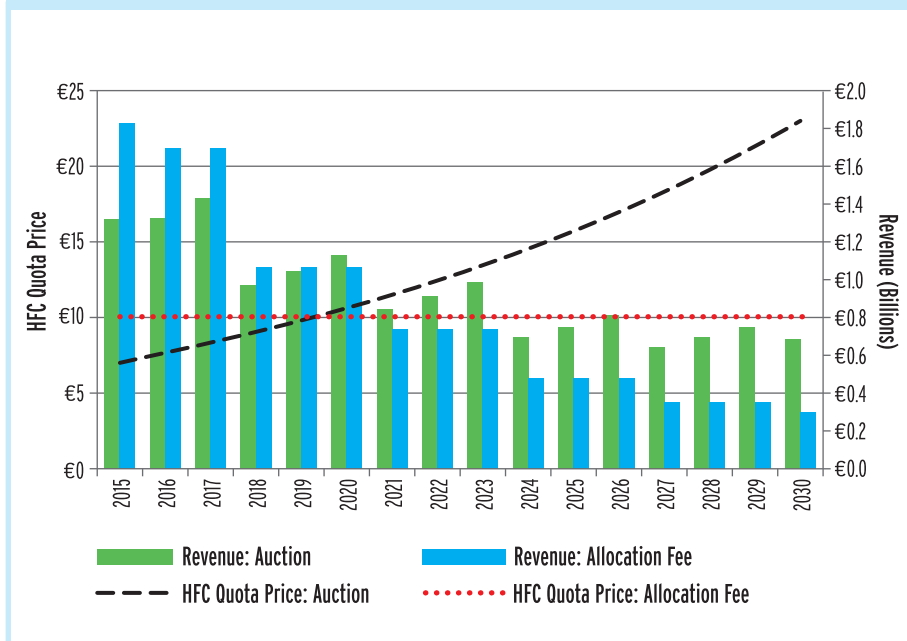
- The presence of monopoly power with respect to individual HFCs or blends; and
- The technical competition within any given portfolio offered by a producer or importer, such as the choice to promote various HFCs or blends over others, i.e. HFC-407F over HFC-404A.

HFC PRICE PREMIUM?

Within two weeks following publication of the EU F-Gas Regulation in the Official Journal of the European Union, the French fluorochemical producer Arkema announced an immediate 15% price increase for HFC-404A, HFC-407A, HFC-407C, HFC-410A, HFC-427A and HFC-507.

To address these windfall profits and generate revenue to offset implementation costs, the European Parliament supported an allocation fee of up to €10 per CO₂e tonne.⁽⁴⁰⁾ Some EU Member States, most notably France and Denmark, also proposed an auction, with Denmark producing an analysis of the expected revenue from the auction (Figure 7).

FIGURE 7: HFC QUOTA PRICE AND REVENUE: ALLOCATION FEE VS AUCTION



PURCHASE AGREEMENTS

Companies, especially SMEs, are strongly advised to avoid installing new HFC-based equipment to insulate themselves from the impact of the HFC phase-down. However, to the extent new HFC-based equipment is installed, companies are encouraged to sign agreements at the time of purchase guaranteeing access to HFCs at predetermined prices.

From 2015 to 2030, the allocation fee and auction would have recouped €13.4 billion and €14.9 billion respectively. This revenue was intended for redistribution back to EU Member States to offset, *inter alia*, implementation costs borne by operators, contractors and national authorities, which are estimated at well over a billion euros a year,⁽⁴¹⁾ and to address disproportionate impacts on:

- **SMEs.** SMEs are considered less capable of absorbing the HFC price premium than their larger competitors and less likely to have long-term HFC purchase agreements at predetermined prices, and are more likely to secure HFCs from distributors on the retail market.
- **Eastern and Southern Europe.** EU Member States with economies in transition or recession, such as those in Eastern and Southern Europe, are expected to be outbid for HFC quotas by EU Member States with stronger economies and purchasing power.

Though an allocation fee and auction were not adopted in the EU F-Gas Regulation, a provision was included that requires the European Commission to assess the existing HFC quota allocation method of free grandfathering by mid-2017 for possible revision.⁽⁴²⁾ It is expected that the European Commission will give serious consideration to submitting a legislative amendment to fix the HFC quota allocation method. Until then, many EU Member States have already adopted or are exploring HFC taxes to achieve the same objectives.⁽⁴³⁾ In the meantime, operators and consumers should factor in the HFC price premium into the purchase of new HFC technologies.

D. Impact on Mid-GWP HFCs and Blends

Although the EU F-Gas Regulation foresees ambitious cuts in HFC consumption over the next 15 years, chemical companies are now developing a range of mid-GWP refrigerants for the European market which are being presented as solutions to the implementation of the EU F-Gas Regulation. The simple truth is that the future is bleak for mid-GWP HFCs and blends in the European Union. In addition to being more expensive and often covered by patents, the HFC phase-down will not allow their widespread use in new products and equipment in most sectors from 2020 onward – thus placing a *de facto* ceiling on their market penetration. Indeed, rather than being a solution, mid-GWP HFCs and blends pose a threat to the HFC phase-down as their use will exacerbate HFC quota shortages and the HFC price premium beyond what is already expected. Given the long life-time of most of the equipment involved, mid-GWP HFCs and blends are, at best, very near-term transitional refrigerants and should only be considered as replacements for higher-GWP HFCs in existing equipment.

For example, Daikin Industries is heavily promoting HFC-32, with a GWP of 675, as an alternative refrigerant for the air-conditioning sector. Studies and trials show, however, that single-split AC systems relying on hydrocarbons (e.g. R290) achieve equal or greater efficiency and performance and at lower cost.⁽⁴⁴⁾ There is therefore a general consensus that, once outdated standards and safety legislation are revised to allow for greater market penetration, hydrocarbons should become the predominant refrigerants. Due to its GWP of 675, HFC-32 has an uphill battle to secure an appreciable market share in the mid-term, and it is expected to have a ceiling on the percentage of the European marketplace it can occupy in single-split AC systems. Manufacturers should not be misled by the 2025 ban on new single-split AC systems (3kg or less) which indicates a GWP under 750 is acceptable.⁽⁴⁵⁾ This ban was a politically negotiated compromise and is expected to have little impact beyond preventing the most egregious uses of refrigerants in this sector, such as HFC-410A; the actual refrigerant mix in new single-split AC systems will be dictated by the HFC phase-down and HFC-32 will soon be above the average GWP (see Figure 4).

Smart investors will take advantage of the emerging European marketplace for new single-split AC systems relying on hydrocarbons. In 2015, over 8 million new units will be placed on the European marketplace, of which approximately 85% will be imported.⁽⁴⁶⁾ This number increases to 9.8 million in 2030 with the imported share expected to remain about the same.⁽⁴⁷⁾ Assuming around 80% of these new single-split AC systems rely on hydrocarbons from 2020 onward, a reasonable assumption under the HFC phase-down, investing in hydrocarbon technologies today will ensure access to a sizeable market in the near future.

IV. International Dimension

A parade of international diplomatic support for a global HFC phase-down now exists. This includes the Bali declaration in 2011, the Rio+20 and Bangkok declarations in 2012, the G20 summit in 2013 and the African Ministerial Conference on the Environment in 2015, among many others. It is well-accepted that the best course of action for a global HFC phase-down is to use the institutions and financial mechanisms of the Montreal Protocol, which has successfully phased out ozone depleting substances, the precursors to HFCs.

As of mid-2015, Parties have submitted four proposals to amend the Montreal Protocol to phase down consumption and production of HFCs. These proposals have been submitted by North America (Canada, Mexico and the United States of America), the Island States (the Federated States of Micronesia, Kiribati, Marshall Islands, Mauritius, Palau, Philippines, Samoa and Solomon Islands), the European Union and India. The Montreal Protocol is well-equipped to ensure flexibility for developing

BUYER BE CAREFUL

The HFC phase-down was not designed to encourage the use of lower-GWP HFC blends in new refrigeration equipment, such as Chemours' Opteon™ and Honeywell's Solstice™. These lower-GWP HFCs and blends only make sense for specific purposes, such as when used as a drop-in or retrofit in installed equipment.

countries to cope with challenges that might arise from “leapfrogging” to low-GWP technologies, in particular by providing differentiated baselines, grace periods and reduction schedules in addition to financial assistance and technology transfer. Moreover, to respond to latest data and emerging technologies in order to achieve its goals, the Montreal Protocol has a unique adjustment mechanism that allows Parties to revise and accelerate reduction schedules as technologies develop.

Successful implementation of the EU F-Gas Regulation will inform and influence the global regulatory framework and choice of technologies made at the international level. The level of ambition in the EU F-Gas Regulation far exceeds any other national measure to date, and its successful implementation is particularly important since it will drive markets toward low-GWP technologies that will later be rolled out worldwide in order to achieve an HFC phase-down under the Montreal Protocol.

