Support contract for an Evaluation and Impact Assessment for amending Regulation (EU) No 517/2014 on fluorinated greenhouse gases

CLIMA.A2/ETU/2019/0016

Impact Assessment Final Report

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Abbreviations

AC	Air Conditioning
AnaFgas model	Model named „Analysis of t fluorinated greenhouse gases in the EU“
AR	Assessment Report of the IPCC
AREA	European association of refrigeration, air conditioning and heat pump contractors
BAU	Business-as-usual
BDR	Business Data Repository
BL scenario	Baseline scenario
BMU	German Federal Ministry of Environment, Nature Conservation and Nuclear Safety (Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit)
BRG	Better Regulation Guidelines
CDM	Clean Development Mechanism
CEN	European Committee for Standardisation
CF scenario	Counterfactual scenario
CFC	Chlorofluorocarbon
CO_2 eq	CO_2 equivalents
CRF	Common Reporting Format
DE	Disposal emissions
DG CLIMA	Directorate-General for Climate Action
EEA	European Environment Agency
EIA	Environmental Investigation Agency
EoL	End-of-life
EPEE	European Partnership for Energy & the Environment (industry association)
EPR schemes	Extended producer responsibility schemes
ETC/ACM	European Topic Centre on Air Pollution and Climate Change Mitigation
ETC/CME	European Topic Centre on Climate Change Mitigation and Energy
EU	European Union
EU27	EU with its 27 Member States as of 1 February 2020
EU ETS	EU Emissions Trading System
F-gases	Fluorinated greenhouse gases
FGR	F-gas Regulation
GDP	Gross domestic product
GHG	Greenhouse gas
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GWP	Global Warming Potential
HC	Hydrocarbon
HCFCs	Hydrochlorofluorocarbons
HCFOs	Hydrochlorofluoroolefins (unsaturated HCFCs)
HFCs	Hydrofluorocarbons
HFEs	Hydrofluoroethers
HFOs	Hydrofluoroolefins (unsaturated HFCs)
HV	High voltage
IA	Impact Assessment
IPCC	Intergovernmental Panel on Climate Change
ISG	Interservice Group
ISO	International Standardisation Organisation
JI	Joint Implementation
LE	Lifetime emissions
MAC	Mobile air conditioning

MaxQ	Maximum quantity
MDI	Metered-dose inhaler
ME	Manufacturing emissions
MEPS	Minimum energy performance standards
MF scenario	Maximum feasibility scenario
MMR	Monitoring Mechanism Regulation
MOP	Meeting of the Parties
MP	Montreal Protocol on Substances that Deplete the Ozone Layer
MP scenario	MP alignment scenario
MRV	Measuring, Reporting and Verifying
MS	Member State
MV	Medium voltage
NGO	Non-Governmental Organisation
NIR	National Inventory Report
ODS	Ozone-Depleting Substance
OPC	Open public consultation
PA scenario	Proportionate action scenario
PFC	Perfluorocarbon
PfS	Production for Sale
POM	Placing on the market
QA	Quality Assessment
RAC	Refrigeration and Air Conditioning Sectors
RACHP	Refrigeration, Air Conditioning and Heat Pump Sectors
REIO	Regional Economic Integration Organisation
RV	Reference value
SME	Small and Medium-sized Enterprise
TARIC code	TARif Intégré Communautaire (Integrated Tariff of the European Communities)
TFA	Trifluoroacetic acid
TFEU	Treaty on the Functioning of the European Union
UAE	United Arab Emirates
UBA	Federal German Environment Agency (Umweltbundesamt)
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organisation
VA	Value Added
VRF	Variable refrigerant flow
WAM scenario	Scenario with additional measures (Schwarz et al. 2011[1])
WEEE	Waste electric and electronic equipment
WFD	Waste Framework Directive
WM scenario	Scenario with measures (Schwarz et al. 2011)
XPS foam	Extruded polystyrene foam

[1] Schwarz, W., et al., 2011, Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases. For the EU Commission (DG CLIMA), Final Report.

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1. Presentation of the study to support the impact assessment for amending the F-gas Regulation

This report presents the findings of 'Task 3: Develop options and recommendations for the review of the Regulation and assess their impacts' under the 'Support contract for an Evaluation and Impact Assessment for amending Regulation (EC) No 517/2014 on fluorinated greenhouse gases (the 'Regulation' or 'FGR' when abbreviated)'.

The project has been commissioned under the contract number: Ref. Ares(2019)7625784 - 11/12/2019. The contract entered into force in April 2020 and runs until April 2022 (24 months). The general objective of this contract is to provide a timely and high-quality input useful for supporting the Commission in drafting, in an almost parallel manner, an evaluation of the F-gas Regulation and an impact assessment for amending the Regulation. The input must be in line with the Commission's Better Regulation Guidelines[2] and must serve to fulfil the obligations in Article 21(2) of the Regulation.

This report presents the work conducted for the impact assessment, including the process and screening of policy options that leads to a shortlist of options. This shortlist is then analysed in an assessment to analyse the environmental, economic and, where relevant, social impacts of the envisaged policy options and policy options bundles.

The report is structured as follows:

- **Section 2** presents the political and legal context of the impact assessment.
- **Section 3** provides the problem definition.
- **Section 4** justifies the need for EU action.
- **Section 5** presents the objectives to be achieved.
- **Section 6** sets out the three policy options to achieve the objectives.
- **Section 7** presents an overview of the envisage measures.
- **Section 8** provides a further specification of the three policy options.
- **Section 9** present the three fully specified policy options.
- **Section 10** provides the impact assessment of the three policy options.
- **Section 11** compares the three policy options and present the preferred policy option.
- **Section 12** presents a plan for the ongoing monitoring and evaluation of impacts.

The sections of this report follow the same structure that will be used for the impact assessment report, in line with the EU Commission's Better Regulation Guidelines (Tool #12).

[2] https://ec.europa.eu/info/sites/info/files/file_import/better-regulation-toolbox-12_en_0.pdf

2. Introduction: Political and legal context

2.1. General background

Fluorinated greenhouse gases ("F-gases") are man-made substances used in numerous industrial applications and include hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), nitrogen trifluoride (NF_3) as well as other fluorinated substances. Due to their high global warming potentials (GWP), F-gases contribute significantly to climate change. Production and consumption of F-gases, specifically HFCs, have increased considerably because they are widely used as substitutes for ozone depleting substances (ODS), which are being phased-out globally under the Montreal Protocol. F-gas emissions are mainly released from refrigeration, air conditioning and heat pump (RACHP) equipment, foams, aerosols, solvents, and fire protection equipment. Other emissions sources include halocarbon production, certain industrial processes in semiconductor and non-ferrous metal industry as well as the use in switchgear for transmission of electricity.

F-gas emissions have long been addressed by international conventions such as the United Nations Framework Convention on Climate Change (UNFCCC) and its Kyoto Protocol. As a party to the Kyoto Protocol, the EU has to report on the status of the reduction commitments made under the UNFCCC and in relation to EU legislation on greenhouse gas (GHG) emission reductions. Regulation (EU) No 525/2013 ("Monitoring Mechanism Regulation", MMR)[3] stipulates the overarching mechanism for monitoring and reporting greenhouse gas emissions. In more detail, Commission Implementing Regulation (EU) No 749/2014 sets the requirements for national reporting under Regulation (EU) No 525/2013.[4]

The EU was the first region in the world where a complete F-gas legislation had been established. The first F-gas Regulation (EC) No 842/2006 of the European Parliament and of the Council of 17 May 2006 on certain fluorinated greenhouse gases" was supplemented with nine Commission implementing regulations. The 2006 Regulation contained provisions related to certification of technicians and companies dealing with F-gases, reporting on F-gases, leakage checking and recovery requirements for F-gas containing equipment, placing on the market bans for few products and equipment containing or relying on F-gases as well as prohibitions of the use of certain F-gases in specific applications. HFCs are addressed not only by the F-gas Regulation, but also by Directive 2006/40/EC ("MAC Directive"), which bans the use of HFCs with a GWP > 150 in new passenger cars since 2017.

Regulation (EC) No 842/2006 was replaced by the current Regulation (EU) No 517/2014, which entered into force on 1 January 2015. The level of ambition of the revised Regulation was significantly extended, inter alia, to include an HFC phase-down schedule and HFC quota allocation system, additional certification and reporting requirements and an additional set of placing on the market and use bans.

Recognising the threat of F-gases, specifically HFCs, to global climate change, the international community decided in 2016 in Kigali (Rwanda) on an Amendment to the Montreal Protocol. The so-called Kigali Amendment entered into force on 1 January 2019 and implements a global HFC phase-down by cutting down the HFC production and consumption by more than 80 % over the next 30 years. There are different baseline years and HFC reduction schedules for Article 5 and non-Article 5 countries, with developed countries starting first and developing countries taking on reduction commitments in the medium-term, in addition to the ODS phase-out also regulated under the Montreal Protocol. The phase-down of HFCs requires the development and uptake of suitable alternative refrigerants with lower global warming potential, which can substitute for HFCs. Beyond the specific reduction schedules, the Kigali Amendment introduced import/export licensing and reporting requirements for HFCs. By extending the scope of controlled substances to HFCs, the Montreal Protocol took an important step towards the long-term goals set by the Paris Climate Agreement. As identified in the evaluation of the Regulation, the EU

[3] Regulation (EU) No 525/2013, accessible under https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32013R0525
[4] Regulation (EU) No 749/2014, accessible under http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uris-erv:OJ.L_.2014.203.01.0023.01.ENG

policy played an important role in facilitating convergence towards a potential future agreement to phase down HFCs under the Montreal Protocol.

2.1 Objectives and measures of the Regulation

In 2012, the Impact Assessment for the revised Regulation was published. It highlighted key issues with the first F-gas Regulation and challenges that still needed to be addressed. Leading on from the issues identified in the 2012 Impact Assessment, both general and specific policy objectives for the revised Regulation were identified. The following table provides an overview of these objectives. The Impact Assessment, alongside a broader body of work, led to the establishment of Regulation (EU) No 517/2014 of the European Parliament and of the Council of 16 April 2014 on fluorinated greenhouse gases, which repealed the Regulation (EC) No 842/2006 and entered into force on 1 January 2015.

Table 1: Summary of the Regulation's objectives identified in the 2012 Impact Assessment

General objective
Keep climate change below 2º C of pre-industrial levels by reducing GHG emissions in the EU by 80 to 95% in 2050 compared to 1990. This target corresponds to the necessary reduction levels identified by the Intergovernmental Panel on Climate Change (IPCC) for developed countries and was endorsed both by the Council and the European Council as the EU 2050 emission reduction target.
Specific objectives
Contribute to the achievement of the EU 2050 reduction target by reducing CO_2 eq from F-gases in the EU by: • Discouraging the use of F-gases with high GWP in the EU where suitable alternatives exist. • Encouraging the use of alternative substances or technologies when they result in lower GHG emissions without compromising safety, functionality and energy efficiency, and achieving higher market shares for these technologies. • Preventing leakage from equipment and proper end-of-life treatment of F-gases in applications. • Facilitating convergence towards a potential future agreement to phase down HFCs under the Montreal Protocol. • Enhancing sustainable growth, stimulate innovation and develop green technologies by improving market opportunities for alternative technologies and gases with low GWP. • Creating efficient and proportionate mechanisms for reaching the environmental objectives while limiting any undesirable effects on SMEs and employment, the administrative burden for companies and authorities, the abatement costs per tonne of CO_2 eq and preserving the competition in the internal market (to the extent possible).

Two key measures under the Regulation aim to drive down demand for (and ultimately emissions of) F-gases: the HFC phase-down and placing on market (or POM) prohibitions.

The **phase-down** implies a progressive reduction of HFCs by two-thirds, starting in 2015 and running through 2030 (Article 15 in conjunction with Annex V). To implement the HFC phase-down, quotas are allocated annually to producers and importers of bulk gases, which allow them to place limited HFC quantities on the market (Article 16). HFCs destined for the following uses are exempted from the phase-down: imports for destruction, feedstock use, exports, military use, semiconductor industry and – from 1 January 2018 – pharmaceutical metered dose inhalers (MDIs) (Article 15 (2)).

However, placing on the market of HFCs for these uses is subject to labelling (stating the exempted use) and reporting requirements. The annual average of the total quantity placed on the market during the period from 2009 to 2012 serves as baseline (183.1 Mt CO_2 eq / 100 %) for the HFC phase-down start in 2015. The table below shows the percentages to calculate the maximum quantity of HFCs to be placed on the market in the respective years.

Table 2: HFC phase-down schedule (Article 15 in conjunction with Annex V of the Regulation)

Year	Percentage of baseline (average POM in the period 2009 to 2012)
2015	100%
2016 to 2017	93%
2018 to 2020	63%
2021 to 2023	45%
2024 to 2026	31%
2027 to 2029	24%
2030	21%

Articles 11 in conjunction with Annex III of the Regulation include **prohibitions** for placing on the market of products and equipment containing or relying on F-gases, while Article 13 includes restrictions for the use of F-gases. Most of the Annex III prohibitions have already come into effect, however, there are still some prohibitions that will become effective in the coming years. These prohibitions are shown in the following table.

Table 3: Prohibitions under the Regulation

Placing on the market restrictions for products and equipment (Article 11 in conjunction with Annex III)		Date of prohibition
3. Fire protection equipment that contain HFC-23		01/01/2016
10. Domestic refrigerators and freezers that contain HFCs with GWP of 150 or more		01/01/2015
11. Refrigerators and freezers for commercial use (hermetically sealed systems)	Containing HFCs with GWP of 2500 or more	01/01/2020
	Containing HFCs with GWP of 150 or more	01/01/2022
12. Stationary refrigeration equipment, that contains, or whose functioning relies upon, HFCs with GWP of 2 500 or more except equipment intended for application designed to cool products to temperatures below – 50 °C		01/01/2020
13. Multipack centralised refrigeration systems for commercial use with a rated capacity of 40 kW or more that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 150 or more, except in the primary refrigerant circuit of cascade systems where fluorinated greenhouse gases with a GWP of less than 1 500 may be used		01/01/2022
14. Movable room air-conditioning equipment (hermetically sealed equipment which is movable between rooms by the end user) that contain HFCs with GWP of 150 or more		01/01/2020
15. Single split air-conditioning systems containing less than 3 kg of fluorinated greenhouse gases, that contain, or whose functioning relies upon, fluorinated greenhouse gases with GWP of 750 or more		01/01/2025
16. Foams that contain HFCs with GWP of 150 or more except when required to meet national safety standards	Extruded polystyrene (XPS)	01/01/2020
	Other foams	01/01/2023
17. Technical aerosols that contain HFCs with GWP of 150 or more, except when required to meet national safety standards or when used for medical applications		01/01/2018
Use prohibitions (Article 13)		
Use of SF_6 in magnesium die-casting and the recycling of magnesium die-casting alloys in quantities of less than 850 kg per year		01/01/2018

Use of F-gases with a GWP of 2500 or more to service or maintain refrigeration equipment with a charge size of 40 tonnes of CO_2 equivalent or more, with the exception of • Military equipment or equipment intended for applications to cool products below - 50 °C • Reclaimed F-gases with a GWP of 2500 or more used for maintenance or servicing of existing refrigeration equipment with labelling according to Article 12 (until 01/01/2030) • Recycled F-gases with GWP of 2500 or more used for maintenance or servicing of existing refrigeration equipment if recovered from such equipment and used by the recovery undertaking or the undertaking where recovery was carried out for maintenance or servicing (until 01/01/2030)	01/01/2020

A list of the key measures and relevant articles is set out in the following table.

Table 4: Key measures of the Regulation and relevant articles

Measure	Relevant articles
Containment	Article 3 to 7
Recovery	Article 8
Training and certification	Article 10
Placing on the market	Article 11 (in conjunction with Annex III) – Prohibitions Article 12 – Labelling Article 13 – Restrictions for the use of F-gases
HFC phase-down and quotas	Article 15 and 16
Registration	Article 17
Reporting	Article 19

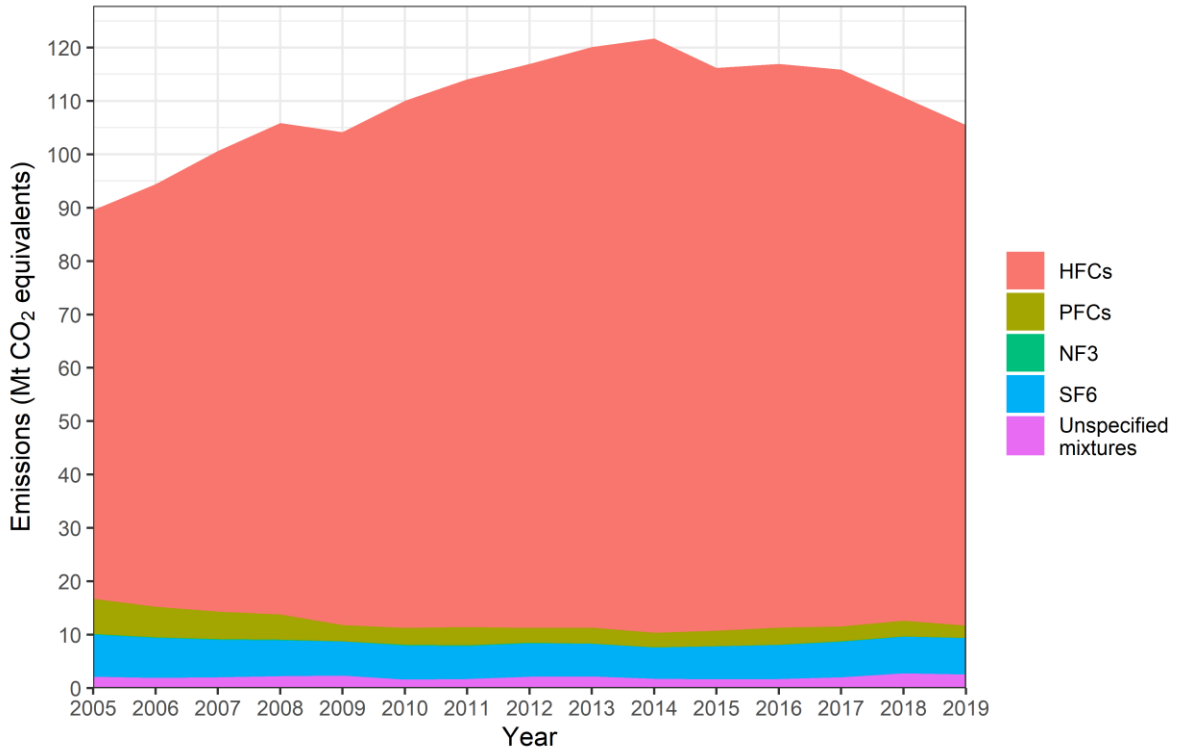
Different actors, F-gases and activities are affected by different provisions. The Regulation currently covers 19 hydrofluorocarbons (HFCs), seven perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) in Annex I, Section 1 to 3. In addition, the Regulation covers "other fluorinated greenhouse gases", which are only subject to reporting obligations according to Article 19 of the Regulation (unless they are part of blends with F-gases from Annex I). The listed gases include five unsaturated hydrofluorocarbons (HFCs)/hydrochlorofluorocarbons (HCFCs), 33 hydrofluoroethers (HFEs) and fluorinated alcohols and four other perfluorinated compounds. The full list of other gases covered can be found in Annex II (Section 1 to 3).

The **evaluation of the Regulation** (undertaken back-to-back with this impact assessment) found that it had been mostly effective in meeting its original objectives and the individual measures were found to work together productively. The Regulation has driven a significant reduction in the supply and emissions of F-gases, predominantly through encouraging a switch to gases with lower GWP, but also through the uptake of alternatives. The evaluation showed that the Regulation has had initial effects in terms of reducing F-gas supply and emissions in the EU.

Figure 1 shows the development of emissions of hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), sulphur hexafluoride (SF_6) and nitrogen trifluoride (NF_3). The group of HFCs is still the most important among the F-gases, both in terms of quantity in tonnes and CO_2 eq, as EEA data show. F-gas emissions increased steadily since the 1990s. In 2014, a turning point was reached, and emissions have been slowly decreasing since then. Likewise, the supply of F-gases (measured in terms of GWP) has also declined: When compared to 2007, the EU total supply of F-gases decreased by 12 % in tonnes and 43 % in CO_2 eq in 2019.

The Regulation has resulted in significant emission savings at very low abatement costs linked to technological change and showed a strong level of coherence both internally and externally.

Figure 1: F-gas emissions in the EU28 from 1990 to 2019



Source: UNFCCC (https://unfccc.int/documents/275968)

Notes: Emissions are represented as Mt CO_2 eq using the GWP values of the Fourth Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC).

Leakage rates have also observed a decline, and the HFC phase-down has been a strong trigger for innovation (aided by some prohibitions addressing single substances or specific applications) – an example of this is the fact that dozens of new blends (especially mixtures consisting of HFCs and unsaturated HFCs), new components and technologies have entered the EU market since 2015.

The evaluation also concluded that the Regulation has ensured compliance with the international obligations to date and has exerted a positive influence on third countries to do likewise. In addition, the Regulation has safeguarded high environmental ambition by maintaining the same obligations across the EU, while also ensuring a level playing field for concerned industries and undertakings among Member States. Given the continued use and emission of F-gases, the evaluation concluded that it remains crucial to have an effective policy in place: F-gas emissions still contributed 2.5 % to the EU's total GHG emissions in 2018. Likewise, the 2020 EEA report reveals that there remains a significant supply of F-gases to the EU market, and thus the potential for future emissions. As such, the Regulation and its high-level objectives continue to reflect and respond to the fundamental need of the EU to reduce demand and emission of F-gases. This relevance is underlined as climate change policy (both in terms of mitigation and adaptation) will stimulate additional demand for equipment which conventionally uses F-gases going forward (e.g. reliance on heat pumps to decarbonise heat demand, and air conditioning and refrigeration to adapt to rising temperatures).

However, the evaluation also identified several challenges associated with the Regulation.

First, the Regulation was designed to meet the climate goals set forward in the 2011 Roadmap[5]. Updated modelling undertaken as part of the evaluation now suggests that the original objectives around emissions reductions will no longer be reached by 2030. Furthermore, the overarching EU Climate objectives have evolved since the Regulation was introduced and now demand significantly more action in all sectors to reduce emissions, in particular reflecting the recently agreed EU Climate Law (through which it is committing to reaching carbon neutrality by 2050 and at least a 55% emission reduction by 2030 compared to 1990).

Connected to this, technological progress since the Regulation was introduced has led to the development of commercially viable alternatives for certain gases and applications. Take up of these new alternatives is not being sufficiently encouraged by the Regulation, in particular in sectors not currently covered by the phase-down (e.g. SF_6, and metered-dose inhalers (MDIs)).

Second, several aspects of the Regulation create a risk of non-compliance with the EU's commitments under the Kigali Amendment. These are:

- the lack of EU HFC phase-down schedule post 2030 (the Kigali Amendment defines a phase-down schedule to 2036)
- the Montreal Protocol considers both HFC consumption (production + imports – exports) and production which both must be phased down, while the EU Regulation paces a requirement only on Placing on the Market (which is close, but not the same, as consumption)
- exemptions that are granted by the Regulation but not by the Montreal Protocol
- a de minimis threshold for placing HFCs on the EU market below which HFCs are not covered by HFC phase-down is part of the Regulation, but not foreseen in the Montreal Protocol
- thresholds for reporting on production, import, export of bulk gases, feedstock use and destruction of F-gases (Annex I) and other fluorinated greenhouse gases (Annex II) exist in the Regulation below which reporting is not required (Article 19 (1)-(3)). Such reporting thresholds are not included in the Montreal Protocol

Third, there have been several implementation challenges which have somewhat undermined the effectiveness of the Regulation over the evaluation period. The key issues are:

1. Illegal trade has emerged as a key issue with and is related to a combination of factors, including aspects related to the interaction between the Regulation and customs rules.
2. Safety codes and legislation at a national level have in some cases prevented the uptake of alternatives.
3. The number of bulk importers benefiting from the new entrants reserve increased by a factor of more than twenty between 2012 and 2019. This results in very low quota shares from the reserve to the real F-gas traders, making verification and prevention of illegal imports more challenging.

Finally, although broadly coherent both externally and internally, there are small areas of incoherence with other EU legislation and some elements of the Regulation were concluded to lack clarity.

2.2 Legislation related to the Regulation

Ozone-depleting substances (ODS) are halogen-containing substances that damage the ozone layer in the upper atmosphere. In 1987, all nations in the world agreed to take action under the Montreal Protocol on Substances that Deplete the Ozone Layer (MP), aiming at phasing out the production and consumption of substances that contribute to ozone depletion. Regulation (EC) No 1005/2009 on substances that deplete the ozone layer (further referred to us the "**Ozone Regulation**") established more

[5] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A52011DC0112

strict requirements, including accelerated phasing out of HCFCs and introducing a new filling and servicing ban for HCFC. As a consequence, in applications such RACHP equipment, foam blowing, solvent uses, aerosols and fire protection systems and fire extinguishers, ODS have been prohibited in the EU and alternatives such as HFCs that belong to fluorinated greenhouse gases (F-gases) have been widely introduced.

Directive 2006/40/EC ("**MAC Directive**") relating to emissions from air conditioning systems in passenger cars, complements the F-gas Regulation by introducing a prohibition on mobile air conditioning containing F-gases. The other obligations of the Regulation such as containment measures continue to apply for this sector, in analogy to all other sectors that are affected by the phase-down and prohibitions.

There are reporting requirements around F-gases in both the Regulation and under the United Nations Framework Convention on Climate Change (UNFCCC), which requires Parties to report their annual national F-gas emissions. In the EU, Regulation (EU) No 525/2013 ("**MMR Regulation**") in conjunction with Regulation (EU) 749/2014 defines the mechanism and requirements for reporting GHG emissions. Under the Regulation, Article 20 stipulates the collection of emission data.

The transition away from high GWP can indirectly impact on energy consumption depending on the efficiency of the new equipment (where equipment is replaced). The Regulation also seeks to improve energy efficiency through better control, monitoring and maintenance of existing RACHP equipment. As such, there is interaction with a number of different regulations which also seek to influence the energy use or increase the energy efficiency of RACHP systems, namely: Directive 2010/31/EU on the **energy performance of buildings;** Directive (EU) 2018/2001 on the **promotion of the use of energy from renewable sources;** the **Energy Labelling Regulation** (EU) No 2017/1369 and in particular the **Ecodesign Directive** 2009/125/EC (which provides consistent EU-wide rules for improving the environmental performance of products, including mandatory requirements regarding energy efficiency, implemented through product-specific regulations). Article 11 (2) of the F-gas Regulation allows an exemption from the placing on the market bans set out in Annex III if the equipment with HFCs (taking into account leakage and recovery rates) would achieve lower overall GHG emissions during its life cycle than the same equipment without HFCs.

The Regulation also has synergies with **EU waste legislation**. The provisions on recovery, recycling, reclamation and destruction contained in the Regulation reflect those in the Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (further referred to as the "**Waste Framework Directive**" or "**WFD**"), **Shipments of Waste Regulation** (EC) No 1013/2006 and the Directive 2012/19/EU of the European Parliament and of the Council of 4 July 2012 on waste electrical and electronic equipment (further referred to as "**WEEE Directive**"). The WFD and related pieces of legislation are connected to Article 8 of the Regulation on recovery of F-gases, which places requirements on various operators and undertakings to ensure the recovery of gases in order to facilitate recycling, reclamation or destruction. Where EU Member States do not have reclamation and destruction facilities and intend to export used F-gases for reclamation and/or destruction, recovered refrigerants being transported to another location are considered to be hazardous waste under the Shipments of Waste Regulation and require specific permits for transport and storage which are issued and controlled by the local environment agency. The WEEE Directive complements the Regulation in that it sets out requirements for Member States to: minimise disposal of WEEE in unsorted municipal waste to ensure correct treatment (and noting as a priority fluorinated GHGs (Article 5(1)); prohibit disposal of separately collected WEEE that has not undergone 'Proper Treatment' (Article 6(1)); and ensure collection and transport of WEEE is done in a way that optimises conditions for preparing for re-use, recycling and confinement of hazardous waste (Article 6(2)). Article 8 of the **WEEE Directive** determines that Member States shall ensure that all separately collected waste electrical and electronic equipment undergoes proper treatment. In terms of 'proper treatment', the WEEE contains (Annex VII) specific directions for the treatment of equipment containing gases of GWP above 15 that these gases must be properly extracted and treated (but does not make specific reference to the Regulation).

The **REACH Regulation** (EC) No 1907/2006 contains several components that have the potential to interact with the Regulation: 1. Annex XIV of REACH lists substances prohibited from being placed on the market and used, unless an authorisation is granted, or the use is exempt from authorisation (although at present none are known substitutes to F-gases); 2. There is an obligation to register substances placed on the market above a certain amount. Individual substances are required to be registered under REACH, meaning that components of blended refrigerants have to be registered. However, a blended refrigerant is considered as a 'preparation' and hence does not need to be registered: and 3. Suppliers of articles are obligated to pass on information to recipients and, upon request, to consumers, in accordance with Article 33, with regard to the contents of substances of very high concern (SVHC).

The Regulation seeks to manage the use, availability and market for F-gases in the EU, of which imports are a key source of supply. Hence there is a strong cross-over between the Regulation and the **Union Customs Code Regulation** (EU) No 952/2013, Regulation (EC) No 765/2008 ("**Market Surveillance Regulation**") which established conditions for the placing of 'products' on the Union market and broader customs legislation and procedures, and Directive 2008/99/EC ("**Environmental Crime Directive**") establishes certain conducts as criminal offences, 'when unlawful and committed intentionally or with at least serious negligence'. In addition, there is a link to the proposal for a "**EU Single Window environment for Customs**", which was published on 28 October 2020, whereby economic operators will be able to electronically submit information required by both customs and non-customs legislation for EU cross-border movements of all goods.

Since the Regulation was adopted pursuant to Article 192 (1) Treaty on the Functioning of the European Union (TFEU), it does not prevent EU Member States from maintaining or introducing **more stringent measures at national level** that are comparable with the TFEU provided the Member State notifies the EU Commission of any such measures. To this end, the evaluation of the Regulation identified that several Member States have introduced (or plan to introduce) additional measures to complement the EU provisions that have been effective to support the reduction of F-gas emissions and uptake of lower GWP alternatives (Belgium*, Bulgaria*, Denmark, Estonia, Finland, France*, Italy, Germany, Poland, Portugal, Spain, and Sweden6) – although the measures where further action has been taken differs by Member State. In addition, some Member States had put in place (or planned to put in place) producer responsibility schemes for the recovery of F-gases and their recycling, reclamation or destruction under Article 9 (Denmark, Estonia, France, Germany and Spain), in addition to schemes that had been developed by industry. Further information on these Member State level actions can be found in the evaluation.

6 *Denotes where measures are being discussed or planned, but are not yet in place.

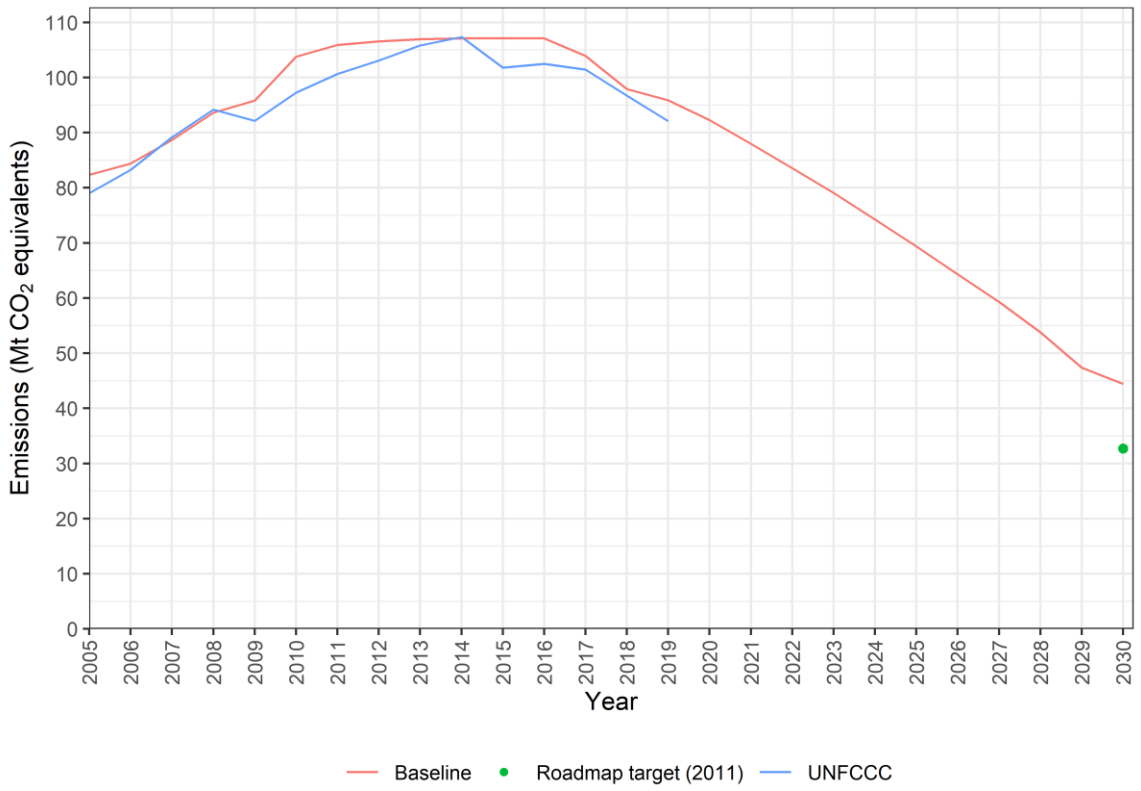
3. Problem definition

The review of the Regulation should address shortcomings identified by the evaluation. This section first describes the problems of the Regulation affecting its relevance, effectiveness, and coherence. In each case the report sets out the general description of the problem, followed by a table summarising the underlying drivers, affected stakeholders, scale of the problem as well as the economic, environmental and social consequences.

3.1. Problem area 1: Regulation is not consistent with overarching EU Climate objectives

As all greenhouse gases, F-gases fall under the scope of the EU's broader climate change objectives and targets and need to play a proportionate role in working towards achieving these objectives. The Regulation was designed to meet the climate goals set forward in the 2011 Roadmap[7]. While demand and thus emissions of F-gases are declining, forward modelling of the baseline indicates that the 2030 goals set for the Regulation will likely not be reached by the current Regulation (Figure 2). The GHG emission target for 2030 is a 60 % reduction compared to 2005 levels, which translates into 33 Mt CO_2 eq for F-gases. Under the baseline continuation, emissions of F-gases will amount to 44 Mt CO_2 eq, thus exceeding the target by 11 Mt CO_2 eq, or 33 %.

Figure 2: Emissions of F-gases modelled and data reported under UNFCCC for the EU27



Source: AnaFgas modelling, UNFCCC (https://unfccc.int/documents/275968)

Note: The roadmap (2011) targets for 2030 correspond roughly to 40% of the emissions in 2005. In addition, and more importantly, the EU climate objectives have evolved since the time of the 2012 Impact Assessment and demands significantly more action in all sectors to reduce emissions. The Paris Agreement from 2015 urges countries to make the necessary contributions so that global warming can be limited to below 2 (and possibly 1.5) degrees, which requires much swifter and wide-ranging changes globally. The EU recently agreed on an EU climate

[7] https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=celex%3A52011DC0112

law by, which it is committing to reaching carbon neutrality by 2050 and at least a 55 % emission reduction by 2030 compared to 1990.

While emission savings fall short, not least in view of the EU Green Deal, the Regulation has not kept pace with technological developments. Since the adoption of the Regulation, new alternatives have become commercially viable which are not sufficiently encouraged by the Regulation (in particular due to exclusion from the phase-down). The evaluation highlighted that viable alternatives may be available in the following applications and sectors:

- use and replacement of perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). Although, PFCs, used mainly in semiconductor and electronics manufacture, and SF_6, used in electrical equipment, photovoltaics, magnesium casting and other special industry applications, accounted for only 1 % of the EU F-gas supply (in tonnes) in 2019, they represented 18 % in terms of CO_2 eq. However, despite their very high GWP (ranging from 7 000 to 23 000) their use is only restricted for specific applications. Especially in the case of SF_6 in electrical equipment, alternatives have been developed and intensively researched or even placed on the market over the past years, but the Regulation is not promoting the deployment of those new alternatives
- Metered-dose inhalers
- Stationary air conditioning: Alternatives to conventional HFCs (i.e. typically R410A) are available for many applications including small single split air conditioning systems and also increasingly larger single split, multi split and VRF systems as well as chillers.
- Heat pumps: Alternatives to conventional HFCs (i.e. R410A, R407C) have been commercialized by several manufacturers for residential, commercial and industrial heat pumps.
- Stationary refrigeration equipment: Alternatives with lower GWP than the conventional HFC-based options are common in all applications including the temperature range below -50°C.
- Transport refrigeration: It relates to refrigeration systems in vans, trucks and trailers as well as reefer containers. Leakage rates tend to be higher in transport refrigeration as compared to stationary applications due to the increased level of vibration in motion. Further regulation would allow for leakage reduction, while providing incentives for the use of lower GWP alternatives to R404A and R134a.
- Fire protection equipment: Alternatives to HFCs including water mist, fluoroketones, inert gases and CO_2 and have been developed and introduced in most application areas years ago.
- Unsaturated HFCs and perfluorodecalin in personal care products
- F-gas regulation does not regulate the use of inhalation anaesthetics.
- Further F-gases such as SO_2F_2 are used at large scale and emitted.

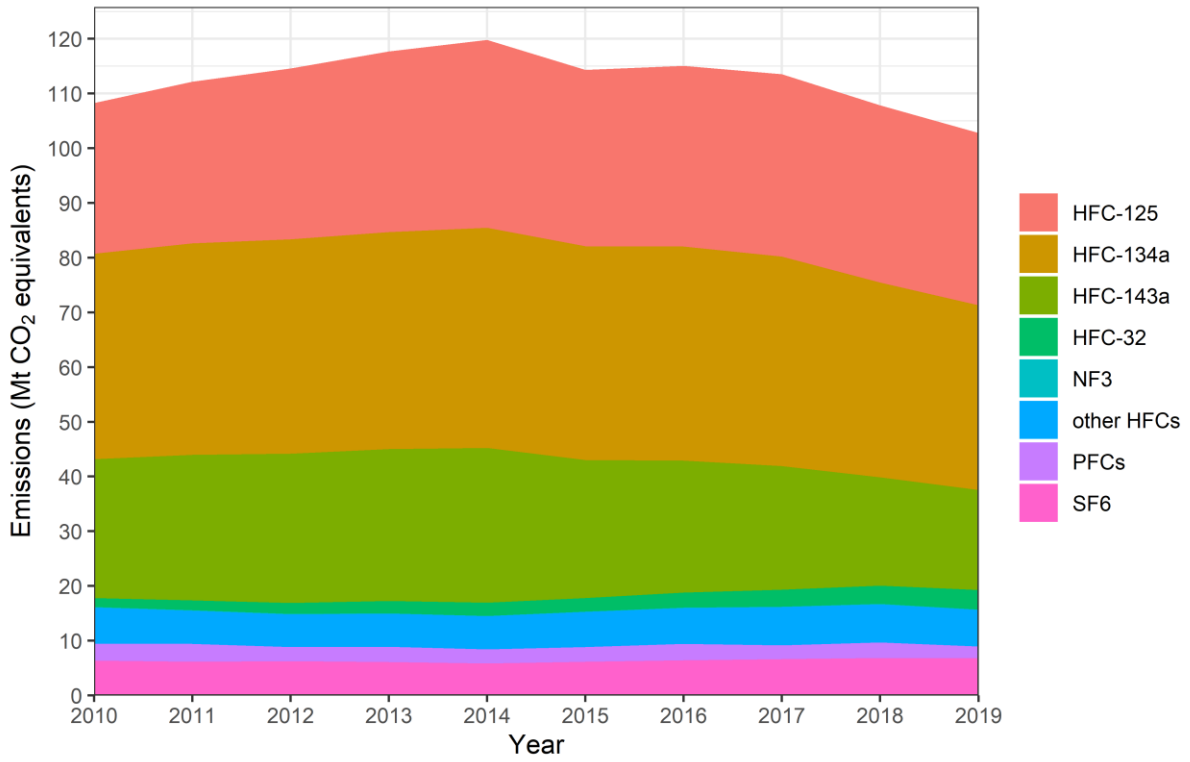
Prevention of F-gas leakages from equipment is key to achieving significant emission reductions. The Regulation has continued to address prevention of leakage from equipment and the provision of proper end-of-life treatment. Data available from surveys in a number of Member States have shown the importance of regular leakage checks and associated servicing activities, especially in the commercial refrigeration sector, as leakage rates have declined (further) in recent years.

However, current emission prevention requirements only concern F-gases listed in Annex I of the Regulation, while no such requirements apply to other fluorinated gases listed in Annex II, such as NF_3, unsaturated H(C)FCs, fluorinated ethers and alcohols and other perfluorinated compounds. As demonstrated in Figure 3, NF_3 alone comprises a smaller proportion of annual emissions[8] but might become

[8] With respect to the remaining gases under Annex II, data is not available with which to assess their complete significance: Not all Annex II gases are subject to UNFCCC reporting, only NF_3. Some Member States report certain emissions on a voluntary basis (e.g. unsaturated HFCs from MAC) but the data are largely incomplete.

more significant in the future due to its high GWP of 17 200.[9] Moreover, high-GWP degradation products have lately been identified in the atmosphere and in water as well. These alternative substances, listed in Annex II of the Regulation, are currently not covered by measures aiming at preventing their emissions.

Figure 3: Reported UNFCCC F-gas emissions by gas/gas group in the EU28



Source: UNFCCC (https://unfccc.int/documents/275968)

Note: CO_2 eq were calculated based on AR4 GWP values. NF_3 emissions are not visible with an average of 0.09 Mt CO_2 eq per year in 2010-2019.

Furthermore, the current containment provisions only apply to F-gas production (Article 7), the use of F-gases in equipment (Article 3 to 5) and the recovery from end-of life equipment (Article 8), but not to other steps along the supply chain, where leakages can also occur. Emissions from refrigerant container management and handling are estimated at 2-5 % of the entire refrigerant market by industry experts.

[9] The GWP of NF_3 is 17 200 in the IPCC AR4 and 17 400 in AR6.

Table 5: Overview of problems related to Problem Area 1 – level of ambition

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
Currently there is no alignment with increase in ambition of EU Climate objectives. Original emission saving ambitions may not be reached.	The EU's new climate objectives are a recent development and this is the first opportunity to address the FGR within this context. Broader modelling to support development of new climate targets suggests more is needed. New EU targets / fit for 55 package highlights need to quickly bring down GHG emissions outside the EU-ETS as regulated by the Effort Sharing Regulation ESR this includes F-gas emissions (except the PFCs from Aluminium production covered under the EU-ETS.	Human health and the environment. GHG emissions, climate change and achievement of EU climate targets. Current projections suggest an exceedance of the 2030 target by 33 % (ca. 11 Mt CO_2 eq).	**High:** Due to the lock-in effect of placing on the market of new equipment that will emit for a considerable time, there could be considerable additional emissions that are unnecessary.	The phase-down schedule is likely to be followed up until 2030 as specified in the FGR. Development after 2030 may follow the Kigali Amendment phase-down schedule which may result in years of stagnation as this lags the existing FGR phase-down to 2030.	The EU is not reducing F-gas emissions where this might be feasible and proportionate. An opportunity to contribute cost-effectively to Fit for 55 and carbon neutrality is lost.	Input resulting from discussions with stakeholders, the Evaluation including modelling of demand and emissions and comparisons of renewed EU 2030 ambition and desired post-2030 ambition with the existing FGR phase-down timeline.
There is insufficient coverage of sectors and activities by different measures	Since the Regulation was adopted in 2014, there have been technological developments through which alternatives for different applications have become technically and commercially viable.	Operators and users of applications not yet covered or prohibited by the FGR.	**High:** The main problem areas are activities that involve the application of PFCs and SF_6 which represented 18 % of supply in 2019 in terms of CO_2 eq. Relates to other applications too. HFC supply to MDIs is around 10 Mt CO_2 eq per year at present.	Without inclusion in the HFC phase-down or the list of prohibitions, uptake of viable alternatives may not be maximised (e.g. due to other market failures, such as information asymmetry or inertia), leading to greater costs associated with the phase down.	Costs of the HFC phase-down would be higher due to the incomplete coverage of activities and applications. Emission savings could be lower.	Input from the Evaluation on the current status of these substances and from discussions with stakeholders.
Containment and leakage checks are not comprehensive	The FGR only requires containment and leakage checks on F-gases listed in Annex I of the Regulation and does not apply to	Manufacturers and transporters of F-gases and parties involved in the supply chain of Annex I gases.	**Low:** Leakage rate data from official Member State sources ***for existing activities covered by the Regulation*** places leak rates at a median 3%,	Manufacturers and transporters of F-gases and parties involved in the supply chain of Annex I gases who are not yet af-	Continued emission in other elements of the supply chain for Annex I gases, and across the supply and use chain for Annex II gases, which	Evaluation

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
	other fluorinated gases listed in Annex II. It also does not apply to manufacturing, storage and transport of bulk gases.	All parties in the supply chain for Annex II gases who are not yet affected by any requirements to reduce leakage of F-gases.	with reported high rates up to 16%. Primary data from a set of retailers in 2014/2015 however showed that leak rates did not go below 6% and routinely went up to 10%. There is limited available data. Those companies who do leak checks are also more likely to take better care of their systems, so there is a sampling bias in many of the studies cited in the Evaluation. There are many refrigeration systems operating in smaller independent shops which may have much higher leak rates in the order of 15% to 25% per year.	fected by any requirements may continue to operate without proper containment as long as the refill price of HFCs does not become prohibitive. Higher emissions than technically necessary (can we say how much?)	may increase with the encouragement of shift to alternatives. Continued incoherence in leak detection systems.	

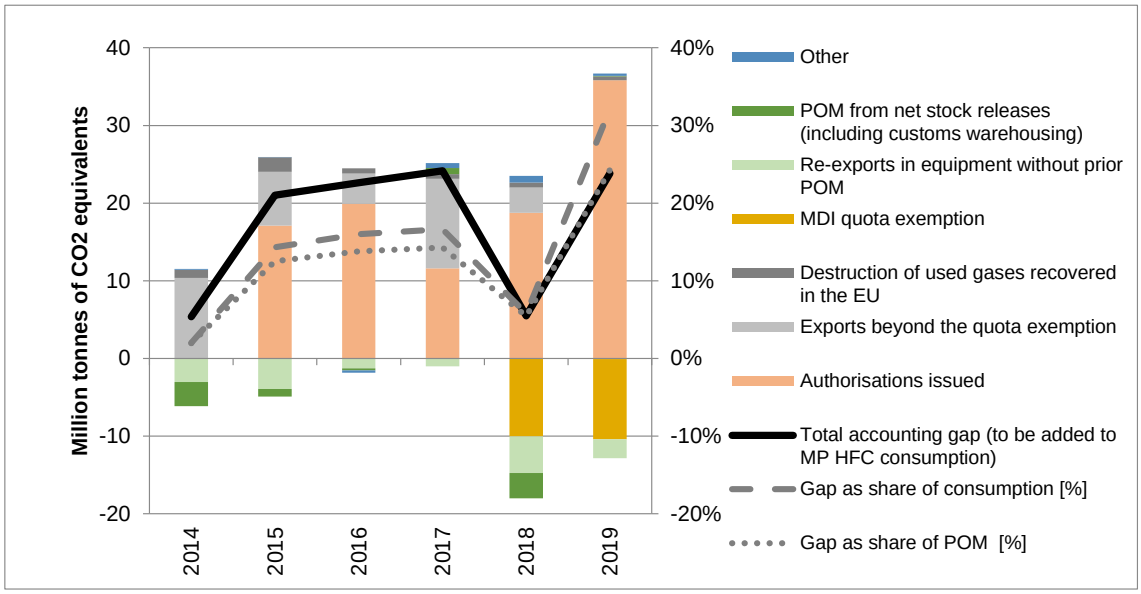
3.2. Problem area 2: Risk of non-compliance with the Montreal Protocol

The Regulation (especially the implementation of the HFC phase-down) is the key mechanism through which the EU complies with its obligations under the Kigali Amendment to the Montreal Protocol. As noted in section 2, the evaluation concluded that the Regulation has ensured compliance with the international obligations to date and has exerted a positive influence on third countries to do likewise.

There are several differences between the Regulation and the Kigali Amendment, in particular with respect to the phase-down schedules. Some add complexity (e.g. use of different baseline years POM)), but do not necessarily create a risk of incompliance as long as the EU's HFC consumption is compliant with the reduction steps required by the Montreal Protocol.

Another example of an area that adds complexity, but not necessarily incoherence, is the phase-down metric. The ***HFC consumption*** metric used under the Montreal Protocol (MP) considerably deviates in definition from the placing on the market ***(POM)*** *metric* used under the phase-down in the Regulation. In 2019, EU-28 quota-relevant POM under the Regulation was about 24 Mt CO_2 eq or 32 % above HFC consumption accounted under the Montreal Protocol. However, the size of these accounting differences has been varying strongly and is subject to several independent parameters and their trends (Figure 4). For a full comparison of the metrics, please refer to Annex 4 of the 2020 EEA F-gas Report[10].

Figure 4: Accounting differences – non-exempted POM vs. MP HFC consumption (EU-28)



Source: Confidential BDR dataset 2020, own calculations

Adjusting for these differences, the EU HFC phase-down implemented under the Regulation is currently compliant with the EU phase-down schedule under the Montreal Protocol, partly due to the fact that the former started four years earlier and thus the reductions will be achieved earlier. However, there are areas where the Regulation may not be sufficient to ensure compliance with the Kigali Amendment.

First, the requirements for continuing the EU HFC phase-down after 2030: Currently this is not regulated in the Regulation. Given the methodological accounting differences, two borderline scenarios were developed to assess whether the ambition level of the POM phase-down will, if continued at the 2030 levels, allowing for all eventualities, i.e. in the way the accounting differences develop, be able to safe-

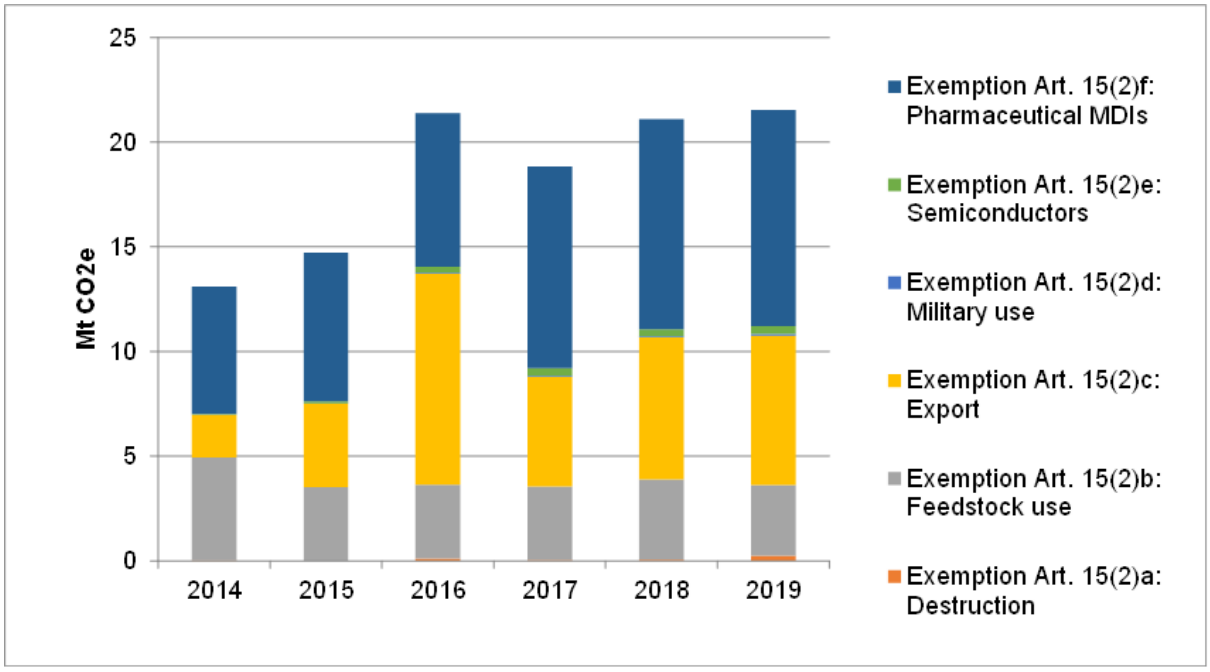
[10] https://www.eea.europa.eu/publications/fluorinated-greenhouse-gases-2020

guard EU compliance with the Montreal Protocol consumption phase-down. In a 'low-consumption' scenario, the 2030 maximum POM level allowed under the Regulation (19.9 Mt CO_2 eq for the EU-27) would correlate to an HFC consumption of 13.5 Mt CO_2 eq which is below the latest Montreal Protocol consumption phase-down step scheduled for 2036 at 24.5 Mt CO_2 eq for the EU-27. However, in the 'high-consumption' scenario, the 2030 maximum POM level under the Regulation would correspond to an EU-27 HFC consumption of 35.0 Mt CO_2 eq, which is above the 2034-2035 limit of 32.7 Mt CO_2 eq. Given this uncertainty on the future development of the accounting differences and the underlying parameters between EU-27 HFC POM and consumption, EU-27 compliance with the latest steps of the Montreal Protocol consumption phase-down starting 2034 and 2036 is not automatically given by the current phase-down rules.

Second, the Montreal Protocol considers both HFC consumption (production + imports – exports) and **production** which both must be phased down, whereas the EU Regulation does not consider a phase-down for production separately. The EU must rely on individual Member States to ensure that production phase-down targets under the Montreal Protocol are being met, hence it is not possible to ensure through the Regulation that these obligations are always met.

Third, the quota **exemptions** that are granted by the Regulation but not by the Montreal Protocol. Article 15 of the Regulation contains exemptions for specific categories of HFCs that are not foreseen by the Montreal Protocol and thus lead to a lack of coherence. These include exemptions for HFC supplied for the use in military equipment (Article 15 (2)(d)), etching of semiconductor material or cleaning of chemicals vapour deposition chambers within the semiconductor manufacturing sector (Article 15 (2)(e)) and metered dose inhalers (Article 15 (2)(f)). Indeed, as regards the gases exempted from the phase-down, the HFCs amounts in CO_2 eq for the use of metered dose inhalers (MDIs) comprise a meaningful source of supply, and a source which increased by about 45% from 2016-19.

Figure 5: HFCs placed on the EU market under the quota exemptions of Article 15 (2)



Source: [EEA 2020 confidential dataset]

Fourth, a **de minimis threshold for placing HFCs on the EU market** below which HFCs are not covered by HFC phase-down. According to Article 15 (2) of the Regulation, this limit is 100 tonnes of

CO_2 eq for producers or importers that place HFCs on the market.[11] Such a threshold is not foreseen in the Montreal Protocol and leads to an inconsistency. That said, the quantity of gases placed on the market which would be affected by this inconsistency is expected to be fairly small based on the national database in Poland where no such threshold exists.

Fifth, **thresholds for reporting** on production, import, export of bulk gases, feedstock use and destruction of F-gases (Annex I) and other fluorinated greenhouse gases (Annex II) exist in the Regulation below which reporting is not required (Article 19 (1)-(3)). Such reporting thresholds are not included in the Montreal Protocol and thus provide an area of incoherence. That said, again the quantity of gases placed on the market which would be affected by this inconsistency is likely fairly small based on the national database in Poland where no such threshold exists.

The Montreal Protocol requires a **licensing system** for import and export of controlled substances. This licensing system covers bulk gases not equipment, and must include mixtures as well as used, recycled and reclaimed substances. The Montreal Protocol does not require a specific design of the licencing system. Article 17 of the Regulation sets out the requirement that all F-gas importers and exporters must be registered prior to such activities in the HFC Registry which is part of the EU F-gas Portal. This licence constitutes a general licence to import and export HFCs. Hence the Montreal Protocol's requirement to have export and import licences for HFCs is fulfilled by requiring registration in EU F-gas Portal and Licensing System before undertaking such activities. However, border controls using this licensing system can be made more effective if full advantage of the upcoming "EU Single Window environment for Customs"[12] is taken.

[11] For example, this would relate to a quantity of 69.93 kg of R134a or 148.15 kg of R32.
[12] https://ec.europa.eu/taxation_customs/sites/taxation/files/201028_single_window_impact.pdf

Table 6: Overview of problems related to Problem Area 2 – seeking alignment with international obligations

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
Post 2030 the FGR has no phase-down schedule that ensures compliance with the Montreal Protocol	The FGR does not specify what the EU phase-down schedule would be after 2030, whereas the Kigali Amendment requires a further phase down.	All stakeholders involved in the production, use and disposal of F-gases after 2030.	**High:** as Compliance needs to be ensured which is not given by current rules.	Without further continuation of the phase-down, the EU cannot comply. If ambition level of 2030 is maintained there is a risk of F-gas emissions remaining above the required 15% of the baseline by 2036.	Breach of the Montreal Protocol and additional unnecessary emissions.	Evaluation and analysis of the Kigali Amendment in conjunction with the FGR.
No separate HFC production phase-down	There is no formal mechanism in the FGR that applies the phase down percentages to HFC production at MS level.	HFC producers and exporters, and Member States.	**High:** The Kigali Amendment specifies in Articles 3 and 4 that production must reduce, while this is currently not guaranteed in the EU as the FGR does not formally enforce it.	Production may not reduce in line with consumption, for example due to excess production for export purposes, or for exempted uses (MDIs)	The affected Member States risk breach of the Montreal Protocol.	Evaluation and analysis of the UN Kigali Amendment in conjunction with the FGR.
Exemptions not foreseen by the Montreal Protocol	Exemptions are granted by the Regulation but not by the Montreal Protocol, including exemptions for HFC supplied for the use in military equipment (Article 15 (2)(d)), etching of semiconductor material or cleaning of chemicals vapour deposition chambers within the semiconductor manufacturing sector (Article 15 (2)(e)) and metered dose inhalers (Article 15 (2)(f)). The FGR also allows an exemption for placing HFCs on the EU market below which HFCs are not covered by phase-down (100 tonnes of CO_2 eq).	Actors involved in HFC supply and use in military equipment, etching of semiconductor material or cleaning of chemicals vapour deposition chambers within the semiconductor manufacturing sector and MDIs. Actors placing HFCs on the market in small quantities.	**High.** As regards the gases exempted from the phase-down, the HFCs amounts in CO_2 eq for the use of metered dose inhalers (MDIs) comprise a meaningful source of supply, and a source which increased by about 45 % in that period from 2016 to 2019. With respect to de minimis thresholds, the quantity of gases placed on the market which would be affected by this inconsistency is fairly small, but non-compliance should be avoided.	Exemptions remain, with risk that sectors continue to grow in use, with consequent increase in future emissions. Actors continue to be able to place HFCs on the market in small quantities without limit.	Breach of the Montreal Protocol and additional unnecessary emissions.	Evaluation and analysis of the Kigali Amendment in conjunction with the FGR.

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
Reporting thresholds not foreseen by the Montreal Protocol	Thresholds for reporting on production, import, export of bulk gases, feedstock use and destruction of F-gases (Annex I) and other fluorinated greenhouse gases (Annex II) exist in the Regulation below which reporting is not required. Reporting thresholds for HFC reporting on production, import, export and destruction (Article 19 (1)-(2)) are not foreseen by the Montreal Protocol.	Producers, importers and exports and destruction companies	**Medium:** The quantity of gases placed on the market which would be affected by this inconsistency is fairly small, but non-compliance should be avoided	Information availability may remain incomplete as there is no natural incentive to report on a voluntary basis.	Breach of the Montreal Protocol	Evaluation and stakeholder discussions.
Trade with Parties have not ratified the Kigali Amendment not prohibited	For alignment with the Montreal Protocol (Article 4 on non-Party trade rules) trade restrictions would need to be put in place – such restrictions do not currently exist	Importers and exporters from EU and non-party countries By restricting countries which are Party to the Montreal Protocol from trading with countries not Party to the Montreal Protocol, they aim at maximising participation in the ODS/HFC regime.	**Low:** Around 15% of EU bulk HFC imports (tonnes) in 2019 came from the US which have not yet ratified the Kigali Amendment (by mid-2021) (with remaining majority from China and Japan). Regarding exports, in 2019 around 65% of EU bulk HFC exports (tonnes) went to the countries which have not yet ratified Kigali, among them US, with Turkey, Saudi Arabia, UAE and India also key export destinations	Trade continues based on market forces, with likely continued significant trade with non-Parties to the Kigali Amendment. That said, it is anticipated that most countries will have ratified by 2028	Breach of the Montreal Protocol	Evaluation and stakeholder discussions.

3.3. Problem area 3: Challenges around implementation and enforcement

The **evaluation of the Regulation** found that it had been mostly effective in meeting its original objectives and the individual measures were found to work together productively. That said, the evaluation also identified a number of challenges which had curtailed the effectiveness of the Regulation and showed that there are several areas where improvements could be made, several of which relate to the implementation and enforcement of the Regulation.

3.3.1. Slow uptake of alternatives

There has been a shift to lower GWP HFCs and mixtures containing HFCs and unsaturated HFCs as well as to natural alternatives. For the users, natural refrigerants such as CO_2, propane and ammonia have the advantage that they are not restricted in any way under the Regulation. Should ambition be increased to reduce the use and emissions of F-gases further, alternatives become increasingly important. However, the evaluation identified barriers to the uptake of alternatives, which have dampened their adoption over the period of implementation to date.

First, there are unjustified barriers to the use of climate-friendly alternatives that relate to safety codes that have not be updated in line with technological progress. Although the Commission and industry have taken steps to address this[13], and progress has been made in some Member States (e.g. Italy and Spain), the evaluation confirmed that this issue still exists but maybe focused on some Member States (e.g. France) and certain refrigerants (safety classification A3). However, although this presents a barrier to uptake, this lies outside the scope of the Regulation and hence changes to the Regulation alone cannot fully resolve this issue.

Second, an insufficient number of technical personnel qualified and experienced to plan, install, service, maintain and repair equipment with climate-friendly alternatives may have reduced the uptake of such technologies. A 2016 report[14] found that 71% of Member States provided training for ammonia but only 0.2-3 % of Member States provided training for other alternatives. Since 2016, training activities around alternatives has continued. The EU funded REAL Alternatives training, a voluntary training programme on F-gas alternatives, covers both flammable refrigerants, including hydrocarbons and low GWP flammable refrigerants now widely in use, and carbon dioxide modules[15]. Up to March 2020, about 600 technicians passed this personnel training on F-gas alternatives across 17 Member States. Also, other trainings are offered by commercial providers or through associations. The share of trained personnel increased but remained rather low in recent years.

3.3.1.1. Illegal trade circumventing (and hence undermining effectiveness of) measures under the Regulation

There is ***evidence of imports of HFCs outside the quota system*** although it is not feasible to provide an accurate estimate of the extent of these illegal activities. A number of actions to prevent the latter activities are ongoing, including by industry itself, but there are several challenges which appear to facilitate illegitimate trade.

Custom controls and surveillance activities are relevant to the success of the Regulation; however, the evaluation clearly highlighted the ***need for stronger coherence with customs activities***. Uncertainty about the role of customs in enforcing the Regulation has shown that instructions for customs and market surveillance authorities were not sufficiently clear. By extension, there is a lack of clarity regarding who is responsible for monitoring elements of the Regulation. In addition, there is no clear cross-

[13] E.g. Commission mandate (M/555)
[14] European Commission (2016): REPORT FROM THE COMMISSION on availability of training for service personnel regarding the safe handling of climate-friendly technologies replacing or reducing the use of fluorinated greenhouse gases, COM/2016/0748 final. Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52016DC0748
[15] The REAL Alternatives training does not cover the use of ammonia as a refrigerant as it is argued that currently already training in ammonia is available and the demand is said to be limited due to its specialist applications.

reference between the Regulation and the specific procedures of the Union Customs Code with which the requirements of the Regulation interact and there is a disconnect between the information gathered for customs checks and under the Regulation (e.g. HFC Registry). Where illegal activities are identified, the remedial approach can differ between Member States and it is unclear how confiscated goods should be treated. These factors together show that customs authorities have been unable to play a sufficiently effective role in enforcing the Regulation, perpetuating the issue of illegal imports.

To achieve better controls and a more harmonised approach across EU regulations, an EU Commission proposal for a "EU Single Window environment for Customs" was published on 28 October 2020, whereby economic operators will be able to electronically submit information required by both customs and non-customs legislation for EU cross-border movements of all goods. By adding real-time, automatic checking of F-gas bulk quota and authorisations, transparency and compliance between the HFC Registry and customs systems can be improved. This in turn could facilitate stronger enforcement by Member States through enhanced control and verification.

Stakeholders from industry and societal organisations both highlighted in particular the transit procedures as a facilitator of illegal activity. Specifically, they noted that the current T1 transit procedure and other special procedures are vulnerable to misuse and exploitation as they are not linked to a reliable registration system for F-gas traders, resulting in HFCs being illegally traded within the EU.

Another issue which curtails the prevention of illegal trade is the ***level of penalties*** applied for infringements. All Member States have introduced penalties for infringements of the Regulation and as allowed by the Regulation, the levels of penalties set vary between Member States. However, there is a growing belief in EU industry that the lack of harmonised penalties across Member States is an issue. stakeholders consider the Regulation has not provided for a level playing field across the EU. Furthermore, the dissuasiveness of penalties has been called into question, in particular relative to the high-profit margins achieved in some parts of the industry.

Online trade has also posed a challenge to ensuring compliance with the Regulation. F-gas containing products are being placed on the EU market via internet marketplaces and on various platforms and as a consequence it is difficult to identify sellers. No data exists on the levels of online sales, but evidence suggests that this is becoming a significant issue for the industry (e.g. the National Confederation of Crafts and Small and Medium Enterprises in Italy has taken the online retailer Amazon to the Court of Rome for the illegal trade in F-gases as a result of the sale of HFCs without requesting proof of certification). Austrian and German authorities also mentioned online sales as an issue since the FGR would not provide them with a legal basis for enforcement when illegal refrigerants are already placed on the market. A German national rule[16] was introduced in June 2021 to avoid illegal trade and enhance transparency of the supply chain.

Finally, deficiencies were also identified in ***market surveillance activities*** to render them ineffective in preventing illegal activity. Although, market surveillance activities have been undertaken in some Member States, not all Member States had taken action and overall activities were scarce. Furthermore, there is a lack of a coherent EU-wide, risk-based inspection and market surveillance regime. This issue is exacerbated by the lack of a real-time, per shipment HFC licensing and warning system.

3.3.1.2. Abuse of quota allocation system

Some company owners with several affiliates (including actors setting up and registering multiple companies) have been trying to maximise their share in new entrants' quota by registering up to hundreds

[16] Bundesgesetzblatt 2021: Drittes Gesetz zur Änderung des Chemikaliengesetzes – Bekämpfung des illegalen Handels mit fluorierten Treibhausgasen. Bundesgesetzblatt Jahrgang 2021 Teil I, Nr. 29.
https://www.bgbl.de/xaver/bgbl/start.xav?start=//*%5b@attr_id=%27bgbl121s1479.pdf%27%5d#__bgbl__%2F%2F*%5B%40attr_id%3D%27bgbl121s1479.pdf%27%5D__1634467563547

of affiliates[17] and getting multiple quota shares. The number of bulk importers applying for declaration-based quota increased by a factor of more than twenty between 2012 and 2019. The EU Commission adopted an Implementing Regulation in 2019 that clarified the quota allocation rules in accordance with the F-gas Regulation which resulted in a decrease in the number of applications for quota from the new entrant reserve for 2020 and 2021. Still, there appears to be a large number of quota holders with no apparent link to the F-gas business. This results in very low quota shares from the reserve to real F-gas traders and makes it more challenging to prevent illegal imports. Furthermore, there may be market players who otherwise would have had no access to the market have started to operate a business model where they buy F-gases on the world market and import them to the EU. These businesses may not necessarily be experts on the products sold, increasing the risk around Regulatory compliance and use of F-gases.

[17] The HFC phase-down features a mechanism to allocate a reserve of total annually allowed HFC quota to incumbents but also new market entrants without previous HFC import or production activity, based on their declaration of quota need.

Table 7: Overview of problems related to Problem Area 3 – Challenges associated with implementation and enforcement

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
Training of operators and technical support staff is lagging in terms of how to install, operate and maintain systems with alternatives to F-gases	Lack of access to available and appropriate training materials (for example due to lack of availability in different languages). Lack of practical training facilities. Lack of trained engineers and technicians involved in installation, maintenance, and equipment design. Lack of specific EU minimum requirements with respect to training on alternatives may result in discrepancies in practice at Member State level. Lack of awareness among technicians about upcoming challenges related to introduction of alternatives to F-gases	Potential users of F-gas alternatives who require support in switching away from F-gases, or current users who require maintenance technical support. Training personnel who want to be trained.	**High:** Only half of the current training centres able to offer training programmes on the safe use of F-gas alternatives (including flammable, high-pressure and/or toxic refrigerants). The training programmes are lacking and spread unevenly across Member States.	Low levels of personnel trained on application of alternatives continues	Uptake of F-gas alternatives may be bottlenecked by lack of sufficient technical staff available, curtailing achievement of policy objectives. This is particularly pertinent once uptake starts to become mainstream and a peak of technical knowledge transfer is required from qualified technicians to users.	Stakeholder discussions and EC (2016) Report on availability of training for service personnel regarding the safe handling of climate-friendly technologies replacing or reducing the use of fluorinated greenhouse gases
Illegal trade	The FGR has led to significant price increases as well as a strictly limited HFC supply. This created one incentive for illegal trade to circumvent supplier registration and/or high prices for controlled F-gases for non-exempt purposes. Lack of coherence with customs legislation. Lack of harmonisation of penalties across Member States. Growth of online sales.	The EU and Member States, as well as actors who operate on the legal market and are undercut by illegal trade.	**High:** The scale of illegal trade is difficult to estimate, as evidence is anecdotal and no estimate could be made of the total illegal trade. However, stakeholder feedback to the evaluation suggests this could be a significant issue. Many believe this was a significant contributor to the reduction in HFC prices following the initial peak in 2017/18.	Illegal trade continues to take place due to a lack of enforcement or a policy environment that does not have the proper instruments.	Innovation and uptake of alternatives may not be taken up in line with expectation if market actors are able to obtain HFCs illegally and are thus not incentivised to legally obtain alternatives or pay the higher price for HFCs legally placed on the market. Inability to check safety of illegally imported substances. Ultimately leading to higher future emissions.	Evaluation

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
Abuse of quota allocation system	The current system of quota allocation for new entrants based on declarations of quota need can be abused by entities applying for quota under a large number of affiliates or by mailbox firms. This allows market players to obtain a greater share of HFC quota while avoiding mandatory verification obligations.	Genuine new entrants to the market, and policy makers in need of verified data on HFCs placed on the market	**High:** Number of bulk importers applying for declaration-based quota increased by a factor of more than twenty between 2012 and 2019. Resulted in a gap where 8% of amounts reported to be placed on the market are not subject to mandatory verification	Continued circumvention of the intention of the quota allocation system	Lack of access to HFCs by legitimate new entrants, difficulty of implementation and incomplete verification of data for the HFC placed on the market by “new entrants.	Evaluation
Lack of flexibility to adapt to future challenges	The FGR itself does not have the in-built flexibility to address serious issues linked to the phase-down, such as market supply or similar.	EU Commission	**High:** Over the period of implementation to date, several issues have arisen to which the EC was unable to react and could not be mitigated with the existing FGR – new measures cannot be introduced through implementing Acts. For example, in 2017 there was a shortage of gas and the EC had no means of reacting.	The FGR remains limited to use policy instruments based on its existing framework, whereby not all challenges could be responded to quickly enough. This could include future decisions under the Montreal Protocol (e.g. related to exemptions from the HFC phase-down, adjustment of GWP values to more recent scientific data (IPCC AR5 or AR6 instead of AR4)), or responding to new scientific evidence regarding F-gases and the ability to amend the Regulations that apply to them (e.g. inclusion in Annex I or II)	This could lead to delayed implementation of international policy or delayed resolution of clear issues that arise from unanticipated changes in the F-gas market.	Evaluation

3.4. Problem area 4: Monitoring and reporting

In the evaluation, data reported under the Regulation were mostly found to provide a reliable basis for monitoring how the EU industries re-acted to the intervention. The review of the coverage of substances, activities and sectors for reporting found that the Regulation continues to capture the most important F-gases, however some gaps and challenges were identified.

The Regulation defines "fluorinated greenhouse gases" or "mixtures" as only those listed in Annex I and II of the Regulation, meaning that ***substances not contained in Annex I or II*** are not strictly covered by reporting measures in Article 19 and Article 20. These include several new substances which have emerged since the adoption of the Regulation in 2014, such as: sevoflurane, enflurane, sulfuryl fluoride, and other fluorinated gases. Moreover, certain applications are not covered by the reporting requirements, so little information is available, e.g. on the use of SF_6 in particle accelerators, the application of certain PFCs (predominantly $C_{10}F_{18}$) in personal care products and medical applications. Due to the lack of mandatory reporting, the extent of use of SF_6 in switchgear and HFEs in anaesthetics and other F-gases is not yet known.

Also, data collected for ***reclamation*** of F-gases was found to be incomplete as only those companies which are also importers of F-gases currently need to report. There is no self-standing reporting obligation for recycling and reclamation undertakings and hence the quantities of F-gas reclaimed may exceed those presented.

While substances replacing HFCs generally have a lower GWP, and thus contribute to climate change mitigation, for a few of the ***alternative*** substances there may be some undesirable environmental effects that require further monitoring. Alternative substances are not currently subject to the reporting obligations. This relates mainly to the generation of environmentally persistent and accumulative trifluoroacetic acid (TFA) as a breakdown product of unsaturated HFCs in the atmosphere and its subsequent accumulation in the aqueous environment. Indeed, the evaluation also noted that improved coherence with REACH could help to facilitate identification and management of potential harmful effects.

The evaluation of the Regulation found that the ***clarity of the mandatory verification*** obligation is not very prescriptive. There are no clear legal prescriptions are in the Regulation relating to the quality of the verification reports, the exact scope of verified data and the levels of assurance to be applied. Thus, the format and hence the quality of reports provided by companies varies. Competent Authorities signalled through the evaluation that verification requirements are quite complicated to understand in particular for smaller companies and verification companies, and clarification is needed in the Regulation itself as the current guidance is not sufficient.

Verification obligations for reporting data to be submitted according to Article 19 are in place for HFC producers and (bulk) importers where the HFCs placed on the market (POM) exceed the threshold of 10 000 tonnes of CO_2 eq. Until 2018, the number of active companies with POM ***below the threshold for mandatory verification*** was relatively constant, between 40-60. The share of companies that were subject to obligatory verification increased from 86 % to 94 % in the period 2015 to 2018 and the share of POM covered by obligatory verification was at 99.8 – 99.97 %. As consequence of the strong increase in companies applying for declaration-based quota, the amount of quota allocated per company from the reserve in 2019 dropped below the threshold of 10 000 tonnes of CO_2 eq fixed in the Regulation for mandatory verification for HFC producers and importers. This resulted in a gap where 8% of amounts reported to be placed on the market are not subject to mandatory verification. Thus, to verify if they had imported higher amounts than reported other less effective actions had to be taken, e.g. inspections.

While holding a quota authorisation is mandatory from a threshold of 100 tonnes of CO_2 eq, Article 19 (4) of the Regulation sets a threshold of 500 tonnes of CO_2 eq for reporting on pre-charged products and equipment containing F-gas and other F-gases that have been placed on the market. The reporting

threshold of 500 tonnes of CO_2 eq is also inconsistent with the reporting threshold for producers, importers and exports of bulk HFCs of one metric tonne or 100 tonnes of CO_2 eq as set out in Article 19 (1). The ***variance in thresholds*** was highlighted by Competent Authorities through the evaluation to have led to confusion in industry and a less than complete compliance.

For equipment importers, the ***date*** by which mandatory annual submission of verification reports must be done is the 31 March, i.e. the same date as the due date for the Article 19 report. However, bulk verification reports have to be available annually by 30 June, i.e. three months after the 31 March due date for the Article 19 report. Hence, the deadlines for submitting of F-gas and verification reports according to Article 19 are currently not aligned.

Furthermore, ***bulk verification reports do not need to be submitted*** by companies unless explicitly requested by EU or national authorities. Thus, the use of the BDR reporting facility dedicated to bulk verification is only voluntary unless this is specifically request-ed. An option to pro-actively submit a bulk verification report to BDR has been available since 2018 (for 2017 POM) and has been used by almost 75 % of companies with obligatory verification (i.e. above the 10 kt CO_2 eq threshold), representing an increasing share of 58 % (2017) to 66 % (2019) of the respective POM above the threshold, measured in CO_2 eq[18].

[18] Note that verification reports where a submission had been explicitly requested by EU and/or Member State authorities in the course of compliance scrutiny are included in those numbers.

Table 8: Overview of problems related to Problem Area 4 – Monitoring and reporting

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
Coverage of monitoring and reporting of F-gases is incomplete: does not capture F-gases outside Annex I and II	Development and introduction of new or other F-gases that are not yet covered in Annex I or Annex II but are starting to appear on the market in significant quantities.	Users, manufacturers and developers of new F-gases.	**Medium:** The scale of emissions from unregulated F-gases depends on their commercial adoption. Use is increasing in some applications The currently identified most important gases include long-chain PFCs, sevoflurane (HFE-347mnz1, GWP 216 (AR5)); enflurane (HCFE-235ca2, GWP 583 (AR5)); sulfuryl fluoride (SO2F2, GWP 4732 (AR5)); Iso-C3F7CN2100) and other H(C)FOs.	Significant emissions may not be detected early enough/discouraged.	Emissions that can be avoided technically and economically would persist.	Evaluation.
Coverage of monitoring and reporting of F-gases is incomplete: does not capture all reclamation	Increasing amounts of reclamation by non-importers	Those involved in reclamation (non-importers)	**Medium:** Current reclamation is small but growing quickly and actively being encouraged by other proposed amendments to FGR.	Reclamation activities continue with partial tracking	Unable to evaluate effectiveness of reclamation Articles	Evaluation.
Coverage of monitoring and reporting of F-gases is incomplete: does not capture alternatives (and potential wider environmental effects)	Introduction of alternatives. Climate-friendly alternatives to high GWP F-gases have different chemical properties that may cause other environmental effects.	Users, manufacturers and developers of alternatives Wider EU society who would be affected by negative impacts of large-scale use of F-gas alternatives.	**Medium:** Current uptake of alternatives is small but growing quickly and actively being encouraged by other proposed amendments to FGR. While no significant environmental harmful effects are likely from the currently known set of alternatives that are likely to be deployed, this does not require proper monitoring to ensure that risks can be controlled.	Use and potential emission of alternatives continues untracked. There is a risk that unforeseen environmental effects are not observed properly by implementing actors, which could reflect poorly on choice made by the EU Commission in promoting such alternatives.	Unable to quantify or gauge significance of potential wider effects of use of alternatives A sub optimal choice of alternatives to HFCs if not all risks and benefits can be considered.	Evaluation.

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
Format and quality of verification reports varies widely	Verification obligations are not clear nor prescriptive. Accompanying guidance is not sufficient, especially for smaller companies	All those obligated to verify reports; Competent authorities and EC	**Medium:** Potentially affects all those obligated to verify, although some reports are found to be better than others	Quality of verification continues to vary significantly	Effectiveness of verification obligation continues to be curtailed, which subsequent impacts on the quality of reported data, and robustness of any evaluation of performance	Evaluation
Increasing bulk production and imports falling below the threshold for mandatory verification limiting coverage	Existence of threshold Increase in registration of new companies, many of which are affiliates of existing companies abusing quota allocation system	Competent authorities and EC	**Medium:** In 2019 around 8% of POM was not covered by mandatory verification	High level of reporting not subject to verification could continue, if not continue to increase	Continued and/or growing uncertainty around robustness of reporting for important sections of the market	Evaluation
Variance in thresholds causing confusion for industry	Different thresholds for different activities and actors	Those gaining quota authorisation, mandated to report, or mandated to verify	**Low:** Although stakeholder noted confusion amongst industry, not all undertakings are affected and not all sit in the areas between thresholds	Difference in thresholds continues, with continuing confusion for industry, in particular those which sit between thresholds. Overtime, some may gain better understanding of the requirements, but with investment of admin costs. Challenge would remain for new entrants	Higher admin burden, especially for smaller companies and new entrants.	Evaluation
Dates of submission are not optimal for industry	Variance in submission dates in the Regulation. Timing relative to reporting requirements of other legislation (e.g. EU ETS)	Those subject to reporting and verification	**Low:** Applies to larger entities which fall under FGR and also affected by other legislation (e.g. EU ETS)	Variance in dates and misalignment with other legislation persists	Additional administrative burden (and peaks in admin burden) persist for industry Poses a challenge to reporting and compliance each year	Evaluation
Submission of verification reports is not mandatory	Bulk verification reports do not need to be submitted by companies unless explicitly requested by EU or national authorities	Competent authorities and EC	**Medium:** Option to proactively submit a bulk verification report to BDR has been available since 2018 and used by ~75 % of companies representing 66 % of POM in tCO_2 eq terms	There may be some continuation of the trend of increasing submission of verification reports, but complete compliance not guaranteed	Continuing uncertainty around robustness of reporting for an element of industry	Evaluation

3.5. Problem area 5: Coherence

The evaluation found that the Regulation interacts with several regulatory instruments, both in the form of other EU policy but also international agreements. In general, the Regulation was found to show a strong level of consistency and coherence with other interventions that have similar objectives, although there are areas that have led to some incoherence and should be addressed, especially regarding trade and customs controls (as discussed above). In addition, an area of difference between the Regulation and the ODS Regulation can be observed with respect to the placing on the market. Article 2(10) of the Regulation defines 'placing on the market' as 'supplying or making available to another party in the Union for the first time […]' and is not clear on further controls along the supply chain. The Ozone Regulation, one the other hand, adopts a wider approach of this concept, including not only the release for free circulation but also the supplying or making available to third per-sons within the EU.

As for internal coherence, the Regulation has generally been found to be consistent and coherent internally and across its implementing acts. There are, however, some areas which require further amendments.

Some industry stakeholders indicated that there is a lack of clarify in Article 15(2)(c) of the Regulation on the export exemption regarding the coverage of the exemption from the HFC phase-down (this is intended to only concern bulk bases but not pre-charged products and equipment).

The following definitions currently contained in the Regulation were considered not sufficiently clear and may therefore affect the implementation of some provisions:

- '*Hermetically sealed equipment*' (Article 2 No 11): The wording of this definition is considered unclear, while lacking a definition of capped valves and capped service port. This is important to ensuring correct application of exemptions relating to hermetically sealed equipment.
- '*Non-refillable container*' (Article 2 No 13): The final clause "without provision having been made for its return and refilling" provides difficulties for implementation.
- '*Recycling*' (Article 2 No 15): This definition is not considered precise enough and needs to be adapted as it is e.g. currently possible in practice to circumvent the use of virgin gases with a GWP of 2500 or more (Article 13 (3)) by topping up the refrigeration equipment with F-gases recovered from other installations, which may be contaminated with acids, water or gas composition that is different from the required composition of the virgin gas.
- '*Reclamation*' (Article 2 No 16): It was noted that the current definition is not sufficiently clear and needs some clarification which purification stages the reclamation process should include.
- '*Destruction*' (Article 2 No 17): The current definition does not distinguish between intentional and unintentional destruction. The latter is difficult to regulate.
- '*Installation*' (Article 2 No 20): Construction of new equipment from parts, including outside the factory, and supplying it or making available to another party should be considered 'placing on the market' and not 'installation', as it is currently not clear whether the placing on the market bans would apply to constructing the equipment outside the factory. This could help avoiding the circumvention of Annex III placing on the market bans for equipment.
- '*Maintenance or servicing*' (Article 2 No 21): It was noted that the definition seems to have been formulated primarily for RACHP installations, but also needs to cover the requirements of other installations.
- '*Stationary*' and '*mobile*' (Article 2 No 23 & 24): Current definitions should be more precise to also cover movable, quasi-stationary or quasi-mobile installations.
- '*Refrigerated truck*' (Article 2 No 26): From the current definition, it is not clear whether "mass" is the maximum allowable mass or the nominal mass.
- '*Technical aerosol*' (Article 2 No 28): Common types of aerosols used for disinfection of cosmetic applications are not explicitly covered by this definition which could be a loophole. In addition, the term aerosol dispenser is not yet defined.

- '*Undertaking*' (Article 2 No 30): It was noted that the term 'undertaking' is currently in some articles (e.g. Article 3(4), 6(2)(b), 6(3)) in the sense of "legal person", while the actual definition includes both natural and legal persons.
- It was also stated that clear definitions to avoid the circumvention of prohibitions of placing on the market or use by simply renaming the equipment are necessary for the categories '*refrigeration equipment*', '*air-conditioning equipment*' and '*heat pump equipment*'. For the same reason, it is also required to clearly assign certain special appliances such as refrigeration machines, ice makers, laundry dryers, humidifiers, dehumidifiers, etc. to these three categories.

Another potential issue is that a definition has not been provided as to what determines '*pre-charged equipment*'. This could cause potential for discrepancies as to whether or not producers and importers have determined their equipment to be pre-charged. As regards reclamation, it was noted that a definition for '*reclamation facility*' should be included, especially to provide a clear distinction from recycling processes.

With respect to activities, the following coherence issues were identified:

- While holding a quota authorisation is mandatory from a threshold of 100 tonnes of CO_2 eq, Article 19(4) of the Regulation sets a threshold of 500 tonnes of CO_2 eq for reporting on pre-charged products and equipment containing F-gas and other F-gases that have been placed on the market.
- The reporting threshold of 500 tonnes of CO_2 eq is also inconsistent with the reporting threshold for producers, importers and exports of bulk HFCs of one metric tonne or 100 tonnes of CO_2 eq as set out in Article 19(1).

In addition, the following issues have been raised for which further clarification might be needed.

- Article 6(1)(c) that requires operators of equipment to include information on quantities of recycled or reclaimed F-gases in their records, currently only refers to installed, but not to added gases. This is important in the context of the ban on use of refrigerants with GWP of 2 500 or more for certain equipment with exemption for recycled or reclaimed refrigerants.
- In Article 6 (1)(f), the information to be included in the records does currently not cover details about leakage repairs. However, rephrasing the provisions as follows "the dates and results of the checks carried out under Article 4(1) to (3) and of leakage repairs" is needed in conjunction with the Article 3(3) requirement to repair leakages without undue delay.
- Although Article 8(1) states that recovery may only be done for the purpose of recycling, reclamation or destruction, one national public authority raised that it is common practice among service technicians that the refrigerant recovered from the equipment is returned to the equipment for e.g. the purpose of repair without any basic cleaning. Returning the potentially contaminated refrigerant to the equipment can lead to malfunctioning and increased energy consumption. Hence, it should be clarified that the recovered refrigerant cannot be used for fill or refill equipment unless it has been recycled or reclaimed.
- According to one public authority, the wording 'appropriately qualified natural persons' (Article 8(3)) is vague and leads to different interpretations.
- It should be clearer in Article 14(2) that verification of HFC pre-charged in imported equipment is required as of 100 tonnes of CO_2 eq.
- In Article 15 it should be clear that the placing on the market of HFCs in excess of the quota limits is strictly prohibited. The current provision "shall ensure" is not strong enough to avoid the need for national public authorities to impose an additional prohibition to be able to designate the violation as a criminal offence.
- Article 17(4) provides that competent authorities, including customs, shall have access to the HFC registry for information purposes. However, the provision does not specify whether and to what occasion the authorities should actually use the HFC register.

Table 9: Overview of problems related to Problem Area 5 – coherence

Problem	Driver	Affected by the problem	Scale of the problem	Development without policy intervention	Consequences	Reference
Several definitions are unclear (e.g. POM, 'hermetically sealed equipment', etc)	The way terms were originally defined in the Regulation Emergence of other legislation with varying definitions	Industry	LOW. Although several definitions were deemed unclear, the evaluation did not identify this as an issue significantly impacting the effectiveness of the Regulation	Definitions remain unchanged	Lack of clarity and additional administrative burden for industry involved in clarifying terms	Evaluation
Lack of clarity in individual provisions	The way provisions were originally defined in the Regulation	Industry	LOW. Although several provisions were deemed unclear, the evaluation did not identify this as an issue significantly impacting the effectiveness of the Regulation	Provisions remain unchanged	Lack of clarity and additional administrative burden for industry involved in clarifying terms	Evaluation

3.6. Summary of problems and their relative importance

The following table provides an overview of all problem areas, problems and their importance.

Table 10: Summary of problem areas and their relevance

Problem area	Problem	Relevance (high, medium, low)	Notes
1 Regulation not consistent with EU climate objectives	As of yet, there is no alignment with increase in ambition of EU Climate objectives. Original emission saving ambitions may not be reached.	*High*	Significant climate contribution is lost
	There is insufficient coverage of sectors and activities by different measures	*High*	Significant share of supply, e.g. SF_6 in switchgear, MDIs, is not covered.
	Containment and leakage checks are not comprehensive	*Low*	Low enforcement levels due to particular expertise needed and high number of installations. Use of electronic tools at national level is recommended to facilitate overview and benchmarking.
2 Risk of non-compliance with Montreal Protocol	Post 2030 the FGR has no phase-down schedule that ensures compliance with the Montreal Protocol	*High*	Need to avoid incompliance
	No separate HFC production phase-down	*High*	Need to avoid incompliance with this rule
	Exemptions not foreseen by the Montreal Protocol	*High*	Quantities placed on the market especially relevant for MDIs may endanger compliance, not that much for other exemptions
	Reporting thresholds not foreseen by the Montreal Protocol	*Medium*	While the total amount of F-gases that is likely not captured well by existing reporting measures is low, this could be seen as a formal breach of the Montreal Protocol

Problem area	Problem	Relevance (high, medium, low)	Notes
	Trade with Parties have not ratified the Kigali Amendment not prohibited	*Low*	Kigali Amendment is still not ratified by summer 2021 by some major trade partners including for the example the USA, India and China, however this is expected for 2028. This is ranked low as it is not required by the Montreal Protocol until 2033.
3 Implementation and enforcement challenges	Training of operators and technical support staff is lagging in terms of how to install, operate and maintain systems with alternatives to F-gases	*High*	This is an issue that the market is likely to resolve eventually but it would hamper alternatives in the current 2020 – 2030 period, which means it is a very relevant issue until significant cutbacks on HFC use from the phase down ensure there is enough demand.
	Illegal trade	*High*	Illegal trade is known to happen and may continue to be a serious problem as regulations become stricter.
	Abuse of quota allocation system	*High*	Does not pertain to the majority of the quota that is held by stakeholders but causes a problem for data verification and to ensure the quota goes to rightful market players.
	Lack of flexibility to adapt to future challenges	*High*	Flexibility is required such that the EC can intervene if the phase-down is creating issues in practice – e.g. shortages for key sectors (such as hospitals).
4 Monitoring and reporting	Coverage of monitoring and reporting of F-gases is incomplete: does not capture F-gases outside Annex I and II	*Medium (High for SO_2F_2)*	The scale of emissions from unregulated F-gases depends on their commercial adoption. Use is increasing in some applications. The currently identified most important gases include long-chain PFCs, sevoflurane (HFE-347mnz1, GWP 216 (AR5)); enflurane (HCFE-235ca2, GWP 583 (AR5)); sulfuryl fluoride (SO_2F_2, GWP 4 732 (AR5)); Iso-C_3F_7CN2100) and other H(C)FOs.
	Coverage of monitoring and reporting of F-gases is incomplete: does not capture all reclamation	Medium	Current reclamation is small but growing quickly and actively being encouraged by other proposed amendments to FGR.
	Coverage of monitoring and reporting of F-gases is incomplete: does not capture alternatives (and potential wider environmental effects)	Medium	Current uptake of alternatives is small but growing quickly and actively being encouraged by other proposed amendments to FGR. While no significant environmental harmful effects are likely from the currently known set of alternatives that are likely to be deployed, this does not require proper monitoring to ensure that risks can be controlled.
	Format and quality of verification reports varies widely	Medium	Potentially affects all those obligated to verify, although some reports are found to be better than others
	Increasing bulk production and imports falling below the threshold for mandatory verification limiting coverage	Medium	In 2019 around 8% of POM was not covered by mandatory verification
	Variance in thresholds causing confusion for industry	*Low*	Although stakeholder noted confusion amongst industry, not all undertakings are affected and not all sit in the areas between thresholds.
	Dates of submission are not optimal for industry	*Low*	Applies to larger entities which fall under FGR and also affected by other legislation (e.g. EU ETS).
	Submission of verification reports is not mandatory	Medium	Option to pro-actively submit a bulk verification report to BDR has been available since 2018 and used by ~75% of companies representing 66% of POM in t CO_2 eq terms.
5 Coherence	Several definitions are unclear (e.g. POM, 'hermetically sealed equipment', etc)	*Low*	Although several definitions were deemed unclear, the evaluation did not identify this as an issue significantly impacting the effectiveness of the Regulation.

Problem area	Problem	Relevance (high, medium, low)	Notes
	Lack of clarity in individual provisions	*Low*	Although several provisions were deemed unclear, the evaluation did not identify this as an issue significantly impacting the effectiveness of the Regulation.

4. Why should the EU act?

The legal basis for this intervention is Articles 191 and 192(1) of the Treaty on the Functioning of the European Union (Environment). It is an area of shared competence between the Union and Member States. Recital (26) of the Regulation outlines the need for action at EU level due to the transboundary nature of the global warming effect of greenhouse gases. Looking forward, although intervention at EU level has seen a reduction in F-gas emissions and compliance with the Montreal Protocol, the problem still persists. There is a need for continued EU action in order to ensure that F-gas emissions reduce in line with the climate ambitions of the EU Green Deal and the Montreal Protocol.

There is a clear imperative to act at EU level. Without the Regulation, each Member State would need to introduce mechanisms to regulate their national F-gas consumption to ensure compliance with the Kigali Amendment, but these options could not guarantee compliance. A quota system would not be feasible at Member State level as an import quota from one Member State into another would not facilitate consistency with the core principles of the EU internal market and free movement of goods. Only a harmonized EU approach can implement the obligations under the Montreal Protocol as regards HFC consumption and respect internal market rules at the same time (i.e. free movement of goods). As such, Member States would instead need to rely on other instruments such as taxes, additional prohibitions and import/export licences.

However, as examined in the evaluation under the assessment of effectiveness, the successful reduction of F-gas emissions to date is due to the HFC phase-down and prohibitions working together. As such, Member States using different measures would likely result in inconsistent and lower reduction in F-gas emissions across Europe. The 2012 Impact Assessment showed that the environmental benefit of having prohibitions alone was approximately 25 % inferior to also having a phase-down, mainly because bans can only be implemented when replacement substances are available for all applications in the sector (i.e. a 100 % penetration rate), whereas the phasedown can gradually take effect also in sectors where replacements are only partly available at the onset of the measure.

The conclusion that the Regulation achieves a higher level of ambition than what would have occurred at individual Member State level was corroborated by stakeholders of all different types through the evaluation (competent authorities, industry, NGOs, etc).

Alongside delivering additional ambition against the core objectives, a further key benefit of action at EU level is the efficiency improvements and achievement of economies-of-scale that stem from coordinated action. For the Regulation, the evaluation identified multiple cost savings of action at EU level:

- National approaches to effectively meet the individual HFC phase-down targets would present a very fragmented and costly situation for all the different industry sectors concerned, particularly those which place their goods on the market in multiple Member States. An EU approach allows for these central requirements to be consistent across Member States, with only small deviations in some countries that have introduced more restrictive or additional measures.
- Under the EU quota allocation system, quotas are not allocated to certain Member States, sectors or applications, but to the whole EU market on an annual basis by the EU Commission. This allows the most efficient abatement solution to be found across a broader market, leading to lower implementation costs.
- Each Member State would still have to set up separate licencing systems for goods being imported and exported to and from the EU from their territory, which would greatly increase administrative burdens for the many companies operating across multiple Member States.
- With no central system in place for reporting, registration and quota management, IT infrastructure would have been needed to be developed separately at Member State level.
- A joint approach across Member States makes it easier to enforce F-gas reduction policies and allows for lessons learned and knowledge sharing across Member States.

- Common legislation has also enhanced the market for new alternatives, providing additional incentive for their development and commercialisation.

The HFC phase-down at EU level, implemented by a quota allocation system, not only increases the environmental benefit and reduces costs by setting an EU-wide cap, but also provides certainty on the allowed maximum quota quantity, creating a level playing field for market players operating in a single, integrated EU market. Likewise, the use of EU-wide placing on the market and use re-strictions, and requirements for labelling and containment also contribute to this level playing field for the F-gas using industry and end-users. Stakeholders across different types who responded to the evaluation OPC agreed that the Regulation has created a level playing field across the EU.

The evaluation concluded that there is clear added value by implementing co-ordinated action at EU level to ensure compliance with the Montreal Protocol and the EU climate goals. Only a common and harmonised EU approach can effectively implement the obligations of the Kigali Amendment to the Montreal Protocol and simultaneously respect internal market rules providing that all Member States will enforce the relevant provisions effectively. Compared to the counterfactual scenario, where Member States and undertakings would need to implement their own systems and undertakings would need to comply in each country they operate in, the EU level approach provides greater efficiency. This is cor-roborated by stakeholders, especially by the responses of the competent authorities from Member States. Revisions of the Regulation focusing on improvement in effectiveness and coherence will further strengthen the benefits resulting from EU action, compared to taking action at individual Member State level.

5. Objectives: What is to be achieved?

In the light of the problems described above, the EU should take action and provide solutions in order to achieve the overall policy objectives in a more effective, coherent and clear manner.

This implies safeguarding continued compliance with international obligations under the Montreal Protocol and increasing the level of ambition to reflect recently updated EU climate targets. Maintaining a good level of control to avoid illegal activities is essential, whilst also working to remove barriers to the uptake of alternatives (e.g. lack of training, national safety barriers) and, prevent abuse of the quota allocation system. Moreover, improvements are needed regarding monitoring and reporting, as well as greater flexibility to respond to political and scientific developments, while clarifications are required in the legal text to improve interpretation and thus implementation and enforcement of the Regulation.

Four groups of measures[19] are considered against a baseline that assumes no action taken. These groups are not mutually exclusive but some of the measures therein are.

Noting that the problems of the Regulation as presented in section 3 concern various aspects of the Regulation, four main objectives for amending the Regulation have been identified. These are presented in the following table.

Table 11: Overview of objectives and groups of measures

Objective	Group of measures	Problem of the Regulation
Objective A: **Raising ambition in line with European Green Deal**	a) Increasing HFC phase-down ambition b) Prohibiting F-gases in products or equipment, where these gases are no longer needed	• 2030 emission savings will likely not be met • There is no alignment with increase in ambition of EU Climate objectives • There is insufficient coverage of sectors and activities by different measures • Containment and leakage checks are not comprehensive
Objective B: **Seeking alignment with the Montreal Protocol**	a) To achieve full alignment, add new phase-down steps beyond 2030 b) To achieve full alignment, remove some exemptions and thresholds not foreseen by the Montreal Protocol c) To achieve full alignment, make separate phasing down of HFC production d) Adding flexibility to be able to align with future Montreal Protocol decisions e) Other alignment	• Post 2030, the FGR has no HFC phase-down schedule that ensures compliance with the Kigali Amendment to the Montreal Protocol • No separate HFC production phase-down • Exemptions and thresholds applied in the FGR are not foreseen under the Montreal Protocol • Reporting is incomplete • Trade with non-Parties still allowed
Objective C: **Improving implementation and enforcement**	a) Certification of technicians to include skills on the use of low-GWP alternatives b) Including detailed rules to empower customs and surveillance authorities in the EU Member States and facilitate the use of the EU "Single Window environment for Customs" c) Strengthening obligations of economic operators to prevent illegal trade d) Limiting the market players to legitimate participants e) More comprehensive monitoring	• Training and certification programmes for service technicians and service companies is lagging in terms of how to install, operate, maintain and repair systems with lower GWP alternatives and do not yet consider energy efficiency • Fight against illegal trade must be supported • Misuse of quota allocation • Reporting and verification are incomplete, and there is lack of alignment when it comes to thresholds and submission deadlines
Objective D: **Other improvements and clarifications**	a) Aligning provisions with other policies and clarifying and streamlining the legal text	• Lack of internal coherence • Lack of flexibility to adapt to future challenges

[19] Where appropriate, sub-measures will be defined within the individual measures presented.

6. Policy options to achieve the objectives

The following three options are considered for the impact assessment:

Option 1: Align with the Montreal Protocol & low-cost measures

This option includes all measures to ensure long-term compliance with the Montreal Protocol. This means in practice that the quantitatively relevant exemption for MDIs is removed, as well as the *de minimis* thresholds on reporting and the quota system, as these are not part of the Montreal Protocol rules. For HFC production, a separate phase-down is introduced to ensure that the Protocol's compliance schedule can be met. Flexibility to adjust to international rules is introduced as well as a future ban on trade with non-parties to the Montreal Protocol.

With regard to emission reductions, this option will adjust the phase-down ambition only to the degree needed to ascertain that the Montreal Protocol consumption phase-down can be met in the long run and under all circumstances. A number of prohibitions to use F-gases in new equipment are added, where this is straightforward from a technology and costs point of view, in order to facilitate meeting the phase-down for other sub-sectors where alternatives are still scarce. Such prohibitions are considered for some AC, refrigeration and firefighting equipment. Additional emission prevention measures will be extended to some Annex II substances and old insulation foams with HFCs will need to be recovered during renovation and demolition activities in order to be destroyed (or reused).

The option also includes additional measures to improve control, implementation and monitoring, but only where this can be done at minimum costs or very efficiently (high benefit with regard to costs). This is the case of adding energy efficiency aspects to the training curriculum for equipment service personnel, clarifying rules for customs and reinforcing control over illegal goods including under special custom procedures. Rules for importers and other market participants are similarly clarified and strengthened and benchmarks for effective penalties at Member State level are proposed. As regards monitoring, the requirement to submit the verification report (rather than just having one) is added, as well as the need to make nil reports for quota holders (if nothing to report). Some substances are added to Annex I (PFCs) and Annex II (SO_2F_2, some unsaturated HFCs/HCFCs and HFEs).

Option 2: Achieve proportionate emission savings and implementation improvements

This option also ensures compliance with the Protocol but includes further measures that will seek to reduce more emissions up to a cost level that is comparable to that asked of other sectors with a view towards reaching carbon neutrality in 2050.

As a starting point, Option 2 therefore includes all measures in Option 1. To reduce more emissions, the phase-down is reinforced on the basis of forcing a technological transition in all sectors where this can be done proportionately according to cost levels assumed in the long-term strategy[20], i.e. at below €390/t CO_2 eq[21]. Additional prohibitions considered include the electricity transmission sector using SF_6 in switchgear, to extend the prohibition to use high GWP substances for servicing to smaller refrigeration equipment, introduce new requirements for personal care products and inhalation anaesthetics. Recovery is extended to foams that could be cost-efficient.

In addition, additional measures are included to improve control and implementation, to address the issues of illegal trade, promote qualified technicians and limit the participation in the quota system to

[20] Long-term low greenhouse gas emission development strategy of the EU and its Member States, https://ec.europa.eu/clima/policies/strategies/2050_en / https://unfccc.int/sites/default/files/resource/HR-03-06-2020%20EU%20Submission%20on%20Long%20term%20strategy.pdf.
[21] Updated stylised carbon value in 2050 as per the latest MIX modelling exercise for the 'Delivering the European Green Deal' policy package proposed by the Commission in July 2021, https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en

serious traders, even though this may result in moderate costs to business stakeholders or authorities. An additional requirement for Member states to provide certification and practical training for relevant climate-friendly alternatives is included. For equipment containing HFOs, installing, servicing, maintenance or repair that involves the refrigerant-carrying circuit will only be allowed by certified personnel in analogy to other F-gases. Importers and producers need to provide evidence for destroying R23, an important GHG, at the moment of import (i.e. "release for free circulation"). A quota allocation fee is introduced to limit the participants to serious traders involved in the business and to avoid placing all the costs on end-users. Labelling requirements are added for some relevant substances of Annex II.

On closing monitoring and reporting gaps, a new obligation to report for recipients of quota-exempted HFCs and some recycling and reclamation facilities is added. The verification thresholds are lowered to increase oversight over quota holders, but an electronic verification process is added to reduce the burden for companies that are compliant as well as have better oversight. Member States are encouraged to establish databases on activities such as servicing, leak checking and sales, for better market control and to derive real-world emission rates.

Option 3: Maximum feasibility and implementation improvements

This option will seek to achieve the maximum GHG emission reductions based on today's technical feasibility and without trade-offs on energy efficiency or safety. It also includes all measures regarded as feasible to improve control, implementation, and monitoring that were considered for the review and/or proposed by stakeholders.

This option therefore includes all measures of Option 1 and 2.

It further proposes a steep phase-down on the basis of maximum technical feasibility and without taking cost considerations into account to exclude action on very difficult sub-sectors. Thus, it is assuming replacement of high and medium high GHGs *as soon as* this is technically possible even if costs go beyond €390/t CO_2 eq at a sub-sectoral basis. On aligning with the Protocol, it additionally removes exemptions for military equipment and semiconductors, which both related to very small amounts being consumed.[22]

To improve implementation, further measures that come with a high burden are also considered. Mandatory certification for importers is added for better oversight and to ensure that they have know-how on how these gases should be handled. Reporting would be extended to exporters of equipment to better gauge the effect of EU produced goods elsewhere. Better estimation of emissions is obtained by requiring operators of switchgear in electrical transmission and large-scale users of inhalation anaesthetics (e.g. hospitals) to report. Member States would be required to establish databases on servicing, leak checking and sales data. Some substances would be moved from Annex II to I, i.e. so that a number of obligations including leak checking, record keeping and recovery would apply to them. A 3-year cycle is introduced for new entrants to apply and join the market.

A certain number of clarifications identified by stakeholders during the evaluation are included in all three options.

[22] Maintaining these exemptions in Option 1 and 2 does not endanger Protocol compliance as these small amounts can be easily compensated by a slightly higher phase-down ambition for all other sectors.

7. Envisaged measures

In order to achieve the objectives of the review and to address the problems identified in the evaluation, a long list of potential measures was developed on the basis of this evaluation, stakeholder feedback received on the Commission's Inception Impact Assessment (IIA) and through the open public consultation, targeted interviews and the stakeholder workshop, input from market and technical experts, other F-gas policy related projects and reports commissioned by the EU Commission as well as practical experience from the implementation of the Regulation. This initial long list of measures has been assessed as part of a screening process, which was performed to eliminate any unfeasible measures from further assessment of impacts.

This section describes the resulting short list, presenting the measures, which have been judged as feasible against the screening criteria applied. Shortlisted measures are further elaborated with respect to the required legislative changes and implementation needs and enforcement action. All shortlisted measures are intended to be legally binding provisions set by the Regulation. The assessment of economic, environmental and social impacts related to these measures follow in section 10.

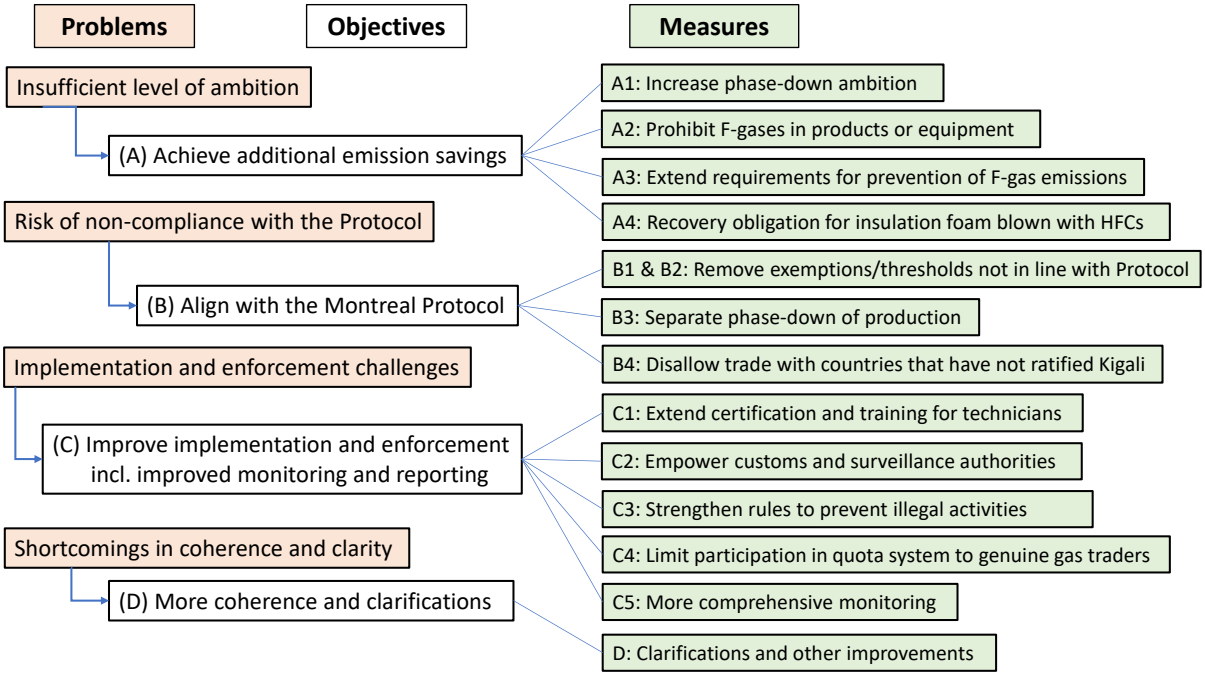
The long list of measures that could target the issues identified in the evaluation was screened against the following criteria:

- **Technical feasibility:** Measures must be technologically and technically feasible.
- **Effectiveness and efficiency**: It may already be possible to show that some measures would uncontrovertibly achieve a worse cost-benefit balance than some alternatives or that they will have a negative impact on another objective.
- **Legal feasibility**: Measures must respect the principle of conferral.[23] They should also respect any obligation arising from the EU Treaties (and relevant international agreements) and ensure respect of fundamental rights. Legal obligations incorporated in existing primary or secondary EU legislation may also rule out certain measures.
- **Enforcement feasibility**: Constraints may not allow for the implementation, monitoring and/or enforcement of theoretical measures. The ability to enforce measures in practice is considered.
- **General feasibility**: Measures that would clearly fail to garner the necessary stakeholder support for legislative adoption and/or implementation could also be discarded.

[23] Under this fundamental principle of EU law, laid down in Article 5 of the Treaty on European Union, the EU acts only within the limits of the competences that EU countries have conferred upon it in the Treaties. These competences are defined in Articles 2–6 of the Treaty on the Functioning of the EU. Competences not conferred on the EU by the Treaties thus remain with EU countries.

The following figure illustrates the envisaged policy measures.

Figure 6: Problems, objectives and related responses in the form of policy measures



Source: Own illustration

Table 12: Detailed overview of envisaged measures

No.	Measure	Problem identified	Legislative change & implementation needs	Enforcement action	Actors affected by this measure
Objective A: Raising ambition in line with the European Green Deal					
A1) Increase HFC phase-down ambition					
A1.1	Increase ambition of the EU HFC phase-down beyond the requirements under the Montreal Protocol by tightening reduction steps until 2030 and introducing additional reduction steps beyond 2030	The present HFC POM phase-down schedule, defined until 2030, does not fully exploit the technically and economically feasible reduction potential. Beyond 2030, cost-efficient HFC reductions are feasible that are more ambitious than the reduction steps necessary to safeguard EU compliance with the Montreal Protocol.	In Annex V, the reduction levels presently set for 2024, 2027 and 2030 could be tightened. Beyond 2030, the reduction schedule could be extended open-ended at more ambitious levels than calculated for safe compliance with the Montreal Protocol.	Continuation of compliance checking procedures under the EU HFC phase-down. No additional action needed.	Producers and importers of HFCs would receive smaller quota amounts EU Commission to adjust quota allocation
A2) Prohibit F-gases in products or equipment					
A2.1	Introduce a POM prohibition for stationary AC and heat pump equipment containing HFCs for different levels of rated capacities	Five years ahead of the prohibition date, a clear transition to alternatives with a GWP below 750 can already be observed. In addition, both small and larger single-split AC systems and heat pumps offer great potential for further GWP reductions, especially given the expected growth rates of the heat pump sector. Since the use of different refrigerants requires different charge sizes, it would make sense to rather base the new prohibition on capacity (kW) in order to create neutrality with regard to the refrigerant used, as also other relevant regulations (incl. ecodesign requirements) also apply to capacity, which would improve coherence.	Annex III No 15 of the Regulation to be replaced, while covering both AC systems and heat pumps which today have both cooling and heating functions. Annex III of the Regulation to be amended to include this new prohibition. Undertakings affected to consider that the new prohibition refers to cooling and heating capacity (kW) instead of charge amount of refrigerant (kg).	Member States to check and enforce the implementation of this prohibition.	Manufacturers of equipment to switch to lower GWP alternatives
A2.2a	Introduce a POM prohibition for small stationary refrigeration hermetic units for commercial and household use that contain or whose functioning relies upon HFCs	Small refrigeration appliances used in commercial and household applications (e.g. ice cream makers, milk coolers attached to coffee machines, Chantilly machines, juice makers, beer coolers) are not specifically addressed by the Regulation, although they still use high GWP HFCs. Due to the small size and hermetic nature of these appliances, end-of-life recovery of contained HFCs is either not possible or is not carried out, so there is no separate collection in the	Annex III of the Regulation to be amended to include this new prohibition.	Member States to check and enforce the implementation of this prohibition.	Manufacturers of equipment to switch to F-gas free alternatives

		waste scheme. In addition, low GWP alternatives, such as hydrocarbons, are already widely available for such appliances and would allow for a full and immediate replacement of F-gases.			
A2.2b	Introduce a POM prohibition for skin cooling equipment used for purposes that are not required for strictly medical reasons and that contain or whose functioning relies upon HFCs	Skin coolers used in beauty treatment are not specifically addressed by the FGR but they use high GWP refrigerants directly emitted. No containment or recovery measures are taken at this point. Low GWP alternatives are available.	Annex III of the Regulation to be amended to include this new prohibition from 1 January 2024.	Member States to check and enforce the implementation of this prohibition.	Manufacturers of equipment to switch to F-gas free alternatives
A2.3	Remove the existing exemption for servicing and maintenance of refrigeration equipment with a charge size below 40 tonnes of CO_2 eq with virgin F-gases	Stationary and mobile refrigeration equipment with a charge size below 40 tonnes of CO_2 eq is currently exempted from the prohibition to use F-gases with a GWP ≥ 2 500 for servicing or maintenance from 1 January 2020. However, industry feedback has shown that special treatment of small refrigeration equipment is not necessary in practice, i.e. that a clear distinction is often not made between charge sizes during servicing and maintenance. In addition, there are suspicions that illegally traded substances were especially used in smaller equipment.	Article 13(3) to be amended to prohibit the use of F-gases with a GWP of 2 500 or more to service or maintain refrigeration equipment irrespective of the charge size.	Member States will need to check and enforce the implementation of this amended use prohibition.	Service technicians and end-users to use only recycled and reclaimed gases
A2.4	Introduce a POM prohibition for fire protection equipment containing or relying on HFCs, except when required to meet national safety standards	Annex III No 3 currently prohibits the POM of fire protection equipment containing HFC-23 (GWP 14 800) since 1 January 2016. Other HFCs such as HFC-227ea, HFC-125 and HFC-236fa are continued to be used, while the EU supply of these substances has decreased significantly since 2015. Industry feedback has shown that alternative technologies are available for such applications that would allow of a full and immediate replacement of HFCs. However, exemptions from such a prohibition should apply to certain sectors, including mining, military, aviation and nuclear power plants, where national safety standards must be met and which require substances with superior extinguishing capacities that cannot be met by the alternatives currently available on the market.	Annex III of the Regulation to be amended to include this new prohibition.	Member States to check and enforce the implementation of this prohibition.	Manufacturers of equipment to switch to HFC-free alternatives
A2.5	Introduce a POM prohibition for personal care products containing F-gases	While HFCs and certain PFCs were used to limited extent in personal care products (e.g. creams, mousses and foams) in the past, unsaturated HFCs and perfluorodecalin ($C_{10}F_{18}$, GWP > 7 500) have entered this market in recent	Annex III of the Regulation to be amended to include this new prohibition.	Member States to check and enforce the implementation of this amended use prohibition.	Manufacturers of these products to switch to F-gas free alternatives

		years, while the formers are rather rarely used due to the high market price. As in technical aerosols, HFCs (HFC-152a, GWP 124) and unsaturated HFCs (HFC-1234ze, GWP 7) are typically applied as propellants where the product is dispensed as a spray, for example, hair spray, cologne and deodorant, while HFC-152a also produces foams or mousses and is used in commercial aerosol foam products such as hair styling and skin conditioning mousses. Perfluorodecalin is widely used and serves as a carrier for oxygen and is thus used in various cosmetic products for skin and nail care. Although the used amount of HFCs and PFCs is rather limited, low GWP and F-gas free alternatives such as propane are already widely available for such uses and would thus allow for a full and immediate replacement of F-gases.			
A2.6	Introduce a POM prohibition for RACHP equipment which contain or whose functioning relies on PFCs or blends containing PFCs	Although PFCs have been almost completely replaced by HFCs, substances such as R14 (GWP 7 390) are still marginally used as retrofit option and low temperature refrigerant in old R22 RACHP systems, which are expected to become obsolete in the coming years. In addition, used blends containing PFCs include ISCEON MO 89 (consisting of HFC-125/PFC-218 (C_3F_8)/R290) used as replacement for R13B1 which has been used in freeze-drying plants, and R508A/B (consisting of HFC-23/ PFC-116 (C_2F_6) used as replacement for R503 which is a CFC. A prohibition of PFCs would allow for a complete and immediate replacement of these high GWP gases, while also preventing any future use.	Annex III of the Regulation to be amended to include this new prohibition.	Member States to check and enforce the implementation of this prohibition.	Manufacturers of equipment to switch to HFC and lower GWP alternatives
A2.7	Introduce a POM prohibition for new medium voltage electrical switchgear for primary and secondary distribution, differentiated by voltage level, using SF_6 as insulating or breaking medium	There have been increasing amounts of SF_6 banked in equipment which might lead to long-term use and operation emissions.	Annex III to be amended to include this new prohibition.	Member States to check and enforce the implementation of this amended use prohibition.	Manufacturers of equipment to switch to alternatives to SF6
A2.8	Introduce a POM prohibition for new high voltage electrical switchgear, differentiated by voltage level, using SF_6 as insulating or breaking medium	There have been increasing amounts of SF_6 banked in equipment which might lead to long-term use and operation emissions.	Annex III to be amended to include this new prohibition.	Member States to check and enforce the implementation of this amended use prohibition.	Manufacturers of equipment to switch to alternatives to SF6

		Up to date the Regulation does only regulate the containment, recovery and training and certification regarding SF_6 in existing electrical switchgear equipment but does not regulate the placing on the market of new equipment that contains SF_6. Alternatives are not widely used, rather in testing phase with some pilot projects.			
A2.9	Introduce a use prohibition for some inhalation anaesthetics containing other F-gases listed in Annex II	While being fully emissive, the use of fluorinated inhalation anaesthetics had not been restricted during the previous review of the Regulation. A certain fluorinated ether (desfluorane; GWP 989) is widely used; alternative options include sevofluorane (GWP 216; AR5) and isofluorane (GWP 350; AR4). Containment measures should apply to these uses.	Article 3 and 13 to be amended to include this use prohibition.	Member States to check and enforce the implementation of this use prohibition.	Users of inhalation anaesthetics (e.g. hospitals) to switch to alternatives not listed in Annex II
A2.10	Apply requirements for prevention of emissions of fluorinated gases to substances listed in Annex II	Emission prevention requirements only concern Annex I gases, while no such requirements apply to the Annex II gases, such as NF_3, unsaturated H(C)FCs, fluorinated ethers and alcohols and other perfluorinated compounds. Thus, for the prevention of emissions related to these gases the Regulation has not been effective.	Scope of Article 3 to be amended to include other fluorinated greenhouse gases listed in Annex II of the Regulation.	Member States to check and enforce the implementation of the extended emission prevention requirements.	Users of Annex II gases (e.g. semiconductor industry, refrigeration and air conditioning industry)
A3) Extend requirements for prevention of F-gas emissions					
A3.1	Apply requirements for prevention of emissions of F-gases to manufacturing, transport, transfer and storage of bulk gases	The current emissions prevention provisions set in Article 3 only apply to operators of equipment, while Article 7 requires precautions to limit F-gas emissions which, however, apply only to producers of fluorinated compounds. To further reduce F-gas emissions, requirements set out in both Articles should apply to all actors with respect to use, manufacturing, transport, transfer and storage of bulk gases.	Article 3 and 7 to be amended.	Member States to check and enforce compliance with the extended requirements.	Gas importers and distributors
A4) Recovery of insulation foam blown with HFCs					
A4.1	Destruction of HFCs in steel-faced panels or reuse	Major emissions from certain foam products containing HFCs will occur at EoL. Current legislation and recovery practices in several Member States do not require the recovery	Article 8 to be amended	Member States to check and enforce compliance with the extended requirements.	Owners of buildings where HFC containing foam products have been used; recycling and demolition compa-

		of HFCs from insulation foams such as steel-faced panels.			nies; facilities performing HFC recovery from foam products and subsequent recycling/destruction.
A4.2	Destruction (or reuse) of HFCs in laminated boards in built-up structures and cavities, unless feasibility is proven by the building owner/demolition company	Major emissions from certain foam products containing HFCs will occur at EoL. Current legislation and recovery practices in several Member States do not require the recovery of HFCs from insulation foams such as laminated boards.	Article 8 to be amended	Member States to check and enforce compliance with the extended requirements.	Owners of buildings where HFC containing foam products have been used; recycling and demolition companies; facilities performing HFC recovery from foam products and subsequent recycling/destruction.
Objective B: Seeking alignment with the Montreal Protocol					
Full alignment, new phase-down steps beyond 2030					
See A1.1	Extend phase-down beyond 2030 and Increase ambition of the HFC POM phase-down in order to safeguard EU compliance with the requirements under the Montreal Protocol under all circumstances	The EU HFC POM phase-down of is defined until 2030. However, EU compliance with the HFC consumption under the Montreal Protocol needs to be safeguarded also after 2030, considering the reduction steps scheduled for 2034 and 2036. Given the differences in definition between POM (FGR) and consumption (MP), an exact ex-ante recalculation between both metrics is not possible and a safety margin has to be considered. Based on scenario analysis of the most significant drivers in the gap between the POM and consumption metrics EU compliance with the MP consumption limits appears safe until 2030.	In Annex V, the reduction level presently set for 2030 could be extended to 2032. Two additional reduction steps could be introduced for 2033-2035 and 2036 onwards (open ended).	Continuation of compliance checking procedures under the EU HFC phase-down. No additional action needed.	Same actors as addressed already
B1) To achieve full alignment, remove some exemption not foreseen by the Montreal Protocol					
B1.1	Remove exemption from POM restriction under the phase-down for HFCs for the use of military equipment	Exemption from the HFC phase-down is not foreseen by the Montreal Protocol.	Article 15(2)(d) to be deleted. The corresponding labelling requirement in Article 12(9) to be removed, as it will become irrelevant once the exemption is removed.	EU Commission to check compliance regarding quota, Member States to enforce.	Military

B1.2	Remove exemption from POM restrictions under the phase-down for HFCs for etching of semiconductor material or cleaning of chemicals vapour deposition chambers within the semiconductor manufacturing sector	Exemption from the HFC phase-down is not foreseen by the Montreal Proto-col.	Article 15(2)(e) to be deleted. The corresponding labelling requirement in Article 12(10) to be removed, as it will become irrelevant once the exemption is removed. Quota to be allocated to semiconductor industry suppliers on the basis of reference values.	EU Commission to check compliance regarding quota, Member States to enforce.	Semiconductor industry
B1.3	Remove exemption from POM restrictions under the phase-down for HFCs for use in metered dose inhalers (MDIs)	Exemption from the HFC phase-down is not foreseen by the Montreal Protocol. Lower GWP alternatives will be become available from 2025. Long-term availability of certain products that must be ensured for patient safety.	Article 15(2)(f) to be deleted. The corresponding labelling requirement in Article 12(12) to be removed, as it will become irrelevant once the exemption is removed. Quota to be allocated to MDI suppliers on the basis of reference values, should start with full amounts.	EU Commission to check compliance regarding quota, Member States to enforce.	MDI manufacturers and other stakeholders related to MDIs
B2) To achieve full alignment, remove some thresholds not foreseen by the Montreal Protocol					
B2.1	Remove exemption from the HFC phase-down for HFC quantities of up to 100 tonnes of CO_2 eq placed on the market	Exemption is not foreseen by the Montreal Protocol. Threshold could be exploited for illegal trade activities.	Article 15 (2) to be amended.		
B2.2	Remove the limit for reporting on production, import, export and destruction of Annex I and II gases	Reporting thresholds for HFC reporting on production, import, export and destruction are not foreseen by the Montreal Protocol.	Article 19 (1) and (2) to be removed.		
B3) To achieve full alignment, make separate phasing down of HFC production					
B3.1	Implement an EU HFC production phase-down in addition to the POM phase-down which would be quantitatively adapted to the Montreal Protocol (i.e. same ambition level)	While the HFC phase-down under the Montreal Protocol considers both HFC consumption and production, the EU phase-down under the F-gas Regulation concerns POM of HFCs. To ensure coherence and compliance with the international requirements, a phase-down schedule for the EU HFC production needs to be introduced. Quota allocation at entity level	New Article and Annex to be included.		Manufacturers of F-gases
B4) Disallow trade with non-Parties to the Montreal Protocol					

B4.1	Introduce prohibition for HFC bulk imports to/exports from the EU to any country not Party to the Montreal Protocol (Kigali Amendment)	For alignment with the Montreal Protocol (Article 4 on non-Party trade rules) trade restrictions would need to be included. By restricting countries which are Party to the Montreal Protocol from trading with countries not Party to the Montreal Protocol, they aim at maximising participation in the ODS/HFC regime.	Introduce a new chapter/article on trade restrictions, especially import and ex-port.		Non-Parties to the Montreal Protocol (Kigali Amendment)
Objective C: Improve implementation and enforcement					
C1) Certification of technicians to include skills on the use of low-GWP alternatives					
C1.1	Training programmes also to add energy efficiency issues (stationary RACHP)	Training programmes do not yet include energy efficiency aspects although being an essential part to reduce indirect emissions.	Article 10 and related implementing acts establishing minimum requirements and conditions for mutual recognition of certification of natural persons to be amended.	Member States to adjust training curricula to include energy efficiency	Training facilities to update their courses to include energy efficiency aspects in the trainings.
C1.2	Certification programmes also for unsaturated HFCs and H(C)FCs and F-gas free alternatives and to include practical training on all alternatives (stationary RACHP)	Lack of appropriately trained, qualified and certified technicians for alternatives to F-gases and as regards energy efficiency as barrier for the uptake of low GWP alternatives.	Article 10 and related implementing acts establishing minimum requirements and conditions for mutual recognition of certification of natural persons to be amended.	Member States to adjust training curricula/establish separate training requirements for alternatives to F-gases.	Technicians to take trainings and get certified. Service companies to send their staff to trainings and certification and to fund participation.
C1.3	Installation/servicing/repair/maintenance of AC equipment only by certified personnel (unsaturated HFCs)	Article 11 (4) specifies that distributors can only sell to certified undertakings and that F-gases can only be purchased by certified undertakings for the purpose of installation, servicing, maintenance or repair of equipment containing or relying on F-gases and also underlines the shared responsibility of distributors and installers for delivering the refrigerant to a certified undertaking. However, unsaturated HFCs are not covered by certification requirement of Article 11 (4), although they have become highly relevant especially for the use in mobile air conditioning equipment.	Article 11(4) to be amended.	Member States to enforce this extended requirement.	Manufacturers of equipment containing unsaturated HFCs and service companies to get their technicians certified.
C2) Detailed rules to empower customs and surveillance authorities in the EU Member States and facilitate the use of the EU “Single Window environment for Customs”					
C2.1	Include specific requirements for customs regarding the treatment of products and equipment illegally placed on the market and illegal F-gas containers once confiscated	Lack of clarify how illegal F-gas containers and products and equipment should be treated by customs at the borders. Some Member States have introduced national rules for their customs,	New Article to be included.	Customs to implement and Member States to enforce and decide on further treatment of confiscated material.	Customs and surveillance authorities in the EU Member States

		but there are no harmonised EU wide requirements in this regard.			
C2.2	Control special procedures (including transit, storage, specific use and processing) for F-gases through the EU with destination to non-EU countries and transit through some Member States with destination in another Member State Controlling customs special procedures. Only permit transit and other procedures for: a) Goods sent to particular destination custom offices b) Transaction where the minimum of 8-digit CN codes are indicated by the importer or exporter				Customs and surveillance authorities in the EU Member States
C3) Strengthen obligations of economic operators to prevent illegal trade					
C3.1	General prohibition of entry into EU territory of non-refillable F-gas containers and other illegal goods under the Regulation and extend the scope to unsaturated HFCs	The Regulation currently only prohibits the POM of non-refillable F-gas containers used for the servicing, maintenance or filling of RACHP equipment, fire protection systems, switchgear or for use as solvents. However, the prohibition does not yet cover the transport, storage and use of non-refillable F-gas containers, which makes it difficult to eliminate them from the EU market once they have entered the EU territory.	Article X to be amended to extend the scope of current placing on the market prohibition listed in Annex III.	Member States to implement this prohibition and check for compliance.	
C3.2	Prohibition for (offline and online) sales and possession of HFCs/F-gases that were illegally placed on the market	Besides offline sales of illegally imported HFCs/F-gases, e-commerce is also presenting a challenge for enforcement as F-gas containing products are being placed on the EU market via internet marketplaces and on platforms that make it difficult to identify sellers. Stakeholders confirmed that unregulated online sales online are an issue and present an avenue for illegal imports.	Include new Article.	Member State to implement and check for compliance.	
C3.3	Mandatory registration in the HFC Registry for importers and exporters of bulk HFCs under all customs procedures, prior to importing/exporting		Article 17 to be updated?	EU Commission to check for compliance, Member States to enforce.	Importers and exporters of bulk HFCs
C3.4	Add obligation for certification for natural persons and undertakings selling bulk F-gases online	Currently no certification requirements exist for selling bulk F-gases online. This represents a challenge for enforcement since bulk F-gases	Include new Article.	Member State to implement and check for compliance.	Online sellers of bulk F-gases

		are being placed on the EU market through internet platforms that do not easily allow for identification of the sellers. Stakeholders confirmed that unregulated internet sales can be an issue.			
C3.5	Add obligation for documentation for downstream sales for bulk HFC/F-gases (e.g. "declaration of conformity") and record keeping	As the Regulation currently focuses on the POM, the legality of substances is difficult for companies to assess at a later point in time, as no documentation on the legal placing on the market is kept. The introduction of documentation requirements could facilitate regulatory interventions along the supply chain and thus enforcement and at the same time increase legal certainty for those who buy and use the substances. The records should be kept by the market participants involved for a period of at least some years after the sale or purchase. Being the first Member State, Germany has recently adjusted its national legislation in include these requirements to prevent illegal trade activities.	Article X to be amended or new Article to be included.	EU Member States to implement and enforce this obligation.	F-gas importers and distributors
C3.6	Add requirement for producers and importers to be registered and hold sufficient quota at the time of release for free circulation/placing on the market / physical entry into territory1241	No overview on quota use and potential quota exceedance throughout the year, only retrospectively.	Amendment of Article 15 (1): "Producers and importers shall ensure that the quantity of hydrofluorocarbons calculated in accordance with Annex V that each of them places on the market does not exceed their respective quota allocated pursuant to Article 16 (5) or transferred pursuant to Article 18 <u>at the time of release for free circulation/placing on the market</u>." Physical entry		HFC producers and importers
C3.7	Add obligation for importers to have quota-exempted quantities labelled during POM/physical entry into territory and that gases much be explicitly labelled as "exempted from quota"				HFC producers and importers
C3.8	Strengthen the obligation on destruction of HFC-23 by-production	Lack of clarity of the evidence to be provided by companies, resulting in low enforcement action. Also improving alignment with the Montreal Protocol.	Amendment of Article 7 to operationalize the provisions on the evidence needed.	Customs to control the requirement.	HFC producers and importers

C3.9	Include minimum penalties to be enforced by EU Member States for quota exceedance, quota authorisation deficits, illegal issuance of authorisations, non-compliance with reporting deadlines and verification obligations and transport, storage and use of HFCs not covered by quota	All Member States have introduced penalties for infringements of the Regulation. However, penalties vary from one Member State to the other and in some cases their level may not be proportionate to the economic gains of illegal activities or benefits from the infringements. Moreover, the different judicial approaches and legal mechanisms related to the penalties are making it difficult to ensure that penalties in all Member States serve the purpose of being dissuasive. Minimum penalties for non-compliance related to quota, authorisations, reporting, verification and illegal trade activities could therefore be introduced to allow for more effective enforcement.	Article 25 to be amended.	Member States to establish related national legislation.	
C4) Limit the market players to legitimate participants					
C4.1	Limit issuing quota authorisations to incumbents	A trend in recent years was that increasing numbers of new entrant quota holders fully authorise their quota to equipment importers. It appears these are illegitimate market participants profiting from free quota allocation. With the current system, it is difficult to check if they fulfil the requirement that they active in the gas trade.			
C4.2	Align the establishment of the annual declaration-based quota allocation with the frequency of the quota allocation based on reference values	Reduction of admin burden for companies and the EU Commission More difficult for rogue traders to obtain quota			
C4. 3	Introduction of a quota allocation fee linked to CO_2 equivalents	Quota allocation fee, proportionate to quota allocation as a means to limit quota holders' windfall profits and have instead state revenues. Would serve as minimum price signal and for HFC supply chain. Alternative to quota auctioning approach. Depending on size of fee, measures to block illegitimate actors might become superfluous. 3 €/t CO_2 eq as the 2024 starting point for the quota allocation fee			
C5) More comprehensive monitoring					
C5.1	Extend labelling requirement to Annex II gases	Alternatives to F-gases and Annex II gases are currently not covered under requirements for labelling and product and equipment information despite their high GWP values.	Amend the scope of Article 12 to include Annex II gases.	EU Commission to amend the implementing act on labelling.	Manufacturers, importers, distributors of equipment to implement further labelling provisions.

C5.2	Registration and reporting obligation for exporters of products and equipment containing F-gases and other fluorinated substances	Lack of market overview and information on exports of F-gases contained in products and equipment	Article 17 to be amended to oblige exporters of pre-charged equipment and products to register. Article 19 to be amended to establish reporting requirements for exporters of pre-charged equipment and products. The reporting system run by the EEA would need to be updated to take into account the additional reporting requirement.		Exporters of products and equipment containing F-gases and other fluorinated substances to register and report annually
C5.3	Reporting obligation for recipients of quota-exempted HFCs	Currently recipients of HFCs exempted from the phase-down regime are not subject to reporting. This is potentially used as a loophole for illegal imports that are labelled as an exempted category (Article 15): HFCs imported for destruction; used as feedstock; for export (not made available to any other party within the EU prior to export); for use in military equipment; for the etching of semiconductor material or the cleaning of chemical vapour deposition chambers within the semiconductor manufacturing; for the production of MDIs.	Amendment of Article 19 to include reporting obligations for recipients of HFCs exempted from the reduction of the quantity of HFCs placed on the market according to Article 15. The reporting system run by the EEA to be updated to take into account the additional reporting requirement.		Recipients of quota-exempted HFCs
C5.4	Reporting obligation for undertakings (facilities) performing recycling of F-gases	Currently, there are no reporting obligations for recycling companies in place, unless they are also HFC bulk producers or importers or a destruction company. Hence, data collected for the recycling of F-gases was found to be incomplete. In view of the increasing relevance of recycling for the HFC market, full overview is needed.	Article 19 to be amended to include reporting obligations for undertakings performing recycling of F-gases. The reporting system run by the EEA to be updated to take into account the additional reporting requirement.	EU Commission to check compliance with the new reporting obligation.	Undertakings performing recycling of F-gases
C5.5	Reporting obligation for undertakings (facilities) performing reclamation of F-gases	Currently, there are no reporting obligations for reclamation companies in place, unless they are also HFC bulk producers or importers or a destruction company. Hence, data collected for the reclamation of F-gases was found to be incomplete. In view of the increasing relevance of reclamation for the HFC market, full overview is needed.	Article 19 to be amended to include reporting obligations for undertakings performing reclamation of F-gases. The reporting system run by the EEA to be updated to take into account the additional reporting requirement.	EU Commission to check compliance with the new reporting obligation.	Undertakings performing reclamation of F-gases

C5.6	Reporting obligation for operators of HV switchgear and electrical equipment (<52 kV) with regard to SF_6 emissions during lifetime and for operators in cooperation with certified personnel of electrical equipment for decommissioning of such equipment.	Currently estimates of SF_6 emissions are likely incomplete due to lack of data and unknown quantities of banked SF_6 in switchgear and other electrical equipment including e.g. particle accelerators.	Article 19 to be accordingly amended. The reporting system run by the EEA to be updated to take into account the additional reporting requirement.		Operators of HV switchgear and other electrical equipment
C5.7	Remove or lower the threshold for verification of bulk HFCs placed on the market	Independent verification is crucial for effective compliance checks. Currently, annual verification is mandatory for placing on the market of bulk HFCs exceeding 10 000 tonnes of CO_2 eq by June each year for activities of the previous calendar year. Companies need to keep the verification report for at least five years, and the verification report is to be made available, on request, to the competent authority of the Member State concerned and the EU Commission. However, given the strong increase in companies applying for new entrants' quota, the amount of quota allocated per company from the reserve dropped below the threshold of 10 000 tonnes of CO_2 eq in 2019 for the first time. However, this could also become a problem in the future. In 2019, this resulted in a gap where 8 % of amounts reported to be placed on the market are not subject to mandatory verification and thus to verify if they had imported higher amounts than reported other less effective actions had to be taken, e.g. inspections. Reducing the threshold to 1 000 tonnes of CO_2 eq would eliminate the need for such additional enforcement actions.	Article 19(6) to be accordingly amended. The reporting system run by the EEA to be updated to take into account the amended verification requirement.	EU Commission to check compliance with this requirement and notify non-compliance cases to EU Member States.	
C5.8	Add obligation to submit verification reports for bulk HFCs	Although companies are obliged to verify annual reports on the placing on the market of HFCs in bulk if the threshold set out in Article 19(6) is exceeded, they are not yet obliged to also upload the verification report to the EEA's Business Data Repository (BDR), i.e. it is only obligatory to keep the verification report for five years and only submit it to the EU Commission or the competent authority of the Member State concerned upon request. The current provision thus requires an additional step for enforcement authorities to request verifi-	Article 19 of the Regulation to be amended to include this new obligation. The reporting system run by the EEA to be updated to take into account the additional verification requirement.	EU Commission (or Member States) to check compliance with this obligation	

		cation reports. Therefore, an obligation for companies to upload their verification reports together with the annual reports would allow enforcement authorities to identify suspicious reports more quickly in order to further verify compliance, resulting in a reduction of administrative costs.			
C5.9	Align reporting and verification thresholds for placing on the market products and equipment	While the annual reporting obligation on product and equipment imports is subject to a threshold of annual imports exceeding 500 tonnes of CO_2 eq, an annual threshold of 100 tonnes of CO_2 eq applies to the obligation to have the declaration(s) of conformity verified according to Article 14(2) and to submit the results of the verification to the EU Commission. In practice, this inconsistency has led to confusion for importers of pre-charged products and equipment. A lowering of the reporting threshold to 100 tonnes of CO_2 eq would therefore be recommended, also in view of the necessary alignment of this threshold with the quota authorisation threshold for placing pre-charged products and equipment on the market.	Article 19(4) to be amended. The reporting system run by the EEA to be updated to take into account the amended reporting threshold.	EU Commission and EU Member States to check compliance with the adjusted reporting threshold.	Importers of pre-charged equipment and products
C5.10	Align reporting and verification dates (separately for bulk and pre-charged products and equipment)	The deadlines for submitting of F-gas reporting and verification reports according to Article 19 are currently not aligned. While it is stated each undertaking reporting the placing on the market 10 000 tonnes of CO_2 eq or more of HFCs during the preceding calendar year must additionally ensure that the accuracy of the data is verified by an independent auditor by 30 June each year, reporting on production, import, export, feedstock use and destruction of the substances listed in Annexes I or II is, however, set to take place by 31 March each year. Pre-charged products and equipment – reporting and verification date 31 March	Dates set out in Article 19 to be amended. The reporting system run by the EEA to be updated to take into account the amended deadlines.	EU Commission and EU Member States to check compliance with the adjusted deadlines	Companies subject to reporting and verification
C5.11	Add legal basis for electronic verification process (separately for bulk and pre-charged products and equipment)	Verification process is lengthy & paper based. Results are not easily available to authorities	Verifiers to have access to F-gas Portal, verification results / corrected data would immediately be available to authorities through the BDR.	EU Commission to include legal basis in Article X or add a new Article	Verifiers to make use of the new procedure.

C5.12	Align reporting and quota authorisation thresholds for placing pre-charged products and equipment on the market	While holding a quota authorisation is mandatory from a threshold of 100 tonnes of CO_2 eq, Article 19(4) of the Regulation sets a threshold of 500 tonnes of CO_2 eq for reporting on pre-charged products and equipment containing F-gas and other F-gases that have been placed on the market, presenting an inconsistency leading to practical problems. Therefore, the reporting threshold should be lowered to 100 tonnes of CO_2 eq.	The reporting threshold set out in Article 19(4) to be amended accordingly. The reporting system run by the EEA to be updated to take into account the amended reporting threshold.	The EU Commission to check compliance with the amendment, while EU Member States would be responsible for enforcement.	
C5.13	Obligation to provide NIL reports for quota holders	The lack of obligation for all registered companies to submit a "NIL" report leads to an avoidable administrative burden for the competent authorities when checking the reports. Obligation to provide nil reports would facilitate compliance checking.	Article 19 and respective Implementing Regulation to be amended.	Member States to check compliance with this obligation.	Registered companies that would not report on a specific year.
C5.14	Encourage or require Member States to use electronic reporting systems for collection of F-gas service intervention, technicians, sale of non-hermetic equipment and emissions data	Article 20 of the Regulation stipulates that Member States shall establish reporting systems for the relevant sectors referred to in this Regulation, with the objective of acquiring (to the extent possible) emissions data that can be used as valid basis for F-gas emissions reporting to the UNFCCC. However, in most cases emission reporting relies on export estimates for emission factors rather than actual emissions data based on the equipment stock present in the country, i.e. data collection schemes, if available, are only partly used for UNFCCC reporting on F-gas emissions. However, as feedback from stakeholders has shown, a strengthening of the EU wide data on F-gas emissions is necessary to identify most potential emissions source and the establishment of national electronic data collection schemes would help to facilitate this objective.	At EU level, Article 20 to be amended to include additional criteria for the implementation of an electronic reporting system to collect national F-gas emission data.	As the introduction of a data collection system is left to the Member States, no enforcement action would be necessary. However, Member States should be requested to inform the EU Commission about progress regarding the development and implementation of such an electronic data collection system.	Member States
C5.15	Include new substances in Annex I	Increasing use and emissions of certain F-gases with high GWPs. Perfluorodecalin ($C_{10}F_{18}$), but also long-chain PFCs (e.g. $C_{14}F_{24}$) Sulfuryl fluoride (SO_2F_2, AR 6GWP 4 630) > optional Annex II Sulfuryl fluoride is used to fumigate hardwood and softwood in containers destined for export. This is done to eliminate pests such as bark bee-	The reporting system run by the EEA to be updated to take into account the additional reporting activities for the new substances.	EU Commission to amend implementing act on reporting.	Companies using the listed F-gases to comply with relevant measures including emission prevention, reporting etc.

		tles. Despite its high GWP of 4 630 and increasing use, sulphuryl fluoride has not been regulated or monitored.			
C5.16	Include new substances in Annex II and require reporting by companies	Although the following substances are fluorinated greenhouse gases, they are not yet covered by the Regulation. While for some of them the areas of use are already known, for others this is not the case. In addition, the extent of use of these substances is not known due to the lack of mandatory reporting. In order to monitor the extent of their usage in the EU, the inclusion of these substances in Annex II of the Regulation, which would make them subject to reporting requirements, would allow monitoring and achieving a complete picture of the current state of their supply and use. Sevoflurane (HFE-347mnz1) Enflurane (HCFE-235ca2) Cis-1-chloro-2,3,3,3-tetrafluoroprop-1-ene (HCFC-1224yd (Z)) 2,3,3,3-tetrafluoro-2-(trifluoromethyl)propanenitrile (C_4F_7N) Perfluorotripropylamine ($C_9F_{21}N$) Perfluoro-N-methylmorpholine ($C_5F_{11}NO$) Perfluorotributylamine ($C_{12}F_{27}N$) Sulfurylfluoride (SO_2F_2) → optional Annex I Fluorinated ethers and alcohols: HFE-7 300; $C_4F_9OCH_3$, $C_4F_9OC_2H_5$ iso-C_3F_7CN	Annex II to be amended to include additional substances. The reporting system run by the EEA to be updated to take into account the additional reporting activities for the new substances.	No additional enforcement action required.	Users of additional substances to be included in Annex II such as importers of inhalation anaesthetics (possibly hospitals, clinics), switchgear manufacturers and potentially operators etc.
C5.17	Move substances from Annex II to Annex I	Unsaturated HFCs (new section in Annex I) Nitrogen trifluoride (NF_3) Perfluoro-cyclopropane (c-C_3F_6)	Annex I to be amended to include the selected Annex II substances. Regulation to be amended to include that these substances are not covered by the HFC phase-down and prohibitions but by containment, labelling and reporting requirements. The reporting system run by the EEA would need to be		Companies using the listed F-gases to comply with relevant measures including emission prevention, reporting.

			updated to take into account these amendments.		

Table 13: Detailed overview of clarifications and other improvements

Objective D: Further clarifications and improvements	
D1	Include the possibility to adopt delegated acts to adapt the Regulation to allow alignment with potential future decisions under the Montreal Protocol (e.g. related to exemptions from the HFC phase-down, adjustment of GWP values to more recent scientific data (IPCC AR5 or AR6 instead of AR4))
D2	Include 20-year time horizon GWP values relative to CO_2 for all substances listed in Annex I and II
D3	Include the possibility to adopt delegated acts to allow for amendments in Annex I and II if new scientific evidence become available
D4	Include confidentiality obligations for Member States in Article 17 and 19, i.e. clarifications that Member States should not reveal confidential business information linked to companies
D5	Include requirement for non-EU importers of pre-charged products and equipment to mandate an "only representative" and have an Economic Operators' Registration and Identification (EORI)
D6	Include requirement to add and the F-gas ID and F-gas quantities expressed in CO_2 eq in customs documents for both bulk and products and equipment (registry)
D7	Enshrine the 'beneficial owner' principle to limit market players, i.e. move related provisions from the Implementing Regulation into the Regulation
D8	Include details on requirements related to the import of pre-charged equipment in the main text of the Regulation
D9	Include clarification that HFCs imported are always considered virgin, require quota and cannot be used for servicing and maintenance purposes
D10	Clarify that the requirement set out in Article 11(4) also covers car garages
D11	Clarify that the exemption in Article 15(2)(c) does not cover exports of HFCs contained in pre-charged equipment
D12	Include that Article 6(1)(c) refers not only to installed gases but also to added gases as regard information to be included in the records by operators of equipment on the quantities of recycled or reclaimed F-gases
D13	Include clarification in Article 6(1)(f) that information to be included in the records should also cover details about leakage repairs
D14	Include clarification in Article 8(1) that the recovered refrigerant cannot be used for fill or refill equipment unless it has been recycled or reclaimed
D15	Include clarification in Article 8(3) as regards the current the wording "appropriately qualified natural persons"
D16	Include clarification in Article 14(2) that verification of HFC pre-charged in imported equipment is required as of 100 tonnes of CO_2 eq
D17	Include clarification in Article 15 that the placing on the market of HFCs in excess of the quota limits is strictly prohibited
D18	Include clarification of the term "exclusively" in Article 18(2)
D19	Align definition of "placing on the market" (Article 2 No 10) with the definition used in the Ozone Regulation
D20	Clarify definitions in Article 2 of "hermetically sealed equipment" (No 11), "non-refillable container" (No 13); "recycling" (No 15); "reclamation" (No 16); "destruction" (No 17); "installation" (No 20); "maintenance or servicing" (No 21); "stationary" (No 23); "mobile" (No 24); "refrigerated truck" (No 26); "technical aerosol" (No 28); "undertaking" (No 30)
D21	Include clear definition of "refrigeration equipment"; "air-conditioning equipment"; "heat pump equipment"; "pre-charged products and equipment"; "reclamation facility"; "consignee"
D22	Include clarification for import (entry of goods) and export (exit of goods)
D23	Make minor corrections in Annex II to formulas, names, etc.
D24	Include clear instructions on custom authorities' and market surveillance authorities' role and cooperation with competent authorities
D25	Include addition that prohibition concerning non-refillable containers for F-gases (Annex I & II)) and other F-gases (Annex II) also covers their transport, storage and use

D26	Make clear that mandatory registration in the HFC Registry for importers/exporters of pre-charged products and equipment prior to import/export is required (while keeping the threshold of 100 tonnes of CO_2 eq)
D27	Add prohibition to make HFCs available to third parties, to transfer HFCs to third parties or to use HFCs which have been placed on the market in violation of the requirements of Article 15(1), including by internet sales, with the exception of provision, transfer or use for return or disposal
D28	Add clarification in Article 18 that authorisations have to be made in the HFC registry, just like quota transfers
D29	Add clarification in Article 2 that placing on the market of HFCs includes emissions of gases from the production process

8. Further specification of policy measures

This chapter intends to provide further specifications of policy measures to explain the technical details.

8.1. Increase HFC phase-down ambition (measure A1.1)

8.1.1. Methodology for the operationalisation of the HFC phase-down and quota calculation system

The HFC POM phase-down as set out in FGR 2014/517 is characterised by the reduction schedule of Annex V of the Regulation, expressed in percentages, which is used for two purposes:

a) Calculation of the EU-wide annual maximum quantities (MaxQ) of HFCs to be placed on the market 2015 onwards, featuring a complex calculation scheme including a baseline derived from 2009-2012 reporting data and quota exemptions
b) Calculation of company-specific HFC quota based on reference values (RV-quota): Company-specific reference values, which are recalculated triennially to determine average POM of HFCs since 2015, are multiplied by the percentage given in Annex V for the respective year and by a factor of 0.89 to determine RV-quota. The gap between the total MaxQ and the sum of RV quota allocated to companies ("new entrants' reserve") is subsequently distributed on a pro-rata basis to all companies having submitted a declaration on additional need (D-quota).

To increase the transparency of the EU-wide schedule for the MaxQ of HFCs, it is proposed for the revision of the FGR to abandon the complex MaxQ calculation rule of FGR 2014/517 and disentangle the previous Annex V schedule into

a) An explicit schedule for the maximum quantity of HFCs to be placed on the EU27 market, beginning in 2024 and expressed in t CO_2 eq/a
b) a reduction schedule in percentage units beginning 2024, for the purpose of calculating RV-quota. The equation to calculate RV quota from reference values involving the 89% reduction factor to feed the new entrants reserve would remain unchanged.

The percentages in the reduction schedule for RV quota should be calculated by dividing the maximum quantities (expressed explicitly in t CO_2 eq) by a new 2015 base value to be defined in a revised Regulation. The 2015 base value needed for a revised Regulation should be calculated based on the methodology defined in FGR 2014/517 to derive the 2015 MaxQ for the EU-28, and account for the change in geographical scope of the EU (EU27 after Brexit) and for a change in scope of quota exemptions due to apply starting 2024 with an FGR revision, based on available data.

The approach to calculate reference values as average POM of HFCs on the EU market since 2015 could be clarified to apply to placing on the EU27 market, based on available data, and should in the case of lifting a quota exemption be amended by special calculation rules for suppliers of (previously) exempted HFCs (see details in section 8.6.1 covering measures B1.1-B1.3 on the removal of quota exemptions).

8.1.2. Ambition levels of the schedule for the HFC maximum quantity of HFCs

The maximum quantity of HFCs for the EU27 in the years 2021-2023 is fixed at approximately 62.3 Mt CO_2 eq under the FGR 2014/517. Table 14 shows how the maximum quantity is bound to develop ion the baseline and gives alternative. schedules calculated for the policy scenarios. For calculation methodology, please refer to Annex 1.5.

Table 14: Options for the FGR phase-down schedule for the maximum quantity of HFCs placed on the EU27 market [Mt CO_2 eq]

	Baseline	MP alignment	Proportionate action	Maximum feasibility
	Quota-exempted sectors as under FGR 2014/517; constant extrapolation assumed for 2030ff.	Quota exemption for MDIs lifted as of 2024	Quota exemption for MDIs lifted as of 2024	Quota exemption for MDIs, semiconductors and military lifted as of 2024
	Mt CO_2 eq	Mt CO_2 eq	Mt CO_2 eq	Mt CO_2 eq
2021 - 2023 (under the existing FGR 2014/517)	62.27	62.27	62.27	62.27
2024 - 2026	37.54	49.04	41.70	41.04
2027 - 2029	25.17	36.67	17.69	15.96
2030 - 2032	19.87	31.37	9.13	6.92
2033 - 2035	19.87	28.72	8.45	5.79
2036 - 2018	19.87	20.54	6.78	5.47
2039 - 2041	19.87	20.54	6.14	5.01
2042 - 2044	19.87	20.54	5.49	4.54
2045 - 2047	19.87	20.54	4.85	4.08
2048 onwards	19.87	20.54	4.20	3.62

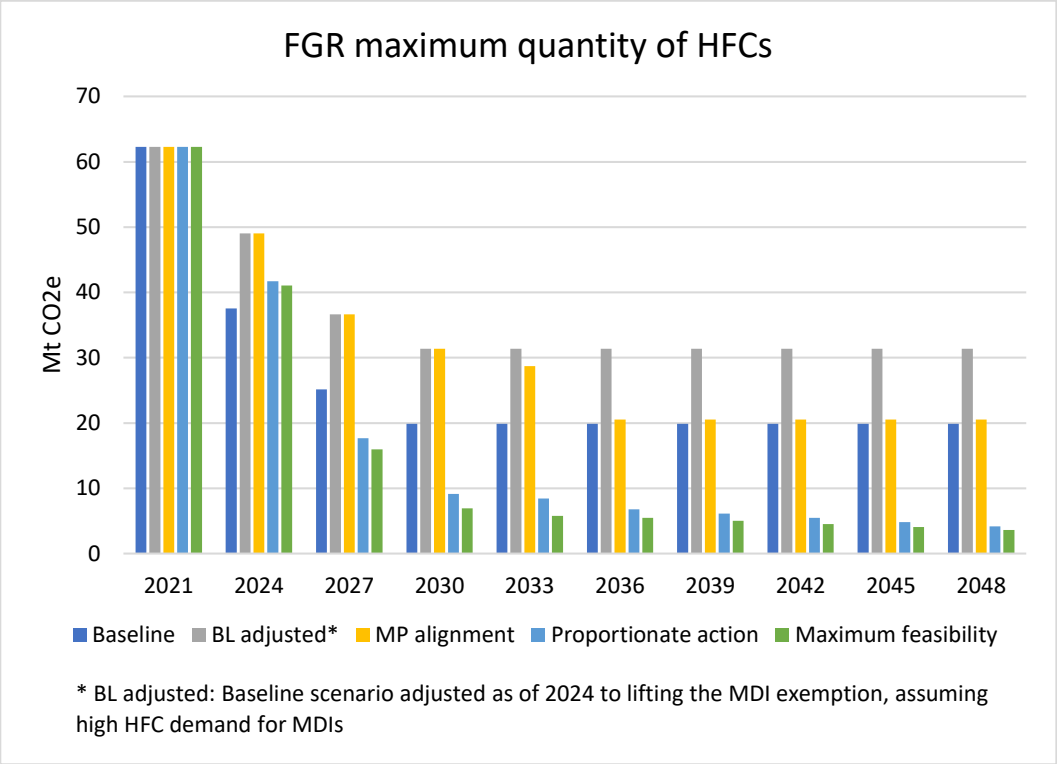
Note: Respective data in units of t CO_2 eq are given in Annex 5.1

Visualisations of the discussed schedules are given in Figure 7 (schedules for the maximum quantity), Figure 8 (reduction steps in absolute terms) and Figure 9 (reduction steps in relative terms).

For improved comparability of the discussed options in terms of considered quota exemptions, time series have been added for an adjusted baseline which incorporates a lift on the MDI quota exemption as of 2024, assuming high MDI demand of approximately 11.5 Mt CO_2 eq per year, consistent with the scenario definition for the *MP alignment* policy option.[24] Figure 7 thus shows how the ambition of the schedule of the maximum quantity in the *MP alignment* policy option basically follows the 'adjusted) baseline and features two reduction steps in 2033 and 2036 in order to safely stay below MP consumption limits.

[24] An adjustment of the *maximum feasibility* scenario to a situation where only the MDI exemption would be lifted, but not the exemptions for semiconductor manufacturing and military use, would result in a schedule close to the one given for maximum feasibility in **Error! Reference source not found.** and Figure 7, however with approximately 0.3 Mt CO_2e subtracted for all years as of 2024.

Figure 7: Options for the development of maximum quantity of HFCs

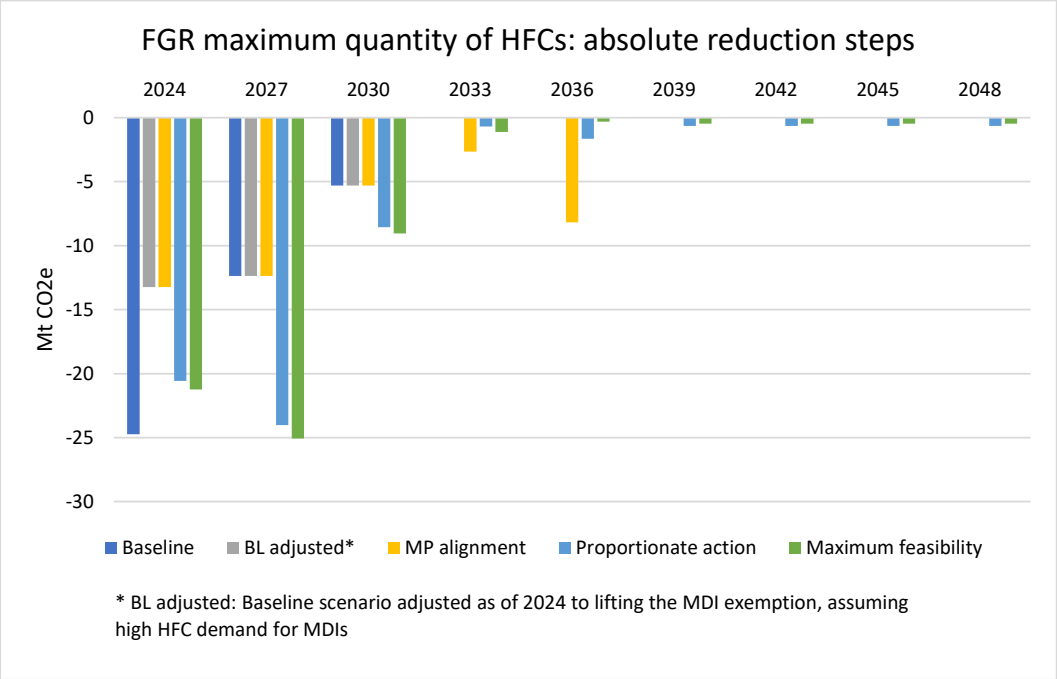


Source: AnaFgas modelling

The *proportionate action* and *maximum feasibility* options feature stronger reduction steps than the *MP alignment* option in 2024, 2027 and 2030 (Figure 8). In return, reduction steps in 2033 and 2036 would be less intense in 2033 and 2036. For the 2039 – 2048 period triennial reduction steps of approximately 0.5 Mt CO_2 eq are in line with the respective scenario calculations for *proportionate action* and *maximum feasibility*. Given the 2036 maximum quantity levels of about 5-7 Mt CO_2 eq for those scenarios,

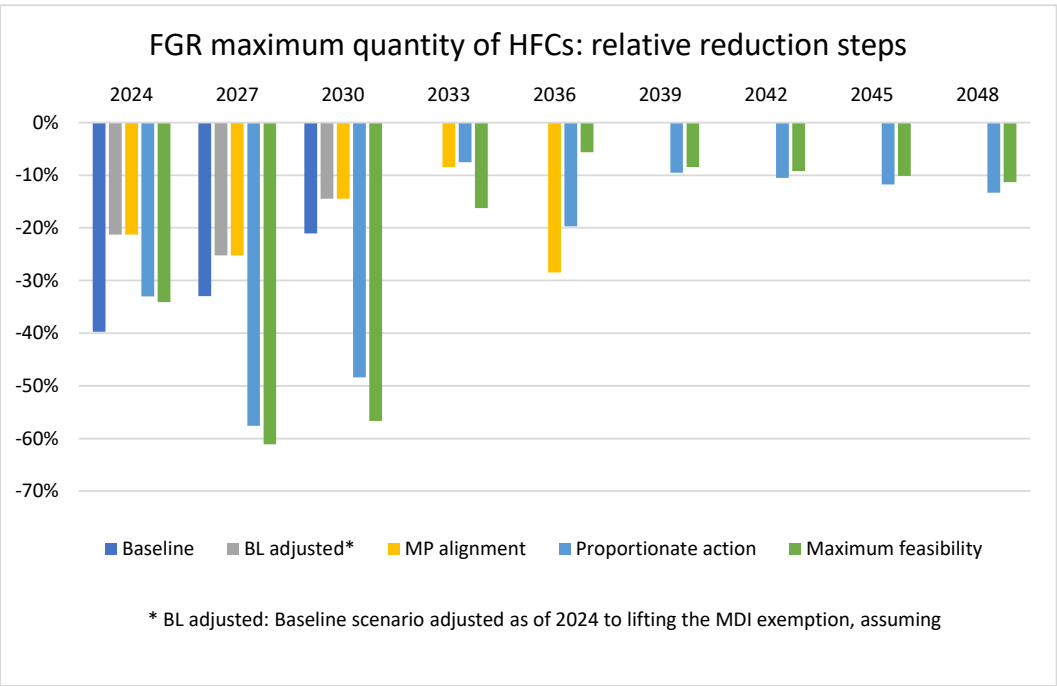
however, those triennial 2039 – 2048 reduction steps would each be equivalent to a reduction of approximately 10 % (Figure 9).

Figure 8: Options for the development of maximum quantity of HFCs: absolute reduction steps



Source: AnaFgas modelling

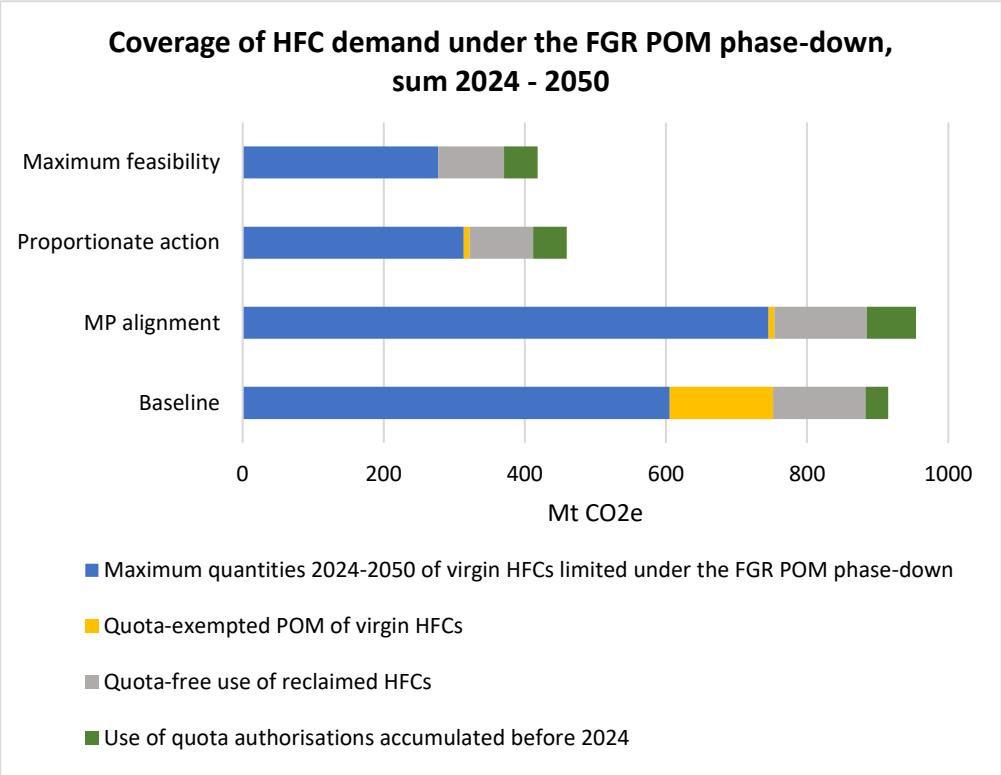
Figure 9: Options for the development of maximum quantity of HFCs: relative reduction steps



Source: AnaFgas modelling

Figure 10 provides an overview on the overall 2024-2050 integral of HFCs covered under the maximum quantities for HFC POM and illustrates the role of quota exemptions for virgin HFCs (FGR Art 15), reclaimed HFCs and the bank of quota authorisations in meeting the overall HFC demand modelled for the baseline and the different policy options:

Figure 10: Coverage of 2024-2050 HFC demand under the FGR POM phase-down



Note: POM: Placing on the market.

Source: AnaFgas modelling

Note that the total HFC demand 2024-2050 in the *MP alignment* scenario slightly exceeds the baseline, as the MP alignment option does include the measure of lifting the MDI exemption (for consistency with the Montreal Protocol, see section 8.6.1.1) and at the same time is designed not add any additional scarcity of HFC supply to the MDI sector in the case of growing future demand of MDIs and related HFCs. The increase in the maximum quantity in the *MP alignment* option compared to the baseline, due to lifting the MDI exemption, was therefore calculated considering a potentially higher HFC demand for MDIs than calculated in the AnaFgas model for both the baseline scenario and the MP alignment scenario. For details, please refer to the MP alignment scenario definition in Annex 1.5.

8.2. Prohibitions of F-gases in products and equipment (measure A2)

8.2.1. POM prohibitions for products and equipment containing or relying on F-gases

8.2.1.1. POM prohibition for stationary AC and HPs containing or relying on HFCs (measure A2.1)

The prohibition related to stationary air conditioning equipment and heat pumps (heating and cooling mode)

- of a rated capacity of up to 12 kW that contain, or whose functioning relies upon fluorinated greenhouse gases with a GWP of 150 or more from 1 January 2025 and

- of a rated capacity of more than 12 kW that contain, or whose functioning relies upon fluorinated greenhouse gases with a GWP of 750 or more from 1 January 2025.

Current technology trends towards low-GWP alternatives can be seen in all AC and heat pump applications and already resulted in the introduction of A2L and A3 refrigerants (such as R32, R454C, R290) in a wide range of air conditioning and heat pump products and ahead of the prohibition spelled out in Annex III(15) of the current regulation[25,26,27].

At the same time, research on charge-size minimisation for flammable refrigerants is progressing fast. In addition, both small and larger single-split air conditioning systems and heat pumps offer great potential for further GWP reductions. However, due to larger charge sizes, safety concerns are more limiting for the larger equipment types so that the introduction of low-GWP alternatives will likely need more time. Given the expected growth rates of the heat pump sector, which is currently mainly driven by the promotion of more energy efficient heating, the choice of refrigerant also fundamentally relevant to reduce CO_2 eq. Safety standards are being revised to allow for easier use of low-GWP alternatives including flammables at higher charges and are expected be updated in the next 2-3 years according to information from experts involved in the standardisation working groups.

The metrics for this prohibition are based on capacity (kW) to align with other relevant regulations (e.g. Ecodesign regulation).

For stationary AC and heat pump applications with <12 kW (<3 kg charge size in the model), a technically feasible prohibition date for F-gases with a GWP >150 in new equipment was set for 1 January 2025[28]. Thus, under the maximum feasibility and proportionate action scenarios, all new equipment contains hydrocarbons beginning in 2025, which gives plenty of time for further technological development. For perspective, within 4 years, R32 was introduced in this sector from near zero to close to 90 %.

For larger stationary AC and heat pump applications with >12 kW (>3 kg charge size in the model), no F-gases with a GWP >750 were assumed in new equipment from 1 January 2025, as the larger charges make the use of flammable refrigerants under current safety standards still difficult.

An exemption would be included to allow for continued use of HFCs where standards and codes do not allow for the use of hydrocarbons. Evidence such as technical documentation to be kept and provided upon request to MS: This would allow for further technical development as stakeholders such as the industry associations EPEE or JBCE pointed out that there may be special circumstances such as long pipes or similar that require higher charges than permitted under standards.

The prohibition would concern manufacturers, importers and distributors of stationary air conditioning and heat pump equipment as well as end-users and service companies.

8.2.1.2. POM prohibition for small hermetic refrigeration and heat pump appliances containing or relying on HFCs and for skin cooling equipment (measure A2.2a and b)

The prohibition A2.2a addresses small hermetic refrigeration and heat pump appliances for household and commercial use which still use high-GWP HFCs. Examples include cream and ice cream makers, juice makers, milk coolers attached to coffee machines, beer and wine coolers, heat pump tumble driers etc.

[25] EU COM 2020: The availability of refrigerants for new split air conditioning systems that can replace fluorinated greenhouse gases or result in a lower climate impact.
https://ec.europa.eu/clima/sites/clima/files/news/docs/c_2020_6637_en.pdf
[26] Announcement by Midea to introduce R290 in split air conditioning units in the EU in 2021 at the Green Cooling Summit 2021, 26 May 2021.
[27] "Energy efficient and climate-friendly split air conditioners now on sale in Europe", https://www.unido.org/news/energy-efficient-and-climate-friendly-split-air-conditioners-now-sale-europe, 19 August 2021
[28] This is also in line with the conclusions of the EU Commission report: EU COM 2020: The availability of refrigerants for new split air conditioning systems that can replace fluorinated greenhouse gases or result in a lower climate impact.

Due to the small charge size and the hermetic nature of these appliances, end-of life recovery of the HFC charge is typically neither possible nor carried out as many appliances are not separated in the waste scheme so that the full charge is emitted at end of life (EoL). Alternatives to HFCs for small hermetic refrigeration units (such as R290) are already widely available and allow for immediate and full replacement of HFCs.

Furthermore, skin cooling equipment relying on HFCs is addressed by prohibition A2.2b. Such devices are not only used for medical but also for cosmetic purposes in beauty treatments, e.g. hair removal, and direct emissions occur. Alternatives are available and should allow for replacement of HFCs.

The prohibitions concerns manufacturers, importers and distributors.

8.2.1.3. POM prohibition for fire protection equipment containing or relying on HFCs (measure A2.4)

The prohibition is based on the significant decrease of HFCs used as fire extinguishing agents since 2015 as well as the large-scale use and availability of non-F-gas alternatives which was confirmed by industry stakeholders and consulted experts. Alternative technologies are common in this sector and allow for an immediate replacement of HFCs, except for when national safety standards are to be met in special applications including mining, military, aviation, and nuclear power plants which require substances with special extinguishing capacities that cannot be met by the alternatives currently available on the market. The model assumes full transition to non-F-gas alternatives by 2030 under all scenarios. From 2025, all HFC quantities can come from reclaimed quantities. The POM prohibition is set to start from 2024.POM prohibition for personal care products containing HFCs and PFCs (A2.5)

This prohibition starts in 2024 and relates to the use of HFCs, unsaturated HFCs and PFCs in personal care products such as creams and liquids for skin and nail care (mainly perfluorodecalin) as well as sprays and mousses for hair and skin care (HFC-blends, unsaturated HFCs). The use of F-gases in these product types is limited as various alternatives are commonly used by most manufacturers.

F-gases contained in this type of products are fully emitted and cannot be recovered or contained (emissive uses).

Stakeholders concerned include manufacturers, importers and distributers of personal care products currently containing F-gases. They would need to adapt their product formulations.

8.2.1.4. POM prohibition for RACHP equipment containing or relying on PFCs or blends containing PFCs (measure A2.6)

PFCs are contained in few refrigerant blends, especially blends that were introduced as retrofit options (drop-in) for equipment formerly containing HCFCs (R22; R503) or CFCs (R13) to allow the use of existing equipment and systems until EoL. Examples include R413A (“Isceon 49”; R134a 88%; C_3F_8 9%; isobutane 3%), R508A (“Klea 5R3”; R23 39%; C_2F_6 61%) and R508B (“Freon 95” or “Suva 95”; R23 46%; C_2F_6 54%; for ultra-low temperature applications).

The analysis of reported data shows that PFCs play a niche role as refrigerants today. Nevertheless, new equipment running on PFC refrigerant blends is still entering the market, mainly for special applications[29]. The prohibition intends to safeguard the emission reductions achieved as PFCs are not covered by the HFC phase down but might possibly be used in (new) mixtures.

The prohibition refers to refrigerant manufacturers and equipment producers, importers and distributors as well as RACHP service technicians.

[29] For example, a vaccine cooler relying on a two-stage system with R449A and R508B (February 2021). https://www.coolingpost.com/products/vaccine-storage-at-80oc/

8.2.1.5. POM prohibition for medium-voltage and high-voltage electrical switchgear

8.2.1.6. using SF_6 (measure A2.7 & A2.8)

In recent years, several alternatives to SF_6 in both MV and HV electrical switchgear were developed. While the market introduction in the MV segment is more advanced and alternatives are widely available, this is not yet the case for HV applications so that more time is needed for this market segment.

The prohibition distinguishes between voltage and distribution levels and relates to

new MV electrical switchgear

- for primary distribution, differentiated by voltage level – up to 24 kV from 2026 and 24-52 kV from 2030, using F-gases with GWP >2 000 as insulating or breaking medium;
- for secondary distribution, differentiated by voltage level – up to 24 kV from 2026 and 24-52 kV from 2030, using F-gases with GWP >2 000 as insulating or breaking medium.

and new HV electrical switchgear

- in the range of 52-145 kV and up to 50 kA short circuit current from 2028, using F-gases with GWP >2 000 as insulating or breaking medium;
- in the range of more than 145 kV and more than 50kA short circuit current from 2031, using F-gases with GWP >2 000 as insulating or breaking medium.

Industry input and literature research suggest that several alternative mixtures and substances are available with GWP <2 000 within the indicated time frames[30]. The transition from SF_6 towards lower-GWP alternatives will lead to a reduction in the demand of SF_6 (Figure 11 and Table 16).

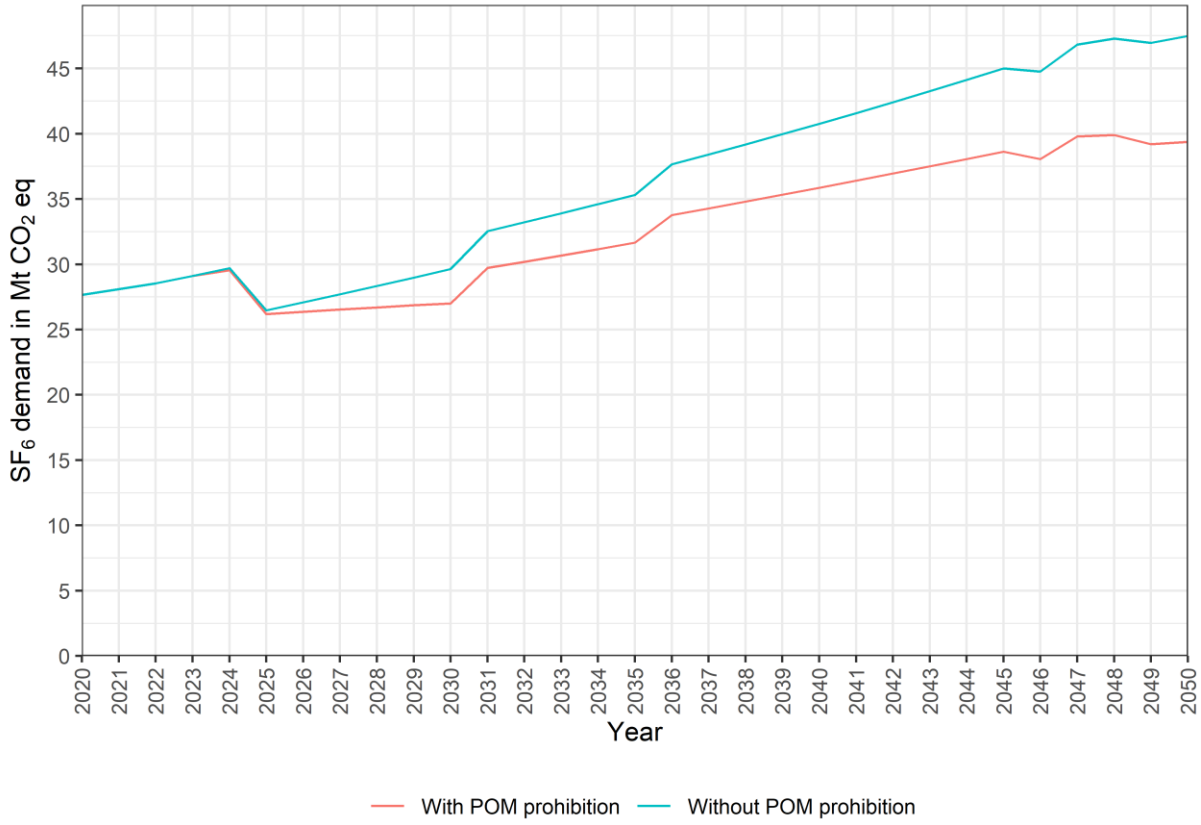
Table 15: Assumed share of SF_6 in new electrical switchgear equipment in Mt CO_2 eq

Year	With prohibition	Without prohibition
2020	100%	100%
2025	94%	100%
2030	52%	100%
2035	40%	100%
2040	29%	100%
2045	17%	100%
2050	5%	100%

Source: Own calculations based on "German Electrical and Electronic Manufacturers' Association: Scenario for reducing SF_6 operating emissions from electrical equipment through the use of alternative insulating gases, March 2020"

[30] E.g. EC report: Report from the Commission assessing the availability of alternatives to fluorinated greenhouse gases in switchgear and related equipment, including medium-voltage secondary switchgear https://ec.europa.eu/clima/sites/default/files/news/docs/c_2020_6635_en.pdf

Figure 11: Demand of SF_6 in electrical switchgear with and without POM prohibition



Source: AnaFgas modelling

Table 16: Modelled demand of SF_6 in electrical switchgear in Mt CO_2 eq under the different assumptions in the EU27

Year	With prohibition	Without prohibition	Reduction
2020	28	28	0
2025	26	26	<1
2030	30	27	3
2035	35	32	4
2040	41	36	5
2045	45	39	6
2050	47	39	8

Source: AnaFgas modelling

8.2.2. Use prohibitions

8.2.2.1. Use exemption for virgin gases in refrigeration equipment with charge size below 40 tonnes CO_2 eq (measure A2.3)

The current provision to use F-gases with GWP >2 500 for servicing and maintenance from 2020 onwards exempts stationary and mobile refrigeration equipment with a charge size below 40 t CO_2 equivalents. Feedback from industry showed that this exemption is not relevant in practice, i.e. a distinction is often not made between charge sizes above and below 40 t CO_2 eq during service and maintenance[31]. Alternatives to high-GWP refrigerants (R404A, R507) are available for all stationary and mobile refrigeration applications including the exempted capacity range.

The stakeholders concerned by removing this exemption are manufacturers, equipment owners/operators, service companies performing maintenance work on existing systems and, indirectly, refrigerant importers and distributors.

8.2.2.2. Use prohibition for inhalation anaesthetics (measure A2.9)

Fluorinated ethers are regularly used as inhalation anaesthetics during operations in human medicine. In Europe, this use is limited to three substances, desflurane (HFE-236ea2; GWP 989, Regulation; GWP 2 590, AR6), sevoflurane (HFE-347mmz1; GWP 216, AR5; GWP 195, AR6) and isoflurane (HCFE-235da2; GWP 350, AR4; GWP 539, AR6; ODP 0.03, WMO 2018).

Based on information from medical experts, for human medicine, desflurane and isoflurane are not needed in ca. 99 % of cases. Practically all operations with the indication for use of inhalation anaesthetics can be conducted with sevoflurane. Isoflurane is still used, mainly because it is the cheapest fluorinated ether. All gases do, however, differ in certain clinical aspects, such as duration of onset and offset, and how well tolerated they are to breathe for the patient.

Isoflurane is routinely used in veterinary medicine and usually fully vented to the atmosphere, according to information from practitioners and clinics. Apart from that, it is also the main gas used in the newly obligatory anaesthesia of mail piglets during castration.

The prohibition relates to the use of inhalation anaesthetics containing F-gases listed in Annex II with GWP >550 from 2024. This refers to desflurane that has not been restricted within the current F-gas Regulation but is commonly used throughout the EU and fully emitted. Lately, a technology to capture inhalation anaesthetics for reclamation has been developed but it is not yet widely used[32].

The prohibition would affect importers and distributors of medical products as well as end-users such as hospitals and clinics.

[31] In this way, the exemption might have been used as a justification in the context of illegal activities.
[32] This technology developed by the company SageTech Medical Equipment allows for recovery and reuse of anaesthetic gases as it captures, extracts and purifies inhalation anaesthetic agents. It consists of a capture canister between the anaesthetic machine and the anaesthetic gas scavenging system and captures the waste gases. The capture canister is then loaded into an automated extraction machine located at the hospital premises. The machine extracts the captured gases and condenses them to liquids. The bulk liquid gas is subsequently transported to a processing facility for purification.

8.3. Further requirements for certain F-gases (measure A2.10)

A2.10 refers to Annex II gases and suggests further requirements for these gases such as emission prevention (Art. 3) This measure is linked to measure C5.15 (section 8.7.5.18) to include new gases in Annex II.

8.4. Extend requirements for the prevention of F-gas emissions (measure A3)

The current emissions prevention provisions set in Article 3 only apply to operators of equipment, while Article 7 requires precautions to limit F-gas emissions which, however, apply only to producers of fluorinated compounds. This measure extends the requirements of Articles 3 and 7 for the prevention of F-gas emissions to manufacturing, transport, transfer and storage of bulk gases (measure A3.1). It will thus concern gas producers, importers, distributors as well as installation and service companies transporting and storing bulk HFCs.

8.5. Recovery of insulation foams blown with HFCs (measure A4)

8.5.1. Reuse or destruction of HFCs in steel-faced panels (A4.1)

This policy measure suggests that HFCs are to be recovered from steel faced insulation panels at end of life for reuse or destruction. In this way, HFC quantities contained in foam banks will not be emitted at end of life of these construction products but will need to undergo an organized recovery and recycling process to prevent emissions. This is aligned with a key policy measure suggested for a review of the ODS Regulation and will lead to comprehensive treatment of end-of life foam products. The measure is included in all three scenarios.

8.5.2. Reuse or destruction of HFCs in laminated boards (A4.2)

This measure addresses laminated foam boards containing HFCs in built-up structures and cavities and requires recovery and subsequent reuse or destruction of HFCs, unless technically not feasible and evidence is provided by the building owner/demolition company. The measure is included in the proportionate action and high-ambition scenarios from 2024.

This is aligned with a policy measure suggested for a review of the ODS Regulation and will lead to comprehensive treatment of end-of life foam products.

8.6. Measures to improve consistency with the Montreal Protocol

8.6.1. Removal of quota exemptions under the FGR POM phase-down for HFCs (measures B1)

The FGR quota exemptions for pharmaceutical MDIs (FGR Art 15 (2) f), for semiconductor manufacturing (FGR Art 15 (2) e) and for military use (FGR Art 15 (2) d) do not have any counterpart in the Montreal Protocol. However, the FGR quota exemptions for imports for destruction (FGR Art 15 (2) a), for feedstock use (FGR Art 15 (2) b) and for exports (FGR Art 15 (2) c) are fully reflected in the accounting rules under the MP.

8.6.1.1. Exemption for MDIs (measure B1.3)

The MDI exemption is quantitatively the most relevant of the FGR quota exemptions outside the MP accounting framework (FGR Art 15 (2) d-f exemptions on military, semiconductors and MDIs) and covers more than 95% of those quota-exempted HFCs. As analysed out in the evaluation report, The HFCs amounts for MDI use have grown by about 45 % from 2015 to 2019 and have reach levels of approximately 10 Mt CO_2 eq per year.

As technical replacement options for high-GWP HFC in the MDI sector are underway and given the high quantitative significance of MDI sector in overall HFC demand and emissions, the measure to lift the MDI exemption as of 2024 is thus assigned to all three policy options. It should be noted that exports

of MDIs containing HFCs are not considered bulk HFC exports and thus not subject to the quota exemption for exports according FGR Art 15(2)c.

However, with a lift of the quota exemption the calculation rules for the determination of reference values for the HFC suppliers to the MDI sectors need to be amended in order to safeguard fair treatment in comparison to the suppliers of other HFC use sectors, subject to the phase-down since 2015:

Necessary amendments to the calculation scheme for Reference Values (RVs)

If the MDI quota exemption is to be lifted as of 2024, special calculation rules for the triennial RV-recalculation need to be introduced in order to avoid that the supply of HFCs to this previously exempted sector would be cut by the quota system more than proportionate to the other, previously non-exempted, HFC use sectors. This means that 2024 allocations levels of RV quota to MDI suppliers should be at 100% of the levels established before lifting the exemption, and that subsequent reduction steps will be proportionate to the relative reduction steps as defined for overall HFC POM:

As a principle, the RVs for companies supplying HFCs to the MDI sector should be based on average POM in EU-27 since 2015. In the case of HFC suppliers for (previously exempted) MDIs, this data is available from company reporting under FGR Art. 19. However, in the case of MDI suppliers the average POM calculated needs to be increased for the calculation of a RV in order to facilitate proportionate treatment as explained above. This increase is to be calculated

a) by dividing by the percentage calculated for 2024 in the new reduction schedule to be applied for the RV-quota calculation (see methodological approach to the implementation of measure A1.1 (increase HFC phase-down ambition) as discussed in section 8.1.1), and
b) by dividing by the 'new entrants reduction factor' of 0.89.

The thus calculated increased average POM is the reference value (RV) for HFC suppliers to the (previously exempted) MDI sector. That RV can be used for the calculation of RV-quota like for all other companies, by multiplying with the 0.89 reduction factor and by multiplying with the RV-quota reduction percentage for the respective year (see section 8.1.1). As the result of this calculation approach, the RV-quota allocated to HFC suppliers of the MDI sector for the first reduction step 2024-2026 under a revised Regulation will equal 100 % of the average 2015-2022 POM. For subsequent reduction steps, the relative reductions for the MDI sector will be proportionate to the reductions applicable to all other HFC use sectors.

8.6.1.2. Exemption for semiconductors (measure B1.2)

Quota-exempted supply of HFCs to the semiconductor manufacturing sector amounts to approximately 0.3 Mt CO_2 eq, less than 5 % of the demand of the MDI sector (see FGR evaluation report).

At present, no viable measures to reduce HFC demand in semiconductor industry for etching or cleaning of chemicals vapour deposition chambers are available. The EU semiconductor manufacturing industry is supplied with HFCs by specialised gas traders providing special-grade gas qualities. Those specialised trades have no or low reference values. If included in the quota system, these gas traders would need to rely on quota transfers from other quota holders in order to maintain HFC supply in case of constant HFC demand. A lift of the quota exemption for semiconductor manufacturing could thus possibly contribute to a supply risk for the semiconductor industry, beyond rising HFC prices.

This measure to increase consistency with the MP by lifting the semiconductor quota exemption by 2024 is thus assigned only to the *maximum feasibility* option. It is not considered for the *MP alignment* and *proportionate action* options. For the *maximum feasibility* option, the calculation approach to increase reference values for HFCs suppliers as described for the MDI sector in section 8.6.1.1 has to be applied as well to semiconductor manufacturing sector mutatis mutandis.

8.6.1.3. Exemption for military use (measure B1.1)

Quota-exempted supply of HFCs for military use has been reported in low quantities of about 0.1 Mt CO_2 eq per year (see FGR evaluation report).

This measure to increase consistency with the MP by lifting the quota exemption for military use by 2024 is assigned only to the *maximum feasibility* option. It is not considered for the *MP alignment* and *proportionate action* options. For the *maximum feasibility* option, the calculation approach to increase reference values for HFCs suppliers as described for the MDI sector in section 8.6.1.1 has to be applied as well to semiconductor manufacturing sector mutatis mutandis.

8.6.2. Removal of thresholds (measures B2)

8.6.2.1. Threshold for HFC POM (B2.1)

This policy measure relates to removing the HFC POM threshold of 100 tonnes of CO_2 eq as currently stated in Article 15 to achieve better alignment with the Montreal Protocol which does not foresee such minimum thresholds for market participants. Thresholds for reporting on production, imports, exports and destruction (B2.2)

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.6.3. Introduction of an EU-wide HFC production phase-down (measure B 3.1)

Next to the HFC consumption phase-down, the Montreal Protocol's Kigali Amendment features a parallel phase-down scheme for the production of HFCs in the EU and its Member States.

The EU & their MS can opt under the Montreal Protocol whether

a) each MS would need to comply individually with their respective HFC production phase-down, or
b) the EU would comply jointly as a "regional economic integration organisation" (REIO).

While the HFC consumption phase-down is complied with jointly as a REIO, the status quo for HFC production is compliance at MS level. Given an EU-wide scheme addressing the HFC production phase-down in a revised FGR, MS may possibly in future agree to switch to the REIO approach.

In order to facilitate EU compliance with that MP HFC production phase-down, the introduction of a EU-wide phase-down scheme for HFC production is proposed for all three policy options:

8.6.3.1. Metrics to be considered for the HFC production phase-down

"Production" as defined under the MP is produced amount minus feedstock use minus destruction. As clarified by means of the reporting rules,

- feedstock use eligible for subtraction is limited to produced amounts for feedstock use in the own country (for EU MS, this would apply on MS level), and
- non-captured amounts of generated HFCs (by-production) are not considered.

The baseline for the HFC production phase-down under the MP is calculated by adding

- the average 2011-2013 HFC production (defined as above) and
- 15% of the HCFC production baseline (as defined below).

The HCFC production baseline is the average of

- 1989 HCFC production + 2.8% of 1989 CFC production

- 1989 HCFC consumption + 2.8% of 1989 CFC consumption[33]

Consumption under the MP is production (as defined above) plus imports minus exports.

The envisaged FGR HFC production phase-down will apply to EU HFC producers. For those companies, uncaptured by-production, production for feedstock use and production destroyed before placing on the market should be considered (= subtracted from gross production reported in section 1A of the reporting questionnaire under FGR Art 19).

"Downstream" destruction of recovered used HFCs, imported into or collected within the EU, should not be considered for the FGR production phase-down. Such amounts (~ 0.5 – 2 Mt CO_2 eq/a in 2015-2019, EU28) destroyed in future can be considered a safety margin for compliance with the MP production phase-down, both at MS or possibly at EU/REIO level.

The activity subject to limitations under the EU FGR production PD should thus be:

"Production for Sale" (PfS) = Gross production (BDR: 1A) – uncaptured (by-)production amounts – Production for destruction – Production for feedstock use

Definition of production for destruction

In this context production for destruction covers the following as annually reported under FGR Art 19:

a) Captured production amounts destroyed by the producer
b) Captured production amounts handed over by the producer to another company for destruction

Definition of production for feedstock use

The subtraction for feedstock use may possibly refer to

a) own feedstock use by the producer
b) production for feedstock use with in the own MS
c) production for feedstock use by any company within the EU
d) production for feedstock use anywhere.

Note that cases a) & b) have been reported so far. Only cases a) & b would be subtractable under MP monitoring rules for compliance on EU MS level. However, to avoid any conflict with EU internal market principles, **the definition should be extended to cases a, b & c[34].**

Coverage of HFC-161

HFC-161 is an HFC according to Annex I of the FGR, but it is not covered under the MP. So far, no production of HFC-161 has been reported in the EU. **An explicit exemption of HFC-161 from the EU PfS production phase-down is thus not necessary.**

[33] For the Member States of the EU-12 of 1989 (Belgium, Denmark, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain and the United Kingdom) consumption data on MS is not available. For those parties to the MP, the Ozone Secretariat at UNEP thus uses HCFC & CFC production data only for the calculation of the HFC production baselines.

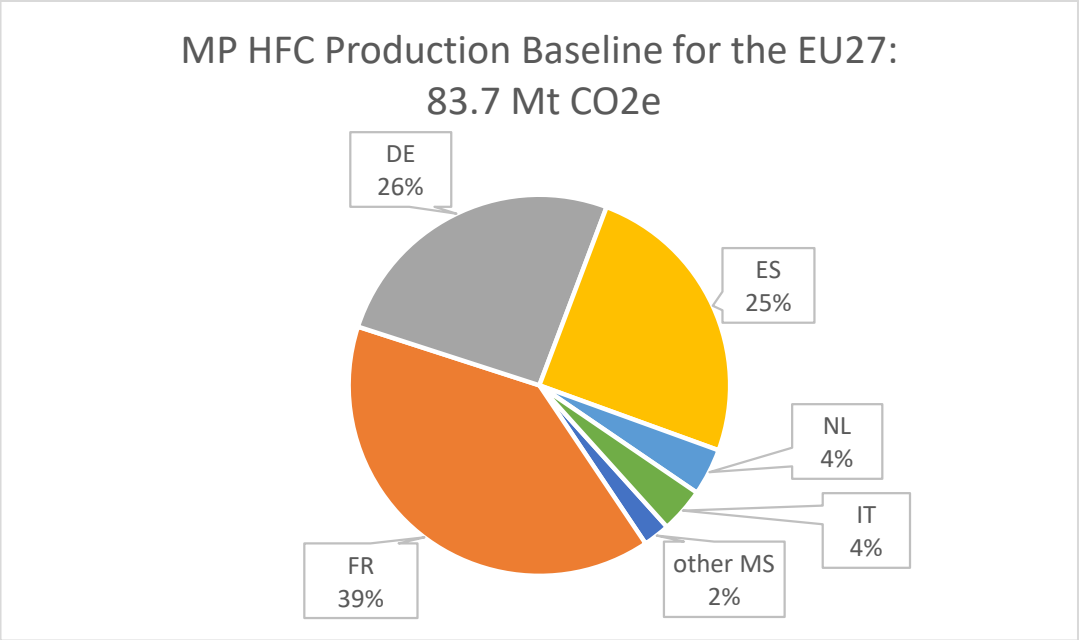
[34] In case HFC amounts would be reported for feedstock use in other EU MS, those could possibly be counterbalanced by downstream destruction of used HFCs, subject to subtraction under MP accounting rules for HFC production. Nevertheless, such an approach could theoretically lead to MP non-compliance at MS level. However, if EU MS will opt for the REIO approach, non-compliance at EU is even more unlikely.

8.6.3.2. The MP HFC production baseline for the EU and its MS

The HFC baseline of EU MS sum up to 83.7 Mt CO_2 eq for the EU27. 72% thereof are derived from 2011-2013 HFC production (corrected for feedstock use and destruction according to MP definitions), 28% are derived from the HCFC production baseline.

98% of the aggregated HFC production baselines for the EU27 are allocated to a set of five Member States: France, Germany, Spain, the Netherlands and Italy:

Figure 12: Distribution of EU HFC Production Baseline among MS



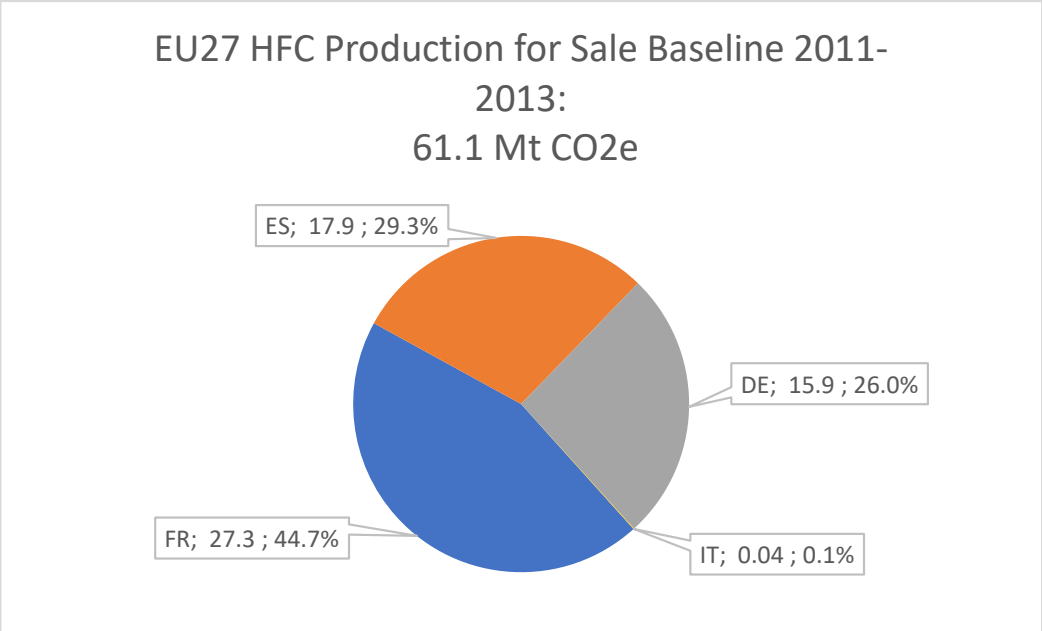
Source: UNEP 2021, own calculations of Öko-Institut

8.6.3.3. HFC production in the EU

Since 2015, HFC Production (defined as Production for Sale, PfS, see section 8.6.3.1) in the EU27 has been limited to France and Germany. HFC production ended 2014 in Spain, and 2012 in Italy. For all other EU MS, the MP HFC production baseline has been fully derived from the HCFC production baseline.

2011-2013 PfS of HFCs was reported by 7 companies in the EU27: 2x DE, 1x ES, 3x FR & 1x IT. Amounts and distribution among MS are given in Figure 13[35].

Figure 13: Distribution of EU HFC PfS Baseline among MS



Source: EEA confidential data 2020, own calculations of Öko-Institut.

The distribution of the PfS baseline between MS thus significantly differs from the MP HFC production baseline[36,37].

8.6.3.4. Allocation of MP HFC production baseline to EU HFC producers

Given the world-wide HFC consumption phase-down schemes agreed under the MP, the MP HFC production phase-down scheme wants to ascertain that overall production is phased down, but at the same time attempts to address a level playing field between HFC producers located in different parties to the MP, while leaving more time for developing countries. The objective of the proposed FGR HFC production phase-down scheme at EU level is thus to facilitate compliance with the MP production phase-down at MS and EU levels and at the same time to facilitate a level playing field between EU and non-EU HFC producers. Therefore, the allocation method of the EU HFC production baseline to involved companies should ideally feature a complete distribution of available production rights.

The general approach for the allocation of the MP baseline to companies is to assign to companies their 2011-2013 PfS baseline and additionally allocate a top-up based on the gap between the EU27 MP HFC production baseline and the aggregated EU27 2011-2013 PfS baseline.

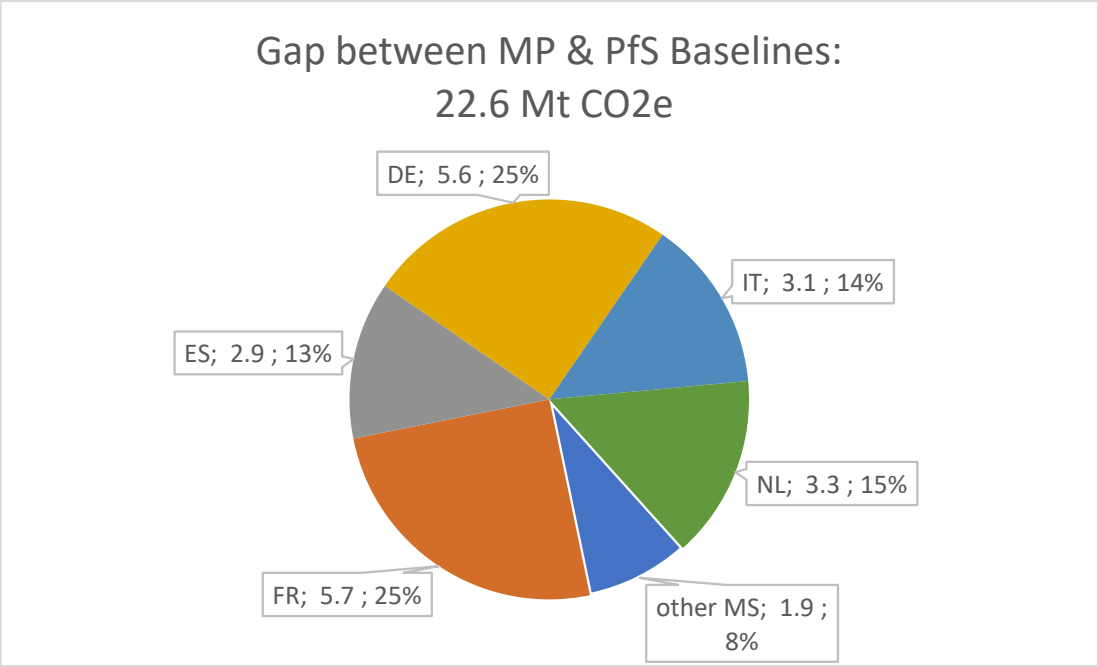
That gap amounts to 22.6 Mt CO_2 eq, that is about 27% of the EU27 baseline under the MP or 37% of the EU-wide 2011-2013 PfS baseline. As new entrant HFC producers in the EU are not expected under

[35] Note that this figure presents confidential data allowing insiders to conclude on the amount of production right of single companies. However, the numbers are central for the quantitative analysis in this chapter. If removed, approximate amounts could still be calculated based on Figure 14 and Figure 12.
[36] Note that no Dutch company would hold a PfS baseline, despite the NL 4% share in the MP baseline.
37 Note also that the Italian producer entitled to the PfS baseline did not (yet) register in the HFC registry. Significant HFC production in 2011 was "offset" by destruction of significant amounts of left-over HFC stocks in 2012, resulting in the very low 2011-2013 PfS baseline. As that company would benefit from allocation rules as proposed below for production 'quota', a late registration of that company's legal successor should be expected.

the circumstances of the production phase-down that gap of 22.6 Mt CO_2 eq should be distributed among the 7 EU27 PfS incumbents.

Figure 14[38] identifies the gaps at MS level and shows the distribution between MS:

Figure 14: Distribution of gap between MP HFC production baseline and EU27 2011-2013 PfS Baseline among MS



Source: UNEP website, EEA confidential data 2020, own calculations of Öko-Institut.

The gaps at MS level, expressed as percentage of the respective 2011-2013 PfS baseline at MS level, is given in Table 17.

Table 17: Gap between MP HFC production baseline and EU27 2011-2013 PfS Baseline

MS	Gap between MP HFC production baseline and 2011-2013 PfS baseline [% of PfS baseline]
FR	20.8%
DE	35.4%
ES	16.1%
IT	8614%
Other MS	NA
EU27 total	**36.9%**

Source: UNEP website, EEA confidential data 2020, own calculations of Öko-Institut

However, a relevant framework condition for a distribution of the gap is that the FGR production phase-down scheme shall be designed to safeguard compliance with the MP production phase-down not only at aggregated EU27 level but also at MS levels. An allocation approach for the gap which would avoid

[38] Data shown in Figure 14 was calculated by subtracting confidential data (Figure 13) from non-confidential data (Figure 12). Thus, Figure 14 is also confidential. However, the size of gaps is central to the analysis.

a stricter restriction of HFC production than in the case of measures taken individually by affected Member States (i.e. France and Germany) to comply with the MP HFC production phase-down does thus necessarily involve that the MS-specific gaps as given in Figure 14 / Figure 17 are allocated to the HFC producers of the respective MS. Given such an approach, MP baselines for France, Germany, Italy and Spain could be fully distributed, while the MP baselines for the other EU27-MS, amounting to about 5.2 Mt CO_2 eq, or 23 %, of the EU wide 'gap' (Figure 14), would not be directly allocated to any EU HC producers. However, given the approach for legal implementation as discussed in section 8.6.3.5

For the allocation of the French and German gaps to French and German HFC producers, a distribution method needs to be defined, for Italy and Spain this does not matter as only one company per MS is involved. The gap could be distributed either

a) Pro rata (same amount in t CO_2 eq per company in the respective MS), or
b) Proportional to the size of the 2011-2013 PfS baseline, or
c) In any combination of both approaches above (e.g. 50 % of gap distributed pro rata, 50 % proportional etc.)

The choice of the distribution method for the gap will imply at what speed and schedule the involved individual incumbents per MS will need to reduce domestic production (once the induvial reduction pathways, starting from the topped-up HFC production baseline, will decline below present production levels). The pro-rata approach appears to be easiest to justify. However, the choice of approach at this level does not have further implications on the general system, or the overall impact assessment.

8.6.3.5. Approach for legal implementation in the FGR

For the legal implementation in the revised FGR it is suggested to follow the approach taken in the ODS-Regulation for the ODS production phase-down which allows both companies and Member States to engage in transfers of production rights.

Thus, the MS holding MP base-line which would not be allocated to specific HFC producers under the distribution mechanism discussed in section 8.6.3.4 (i.e. all involved MS except DE, FR, IT & ES), could possibly transfer/sell such baseline to other MS, or to companies in other MS, provided that all involved MS agree and that the Commission is informed beforehand.

8.6.4. Disallow trade with non-Parties to the Montreal Protocol (measure B4.1)

In line with Article 4 of the MP, this policy measure introduces a prohibition of imports/exports of bulk HFCs from/to any country not Party to the Kigali Amendment as of 2028. The measure intends to safeguard compliance.

8.7. Measures to improve implementation and enforcement (measures C)

8.7.1. Measures to extend current certification programmes for technicians to include skills on the use of low-GWP alternatives (measures C1)

For the enhancement of the existing training requirements and certification schemes, it is suggested to add energy efficiency to the training requirements for technical personnel in the stationary RACHP sector in all scenarios, to add synergy with energy saving policies. This would expand the existing minimum requirements pursuant to Commission Regulation 2015/2067[39] and support the role of further decarbonisation of the sectors and might lead to additional emission reductions through further awareness raising and technical skills (measure C1.1).

[39] Commission Implementing Regulation (EU) 2015/2067 of 17 November 2015 establishing, pursuant to Regulation (EU) No 517/2014 of the European Parliament and of the Council, minimum requirements and the conditions for mutual recognition for

For the proportionate action and maximum feasibility scenarios it is further proposed to extend the existing certification schemes for the RACHP sector to unsaturated HFCs, unsaturated HCFCs as well as natural alternatives and to require practical training on all alternatives (measure C1.2). In this way, the required minimum theoretical and practical skills of technical personnel in the RACHP sector are aligned with the increasing use of alternatives to F-gases and the necessary qualification of technicians to install, service and maintain related equipment and systems.

8.7.2. Measures that affect customs and market surveillance authorities to prevent illegal trade (measures C2)

8.7.2.1. Requirements for the treatment of products and equipment and containers illegally placed on the market

Include specific requirements for customs regarding the treatment of products and equipment illegally placed on the market and illegal F-gas containers once confiscated.

8.7.2.2. Controlling special customs procedures for F-gases

This measure intends to provide for better control of special customs procedures (including transit, storage, specific use and processing) for F-gases through the EU with destination to non-EU countries and transit through some Member States with destination in another Member State. Permits should be given only to transit and other procedures for:

a) Goods sent to particular destination custom offices

b) Transaction where the minimum of 8-digit CN codes are indicated by the importer or exporter

The measure is included in all three scenarios.

8.7.3. Strengthen obligations of economic operators to prevent illegal trade (measures C3)

8.7.3.1. Prohibition of entry into EU territory of non-refillable F-gas containers (measure C3.1)

In all scenarios, a general prohibition of entry into EU territory of non-refillable F-gas containers and other illegal goods under the Regulation is proposed. Furthermore, it is suggested to extend the scope of such prohibition to unsaturated HFCs since these gases are increasingly being used in various applications.

The measure is included in all three scenarios.

8.7.3.2. Prohibition for offline and online sales and possession of F-gases illegally placed on the market (measure C3.2)

For all scenarios, a prohibition for (offline and online) sales and possession of HFCs/F-gases that were illegally placed on the market is included. This will improve market transparency and support enforcement of existing provisions.

8.7.3.3. Certification for importers and exporters of bulk HFCs under all customs procedures (measure C3.3)

It is suggested that importers and exporters of bulk HFCs under all customs procedures are required to hold certification pursuant to Commission Implementing Regulation (EU) 2015/2067, notably a Category III certificate.

The policy measure is included in the maximum feasibility scenario.

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the certification of natural persons as regards stationary refrigeration, air conditioning and heat pump equipment, and refrigeration units of refrigerated trucks and trailers, containing fluorinated greenhouse gases and for the certification of companies as regards stationary refrigeration, air conditioning and heat pump equipment, containing fluorinated greenhouse gases; https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:JOL_2015_301_R_0008

8.7.3.4. Certification for selling bulk F-gases online (measure C3.4)

For online sales, the requirement to hold a Category III certificate pursuant to Commission Implementing Regulation (EU) 2015/2067 is suggested. This measure intends to create awareness among customers and sellers and to prevent illegal trade.

The policy measure is included in the maximum feasibility scenario.

8.7.3.5. Documentation for downstream sales for bulk F-gases (measure C3.5)

The measure includes adding an obligation for documentation for downstream sales for bulk F-gases (e.g. “declaration of conformity”) and record keeping to improve market transparency and prevent illegal trade.

The measure forms part of the maximum feasibility scenario.

8.7.3.6. Registration and quota for producers and importers at the time of physical entry into territory (measure C3.6)

For all scenarios, it is suggested to add a requirement for producers and importers to be registered and hold sufficient quota at the time of release for free circulation/placing on the market / physical entry into territory.

8.7.3.7. Labelling of imported quota-exempted quantities (measure C3.7)

For all scenarios, an additional obligation for importers to have quota-exempted quantities labelled during physical entry into territory/POM is proposed. The requirement would be that gases must be explicitly labelled as “exempted from quota”.

8.7.3.8. Strengthen the obligation on destruction of HFC-23 by-production (measure C3.8)

This measure expands the obligation on destruction of HFC-23 by-production (Article 7(2)) by including the need to have a declaration of conformity and supporting evidence.

The measure is included in the proportionate action and high-ambition scenarios.

8.7.3.9. EU-wide minimum penalties for non-compliance (measure C3.9)

For all scenarios, a requirement to include minimum penalties to be enforced by EU Member States is suggested for quota exceedance, quota authorisation deficits, illegal issuance of authorisations, non-compliance with reporting deadlines and verification obligations and transport, storage and use of HFCs not covered by quota.

8.7.4. Measures to limit the market players to legitimate participants (measures C4)

8.7.4.1. Limit issuing quota authorisations to incumbents (C4.1)

The measure is included in all scenarios. It limits issuing quota authorisations to incumbents, i.e. companies which hold a reference value.

Under the FGR 517/2014 new entrants issuing were allowed to issue quota authorisation provided that the corresponding quantities of hydrofluorocarbons are physically supplied by the authorising new entrant. However, the number of quota holders having exclusively used their quota, mostly stemming from the new entrants’ reserve to issue (most likely: sell) quota authorisations has risen from below ten in 2015 to more than 400 in 2019. Proof of physical supply as required with the annual report under FGR Art 19 was often found to be insufficient. Large-scale misuse of the provisions of FGR 2014/517 is very likely. A restriction of quota authorisations to incumbents, i.e. companies holding a reference value, is sensible to avoid such fraudulent activities. Any new entrant will become an incumbent after recalculation (every 3 years). this measure therefore guarantees that companies have been on the market legitimately for at least 2 years before being able to give authorisations.

8.7.4.2. Alignment of frequency of quota allocation (measure C4.2)

For all scenarios, this measure aligns the establishment of the annual declaration-based quota allocation with the frequency of the quota allocation based on reference values

8.7.4.3. Introduction of a quota allocation fee (measure C4.3)

Suggested for proportionate action and maximum feasibility scenarios

Under the FGR 517/2014, the allocation of quota for the HFC phase-down is for free based on a grandfathering approach, complemented with a reserve for new entrants to be distributed evenly among all applicants. Unlike the EU ETS, where emission certificates are being auctioned, EU governments thus do not claim a fee which could possibly be re-distributed into the affected sectors with the aim to support the Regulation's objectives.

As discussed in the evaluation report, the free allocation of quota has incentivised illegitimate players to set up in large scales companies for the sole purpose of receiving quota and benefitting from the spread in HFC prices between the world market and the EU market created by the FGR HFC phase-down.

While the replacement of the grandfathering scheme by an auctioning scheme for quota was not analysed detail in this impact assessment due to anticipated too high administrative efforts, the introduction of a quota allocation fee is considered with the objective to reduce the incentive for illegitimate players to apply for quota, as a considerable upfront payment would be required for the receipt of quota.

The fee is suggested to be raised proportionate to the size of the quota allocation[40]. The size of the fee (in €/ t CO_2 eq) is intended to be significantly below levels observed for HFC price increases on the EU market in order to make sure that the fee would only partially draw on the profits gained by quota recipients and that the fee would thus ***not*** act comparably to a tax possibly involving a pass-through of cost to end-users.

That allocation fee is proposed to be set at 3 €/ t CO_2 eq for 2024, thus below recent market levels on HFC price increases (6 €/t CO_2 eq as OEM purchasing prices[41] in Q4 2020). The fee per t CO_2 eq is proposed to rise over time in reverse proportion to the development of the EU-wide maximum quantity for HFCs to be placed on the EU market under the FGR POM phase-down (for MaxQ schedules under the different policy options, please refer to section 8.1.2).

The procedure for raising the allocation fee may work as follows:

1) Calculation of RV-based quota, as established under FGR 517/2014, considering amendments related to lifting quota exemptions as discussed in section 8.6.1
2) Subtraction of quota penalties to be considered for incumbents.
3) Calculation of declaration-based quota for the for HFC quota remaining from the maximum quantity after step 2 as set out in FGR 517/2014
4) Subtraction of quota penalties for recipients of declaration-based quota and redistribution among declarants whose declarations have not yet been fully satisfied.
5) Flexibility for the European Commission to temporarily withhold quota allocation in case of pending decisions on quota penalties.
6) Communication to incumbents and declarants of quota amounts reserved for allocation (after subtraction of quota penalties), request to pay allocation fee by an appropriate deadline

[40] The concept of a flat-rate allocation fee per company, comparable to a flat-rate registration fee, was dismissed as it would discriminate small companies versus large incumbent quota holders.
[41] Source: Öko-Recherche HFC price monitoring on behalf of the European Commission

7) Quota amounts where the fee has not been paid by the deadline to be distributed free of charge, on pro-rata basis to all declarants which have fully paid their fee and whose declaration had not yet been fully satisfied.

The measure to introduce a quota allocation fee is proposed for the policy options "*proportionate action*" and "*maximum feasibility*". In the "*MP alignment*" policy option, the free allocation approach of FGR 2014/517 would be maintained.

8.7.5. Measures for more comprehensive monitoring (measures C5)

8.7.5.1. Extension of labelling requirements (measure C5.1)

This measure builds on the provisions of Article 12 and extends the labelling requirements to Annex II gases including unsaturated HCFCs and HFCs, NF_3 and fluorinated ethers used as anaesthetics and SO_2F_2. The measure also links to measure C5.16 (include new substances in Annex II and require reporting by companies) for consistency and is suggested for the proportionate action and maximum feasibility scenarios.

8.7.5.2. Registration and reporting for exporters of products and equipment (measure C5.2)

For the maximum feasibility scenario, it is suggested to include a registration and reporting obligation for exporters of products and equipment containing F-gases and other fluorinated substances.

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.3. Reporting for recipients of quota-exempted HFCs (measure C5.3)

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.4. Reporting for recycling companies (measure C5.4)

This measure relates to companies performing recycling of F-gases and sets reporting obligations.

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.5. Reporting for reclamation companies (measure C5.5)

The measure relates to reclamation facilities and establishes reporting obligations.

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.6. Reporting for operators of high-voltage electrical switchgear (measure C5.6)

The measure entails reporting obligation for operators of HV switchgear and electrical equipment (<52 kV) with regard to SF_6 emissions during lifetime and for operators in cooperation with certified personnel of electrical equipment for decommissioning of such equipment. This measure is only intended for option 3 (maximum feasibility scenario).

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

The measure is included in the high ambition scenario only.

8.7.5.7. Adjustment of verification threshold for bulk HFCs (measure C5.7)

The measure relates to verification obligations and is included in all three scenarios. However, the applicable thresholds vary between scenarios.

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.8. Obligation to submit verification reports for bulk HFCs (measure C5.8)

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.9. Reporting and verification thresholds and dates (measures C5.9, C5.10)

8.7.5.10. Bulk POM verification thresholds

Based on the quota amounts[42] received by companies in the years 2018, 2020 and 2021, an analysis was conducted to determine the share of companies which received quota amounts above different thresholds as well as the share of total allocated quota covered by different verification thresholds.

The total amount of allocated quota limited by the current F-gas regulation is decreasing to reach 31 % of 2021 values in 2030[43]. Under the assumption that the total number of companies remains at 2021 levels (i.e. 1 772) between 2021 and 2030 and that companies' share of total allocated quota is constant during this period, a projection of shares of companies and quota below different thresholds is developed and laid out in Table 18 and Table 19.

Table 18: Share of companies which received quota amounts above different thresholds

% of companies with quota …	2018	2020	2021	2025	2030
>500t CO_2 eq	100%	99%	99%	98%	97%
>1 000t CO_2 eq	100%	99%	98%	95%	86%
>2 000t CO_2 eq	99%	99%	89%	86%	83%
>2 500t CO_2 eq	99%	98%	88%	85%	59%
>3 000t CO_2 eq	99%	98%	87%	84%	30%
>5 000t CO_2 eq	98%	98%	84%	32%	15%
>10 000t CO_2 eq	97%	19%	23%	14%	3%
>20 000t CO_2 eq	33%	17%	12%	3%	2%

Source: DG Clima HFC registry, own calculations.

[42]Both quota allocated based on reference values as well as quota based on declarations were considered.
[43] See also the Maximum Quantity schedules as discussed in section 0

Table 19: Share of total allocated quota covered by different verification thresholds

% of Quota covered with threshold...	2018	2020	2021	2025	2030
>500t CO_2 eq	100.0%	100.0%	100.0%	100.0%	99.9%
>1 000t CO_2 eq	100.0%	100.0%	100.0%	99.8%	99.3%
>2 000t CO_2 eq	100.0%	100.0%	99.5%	99.3%	99.0%
>2 500t CO_2 eq	100.0%	100.0%	99.5%	99.2%	94.4%
>3 000t CO_2 eq	100.0%	100.0%	99.4%	99.1%	87.5%
>5 000t CO_2 eq	100.0%	99.9%	99.1%	88.0%	82.7%
>10 000t CO_2 eq	99.9%	91.6%	85.7%	82.3%	75.3%
>20 000t CO_2 eq	91.8%	90.8%	81.0%	75.2%	74.1%

Source: DG Clima HFC registry, own calculations

The analysis shows that while a threshold for a verification obligation of 10 000 t CO_2 eq affects 19 % of companies and covers about 92 % of reportable quota use in 2020, the same threshold would only cover about 75 % of reportable quota use in 2030. In order to achieve a quota coverage close to 100 % in the 2030 time-horizon (like in place until 2018), the threshold for the verification obligation would need to be lowered to 2 000 t CO_2 eq. Then, a quota coverage of 99 %, affecting 83 % of quota holders (approx. 1 500 out of ~1 800 assumed quota holders) would be reached. A threshold of 1 000 t CO_2 eq would de facto probably have very similar effects like a threshold of 2 000 t CO_2 eq. Only few additional companies are likely to be affected.

8.7.5.11. RAC Equipment verification thresholds

Authorisation use as reported by equipment importing companies for the year 2020 (approximately 1,000 companies reporting on imports of approx. 10 Mt CO_2 eq) was compared to different thresholds for verification. Table 20 shows that while a threshold of 100 t CO_2 eq requires about 83 % of equipment importing companies to verify their report, a threshold of 500 t CO_2 eq would reduce this share to 61 % and a threshold of 1 000 t CO_2 eq would require less than half of equipment importing companies to verify their report. Due to the large amount of small equipment importing companies, a verification threshold of 1 000 t CO_2 eq would still cover 98 % of the HFCs in imported equipment[44].

[44] NB: Since about 17% of companies reporting on equipment imports report on amounts below 100t CO_2e, their imports are included as being 0 in the dataset used for the analysis. This leads to a slight overestimation of the amount of gas covered by different verification thresholds.

Table 20: Authorisation use by companies compared to verification thresholds

Verification threshold option	% of companies with authorisation use above threshold for obligatory verification	% of authorisation use above threshold for obligatory verification
>100t CO_2 eq	83%	100%
>500t CO_2 eq	61%	99%
>1 000t CO_2 eq	48%	98%
>2 000t CO_2 eq	36%	96%
>2 500t CO_2 eq	33%	96%
>3 000t CO_2 eq	29%	95%
>5 000t CO_2 eq	22%	92%
>10 000t CO_2 eq	15%	86%
>20 000t CO_2 eq	8%	76%

Source: Data reported by companies to EEA BDR, own calculations

8.7.5.12. Conclusion on verification thresholds

In the sole perspective of bulk verification, a threshold of 2 000 t CO_2 eq would be advisable in order to secure ~99 % quota coverage in the 2030 time-horizon.

In the sole perspective of equipment verification, a 500 t CO2 eq threshold would likely secure 99 % coverage of RAC equipment imports while restricting the verification obligation to about 60 % of importers.

For a joint threshold for bulk & equipment verification a threshold of 1 000 t CO_2 eq is suggested which would likely cover about 99 % of bulk quota & 98 % of equipment imports while lifting the verification obligation for approx. 50 % of equipment importers.

8.7.5.13. Legal basis for electronic verification process (measure C5.11)

The measure is included in the proportionate and high ambition scenarios. Separate processes for bulk and pre-charged products and equipment are to be set up.

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.14. Reporting and quota authorisation thresholds for imported products and equipment (measure C5.12)

The measure is included in all scenarios and establishes thresholds related to reporting and quota authorisations for imported products and equipment.

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.15. Obligation to provide NIL reports for quota holders (measure C5.13)

The measure sets an obligation for registered companies with activities below the reporting thresholds to provide a NIL report for the respective reporting year. It intends to facilitate compliance checks for quota and authorisation holders and represents also an alignment with reporting obligations under the EU ODS Regulation.

For details, please refer to Table 22 (Overview on details of measures related to reporting and verification and assignment to policy options) in section 8.8 (Summary on conclusion for measures related to reporting and verification).

8.7.5.16. Use of electronic reporting systems for collection of F-gas data (measure C5.14)

In medium scenario: Encourage Member States to use electronic reporting systems for collection of F-gas service intervention, technicians, sale of non-hermetic equipment and emissions data

In high ambition scenario: Require Member States to use electronic reporting systems for collection of F-gas service intervention, technicians, sale of non-hermetic equipment and emissions data

8.7.5.17. Inclusion of new substances in Annex I (measure C5.15)

This measure suggests including new substances in Annex I which are not currently covered by the FGR. The measure is included in all scenarios.

Perfluorodecalin ($C_{10}F_{18}$): consistency with UNFCCC reporting requirements where perfluorodecalin is already included. Two isomers of perfluorodecalin exist that have different GWP values. UNFCCC reporting follows the AR4 GWPs, where perfluorodecalin is not differentiated by isomer and is assigned a GWP of '>7 500' (UNFCCC simply states a GWP of 7 500[45]). The 6th IPCC AR differentiates between the cis- and trans-isomer and states GWPs of 7 800 and 7 120, respectively.

Long-chain PFCs, on average, feature high GWP values and are increasingly used in various industry applications, as shown in the following table.

Table 21: Long-chain PFCs to be included in policy measure C5.15

Substance	Application	Current EU market size (year)
C_6F_{12} pp1c	Misc applications inc medical research and tagging and tracing applications	< 100 kg, growth to several 100 kg expected short-term
C_6F_{14}	Direct contact cooling; Heat transfer fluid in ORC Medical research, insulation	Already part of Annex I; other isomer: isomer perfluoro-i-hexane specifically perfluoro-2-methylpentane also relevant (ca. 90 t in EU)
C_9F_{16} pp3	Direct contact cooling and other applications including tracing and tagging,	1-3 tonnes
$C_{10}F_{18}$ pfd	Main use is in eye surgery	4-6 tonnes
$C_{14}F_{24}$ pp11	Polymer transfer agent	1-2 tonnes

Sulfuryl fluoride (SO_2F_2, AR6 GWP 4 630) is used, mainly as a fumigant in postharvest treatment, in large quantities as an alternative to methyl bromide, which was phased-out under the MP.

8.7.5.18. Include new substances in Annex II and require reporting by companies, emission prevention, labelling (measure C5.16)

The measure is linked to measures A2.10 (section 8.3). It proposes to include the following substances in Annex II:

- Sevoflurane (HFE-347mmz1, AR6 GWP 195)
    - Most used inhalation anaesthetic in Europe together with desflurane
- Enflurane (HCFE-235ca2, AR6 GWP 654)

[45] https://unfccc.int/process-and-meetings/transparency-and-reporting/greenhouse-gas-data/frequently-asked-questions/global-warming-potentials-ipcc-fourth-assessment-report

  - Isomer of isoflurane
  - Was used in Europe as an inhalation anaesthetic but not for some decades

- Cis-1-chloro-2,3,3,3-tetrafluoroprop-1-ene (HCFC-1224yd(Z), no AR GWPs)
  - Alternative to HFCs to be used as refrigerant in centrifugal chillers, binary cycle generators and waste heat recovery heat pumps, but also as blowing agent, aerosol solvent, and cleaning solvent[46]

- Cis/Trans-1,2-difluoroethylene (HFC-1132, no AR GWP)
  - Part of a new coolant for electric vehicles as an alternative to HFC-1234yf[47]

- 1,1-difluoroethylene (R1132a, vinylidene fluoride, AR6 GWP 0.052)
  - Part of new refrigerant mixtures (R468A[48], R473A[49])

- 2,3,3,3-tetrafluoro-2-(trifluoromethyl)propanenitrile ($(CF_3)_2CFCN$, C4-PFN or Novec 4710 AR6 GWP 2 750)
  - Alternative for SF_6 as insulation gas in electrical switchgear and transmission lines
  - Used in a mixture with CO_2 that reduces the GWP of the mixture from 2 100 to 292, according to the gas manufacturer[50] (using the AR6 GWP of Novec 4710 and the stated mole % of 3.5 from the manufacturer, the AR6 GWP of the mixture would be 382)

- 1,1,1,3,4,4,4-heptafluoro-3-(trifluoromethyl)-2-butanone ($(CF_3)_2CFC(O)CF_3$, Novec 5110, GWP <1 according to manufacturer[51])
  - Alternative for SF_6 as insulation gas in electrical switchgear and transmission lines

- Perfluorotripropylamine ($C_9F_{21}N$, AR6 GWP 9 030)
  - Used as heat transfer fluid in the semiconductor industry[52]

- Perfluoro-N-methylmorpholine (FC-3284, $C_5F_{11}NO$, no AR GWP)
  - Used as heat transfer fluid in the semiconductor industry[53]

- Perfluorotributylamine (PFTBA, FC-43, $C_{12}F_{27}N$, AR6 GWP 8 490)
  - Used in electronics industry, for medical and analytical purposes and as a heat transfer fluid[54]

- Fluorinated ethers and alcohols: HFE-7300[55] (AR 6 GWP 405); HFE-7100[56] ($C_4F_9OCH_3$; average AR6 GWP 491[57]), HFE-7200[58] ($C_4F_9OC_2H_5$; AR6 GWP 34.3)

[46] https://www.agc-chemicals.com/jp/en/products/detail/index.html?pCode=JP-EN-G016
[47] https://www.coolingpost.com/world-news/daikin-develops-more-efficient-refrigerant-for-electric-vehicles/
[48] https://www.coolingpost.com/world-news/refrigerant-report-lists-new-honeywell-and-daikin-refrigerants/
[49] https://www.coolingpost.com/world-news/new-refrigerant-options-await-ashrae-approval/
[50] https://multimedia.3m.com/mws/media/1132124O/3m-novec-4710-insulating-gas.pdf
[51] https://multimedia.3m.com/mws/media/1132123O/3m-novec-5110-insulating-gas.pdf
[52] German emission reporting: https://www.umweltbundesamt.de/sites/default/files/medien/5750/publikationen/2021_01_07_texte_02-2021_abschlussbericht_inventarerhebung_2017-2018.pdf, p.26.
[53] https://multimedia.3m.com/mws/media/64887O/3m-fluorinert-electronic-liquid-fc3284-en.pdf
[54] https://multimedia.3m.com/mws/media/64889O/3m-novec-fluorinert-electronic-liquid-fc43.pdf
[55] https://multimedia.3m.com/mws/media/338713O/3m-novec-7300-engineered-fluid.pdf
[56] https://multimedia.3m.com/mws/media/199818O/3m-novec-7100-engineered-fluid.pdf
[57] HFE-7100 consists of two isomers of $C_4F_9OCH_3$ with different AR6 GWPs of 544 and 437. The average GWP is 492.
[58] https://multimedia.3m.com/mws/media/199819O/3m-novec-7200-engineered-fluid-en.pdf

- Used as heat transfer fluids, cleaning and rinsing agents for industry applications, carrier for lubricants and other specialized industry applications.

- Sulfuryl fluoride (SO_2F_2, AR6 GWP 4 630)
    - Used mainly as a fumigant in postharvest treatment in large quantities as an alternative to methyl bromide
    - To be included in Annex II or potentially Annex I (see measure C5.14, section 8.7.5.17)

8.7.5.19. Move substances from Annex II to Annex I (measure C5.17)

The measure proposes to move certain substances from Annex II to Annex I. Specifically, the measure includes that

- perfluorocyclopropane (c-C_3F_6) would be moved to section 2 of Annex I,
- nitrogen trifluoride (NF_3) would be moved to section 3 of Annex I and
- the entire section 1 in Annex II that covers unsaturated H(C)FCs would be moved to a new section in Annex I.

Since this measure is already covered by other measures (A2.10 and C5.1), it is not further considered in the assessment.

8.8. Summary on conclusion for measures related to reporting and verification

Table 22: Overview on details of measures related to reporting and verification and assignment to policy options

Topic of measure		FGR 2014	Comment	Policy option 1: "MP alignment"	Policy option 2: "proportionate action"	Policy Option 3: "Maximum feasibility"
Reporting obligation & thresholds (Art 19)						
B2.2	Production	Threshold: 1 t / 100 t CO_2 eq of Annex I & II	For HFCs, a reporting threshold in inconsistent with the EU reporting obligation under the MP	Remove threshold for HFCs, keep threshold for other Annex I & Annex II gases	= option 1	= option 1
B2.2	Bulk import	Threshold: 1 t / 100 t CO_2 eq of Annex I & II	For HFCs, a reporting threshold in inconsistent with the EU reporting obligation under the MP	Remove threshold for HFCs, keep threshold for other Annex I & Annex II gases	= option 1	= option 1
B2.2	Bulk export	Threshold: 1 t / 100 t CO_2 eq of Annex I & II	For HFCs, a reporting threshold in inconsistent with the EU reporting obligation under the MP	Remove threshold for HFCs, keep threshold for other Annex I & Annex II gases	= option 1	= option 1
B2.2	destruction	Threshold: 1 t / 1000 t CO_2 eq of Annex I & II	For HFCs, a reporting threshold in inconsistent with the EU reporting obligation under the MP	Remove threshold for HFCs, keep threshold for other Annex I & Annex II gases	= option 1	= option 1
C5.4	Recycling	None	Obligation for bulk importers in 2014 FGR; Formal obligation for registration in HFC registry not necessary	none	none	Add obligation for Annex I & Annex II gases, threshold: 1 t / 100 t CO_2 eq
C5.5	Reclamation	None	Obligation for bulk importers in 2014 FGR; Formal obligation for registration in HFC registry not necessary	none	Add obligation for Annex I & Annex II gases, threshold: 1t / 100 t CO_2 eq	= option 2
C5.3	Recipients of quota-exempted gases for destruction, feedstock use & export	Existing reporting obligation for destruction, feedstock use & export		Keep FGR 2014	Keep FGR 2014	Keep FGR 2014
C5.3	Recipients of quota-exempted gases for military uses, semiconductor industry & pharmaceutical MDIs	none		none	Add obligation to report on received exempted HFCs & identify supplier, no threshold	= option 2

C5.9	Product/Equipment imports	Threshold: 500 t CO_2 eq of Annex I & II	Higher than 100 t CO_2 eq HFC threshold for authorisation obligation and verification obligation Reporting threshold defined in CO_2 eq leaves large gap for importers of HFO equipment (vehicle AC)	Threshold: 100 t CO_2 eq of HFCs and 500 t CO_2 eq of Annex I & II	= option 1	Threshold: 1t / 100 t CO_2 eq of Annex I & II
C5.2	Product/Equipment exports	None	Formal obligation for registration in HFC registry not necessary HFC equipment exports relevant in quota & MP context: reexports from inward processing. SF_6 likely relevant in absolute terms	none	none	Threshold: 1t / 100 t CO_2 eq of HFCs & SF_6
C5.6	Operation and decommissioning of electrical equipment / SF_6	None	**Reporting on lifetime losses by grid operators:** Formal obligation for registration in HFC registry not necessary, Scope of reportable data should include: Country of operation, type and quantity of refilled equipment, SF_6 amounts refilled **Reporting obligation directed to undertakings active in the decommissioning of electrical equipment (EoL treatment).** Formal obligation for registration in HFC registry not necessary, Scope of reportable data should include: Country of decommissioning, type of equipment Standard charge Recovered charge Supplementary Obligation for equipment operators to provide standard charge to decommissioner to be added	None	None	Threshold: 5 kg SF_6 [~ 100 t CO_2 eq)
C5.13	Mandatory NIL report for registered companies with activities below reporting thresholds	None	Would help compliance checks for quota & authorisation holders	Obligatory for quota holders	= option 1	Obligatory for both • quota holders for the respective year • equipment importers holding authorisation at the end of the respective year

Verification obligation & thresholds (Art 19 & 14)						
C5.8	POM of HFCs (bulk)	Threshold: 10 000 t CO_2 eq	See analysis in section 8.7.5.8	Threshold: 2 000 t CO_2 eq	Threshold: 1 000 t CO_2 eq	= option 2
C5.10	POM of HFCs in RAC equipment	No explicit threshold,	In FGR 2014, da-facto application of 100t CO_2 eq threshold based on Art 15 See analysis in section 8.7.5.9	Threshold: 1 000 t CO_2 eq	= option 1	Threshold: 500 t CO_2 eq
C5.10	POM of HFCs in RAC equipment	Verification obligation defined on Declarations of Conformity (FGR Art14, DoC), not on Art 19 report		clarify verification obligation to apply to both Art 19 report & DoCs	= option 1	= option 1
Submission obligation for verification reports (Art 19 & 14)						
C5.9	POM of HFCs (bulk)	On request by authorities	BDR submission facility is available	Obligatory in all cases above threshold	= option 1	= option 1
C5.10	POM of HFCs in RAC equipment	Obligatory in all cases above threshold	BDR submission facility is available	Keep FGR 2014	Keep FGR 2014	Keep FGR 2014
Timing of reporting obligation (Art 19)						
C5.11	All reporters	31 March		Keep FGR 2014	Keep FGR 2014	Keep FGR 2014
Timing of verification (& submission) obligation (Art 19, Art 14)						
C5.11	POM of HFCs (bulk)	30 June	Joint date for bulk & equipment preferable, 30 June is challenge for compliance process	30 April	= option 1	= option 1
C5.11	POM of HFCs in RAC equipment	31 March	Equalling reporting deadline. Timespan between report & verification makes sense many Verifiers are busy with ETS for 31 March deadline	30 April	= option 1	= option 1

Integration of electronic verification into the BDR reporting process						
C5.12	POM of HFCs (bulk)	none	Process modelled after established ETS processes would render verification processes more efficient and easier accessible for compliance checks. Processes would cover verification thresholds & submission obligations & is in line with approach to timing deadlines	none	Set legal basis	= option 2
C5.12	POM of HFCs in RAC equipment	none		none	Set legal basis	= option 2

9. Fully specified policy options

The following table provides an overview of the policy options and measures.

Table 23: Overview of policy options and measures

		POLICY OPTION 1: Alignment with the Montreal Protocol & low-cost implementation	**POLICY OPTION 2: Achieve proportionate emission savings and implementation improvements**	**POLICY OPTION 3: High ambition / maximum feasibility**
Objective A: Raising ambition in line with the EU Green Deal				
A1) Increase HFC phase-down ambition	**A1.1**	HFC POM phase-down → ensure long-term compliance under all circumstances	HFC POM phase-down → MP compliance & further steps at proportionate costs (among others, < 390 €/t CO_2 eq)	HFC POM phase-down → compliance & further steps to force further replacement of F-gases as soon as technically and economically possible
A2) Prohibit F-gases in products or equipment	**A2.1**		POM prohibition for HFCs in stationary AC and HPs ≤ 12 kW and GWP ≥ 150 from 2025 > 12 kW and GWP ≥ 750 from 2025	POM prohibition for HFCs in stationary AC and HPs ≤ 12 kW and GWP ≥ 150 from 2025 > 12 kW and GWP ≥ 750 from 2025
	A2.2	POM prohibition for HFCs in small hermetic stationary refrigeration units for commercial and household use from 2024	POM prohibition for HFCs in small hermetic stationary refrigeration units for commercial and household use from 2024	POM prohibition for HFCs in small hermetic stationary refrigeration units for commercial and household use from 2024
	A2.3		Remove the existing exemption for servicing and maintenance of refrigeration equipment with a charge size below 40 tonnes of CO_2 eq with virgin F-gases	Remove the existing exemption for servicing and maintenance of refrigeration equipment with a charge size below 40 tonnes of CO_2 eq with virgin F-gases
	A2.4	POM prohibition for fire protection equipment containing or relying on HFCs, except when required to meet national safety standards from 2024	POM prohibition for fire protection equipment containing or relying on HFCs, except when required to meet national safety standards from 2024	POM prohibition for fire protection equipment containing or relying on HFCs, except when required to meet national safety standards from 2024
	A2.5		POM prohibition for HFCs and PFCs in personal care products from 2024	POM prohibition for HFCs and PFCs in personal care products from 2024
	A2.6	POM prohibition for PFCs and blends containing PFCs in RACHP equipment from 2024	POM prohibition for PFCs and blends containing PFCs in RACHP equipment from 2024	POM prohibition for PFCs and blends containing PFCs in RACHP equipment from 2024
	A2.7		POM prohibition for new medium voltage electrical switchgear	POM prohibition for new medium voltage electrical switchgear

		POLICY OPTION 1: Alignment with the Montreal Protocol & low-cost implementation	POLICY OPTION 2: Achieve proportionate emission savings and implementation improvements	POLICY OPTION 3: High ambition / maximum feasibility
			• for primary distribution, differentiated by voltage level – up to 24 kV from 2026 and 24-52 kV from 2030, using F-gases with GWP >2 000 as insulating or breaking medium; • for secondary distribution, differentiated by voltage level – up to 24 kV from 2026 and 24-52 kV from 2030, using F-gases with GWP >2 000 as insulating or breaking medium.	• for primary distribution, differentiated by voltage level – up to 24 kV from 2026 and 24-52 kV from 2030, using F-gases with GWP >2 000 as insulating or breaking medium; • for secondary distribution, differentiated by voltage level – up to 24 kV from 2026 and 24-52 kV from 2030, using F-gases with GWP >2 000 as insulating or breaking medium.
	A2.8		POM prohibition for new high voltage electrical switchgear • in the range of 52-145 kV and up to 50 kA short circuit current from 2028, using F-gases with GWP >2 000 as insulating or breaking medium; • in the range of more than 145 kV or more than 50 kA short circuit current from 2031, using F-gases with GWP >2 000 as insulating or breaking medium.	POM prohibition for new high voltage electrical switchgear • in the range of 52-145 kV and up to 50 kA short circuit current from 2028, using F-gases with GWP >2 000 as insulating or breaking medium; • in the range of more than 145 kV or more than 50 kA short circuit current from 2031, using F-gases with GWP >2 000 as insulating or breaking medium.
	A2.9		Use prohibition for inhalation anaesthetics containing other F-gases listed in Annex II with GWP > 500 from 2024	Use prohibition for inhalation anaesthetics containing other F-gases listed in Annex II with GWP > 500 from 2024
	A2.10	Further requirements for Annex II gases (Section 1 gases, NF_3, inhalation anaesthetics, Sulfuryl fluoride)	Further requirements for Annex II gases (Section 1 gases, NF_3, inhalation anaesthetics, Sulfuryl fluoride)	Further requirements for Annex II gases (Section 1 gases, NF_3, inhalation anaesthetics, Sulfuryl fluoride)
A3) Extend requirements for the prevention of F-gas emissions	**A3. 1**		Emission prevention requirements for manufacturing, transport, transfer and storage of bulk gases → Annex I all and Annex II partly (Section 1 gases, NF_3, inhalation anaesthetics, Sulfuryl fluoride))	Emission prevention requirements for manufacturing, transport, transfer and storage of bulk gases → Annex I all and Annex II partly (Section 1 gases, NF_3, inhalation anaesthetics, Sulfuryl fluoride))
A4) Recovery of insulation foams blown with HFCs	**A4.1**	Destruction of HFCs in steel-faced panels or reuse from 2024	Destruction of HFCs in steel-faced panels or reuse from 2024	Destruction of HFCs in steel-faced panels or reuse from 2024

		POLICY OPTION 1: Alignment with the Montreal Protocol & low-cost implementation	POLICY OPTION 2: Achieve proportionate emission savings and implementation improvements	POLICY OPTION 3: High ambition / maximum feasibility
	A4.2		Destruction (or reuse) of HFCs in laminated boards in built-up structures and cavities, unless feasibility is proven by the building owner/demolition company from 2024	Destruction (or reuse) of HFCs in laminated boards in built-up structures and cavities, unless feasibility is proven by the building owner/demolition company from 2024
Objective B: Seeking alignment with the Montreal Protocol				
B1) To achieve full alignment, remove some exemptions not foreseen by the Montreal Protocol	**B1.1**			Remove POM exemption for military equipment
	B1.2			Remove POM exemption for semiconductors
	B1.3	Remove POM exemption for MDIs	Remove POM exemption for MDIs	Remove POM exemption for MDIs
B2) To achieve full alignment, remove some thresholds not foreseen by the Montreal Protocol	**B2.1**	Remove HFC POM threshold of 100 tonnes of CO_2 eq	Remove HFC POM threshold of 100 tonnes of CO_2 eq	Remove HFC POM threshold of 100 tonnes of CO_2 eq
	B2.2	Remove reporting thresholds	Remove reporting thresholds	Remove reporting thresholds
B3) To achieve full alignment, make separate phasing down of HFC production	**B3.1**	HFC production phase-down	HFC production phase-down	HFC production phase-down
B4) Disallow trade with non-Parties to the Montreal Protocol	**B4.1**	Prohibition of imports/exports of bulk HFCs from/to any country not Party to the Kigali Amendment as of 2028	Prohibition of imports/exports of bulk HFCs from/to any country not Party to the Kigali Amendment as of 2028	Prohibition of imports/exports of bulk HFCs from/to any country not Party to the Kigali Amendment as of 2028
Objective C: Improve implementation and enforcement				
C1) Certification of technicians to include skills on the use of low-GWP alternatives	**C1.1**	Adding energy efficiency issues to be part of training	Adding energy efficiency issues to be part of training	Adding energy efficiency issues to be part of training
	C1.2		Certification programmes also for saturated HFCs and HCFCs and other natural alternatives and to include practical training on all alternatives	Certification programmes also for saturated HFCs and HCFCs and other natural alternatives and to include practical training on all alternatives
	C1.3		Installation/servicing/repair/maintenance of RACHP equipment only by certified personnel (unsaturated HFCs)	Installation/servicing/repair/maintenance of RACHP equipment only by certified personnel (unsaturated HFCs)

		POLICY OPTION 1: Alignment with the Montreal Protocol & low-cost implementation	POLICY OPTION 2: Achieve proportionate emission savings and implementation improvements	POLICY OPTION 3: High ambition / maximum feasibility
C2) Including detailed rules to empower customs and surveillance authorities in the EU Member States and facilitate the use of the EU "Single Window environment for Customs"	**C2.1**	Include specific requirements for customs regarding the treatment of products and equipment illegally placed on the market and illegal F-gas containers once confiscated	Include specific requirements for customs regarding the treatment of products and equipment illegally placed on the market and illegal F-gas containers once confiscated	Include specific requirements for customs regarding the treatment of products and equipment illegally placed on the market and illegal F-gas containers once confiscated
	C2.2	Control special procedures (including transit, storage, specific use and processing) for F-gases through the EU with destination to non-EU countries and transit through some Member States with destination in another Member State Controlling customs special procedures. Only permit transit and other procedures for: c) Goods sent to particular destination custom offices d) Transaction where the minimum of 8-digit CN codes are indicated by the importer or exporter	Control special procedures (including transit, storage, specific use and processing) for F-gases through the EU with destination to non-EU countries and transit through some Member States with destination in another Member State Controlling customs special procedures. Only permit transit and other procedures for: a) Goods sent to particular destination custom offices b) Transaction where the minimum of 8-digit CN codes are indicated by the importer or exporter	Control special procedures (including transit, storage, specific use and processing) for F-gases through the EU with destination to non-EU countries and transit through some Member States with destination in another Member State Controlling customs special procedures. Only permit transit and other procedures for: a) Goods sent to particular destination custom offices b) Transaction where the minimum of 8-digit CN codes are indicated by the importer or exporter
C3) Strengthen obligations of economic operators to prevent illegal trade	**C3.1**	General prohibition of entry into EU territory of non-refillable F-gas containers and other illegal goods under the Regulation and extend the scope to unsaturated HFCs	General prohibition of entry into EU territory of non-refillable F-gas containers and other illegal goods under the Regulation and extend the scope to unsaturated HFCs	General prohibition of entry into EU territory of non-refillable F-gas containers and other illegal goods under the Regulation and extend the scope to unsaturated HFCs
	C3.2	Prohibition for (offline and online) sales and possession of HFCs/F-gases that were illegally placed on the market	Prohibition for (offline and online) sales and possession of HFCs/F-gases that were illegally placed on the market	Prohibition for (offline and online) sales and possession of HFCs/F-gases that were illegally placed on the market
	C3.3			Mandatory certification of importers pursuant to Commission Implementing Regulation 2015/2067, notably Category III certificate.
	C3.4			Add obligation for certification for natural persons and undertakings selling bulk F-gases online
	C3.5			Add obligation for documentation for downstream sales for bulk HFC/F-gases

		POLICY OPTION 1: Alignment with the Montreal Protocol & low-cost implementation	POLICY OPTION 2: Achieve proportionate emission savings and implementation improvements	POLICY OPTION 3: High ambition / maximum feasibility
				(e.g. "declaration of conformity") and record keeping
	C3.6	Add requirement for producers and importers to be registered and hold sufficient quota at the time of release for free circulation/placing on the market / physical entry into territory	Add requirement for producers and importers to be registered and hold sufficient quota at the time of release for free circulation/placing on the market / physical entry into territory	Add requirement for producers and importers to be registered and hold sufficient quota at the time of release for free circulation/placing on the market / physical entry into territory
	C3.7	Add obligation for importers to have quota-exempted quantities labelled during physical entry into territory/POM Gases must be explicitly labelled as "exempted from quota"	Add obligation for importers to have quota-exempted quantities labelled during physical entry into territory/POM Gases must be explicitly labelled as "exempted from quota"	Add obligation for importers to have quota-exempted quantities labelled during physical entry into territory/POM Gases must be explicitly labelled as "exempted from quota"
	C3.8		Strengthen the obligation on destruction of HFC-23 by-production	Strengthen the obligation on destruction of HFC-23 by-production
	C3.9	Include minimum penalties to be enforced by EU Member States for quota exceedance, quota authorisation deficits, illegal issuance of authorisations, non-compliance with reporting deadlines and verification obligations and transport, storage and use of HFCs not covered by quota	Include minimum penalties to be enforced by EU Member States for quota exceedance, quota authorisation deficits, illegal issuance of authorisations, non-compliance with reporting deadlines and verification obligations and transport, storage and use of HFCs not covered by quota	Include minimum penalties to be enforced by EU Member States for quota exceedance, quota authorisation deficits, illegal issuance of authorisations, non-compliance with reporting deadlines and verification obligations and transport, storage and use of HFCs not covered by quota
C4) Limit the market players to legitimate participants	**C4.1**	Limit issuing quota authorisations to incumbents, i.e. based on reference-based quota	Limit issuing quota authorisations to incumbents, i.e. based on reference-based quota	Limit issuing quota authorisations to incumbents, i.e. based on reference-based quota
	C4.2	Align the establishment of the annual declaration-based quota allocation with the frequency of the quota allocation based on reference values	Align the establishment of the annual declaration-based quota allocation with the frequency of the quota allocation based on reference values	Align the establishment of the annual declaration-based quota allocation with the frequency of the quota allocation based on reference values
	C4.3		Introduction of a quota allocation fee linked to CO_2 eq	Introduction of a quota allocation fee linked to CO_2 eq
C5) More comprehensive monitoring	**C5.1**		Extend labelling requirement to Annex II gases	Extend labelling requirement to Annex II gases

		POLICY OPTION 1: Alignment with the Montreal Protocol & low-cost implementation	POLICY OPTION 2: Achieve proportionate emission savings and implementation improvements	POLICY OPTION 3: High ambition / maximum feasibility
	C5.2			Registration and reporting obligation for exporters of products and equipment containing F-gases and other fluorinated substances
	C5.3		Reporting obligation for recipients of quota-exempted HFCs	Reporting obligation for recipients of quota-exempted HFCs
	C5.4		Reporting obligation for undertakings (facilities) performing recycling of F-gases	Reporting obligation for undertakings (facilities) performing recycling of F-gases
	C5.5		Reporting obligation for undertakings (facilities) performing reclamation of F-gases	Reporting obligation for undertakings (facilities) performing reclamation of F-gases
	C5.6			Reporting obligation for operators of HV switchgear and electrical equipment (< 52 kV) with regard to SF_6 emissions during lifetime and for operators in cooperation with certified personnel of electrical equipment for decommissioning of such equipment
	C5.7	Remove or lower the threshold for verification of bulk HFCs placed on the market	Remove or lower the threshold for verification of bulk HFCs placed on the market	Remove or lower the threshold for verification of bulk HFCs placed on the market
	C5.8	Add obligation to submit verification reports for bulk HFCs	Add obligation to submit verification reports for bulk HFCs	Add obligation to submit verification reports for bulk HFCs
	C5.9	Align reporting and verification thresholds for placing on the market products and equipment	Align reporting and verification thresholds for placing on the market products and equipment	Align reporting and verification thresholds for placing on the market products and equipment
	C5.10	Align reporting and verification dates (separately for bulk and pre-charged products and equipment)	Align reporting and verification dates (separately for bulk and pre-charged products and equipment)	Align reporting and verification dates (separately for bulk and pre-charged products and equipment)
	C5.11		Add legal basis for electronic verification process (separately for bulk and pre-charged products and equipment)	Add legal basis for electronic verification process (separately for bulk and pre-charged products and equipment)

		POLICY OPTION 1: Alignment with the Montreal Protocol & low-cost implementation	POLICY OPTION 2: Achieve proportionate emission savings and implementation improvements	POLICY OPTION 3: High ambition / maximum feasibility
	C5.12	Align reporting and quota authorisation thresholds for placing pre-charged products and equipment on the market	Align reporting and quota authorisation thresholds for placing pre-charged products and equipment on the market	Align reporting and quota authorisation thresholds for placing pre-charged products and equipment on the market
	C5.13	Obligation to provide NIL reports for quota holders	Obligation to provide NIL reports for quota holders	Obligation to provide NIL reports for quota holders
	C5.14		Encourage Member States to use electronic reporting systems for collection of F-gas service intervention, technicians, sale of non-hermetic equipment and emissions data	Require Member States to use electronic reporting systems for collection of F-gas service intervention, technicians, sale of non-hermetic equipment and emissions data
	C5.15	Include new substances in Annex I	Include new substances in Annex I	Include new substances in Annex I
	C5.16	Include new substances in Annex II and require reporting by companies	Include new substances in Annex II and require reporting by companies	Include new substances in Annex II and require reporting by companies
Objective D: Clarifications				
		All clarifications	All clarifications	All clarifications

Note: Objective D relates to the clarifications listed in the following table.

Table 24: Overview of further clarifications and improvements.

Objective D: Further clarifications and improvements	
D1	Include the possibility to adopt delegated acts to adapt the Regulation to allow alignment with potential future decisions under the Montreal Protocol (e.g. related to exemptions from the HFC phase-down, adjustment of GWP values to more recent scientific data (IPCC AR5 or AR6 instead of AR4))
D2	Include 20-year time horizon GWP values relative to CO_2 for all substances listed in Annex I and II
D3	Include the possibility to adopt delegated acts to allow for amendments in Annex I and II if new scientific evidence become available
D4	Include confidentiality obligations for Member States in Article 17 and 19, i.e. clarifications that Member States should not reveal confidential business information linked to companies
D5	Include requirement for non-EU importers of pre-charged products and equipment to mandate an “only representative” and have an Economic Operators' Registration and Identification (EORI)
D6	Include requirement to add and the F-gas ID and F-gas quantities expressed in CO_2 eq in customs documents for both bulk and products and equipment (registry)
D7	Enshrine the ‘beneficial owner’ principle to limit market players, i.e. move related provisions from the Implementing Regulation into the Regulation

D8	Include details on requirements related to the import of pre-charged equipment in the main text of the Regulation
D9	Include clarification that HFCs imported are always considered virgin, require quota and cannot be used for servicing and maintenance purposes
D10	Clarify that the requirement set out in Article 11(4) also covers car garages
D11	Clarify that the exemption in Article 15(2)(c) does not cover exports of HFCs contained in pre-charged equipment
D12	Include that Article 6(1)(c) refers not only to installed gases but also to added gases as regard information to be included in the records by operators of equipment on the quantities of recycled or reclaimed F-gases
D13	Include clarification in Article 6(1)(f) that information to be included in the records should also cover details about leakage repairs
D14	Include clarification in Article 8(1) that the recovered refrigerant cannot be used for fill or refill equipment unless it has been recycled or reclaimed
D15	Include clarification in Article 8(3) as regards the current the wording “appropriately qualified natural persons”
D16	Include clarification in Article 14(2) that verification of HFC pre-charged in imported equipment is required as of 100 tonnes of CO_2 eq
D17	Include clarification in Article 15 that the placing on the market of HFCs in excess of the quota limits is strictly prohibited
D18	Include clarification of the term “exclusively” in Article 18(2)
D19	Align definition of “placing on the market” (Article 2 No 10) with the definition used in the Ozone Regulation
D20	Clarify definitions in Article 2 of “hermetically sealed equipment” (No 11), “non-refillable container” (No 13); “recycling” (No 15); “reclamation” (No 16); “destruction” (No 17); “installation” (No 20); “maintenance or servicing” (No 21); “stationary” (No 23); “mobile” (No 24); “refrigerated truck” (No 26); “technical aerosol” (No 28); “undertaking” (No 30)
D21	Include clear definition of “refrigeration equipment”; “air-conditioning equipment”; “heat pump equipment”; “pre-charged products and equipment”; “reclamation facility”; “consignee”
D22	Include clarification for import (entry of goods) and export (exit of goods)
D23	Make minor corrections in Annex II to formulas, names, etc.
D24	Include clear instructions on custom authorities’ and market surveillance authorities’ role and cooperation with competent authorities
D25	Include addition that prohibition concerning non-refillable containers for F-gases (Annex I & II)) and other F-gases (Annex II) also covers their transport, storage and use
D26	Make clear that mandatory registration in the HFC Registry for importers/exporters of pre-charged products and equipment prior to import/export is required (while keeping the threshold of 100 tonnes of CO_2 eq)
D27	Add prohibition to make HFCs available to third parties, to transfer HFCs to third parties or to use HFCs which have been placed on the market in violation of the requirements of Article 15(1), including by internet sales, with the exception of provision, transfer or use for return or disposal
D28	Add clarification in Article 18 that authorisations have to be made in the HFC registry, just like quota transfers
D29	Add clarification in Article 2 that placing on the market of HFCs includes emissions of gases from the production process

10. Impact assessment of policy options

The three policy options described in section 7 have been analysed to assess the potential impacts of their implementation across environmental, economic and social indicators. Analysis is based on the toolbox of the Better Regulation Guidelines. For environmental impacts, this includes analysis of impacts on the climate via global warming potential. For economic and social impacts, three stakeholder groups are distinguished and discussed separately where appropriate for each policy option: Businesses, Member State competent authorities, and the European Commission (including the European Environment Agency)[59].

The list of impacts identified is presented in Table 25.

Table 25: List of impacts

Environmental impacts
Direct F-gas emissions
Energy use / indirect emissions
Cross-media effects / toxicity
Economic impacts
Operative costs of F-gas using industries
Administrative costs
- to businesses
- to Member State competent authorities
- to the EU Commission and the EEA
Distribution of costs
- across business size
- across EU regions
Macroeconomic impacts on the EU
Distributional effects between equipment operators and undertakings of the HFC supply chain
Impact on consumer prices
Impact on trade flows (imports and exports)
Impact on R&D and innovation
Impact on competitiveness
Social impacts
Employment effects
Public health & safety and health systems

In accordance to the Better Regulation Guidelines, the environmental, economic and social impacts of the policy options are assessed in comparison to a **baseline** development. This baseline describes the likely developments in relation to emissions and costs etc in case none of the policy measures would be taken and that the FGR of 2014 would continue to apply [60].For the assessment of emissions under the baseline, a continuation of the FGR POM HFC phase-down scheme was assumed beyond 2030 with the existing exemptions and without any additional phase-down steps. For related cost, it should be noted that cost due to risen HFC process and cost for technological change assessed as 'additional' in the context of the FGR evaluation (i.e. additional to the counterfactual scenario of having no 2014 FGR revision, and instead a continuation of the 2006 FGR) will in principle continue to apply to the industry. However, cost calculated for a continued 2014 FGR (including the assumption on the contin-

[59] EC Better Regulation guidelines, available at: Better regulation: guidelines and toolbox | European Commission (europa.eu)
[60] In relation to the HFC production phase-down set out by the MP, measures to comply at MS level are assumed for the baseline, where necessary (see section 8.6.3).

ued HFC POM phase-down mentioned above) as compared to the counterfactual scenario of a continued 2006 FGR are considered part of the baseline for the impact assessment and only additional (or saved) cost induced by the policy options in comparison to the baseline are considered for the impact assessment.

10.1. Environmental impacts

10.1.1. Direct F-gas emissions

10.1.1.1. Total emissions of F-gases

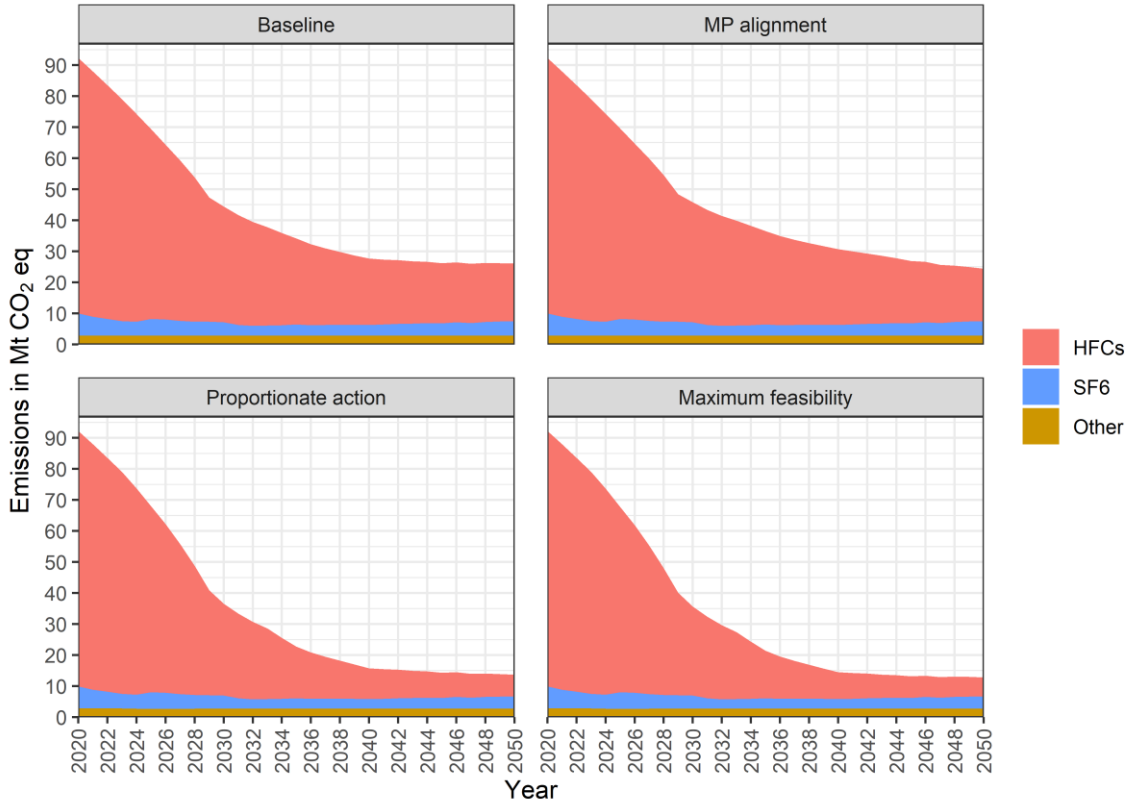
The Regulation already had an impact on the emission of F-gases in the EU (see Evaluation report[61]). For the future, the projections show that without further EU action (baseline scenario), the emissions will decrease until 2040 and stagnate until 2050 at 27 Mt CO_2 eq (Figure 15 and

Table 26). Under the MP scenario, emissions will exceed baseline values until 2046 and will drop slightly below the baseline from 2047. In contrast, under the PA scenario, emissions slightly fall below the baseline already in 2025, further strongly decrease until 2040 and then level out until 2050 at around 14 Mt CO_2 eq. The MF scenario shows a similar development in emissions, but the decrease is more pronounced and emissions level out at around 13 Mt CO_2 until 2050.

Across all scenarios, HFCs are by far the most important contributor to the overall emissions, especially in the years until 2040. Under the PA and MF scenario, SF_6 shows slightly more reduction in emissions compared to the baseline and the MP scenario, while other F-gases (PFCs, unsaturated H(C)FCs and NF_3) show no discernible difference between scenarios.

[61] Support contract for an Evaluation and Impact assessment for amending Regulation (EU) No 517/2014 on fluorinated greenhouse gases. CLIMA.A2/ETU/2019/0016. September 2021. Evaluation Final Report by Öko-Recherche, Ricardo and Öko-Institut.

Figure 15: Modelled emissions of F-gases under the different scenarios in the EU27



Source: AnaFgas modelling

Table 26: Modelled emissions of F-gases in Mt CO_2 eq under the different scenarios in the EU27

Year	Gas group	BL	MP	PA	MF	MP-BL	PA-BL	MF-BL
2020	**Total**	**92**	**92**	**92**	**92**	**0 (0%)**	**0 (0%)**	**0 (0%)**
	HFCs	82	82	82	82	0 (0%)	0 (0%)	0 (0%)
	SF6	7	7	7	7	0 (0%)	0 (0%)	0 (0%)
	Other	3	3	3	3	0 (0%)	0 (0%)	0 (0%)
2025	**Total**	**69**	**69**	**68**	**68**	**0 (0%)**	**-1 (-1%)**	**-1 (-1%)**
	HFCs	61	61	60	60	0 (0%)	-1 (-2%)	-1 (-2%)
	SF6	5	5	5	5	0 (0%)	0 (0%)	0 (0%)
	Other	3	3	3	3	0 (0%)	0 (0%)	0 (0%)
2030	**Total**	**44**	**46**	**37**	**36**	**2 (5%)**	**-7 (-16%)**	**-8 (-18%)**
	HFCs	37	39	30	29	2 (5%)	-7 (-19%)	-8 (-22%)
	SF6	4	4	4	4	0 (0%)	0 (0%)	0 (0%)
	Other	3	3	3	3	0 (0%)	0 (0%)	0 (0%)
2035	**Total**	**35**	**37**	**23**	**21**	**2 (6%)**	**-12 (-34%)**	**-14 (-40%)**
	HFCs	28	30	17	15	2 (7%)	-11 (-39%)	-13 (-46%)
	SF6	4	4	3	3	0 (0%)	-1 (-25%)	-1 (-25%)
	Other	3	3	3	3	0 (0%)	0 (0%)	0 (0%)
2040	**Total**	**27**	**30**	**16**	**15**	**3 (11%)**	**-11 (-41%)**	**-12 (-44%)**
	HFCs	21	24	10	9	3 (14%)	-11 (-52%)	-12 (-57%)
	SF6	3	3	3	3	0 (0%)	0 (0%)	0 (0%)
	Other	3	3	3	3	0 (0%)	0 (0%)	0 (0%)
2045	**Total**	**26**	**27**	**14**	**13**	**1 (4%)**	**-12 (-46%)**	**-13 (-50%)**
	HFCs	19	20	8	7	1 (5%)	-11 (-58%)	-12 (-63%)
	SF6	4	4	3	3	0 (0%)	-1 (-25%)	-1 (-25%)
	Other	3	3	3	3	0 (0%)	0 (0%)	0 (0%)
2050	**Total**	**27**	**25**	**14**	**13**	**-2 (-7%)**	**-13 (-48%)**	**-14 (-52%)**
	HFCs	19	17	7	6	-2 (-11%)	-12 (-63%)	-13 (-68%)
	SF6	5	5	4	4	0 (0%)	-1 (-20%)	-1 (-20%)
	Other	3	3	3	3	0 (0%)	0 (0%)	0 (0%)

Source: AnaFgas modelling

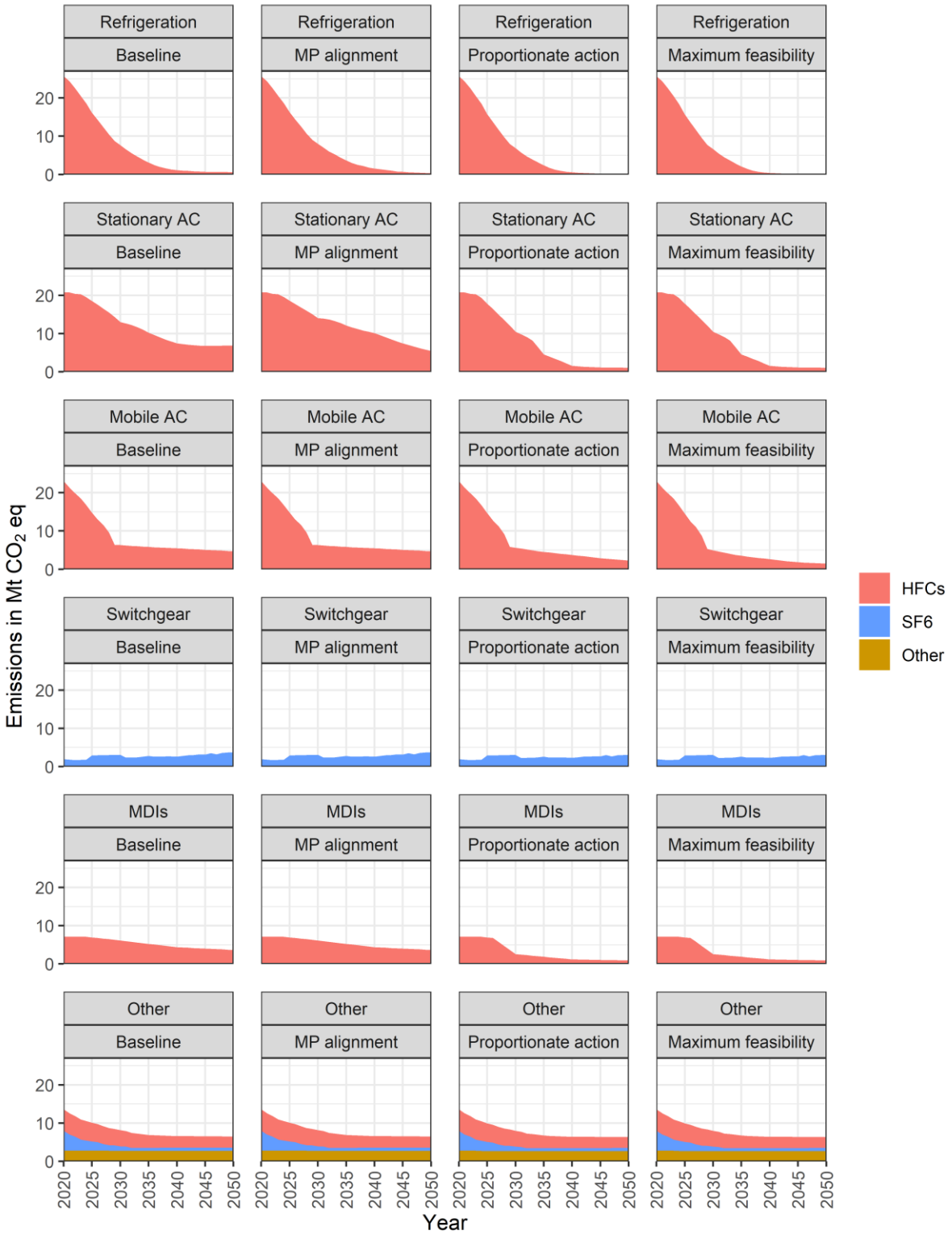
Note: BL is baseline, MP is MP alignment, PA is proportionate action, MF is maximum feasibility

Looking at the different sectors, emissions from stationary AC applications show the most pronounced deviations between scenarios (Figure 16, see Annex 1.7). Cumulative emissions from 2020 to 2050 are higher for the MP scenario compared to the baseline in the sectors of stationary AC and refrigeration (Table 27). Both the PA and MF scenario show lower cumulative emissions for all sectors, with the MF scenario having the lowest emissions. Differences between the PA and MF scenario are mostly due to mobile AC and, to a lesser extent, refrigeration applications.

The sector “Others” in Figure 16 contains multiple smaller sectors that are shown in detail in Figure 17 (see also Annex 1.7). The largest contributors to the emissions in this miscellaneous sector are HFCs and PFCs from the production of halocarbons. There are only small differences between scenario because it is assumed in the model that the effect of further policy action will be small for these sectors.

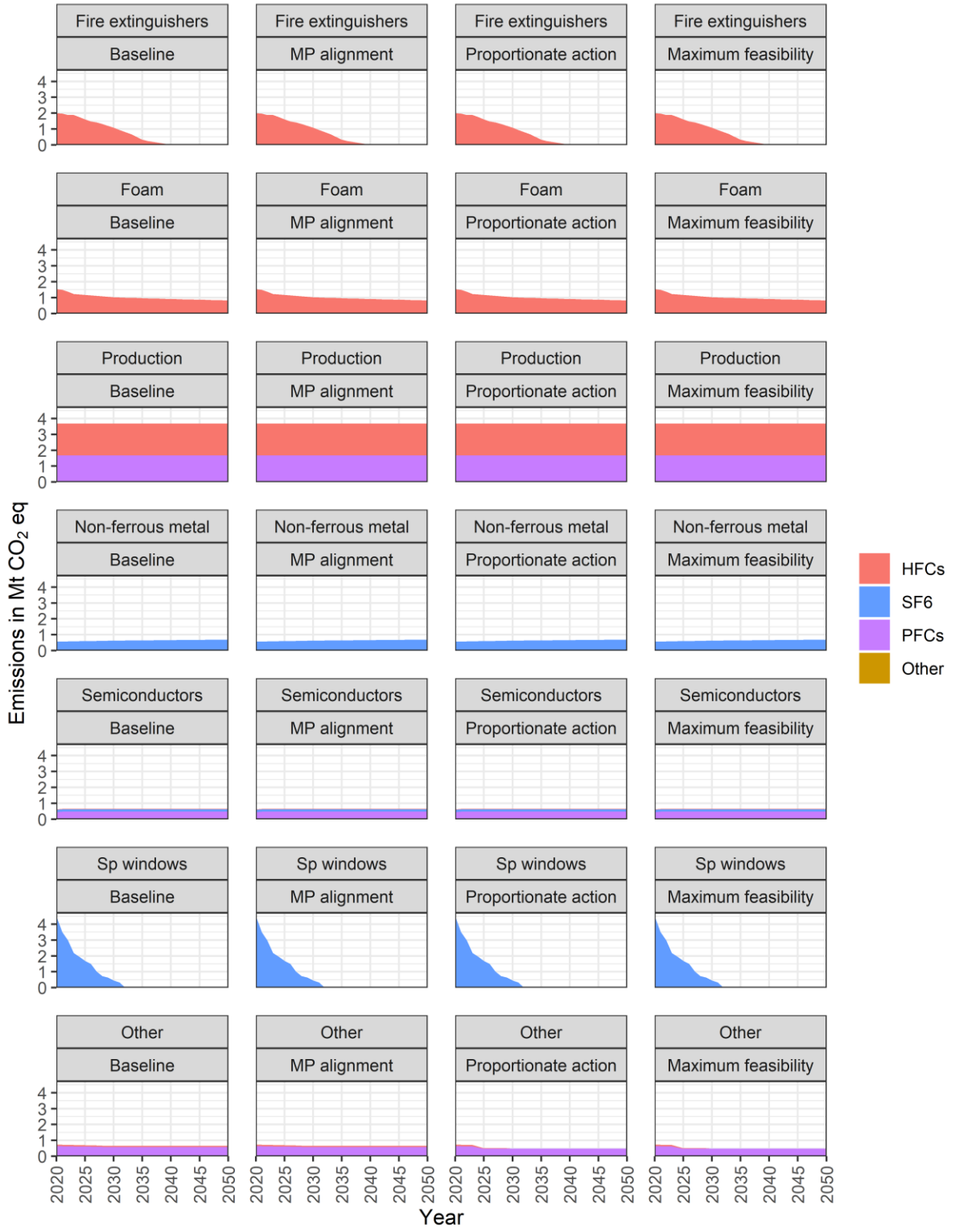
Overall, the PA and MP scenario would lead to a 19 % and 21 % cumulative reduction in F-gas emissions in CO_2 eq from 2020 to 2050, respectively.

Figure 16: Modelled emissions of F-gases under the different scenarios in the EU27 by important sector



Source: AnaFgas modelling

Figure 17: Modelled emissions of F-gases under the different scenarios in the EU27 in the sector "Other"



Notes: 'Production' is F-gases emitted in the production process of HFCs, 'Sp window' is soundproof windows

Source: AnaFgas modelling

Table 27: Sum of modelled cumulative emissions of F-gases in Mt CO_2 eq from 2024 to 2050 for the different scenarios for important sectors in the EU27

Sector	BL	MP	PA	MF	MP-BL	PA-BL	MF-BL
Refrigeration	128	134	112	107	6 (5%)	-16 (-13%)	-21 (-16%)
Stationary AC	284	311	169	169	27 (10%)	-116 (-41%)	-116 (-41%)
Mobile AC	187	187	150	127	0 (-)	-37 (-20%)	-60 (-32%)
Switchgear	78	78	71	71	0 (-)	-7 (-9%)	-7 (-9%)
MDIs	138	138	66	66	0 (-)	-72 (-52%)	-72 (-52%)
Other	200	200	196	196	0 (-)	-4 (-2%)	-4 (-2%)
Total	**1 016**	**1 050**	**763**	**736**	**33 (3%)**	**-253 (-25%)**	**-280 (-28%)**

Source: AnaFgas modelling

Note: BL is baseline, MP is MP alignment, PA is proportionate action, MF is maximum feasibility

10.1.1.2. Emissions from recovery of foams

The estimated lifetime of insulation XPS and PU rigid foam is 50 years[62]. Since modelling was conducted until 2050, the model covers emissions from recovery for installations in the time between 1995 and 2000. Mainly HFC-134a was used in these types of foam installations during this time. Table 28 shows the projected quantities of HFCs in CO_2 equivalents in stock from 2045 to 2050 and the resulting lifetime emissions and emissions at end-of-life, assuming an emission rate of 100 %, i.e. quantities contained in EoL equipment. The AnaFgas model does not consider disposal emissions for foams. Thus, the change in stock matches the lifetime emissions but not the emissions at EoL of equipment.

Until 2050, total emissions of 1.89 Mt CO_2 eq would result from the disposal of EoL equipment in the EU27, without measures to ensure recovery of HFCs from the disposal of foam banks. This would, however, only be a fraction of the EoL emissions occurring in the years past 2050, with ca. 45 Mt CO_2 eq of HFCs still being in stock (Table 28).

Table 28: Modelled quantities of HFCs in Mt CO_2 eq for XPS and PU rigid foam in the EU27

Year	In stock	Lifetime emissions	In EoL equipment / Emissions at EoL
2045	47.051	0.426	0.030
2046	46.626	0.422	0.076
2047	46.204	0.418	0.175
2048	45.786	0.413	0.340
2049	45.373	0.409	0.516
2050	44.964	0.405	0.753

Source: AnaFgas modelling

Note: Emissions at EoL were calculated independently from the AnaFgas modelling but based on the data from the model. Therefore, the stock data is in line with the lifetime emissions but not the EoL emissions.

[62] Schwarz, W., et al., 2011, Preparatory study for a review of Regulation (EC) No. 842/2006 on certain fluorinated greenhouse gases. For the EU Commission (DG CLIMA), Final Report.

For the EU28, the EoL emissions reach 0.796 Mt CO_2 eq in 2050 and the total disposal emissions until 2050 would sum up to 1.99 Mt CO_2 eq.

To assess the effect of the different policy options on emission savings from the recovery of HFCs in EoL equipment, modelled quantities of HFCs have to be assigned to the two different technologies covered by those options, namely steel-faced panels and laminated boards. Table 30 shows the quantities of HFCs in EoL equipment in the years 2045 to 2050 in Mt CO_2 eq.

Option 1 includes the measure to recover insulation foams blown with HFCs in steel-faced panels (Objective A4.1). Assuming 100 % recovery, this would save 0.36 Mt CO_2 eq of HFC emissions between 2045 and 2050. Option 2 and 3 extend this measure to include laminated boards (Objective A4.2). This would save an additional 1.22 Mt CO_2 eq of HFC emissions between 2045 and 2050 (total savings of 1.58 Mt CO_2 eq). It must be noted however that the model only extends to the year 2050 and the effect of these measures will reduce emissions continuously in the years past 2050, amplifying the total effect on emission savings substantially.

Table 29: Modelled quantities of HFCs in Mt CO_2 eq in EoL equipment in the EU27

Year	Steel-faced panels	Laminated boards	Block foam/ pipe section
2045	0.011	0.011	0.009
2046	0.025	0.030	0.021
2047	0.037	0.106	0.032
2048	0.067	0.215	0.058
2049	0.094	0.341	0.081
2050	0.125	0.521	0.107

Source: Calculated based on AnaFgas data and expert assessment

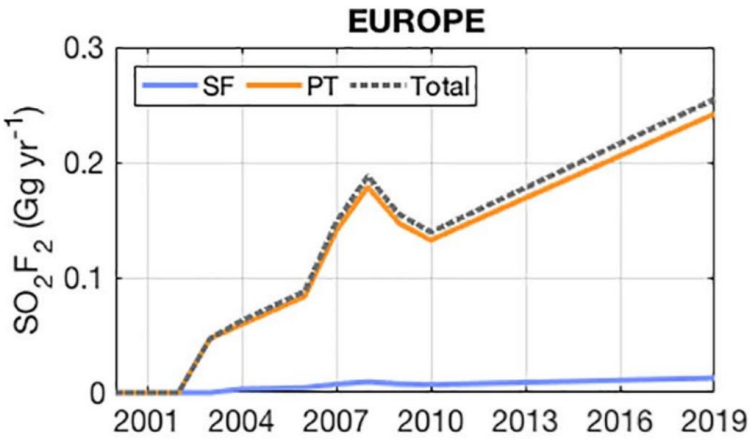
Note: Based on the assumption that from 1995 to 2000, 70 % of foam installations were in equal parts panels and boards and 30 % block foam/pipe section.

10.1.1.3. Emissions of sulfuryl fluoride (SO_2F_2)

Emissions of SO_2F_2 can only be based on estimates since no reported data are currently available.

Based on measurements of SO_2F_2 in the atmosphere, model estimates of emissions in Europe are increasing in recent years and mainly originate from the use as a fumigant in postharvest treatment and, to a much lesser degree, structural fumigation of dried fruits, tree nuts, grain flours and timbers, as a replacement of the ozone depleting methyl bromide (Figure 18). In 2019, estimated annual emissions in Europe reached 250 t. Based on the IPCC AR6 report's GWP for SO_2F_2 of 4 630, estimated emissions in Europe amounted to 1.16 Mt CO_2 eq.

Figure 18: Estimated annual average emissions of sulfuryl fluoride (SO2F2) in Europe by source

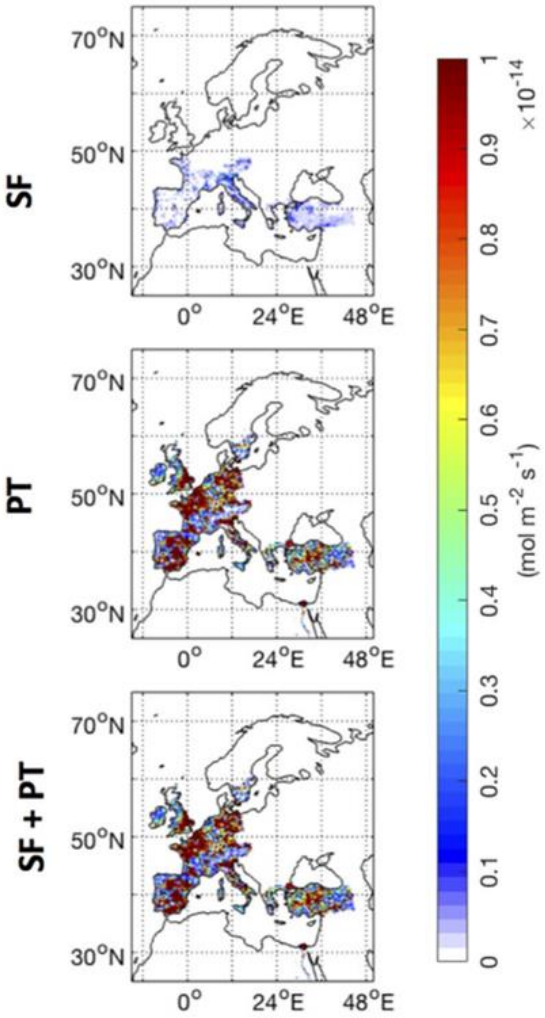


Source: Gressent, A., et al. (2021) 'Growing Atmospheric Emissions of Sulfuryl Fluoride', Journal of Geophysical Research: Atmospheres 126(9) (DOI: 10.1029/2020JD034327).

Note: Europe is Italy, Switzerland, Germany, France, UK, Belgium, Greece, Spain, Ireland, Portugal, The Netherlands, Sweden, Austria and Turkey; SF is structural fumigation; PT is postharvest treatment

For the EU27, no estimated emission value can be given. Based on the more regional analysis of emission points across Europe in Figure 19, the value could lie below the above stated 1.16 Mt CO_2 eq, since the UK and Turkey are significant sources of SO_2F_2. On the other hand, not all EU member states are included in the analysis, especially no Eastern European countries.

Figure 19: Estimated average emissions of sulfuryl fluoride (SO_2F_2) in Europe by source



Note: Europe is Italy, Switzerland, Germany, France, UK, Belgium, Greece, Spain, Ireland, Portugal, The Netherlands, Sweden, Austria and Turkey; SF is structural fumigation; PT is postharvest treatment

Source: Modified from Gressent, A., et al. (2021) 'Growing Atmospheric Emissions of Sulfuryl Fluoride', Journal of Geophysical Research: Atmospheres 126(9) (DOI: 10.1029/2020JD034327).

10.1.1.4. Emissions of inhalation anaesthetics

Emissions of inhalation anaesthetics can only be based on estimates since no reported data are available.

Inhalation anaesthetics were not part of the AnaFgas model and were independently assessed for the EU27 based on expert information.

Inhalation anaesthetics are used during surgery and are partially metabolized within the patient's body. The metabolism rate varies between gases, with sevoflurane having the highest rate with 5 %, followed by isoflurane with 0.2 % and desflurane with 0.02 %.[63] The following table shows the final emissions in the EU27 from use in human medicine for specific years, with the metabolized quantities already deducted.

Table 30: Emissions of fluorinated inhalation anaesthetics in the EU27 from use in human medicine

	GWP	2010	2015	2016	2017	2018	2019	2020
Metric tonnes								
Desflurane		145	214	229	244	260	277	294
Sevoflurane		157	242	260	280	299	320	341
Isoflurane		134	92	82	72	61	49	37
Sum		**436**	**548**	**571**	**596**	**620**	**646**	**671**
kt CO_2 eq (GWP from AR4, AR5 and FGR)								
Desflurane	*989*	144	211	226	242	257	274	290
Sevoflurane	*216*	34	52	56	60	65	69	74
Isoflurane	*350*	47	32	29	25	21	17	13
Sum		**225**	**296**	**311**	**327**	**343**	**360**	**377**
kt CO_2 eq (GWP from AR6)								
Desflurane	*2 590*	377	554	592	633	674	717	760
Sevoflurane	*195*	31	47	51	55	58	62	67
Isoflurane	*539*	72	50	44	39	33	26	20
Sum		**479**	**650**	**688**	**726**	**765**	**805**	**847**

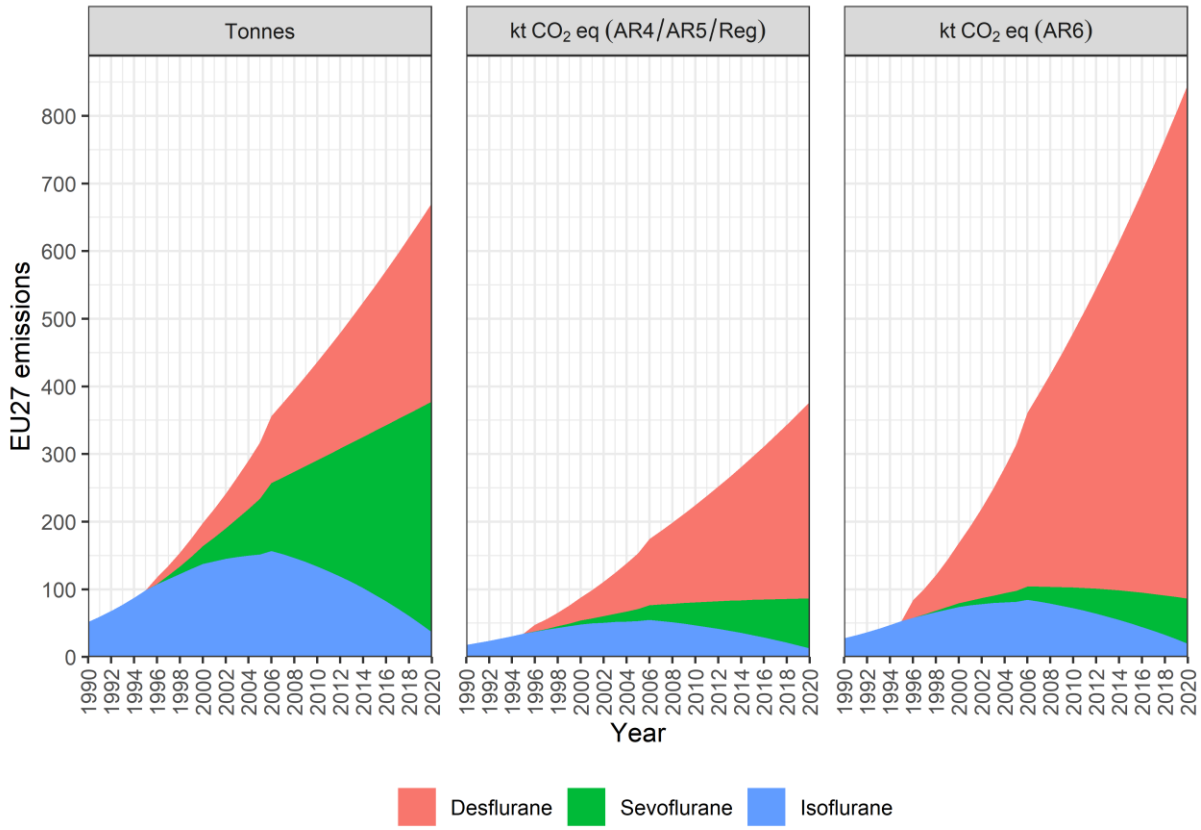
Source: Estimates based on expert information

Note: GWPs for calculation of CO_2 eq from IPCC AR4 report for isoflurane, from AR5 for sevoflurane and from Regulation for desflurane; GWPs for calculation of CO_2 eq from IPCC AR6 report for all gases

According to expert information, isoflurane is the main anaesthetic gas used for operations in veterinary medicine. Corresponding emissions, however, cannot be quantified. Based on data for 2019 from one large German university apothecary that supplies the corresponding human and veterinary clinics, the use of isoflurane in veterinary operations could be approximately half of the use in human medicine. This does not include quantities used for other applications, such as the castration of piglets in Germany. It is also unlikely that the downward trend in the use of isoflurane in human medicine is mirrored for veterinary medicine since other fluorinated ethers are not used to replace isoflurane. Due to the use in piglet castration in Germany, emissions of isoflurane could increase in the coming years.

[63] Vollmer, M K; Rhee, T S; Rigby, M; Hofstetter, D; Hill, M; Schoenenberger, F; Reimann, S (2015) Modern inhalation anesthetics: Potent greenhouse gases in the global atmosphere. Geophysical Research Letters, 42, 1606-1611.

Figure 20: Emissions of three fluorinated inhalation anaesthetics in the EU27, expressed in different metrics



Source: AnaFgas modelling

Note: Middle pane - GWPs for calculation of CO_2 eq from IPCC AR4 report for isoflurane, from AR5 for sevoflurane and from Regulation for desflurane; right pane - GWPs for calculation of CO_2 eq from IPCC AR6 report for all gases

Prognoses regarding the future use and emissions of inhalation anaesthetics is difficult. For one, based on expert assumptions, the number of operations is increasing, while new equipment uses less gas. This could lead to a further increase in the used quantities of gas for another one to two years. After that, use and emissions could stagnate, but this is highly speculative. Concerning the shares of different gases, in human medicine, a trend towards the more “eco-friendly” sevoflurane could be counterbalanced by the fact that desflurane allows for more operations per unit time, since patients regain consciousness earlier when using desflurane, compared to sevoflurane. In veterinary medicine, isoflurane is the most used inhalation anaesthetic and will be used in the EU for piglet castration.

Since the prohibition defined in section 8.2.2.2 covers gases with a GWP of >550 from 2024, this would affect desflurane.

Assuming constant emissions of inhalations anaesthetics from 2020, the prohibition would result in no use of desflurane from 2024. From 2024, 0.76 Mt CO_2 eq would be saved in the EU27, annually. Assuming that no other alternatives are available, the use of sevoflurane and isoflurane should increase, corresponding to the decrease in desflurane. This would result in additional yearly emissions of ca. 0.067 Mt CO_2 eq from sevoflurane and isoflurane from 2024. Until 2050, the prohibition would reduce emissions of inhalation anaesthetics by ca. 19 Mt CO_2 eq.

10.1.2. Energy use / indirect GHG emissions

The revision of the Regulation can also have an impact on ***energy efficiency and consumption*** as it incentivises the technological change in energy-using equipment, in particular in the RACHP sector.

In the AnaFgas modelling framework, final energy consumption of RAC equipment was calculated both for the baseline scenario and the three policy options scenarios. The assumptions on energy efficiency characteristics of the different technology options are consistent with the assumptions made for the evaluation of the 2014 FGR revision and are documented in Annex 2.

Table 31 summarises modelled savings of final energy use in the RAC sectors in the policy scenarios in comparison to the baseline for the key assessment period 2024-2036 as well as an outlook to 2050: For the "proportionate action" and "maximum feasibility" scenarios average energy savings of approximately 2-3 GWh/a were calculated for the 2024-2036 period, due to the deployment of slightly more energy-efficient low-GWP technologies in those scenarios. For the "MP alignment" scenario, however, average 2024-2036 final energy use is about GWh/a higher than the baseline as the technology change incentivised by a revised FGR would be slower in the 2020s and early 2030s. In the 2050-time horizon, however, all three policy scenarios result in energy savings, ranging from to 2 GWh/a (MP alignment scenario) to about 8-9 GWh/a (proportionate action and maximum feasibility).

However, in relation to total baseline energy use in the RAC sectors, the modelled differences for the policy scenarios are very small at about -0.1 % - 0.3 % in the 2024 - 2036-time horizon, or 0.1 % – 0.5% in the 2050-time horizon.

Table 31: EU27 final energy use savings in the RAC sector, policy scenarios in comparison to the baseline

Sector	Unit	Time horizon	MP alignment scenario	Proportionate action scenario	Maximum feasibility scenario
Refrigeration	GWh/a	2024- 2036 average	-0.1	0.7	0.9
Stationary A/C	GWh/a	2024- 2036 average	-0.8	1.6	1.4
Mobile A/C	GWh/a	2024- 2036 average	0.0	0.3	0.5
Total RAC sector	**GWh/a**	**2024- 2036 average**	**-0.9**	**2.5**	**3.0**
Total RAC sector	**GWh/a**	**2050**	**2.3**	**8.2**	**9.1**
Refrigeration	% of baseline	2024- 2036 average	-0.1%	0.4%	0.6%
Stationary A/C	% of baseline	2024- 2036 average	-0.1%	0.2%	0.2%
Mobile A/C	% of baseline	2024- 2036 average	0.0%	0.3%	0.6%
Total RAC sector	**% of baseline**	**2024- 2036 average**	**-0.1%**	**0.3%**	**0.3%**
Total RAC sector	**% of baseline**	**2050**	**0.1%**	**0.5%**	**0.5%**

Source: AnaFgas modelling

Effects on EU27 CO_2 emissions, resulting from energy savings in the RAC sector (Table 32), but including also changes in CO_2 emission from other sectors in response to the analysed F-gas policy options were quantified by means of GEM E-3 model operated by the European commission's Joint Research Centre (JRC). The results are summarised in Table 32, further background is provided in Annex 4. Effects on CO_2 emissions were found to be small, up to about 0.5 Mt CO_2 eq/a or 0.02% of baseline CO_2 emissions.

Table 32: EU27 CO_2 emissions, policy scenarios in comparison to the baseline

CO_2 emission category	unit	time horizon	MP alignment scenario	proportionate action scenario	maximum feasibility scenario
CO_2 emissions from combustion of fuels	Mt CO_2	2030	0.21	-0.33	-0.43
CO_2 emission from industrial processes	Mt CO_2	2030	-0.03	0.03	0.03
Total indirect CO_2 emissions	Mt CO_2	2030	**0.2**	**-0.3**	**-0.4**
Total indirect CO_2 emissions	Mt CO_2	2050	**-0.1**	**-0.3**	**-0.4**
CO_2 emissions from combustion of fuels	% of baseline	2030	0.01%	-0.02%	-0.02%
CO_2 emission from industrial processes	% of baseline	2030	-0.01%	0.01%	0.01%
Total indirect CO_2 emissions	% of baseline	2030	**0.01%**	**-0.01%**	**-0.02%**
Total indirect CO_2 emissions	% of baseline	2050	**0.00%**	**-0.02%**	**-0.02%**

Source: AnaFgas modelling, JRC GEM-E3 modelling

In comparison to the policy options' effect on direct F-gases emissions (section 10.1.1) the effects on CO_2 emissions range up to about 5 %.

10.1.3. Cross-media effects / toxicity

As discussed in the evaluation report for the 2014 FGR revision, emissions in particular of the unsaturated HFC-1234yf contribute to the formation of trifluoroacetyl fluoride (TFF) which in turn reacts with water and forms trifluoroacetic acid in the atmosphere that deposits as trifluoroacetate (TFA) in the environment[64]. The TFA formation capacity of HFC-1234yf[65] is approximately five times the TFA formation capacity of high-GWP saturated HFC-134a[66], subject to replacement by HFC-1234yf in some sectors, especially passenger cars. TFA is considered as being highly persistent and highly mobile, meaning that once it is in the environment, it is difficult to reverse the situation. TFA appears to accumulate in surface waters (and groundwater) after being washed out of the atmosphere.

Figure 21 shows EU27 emissions of HFC-1234yf in the 2020 – 2050 time period modelled for the baseline scenario and the three policy scenarios. Baseline emissions are expected to approximately triple from 2020 to 2030 and to increase by about 10 % from 2030 to 2050. Until 2030 emissions in the policy scenarios hardly differ from the baseline. By 2050, EU HFC-1234yf emissions in the proportionate action and maximum feasibility scenarios are calculated to be about 2 700 t or 16 % or above the baseline, while emissions in the MP alignment scenario remain closely below the baseline.

Emissions of HFC-1234yf are mainly driven by the use in passenger cars (Figure 22). Replacement of HFC-134a in car AC systems leads to a steep increase in emissions until 2029, although the average charge sizes are assumed to gradually decrease until 2028 (see Annex 1.1). Emission rates for passenger cars are kept constant in the model, with 10 % lifetime emissions and 40 % disposal emissions (see Annex 1.2).

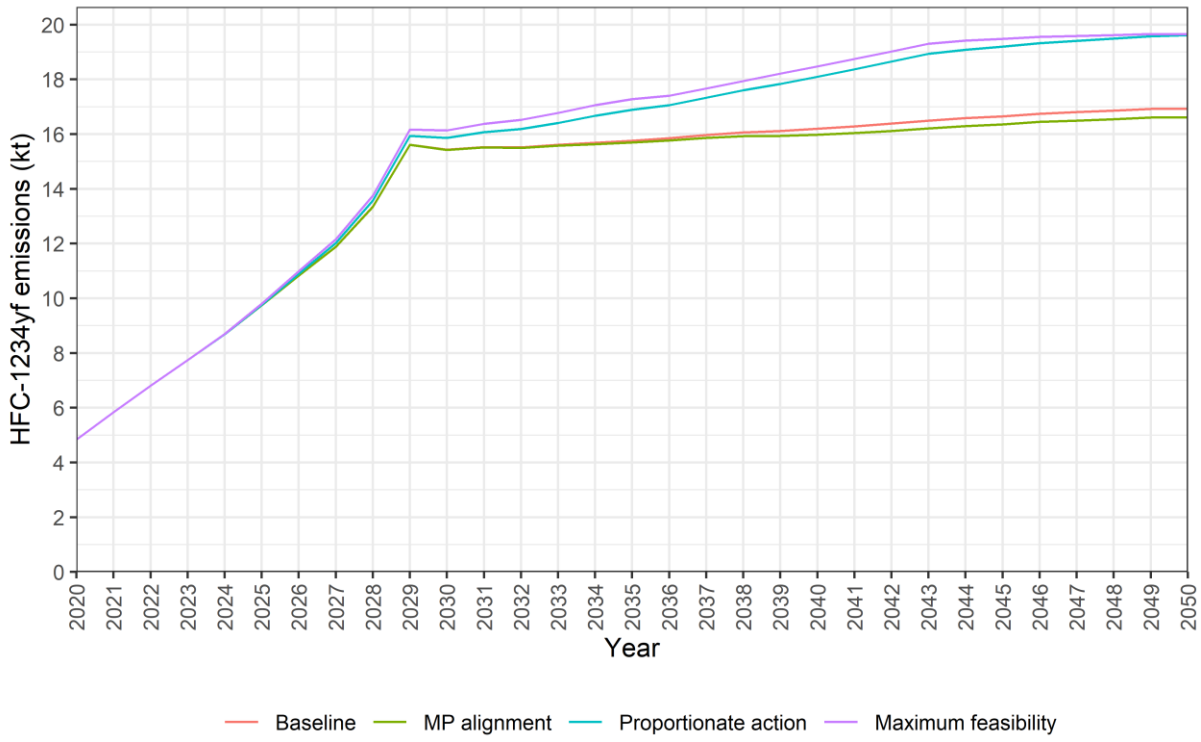
[64] See Behringer et al. (2021): Persistent degradation products of halogenated refrigerants and blowing agents in the environment: type, environmental concentrations, and fate with particular regard to new halogenated substitutes with low global warming potential, UBA-TEXTE 73/2021; https://www.umweltbundesamt.de/en/publikationen/persistent-degradation-products-of-halogenated

[65] Hurley, M. D., T. J. Wallington, M. S. Javadi, & O. J. Nielsen (2008): Atmospheric chemistry of CF3CFCH2: Products and mechanisms of Cl atom and OH radical initiated oxidation. Chemical Physics Letters 450:263–267.

[66] Wallington, T. J., M. D. Hurley, J. M. Fracheboud, J. J. Orlando, G. S. Tyndall, J. Sehested, T. E. Møgelberg, & O. J. Nielsen (1996): Role of excited CF3CFHO radicals in the atmospheric chemistry of HFC-134a. The Journal of Physical Chemistry 100:18116–18122.

Since, on a molar basis, HFC-1234yf is almost entirely converted to TFA during atmospheric degradation and HFC-1234yf and TFA have very similar molar masses[67], the emissions depicted in Figure 21 can be directly interpreted as TFA burden to the environment from HFC-1234yf alone. Based on modelling studies, it can be assumed that 30-40 % of the TFA will deposit within Europe and 60-70 % will be transported to other regions[68].

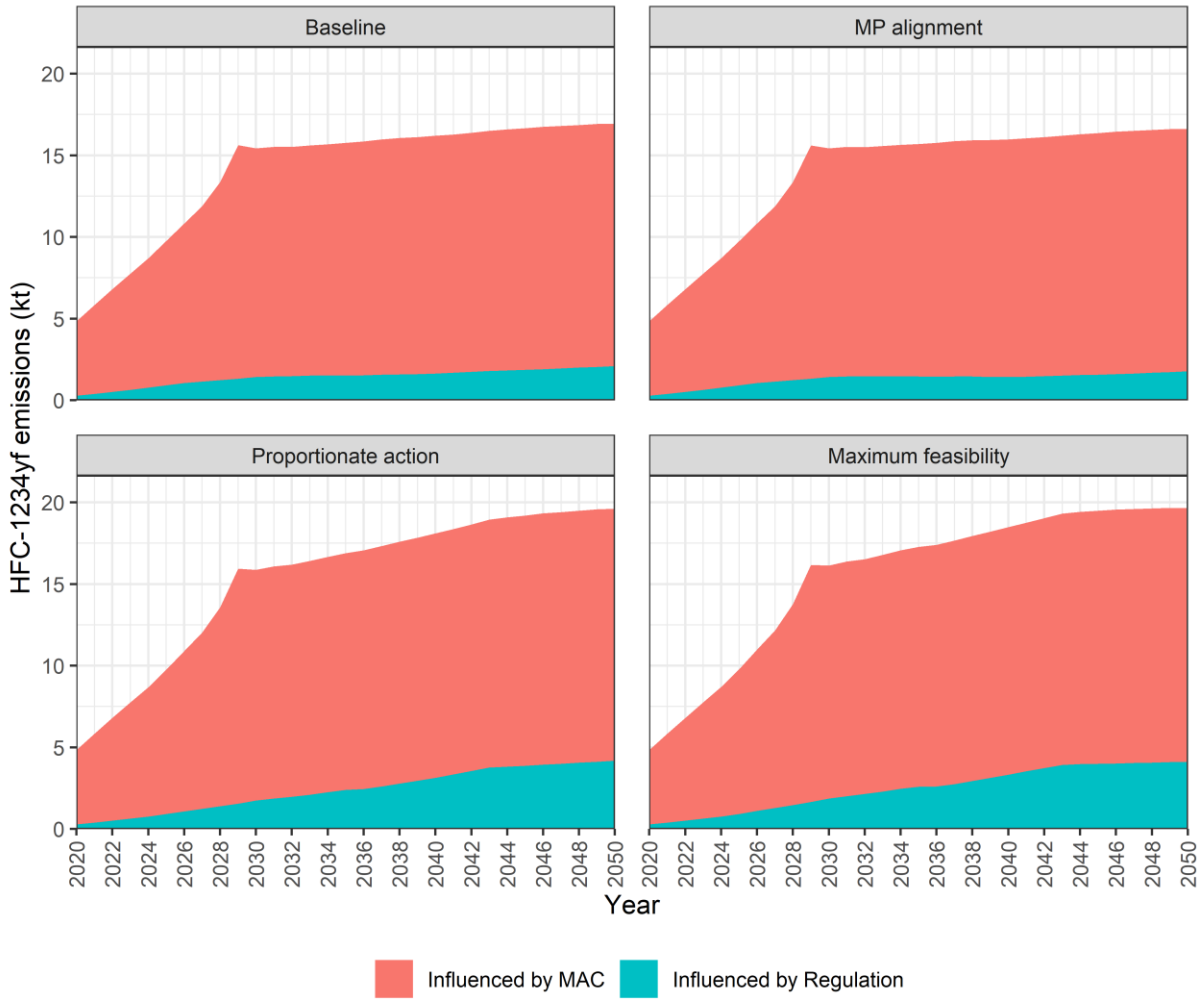
Figure 21: EU27 emissions of unsaturated HFC-1234yf for the different scenarios



Source: AnaFgas modelling

[67] Molar masses of TFA and HFC-1234yf are 114 g/mol (https://pubchem.ncbi.nlm.nih.gov/)
[68] Henne, S., D. E. Shallcross, S. Reimann, P. Xiao, D. Brunner, S. O'Doherty, & B. Buchmann (2012): Future Emissions and Atmospheric Fate of HFC-1234yf from Mobile Air Conditioners in Europe. Environmental Science & Technology 46:1650–1658.

Figure 22: EU27 emissions of unsaturated HFC-1234yf for the different scenarios and their influence by MAC Directive and Regulation



Source: AnaFgas modelling

Note: 'Influenced by MAC' shows emissions from the subsectors passenger cars and small trucks (N1), 'Influenced by Regulation includes all other subsectors, e.g. emissions from mixtures containing HFC-1234yf in refrigeration and stationary air-conditioning.

10.2. Economic impacts

10.2.1. Operative cost of F-gas using industries / equipment operators

In consistency to the analytic approach taken for the evaluation of the 2014 FGR revision, operative compliance cost of the users (= operating of equipment relying of F-gases or alternatives) are separately analysed for cost of technological change and cost incurred due to HFC price increases induced by the HFC-phasedown: Cost of technological change are based on investment and operating expenditures of equipment, assuming pre-phase-down price levels (2014). The impact of HFC prices on F-gas users, risen in the past and expected to further rise in the future, are captured as HFC-price related cost increases.

Assumptions for the cost modelling in relation to cost of technological change are documented in Annex 2.

Further development of HFC prices

For the evaluation of the 2014 FGR revision, the average HFC price increase due to the FGR HFC phase-down at distributor level had been estimated as 8 €/t CO_2 eq for the 2015-2019 evaluation period. The modelling of future HFC prices is subject to very high uncertainty. For the present impact assessment pathways for HFC prices until 2050 for the different scenario have been estimated based on experience gained in the evaluation period, on the development of future restriction to EU HFC supply under a continued, and possibly tightened EU27 phase-down, and assuming an effective implementation preventing illegal HFC imports (Table 33).

Table 33: Assumptions on HFC price increases vs 2014 pre-phase-down price levels, distributor selling prices

scenario	unit	2015 - 2019 average	2025	2030	2035	2040	2045	2050
Baseline	€$_{2019}$/t CO_2 eq	8	28	37	38	39	40	40
MP alignment	€$_{2019}$/t CO_2 eq		27	29	33	41	46	50
Proportionate action	€$_{2019}$/t CO_2 eq		37	68	95	119	138	161
Maximum feasibility	€$_{2019}$/t CO_2 eq		38	74	112	141	159	180

Source: AnaFgas cost modelling

For the baseline, considering until 2030 the reduction steps under the phase-down schedule as defined in the 2014 FGR revision, and afterwards a constant supply restriction, HFC surcharges are assumed to rise to 37 €/t CO_2 eq by 2030. Given further increasing HFC demand beyond 2030 in some subsectors, in particular heat pumps, baseline price assumptions for the 2050 time-horizon reach 40 €/t CO_2 eq.

In the MP alignment scenario, HFC prices are assumed to be slightly below the baseline until 2035, in line with the slightly more relaxed supply limits in that time horizon. After 2036, HFC price assumptions in the MP alignment scenario are rising 5 % - 20 % above baseline levels as the stringency of the HFC supply limits would then exceed the baseline.

For the proportionate action and maximum feasibility scenarios, featuring significantly more stringent limits to EU27 HFC supply, HFC prices are assumed to increase much faster than in the baseline. By 2030, the price increase in the proportionate action scenario might by at about 85 % above the baseline (68 €/ t CO_2 eq) and about double the baseline in the maximum feasibility scenario (74 €/ t CO_2 eq). By 2050 the HFC price increases in these scenarios might be at about 400 % or 450 % of the baseline, respectively at about 160 €/ t CO_2 eq and 180 €/ t CO_2 eq.

Total equipment operators' additional compliance cost

Table 34 summarises for all three policy scenarios the total additional compliance cost of EU F-gas using industries / equipment operators in comparison to the baseline. The focussed time horizon is the 2024-2036 interval, centring on 2030 and but also covering the full period from 2024, the expected entry into force of a revised Regulation, until 2036, the year of the latest HFC reduction step under the Montreal Protocol. In addition to the 2024-2036 average, a long-term outlook to the 2050 time-horizon is given in Table 35.

Total compliance costs are expressed Euros per year and as percentages of total equipment operators' expenditures in the baseline scenario, and are further differentiated into

- cost of additional HFC price increases to be expected under respectively modified HFC reduction schedules, to be borne by those users who continue to operate or invest in equipment

relying on HFCs, (such costs are reflected as profits in the HFC supply chain, or as state income to the degree of fees raised for quota allocation)

- and into cost of technological change for investment in and operation equipment relying on low-GWP alternatives.

Respective data on sub-sector level is given in Annex 3.1. Data on baseline compliance cost, in comparison to a counterfactual scenario assuming no 2014 FGR revision, is given in Annex 3.3.

Table 34: Equipment operators' additional compliance cost, 2024-2036 average (costs difference between policy scenarios and baseline)

Sector	time horizon	MP alignment scenario				proportionate action scenario				maximum feasibility scenario			
		total compliance cost vs baseline		thereof: additional HFC price increase	thereof: cost of technological change	total compliance cost vs baseline		thereof: additional HFC price increase	thereof: cost of technological change	total compliance cost vs baseline		thereof: additional HFC price increase	thereof: cost of technological change
		Mio EUR/a	% of baseline	Mio EUR/a	Mio EUR/a	Mio EUR/a	% of baseline	Mio EUR/a	Mio EUR/a	Mio EUR/a	% of baseline	Mio EUR/a	Mio EUR/a
Refrigeration	2024- 2036 average	-32.7	-0.1%	-8.6	-24.2	162.7	0.5%	230.1	-67.5	115.1	0.3%	239.9	-124.8
Stationary AC	2024- 2036 average	118.3	0.1%	92.2	26.1	-364.6	-0.3%	-282.1	-82.6	-303.5	-0.3%	-221.0	-82.6
Mobile AC	2024- 2036 average	-55.2	-0.2%	-55.2	0.0	327.9	1.1%	218.8	109.1	422.6	1.5%	152.0	270.6
Propellants, solvents & fire protection	2024- 2036 average	181.4	0.0%	181.4	0.0	245.4	0.0%	242.2	3.1	273.6	0.0%	270.5	3.1
Foam	2024- 2036 average	-0.1	0.0%	-0.1	0.0	0.3	0.1%	0.3	0.0	0.3	0.1%	0.3	0.0
Other HFCs	2024- 2036 average	0.0	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0	NA	0.0	0.0
SF_6	2024- 2036 average	0.0	0.0%	0.0	0.0	49.3	3.6%	0.0	49.3	49.3	3.6%	0.0	49.3
Total	**2024- 2036 average**	**211.7**	**0.0%**	**209.8**	**1.9**	**420.8**	**0.1%**	**409.4**	**11.5**	**557.4**	**0.1%**	**441.7**	**115.7**
Total	**2050**	**-341.4**	**0.0%**	**114.6**	**-456.1**	**-835.2**	**-0.1%**	**189.4**	**-1 024.6**	**-897.8**	**-0.1%**	**142.2**	**-1 040.1**

Source: AnaFgas cost modelling

Table 35: Equipment operators' additional compliance cost, 2050 (costs difference between policy scenarios and baseline)

Sector	time horizon	MP alignment scenario				proportionate action scenario				maximum feasibility scenario			
		total compliance cost vs baseline		thereof: additional HFC price increase	thereof: cost of technological change	total compliance cost vs baseline		thereof: additional HFC price increase	thereof: cost of technological change	total compliance cost vs baseline		thereof: additional HFC price increase	thereof: cost of technological change
		Mio EUR/a	% of baseline	Mio EUR/a	Mio EUR/a	Mio EUR/a	% of baseline	Mio EUR/a	Mio EUR/a	Mio EUR/a	% of baseline	Mio EUR/a	Mio EUR/a
Refrigeration	2050	-145.6	-0.4%	-41.7	-104.0	-283.9	-0.9%	-21.8	-262.2	-360.4	-1.1%	-37.2	-323.2
Stationary AC	2050	-489.7	-0.2%	-137.6	-352.1	-1654.6	-0.7%	-520.5	-1 134.1	-1616.0	-0.7%	-481.9	-1 134.1
Mobile AC	2050	93.1	0.5%	93.1	0.0	580.9	3.2%	415.4	165.4	511.8	2.8%	300.7	211.0
Propellants, solvents & fire protection	2050	200.8	0.0%	200.8	0.0	349.1	0.1%	316.3	32.9	393.5	0.1%	360.6	32.9
Foam	2050	0.0	0.0%	0.0	0.0	0.0	0.0%	0.0	0.0	0.0	0.0%	0.0	0.0
Other HFCs	2050	0.0	NA	0.0	0.0	0.0	NA	0.0	0.0	0.0	NA	0.0	0.0
SF_6	2050	0.0	0.0%	0.0	0.0	173.3	9.1%	0.0	173.3	173.3	9.1%	0.0	173.3
Total	**2050**	**-341.4**	**0.0%**	**114.6**	**-456.1**	**-835.2**	**-0.1%**	**189.4**	**-1 024.6**	**-897.8**	**-0.1%**	**142.2**	**-1 040.1**

Source: AnaFgas cost modelling

In the **2024-2036 average time horizon**, F-gas users' total compliance cost range from about 210 Mio €/year in in the *MP alignment* scenario to about 420 Mio €/year in the *proportionate action* scenario and to about 560 Mio €/year in the *maximum feasibility* scenario.

In all scenarios, the total compliance cost are determined to a very high extent by the cost of remaining HFC users due to increased HFC prices (based on assumptions on future HFC price increases in Table 33): HFC price increases account for 99 % of 2024-2036 cost in the *MP alignment* scenario, for 97 % in the *proportionate action* scenario and for about 80 % in the *maximum feasibility* scenario. The overall technological cost of those equipment operators expected to switch to low-GWP alternatives are low as they are balanced between increased investment and reduced operating cost.

However, there are strong variations on sectoral level: While cost of technological change is negative in all scenarios in the refrigeration and stationary AC sectors, significant positive costs are expected for the mobile AC and SF_6 (electrical switchgear) sectors, however only in the *proportionate action* and *maximum feasibility* scenarios, as no mitigation actions for those sectors is expected in the *MP alignment* scenario. For the switchgear / SF_6 sector the additional cost in both scenarios are estimated at 3.6 % of baseline total operating expenditure, for mobile AC the average ratio is calculated at 1.2 % in the *proportionate action* scenario (considering also HFC price increases of almost twice the technological cost) and at 1.5 % in the *maximum feasibility* scenario (considering also HFC price increases of roughly half the technological cost).

In the *MP alignment* scenario 2024-2036, significant additional cost due to HFC price increases are expected primarily for pharmaceutical metered dose inhalers (MDIs)[69] due to the measure of lifting the MDI quota exemption which is contained in all three policy options. Given the very high end-user prices for MDIs, however, the cost increase for end-users is estimated at below 0.1%. Positive HFC-price related cost in the *MP alignment* scenario 2024-2036 in the stationary AC sector is due to less technological change in comparison to the baseline, negative HFC-price related cost in the refrigeration and mobile AC sectors is due to slightly lower expected HFC prices.

In the *proportionate action* and *maximum feasibility* scenarios 2024-2036, significant positive HFC-price-related cost next to the mobile AC and MDI sectors (as discussed above) is expected for the refrigeration sector as in those scenarios the HFC prices may rise quicker than HFC demand is reduced due to technological change. Additional cost, however, is expected to be below 0.5 % of baseline total expenditure. For the stationary AC sector, a quicker technological change is expected as supported e.g. by specific POM prohibition measures (see section 8.2.1.1) in those policy options, resulting in less HFC-price related cost than in the baseline.

In the long-term 2050 perspective, total end-users' compliance cost are expected to be negative in all policy scenarios, ranging roughly from -340 Mio €/year in the *MP alignment* scenario to -840 Mio €/year in the *proportionate action* scenario and to -900 Mio €/year in the *maximum feasibility* scenario. All scenarios feature some additional HFC-price related cost in the range of 110-170 Mio €/year for remaining HFC users, more than outweighed, however by significant cost savings through technological change.

Emission reduction cost

Emission reduction cost compare the cost of technological change for investment in and operation of equipment based on low-GWP alternatives to the emissions saved during the lifetime of the respective equipment. In line with the methodology applied for the evaluation of the 2014 FGR Revision, equipment operators' cost for increased HFC prices are not considered for the calculation of emission reduction cost as those HFC-price related costs are borne by those operators which do not (fully) replace high-GWP HFCs and thus do not contribute to emission savings. Cost due to further increases of the HFC-

[69] In Table 33, MDIs are summarised in the 'Propellants, solvents & fire protection' sector. For data on subsector level, please refer to Annex 3.1.

price are thus not directly linked to actual emission reductions and lead to distributional effects, see section 10.2.8.

Table 36 summarises for all three lifetime-integrated emission reductions of new equipment, respective cost of technological change and thereof calculated emission reduction costs. As for operators' full compliance cost in Table 34 above, the focussed time horizon is on equipment installed in the 2024-2036 average, amended by an outlook to 2050 in Table 37.

Respective data on sub-sector level is given in Annex 3.2.

Table 36: Emission reduction costs, average 2024-2036

Sector	time horizon for new installed equipment	MP alignment scenario			proportionate action scenario			maximum feasibility scenario		
		lifetime-integrated emission reductions of new equipment compared to baseline	Cost of technological change of lifetime-integrated emission reductions	Calculated emission reduction cost for technological change	lifetime-integrated emission reductions of new equipment compared to baseline	Cost of technological change of lifetime-integrated emission reductions	Calculated emission reduction cost for technological change	lifetime-integrated emission reductions of new equipment compared to baseline	Cost of technological change of lifetime-integrated emission reductions	Calculated emission reduction cost for technological change
		Mt CO_2 eq	Mio €	€ / t CO_2 eq	Mt CO_2 eq	Mio €	€ / t CO_2 eq	Mt CO_2 eq	Mio €	€ / t CO_2 eq
Refrigeration	2024- 2036 average	-1.9	-5.5	NA	1.7	-120.8	-72.5	2.1	-188.6	-91.6
Stationary A/C	2024- 2036 average	-3.0	196.9	NA	7.3	-559.4	-76.3	7.3	-559.4	-76.3
Mobile A/C	2024- 2036 average	0.0	0.0	NA	1.7	96.2	57.9	2.9	303.9	106.4
Propellants, solvents & fire protection	2024- 2036 average	0.0	0.0	NA	2.5	3.3	1.3	2.5	3.3	1.3
Foam	2024- 2036 average	0.0	0.0	NA	0.0	0.0	NA	0.0	0.0	NA
Other HFCs	2024- 2036 average	0.0	0.0	NA	0.0	0.0	NA	0.0	0.0	NA
SF6	2024- 2036 average	0.0	0.0	NA	0.7	79.5	115.8	0.7	79.5	115.8
Total	**2024- 2036 average**	**-4.9**	**191.4**	**NA**	**13.8**	**-501.1**	**-36.3**	**15.4**	**-361.2**	**-23.4**
Total	**2050**	**4.4**	**-781.1**	**-178.1**	**16.0**	**-1 005.2**	**-62.7**	**16.3**	**-841.2**	**-51.7**

Source: AnaFgas cost modelling

Table 37: Emission reduction costs 2050

Sector	time horizon for new installed equipment	MP alignment scenario			proportionate action scenario			maximum feasibility scenario		
		lifetime-integrated emission reductions of new equipment compared to baseline	Cost of technological change of lifetime-integrated emission reductions	Calculated emission reduction cost for technological change	lifetime-integrated emission reductions of new equipment compared to baseline	Cost of technological change of lifetime-integrated emission reductions	Calculated emission reduction cost for technological change	lifetime-integrated emission reductions of new equipment compared to baseline	Cost of technological change of lifetime-integrated emission reductions	Calculated emission reduction cost for technological change
		Mt CO_2 eq	Mio €	€ / t CO_2 eq	Mt CO_2 eq	Mio €	€ / t CO_2 eq	Mt CO_2 eq	Mio €	€ / t CO_2 eq
Refrigeration	2050	0.7	-71.4	-104.7	0.6	-122.2	-222.0	0.5	-142.0	-262.9
Stationary A/C	2050	3.7	-709.7	-191.6	8.1	-1 474.0	-183.1	8.1	-1 474.0	-183.1
Mobile A/C	2050	0.0	0.0	NA	2.1	206.2	97.3	2.4	390.1	163.8
Propellants, solvents & fire protection	2050	0.0	0.0	NA	2.9	34.2	11.8	2.9	34.2	11.8
Foam	2050	0.0	0.0	NA	0.0	0.0	NA	0.0	0.0	NA
Other HFCs	2050	0.0	0.0	NA	0.0	0.0	NA	0.0	0.0	NA
SF6	2050	0.0	0.0	NA	2.4	350.5	145.2	2.4	350.5	145.2
Total	**2050**	**4.4**	**-781.1**	**-178.1**	**16.0**	**-1 005.2**	**-62.7**	**16.3**	**-841.2**	**-51.7**

Source: AnaFgas cost modelling

In the **2024-2036 time-horizon** for new installed equipment, average lifetime-integrated emissions under the *MP alignment* scenario exceed respective baseline emissions. Thus, no meaningful average emission reduction cost can be calculated for that scenario. Under the other policy scenarios, average emission reduction costs for that time horizon are negative at -36 €/tCO_2 eq (*proportionate action*) or -23 €/t CO_2 eq (*maximum feasibility*), as the deployment of low-GWP alternatives is cost-effective in average. However, results deviate at sectoral level: Sectoral averages of emission reduction cost in the refrigeration and stationary AC sectors are strongly negative at about -70 - -90 €/t CO_2 eq. Average cost in the propellants, solvents & fire protection sectors is positive but low at about 1 €/t CO_2 eq. In the mobile AC sector, average emission reduction costs range from 58 €/t CO_2 eq in the *proportionate action* scenario to 106 €/t CO_2 eq in the *maximum feasibility* scenario. For the SF_6 sector (electrical switchgear) average emission cost for installation installed under both these policy scenarios in the 2024-2036 time-horizon are calculated at 116 €/t CO_2 eq. For emission reduction cost calculated at subsector level please refer to Annex 3.2.

In the long-term perspective looking at installations installed in the **2050 time-horizon**, average emission reduction costs are negative under all policy scenarios. Under the *MP alignment* scenario, emission reduction costs are strongly negative at almost -180 €/t CO_2 as the deployment of only the most cost-efficient HFC substitutions was considered was this scenario. Under the *proportionate action* and *maximum feasibility* scenarios, emission reduction costs are also negative at about -60 €/t CO_2 eq. However, lifetime-integrated emission reductions are about 4 times as high as in the *MP alignment* scenario. The spread of emission reduction cost at sectoral level for 2050 is similar as discussed for the 2024-2036 time-horizon above.

10.2.2. Administrative costs to businesses

The implementation of the recommended policy measures is expected to impact the administrative burden to businesses, both through the requirement of an initial one-off implementation cost to enact the measure, and a change in ongoing annual operational costs. Table 10-12 below outlines the list of policy options for which there is expected to be an impact upon administrative burden. This is not a definitive list of measures, but a table containing the measures for which a change in administrative has been estimated. The policies have been grouped initially according to objective (A, B, C), with the costs for implementing the measures under each objective aggregated based upon the three levels of ambition – Low Scenario, Medium Scenario and High Scenario. The total aggregated change in administrative costs to industry have been detailed in Table 38 (annual costs) and Table 39 (initial costs). Although a number of the individual measures are expected to lead to a reduction in administrative burden for businesses, there is expected to be an overall increase in costs for industry under the medium and high policy scenarios.

Table 220 in Annex 7 provides an explanation of the methodology used to calculate the impact upon administrative burden for each policy option. This includes the approach used to determine the number of companies impacted by the proposed policy, and the change in administrative cost per company as a result. For a number of measures the administrative cost is expected to be consistent across different sized companies. However, in some instances, given costs will vary with levels of activity, this has then typically been split by size according to the split of companies in the EEA reporting database or through data collected on company size through a German industrial survey[70] of RACHP installation and servicing companies, with supporting expert judgement. The cost for each measure has been based upon a combination of expert judgement and feedback received from stakeholders based upon the requirements of the current Regulation.

[70] VDFK, 2019, Kälte-Klima-Konjunkturumfrage

The table below shows the aggregated change in annual administrative costs under each of the three ambition scenarios. The total costs have been outlined per both objective and policy scenario. In addition, a separate cost has been calculated to determine the total cost including the attendance of training to comply with measure C1.1/C1.2. Due to the high cost of this single measure, it was considered useful to illustrate the difference in the total cost when this measure is excluded.

Table 38: Total annual administrative costs to industry

EURO	Low	Medium	High
Objective A	-	19 016	19 016
Objective B	100	100	100
Objective C	-7 341	14 390	26 743
Total Days/Year	-7 241	33 506	45 859
Total Cost	-1 665 516	7 706 297	10 547 457
Total Cost (inc training days)	-1 665 516	28 457 960	31 299 120

The table below shows the aggregated change in one-off administrative costs as a result of implementing the policy measures under each of the three ambition scenarios.

Table 39: Total initial administrative costs to industry

EURO	Low	Medium	High
Objective A	13 075	13 075	13 075
Objective B	-	-	-
Objective C	-	-	3 063
Total Days/Year	**13 075**	**13 075**	**16 138**
Total Cost	**3 007 250.00**	**3 007 250.00**	**3 711 803.77**

10.2.3. Administrative costs to Member State authorities

The additional administrative burden of the policy options falling on member state competent authorities and customs authorities has been appraised following the Standard Cost Model process. Evidence and data regarding the potential costs is scarce, likely given the nature of the exercise: given we are estimating costs in the future which have not yet been incurred, and because administrative burden typically depends on the detailed implementation of the options. The assessment is based on qualitative sentiment provided by stakeholders, coupled with the administrative burden estimates from the evaluation and elicitation using the expertise of the project team.

The estimated additional administrative burden under each policy package is presented in the following table. A more detailed assessment split by measure is included in Annex 7.

Table 40: Total costs per policy option

	Upfront	Ongoing
Option	Days	Days pa
Low	246	17 – 3 100
Medium	246	5 280 – 8 360
High	90 920	10 700 – 13 800

There will be an additional burden associated with each option. Some of the potential underlying measures imply no or negligible costs for Member State Competent Authorities and Customs Authorities. The level of additional burden increases with the ambition of each option, as expected. That said, even the high ambition policy package would only deliver moderate increase in administrative burden

(When viewed relative to the total burden of the existing Regulation, appraised in the evaluation to imply a cost of around 58 300 days per annum).

The range of costs is driven by the inclusion and exclusion of costs associated with measures which are arguably not truly additional to the existing Regulation and hence are associated with the option. The low bound cost excludes (and the high bound includes) the additional burden associated with:

- Measure C2.1 - Include specific requirements for customs regarding the treatment of products and equipment illegally placed on the market and illegal F-gas containers once confiscated: Custom costs depend mostly on the risk profiling of the goods, and thus the controls actually carried out. In theory, illegal imports should already be dealt with in an effective way – i.e. confiscation and destruction, but in practice this does not always happen. Hence these costs in theory should already be incurred today, and hence are not truly additional to the option considered here but are not in practice.

- Measure C3.1 – General prohibition of entry into EU territory of non-refillable F-gas containers: Under the existing Regulation, the prohibition relates to placing non-refillable containers on the market. This extends the prohibition into the territory, which in theory is a small change with negligible costs. Given this is a small change, most im-porters are anticipated to already comply. But a small number (estimated to be approximately 5% of importers are) not currently conducting this practice and will therefore incur additional administrative cost. That said, given these actors should already comply with the Regulation, these costs are not truly additional and associated with this measure.

- Measure C3.2 - Prohibition for (offline and online) sales and possession of HFCs/F-gases that were illegally placed on the market: In theory MS should already be monitoring the market for illegal goods to a sufficient degree already. This measure would add more legal certainty around taking enforcement action, and in that way could lead to cost savings.

The most significant measure is C5.14 (requiring the use of electronic reporting). Although a handful of Member States currently use such systems (the additional costs for whom are anticipated to be negligible), it is uncertain whether the remaining large number of Member States have equivalent systems. As such this package includes and upfront cost for development and ongoing cost for maintenance and use of such systems. Additional prohibitions under the medium scenario and the additional requirements for training and certification programmes also contribute a significant increase in administrative burden for Member States.

10.2.4. Administrative costs to the European Commission and the European Environment Agency

As for Member State Competent Authorities above, evidence and data regarding the potential additional costs for the European Commission and EEA has been provided by these stakeholders themselves. The estimated additional administrative burden under each policy package is presented in the following tables. A more detailed assessment split by measure is included in Annex 7.

Table 41: Total costs per option – European Commission (DG CLIMA)

	Upfront	Ongoing
Option	Days	Days pa
Low	10 - 677	100 - 338
Medium	2 220 – 2 880	2 310 – 2 550
High	2 220 – 2 880	2 350 – 2 590

All policy packages will imply an increase in administrative burden for the Commission. As expected, the Costs vary by scenario, in particular there is a significant jump between low to medium options.

The costs for the medium and high policy packages are large relative to current costs for CLIMA: the evaluation identified the existing Regulation implies a burden of around 1 300 days per annum. The largest measure, and the driver of this result, is measure C4.3 (introduction of a quota allocation fee). This is anticipated to require significant resource both upfront and on an ongoing basis (2 600 days upfront and per annum) to set up and operate the system, in particular related to the collection and distribution of funds. These costs are likely to be outsourced and will be fully offset by the revenues collected, but either way this places an additional burden at the European level (captured here for DG CLIMA).

The range of costs is driven by the inclusion and exclusion of costs associated with:

- The collection of measures which could imply additional costs for CLIMA if controls are to be automated and thus require further development of Certex (measures B4.1, C2.2 and C3.6). That said, automation is not necessarily required by the Regulation – without these costs would be significantly more moderate and do not exceed much the current costs.
- Measure C3.2 – as above for Member States, the cost of this measure is arguably not additional to the existing Regulation.

Table 42: Total costs per option - EEA

	Upfront	Ongoing
Option	Days	Days pa
Low	42	-2
Medium	142	10
High	292	328

For the EEA, only costs related to monitoring, reporting and verification are relevant. Again, costs vary by scenario, with large step ups between the scenarios. In fact, the low scenario could deliver savings for EEA (driven by the measures that reduce the numbers of firms subject to reporting or verification measures). The additional administrative burden for the medium option compares favourably to current costs of Regulation which were appraised in the Evaluation to be around 430 days per annum. The measure which has the greatest impact on the administrative burden for the EEA is anticipated to be those which imply changes to reporting and verification obligations, in particular for exporters of products and equipment containing F-gases.

10.2.5. Distribution of cost across business size

In the HFC supply chain, a high share of SMEs is likely to be found among equipment importers and service companies. For both, however, no particular disadvantage can be anticipated:

- Equipment importers face basically the same surcharges on HFCs in equipment like EU OEMs.
- Service companies do benefit from higher margins on increasing HFC prices. As the increase of HFC prices is assumed to be far higher in the '*maximum substitution'* and '*proportionate action'* policy options than in the *'MP alignment'* scenario, such benefits to SME service companies would occur to a lower degree in the *'MP alignment'* policy option.

For equipment operators, subject to operative cost as assessed in section 10.2.1, unfortunately no reliable data is available to quantitatively assess the distribution of compliance cost across business size and possibly identify impacts on small and medium enterprises (SMEs). The impact on SMEs

among equipment operators can be approximated by the compliance cost expressed in relation to baseline total expenses as given on aggregate level in section 10.2.1, and on disaggregated level in the Annex 3.1.

The administrative costs were calculated on a per company basis, with costs based upon the size of the company, defined as large, medium or small. For a number of measures the administrative cost is expected to be fixed across different sized companies, but for some other measures there is expected to be a difference based upon activity level. The approach taken to determining the breakdown of company size has been outlined in the 'administrative cost to industry' section above. The costs to industry participants have been based upon a mixture of stakeholder feedback, literature review and expert judgement of the sector. Due to the relatively limited stakeholder feedback and absence of reliable cost data within the available literature, expert judgement of the sector has played a key role in determining the costs borne to companies. The table below outlines the expected cost per company based upon their size. Please note the costs below represent the combined measures. No single company will be expected to incur these total costs as each measure will not apply to any single company. They are representative of the difference in the costs per company size, rather than the costs per company.

Table 43: Total annual administrative cost per company based on size (combined total for all measures)

EURO	Small	Medium	High
Total Annual Cost per Company for all measures	5 700	13 300	26 000

10.2.6. Distribution of cost across EU regions

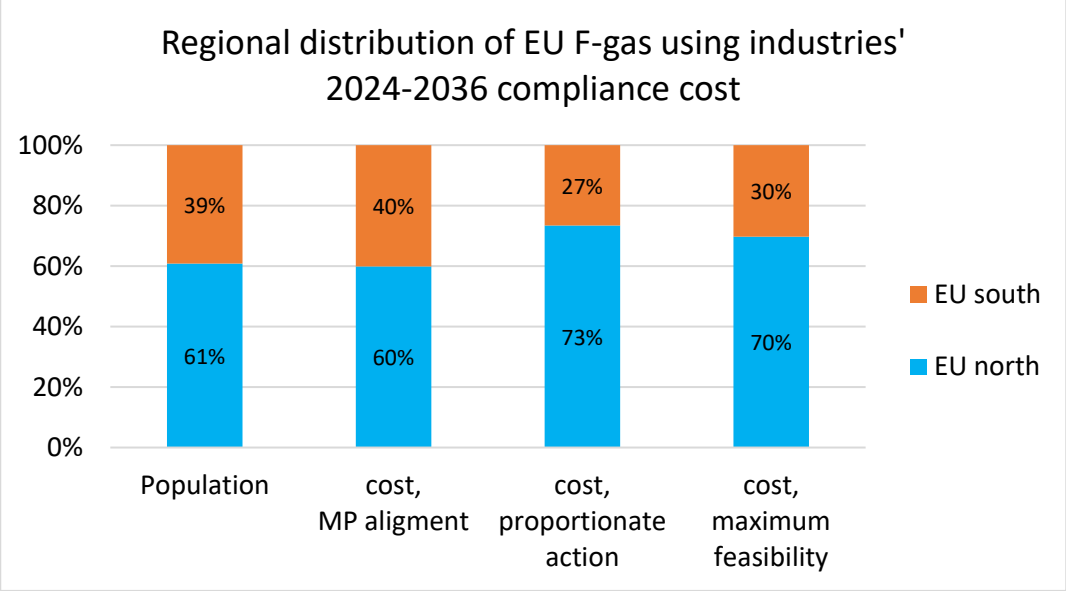
In the sub-sectors of commercial refrigeration, transport refrigeration, mobile AC as well as for aerosols a large number of installations may be affected by an amendment of the Regulation and the type of equipment is relatively equally distributed among Member States. Investments in replacement technologies will show some variations: As discussed in the evaluation of the 2014 FGR Revision, the use of natural refrigerants has been common in Northern European countries for many years, especially CO_2 technology in commercial refrigeration, so that a large number of installations have been running on alternatives for years. Furthermore, the structure of applications differs between Member States especially in the commercial refrigeration sector as small shop formats are more common in Southern Europe requiring different types of refrigeration and air conditioning systems than hypermarkets and large shopping malls.

Stationary AC units as well as AC systems in buses and trams are more frequently used in warmer Mediterranean climate in southern Member States than in temperate climate in the north. Furthermore, the use of reversible heat pumps is expected to grow, especially in southern Europe. Therefore, for these subsectors higher direct net costs will occur for Southern European countries: On the other hand, heating-only heat pumps are more frequently used in the northern EU region. Other sub-sectors concern small numbers of installations in few Member States, such as halocarbon production plants and XPS foam blowing installations.

For the impact assessment of the policy options, additional compliance cost of F-gas users in comparison to the baseline were analysed for distribution patterns between northern and southern EU countries. Assumptions made on regional distribution on sub-sector level are given in Annex 2.3.

Figure 23 presents the results of this analysis by comparing relative shares of cost distribution in the policy scenarios with the distribution of population (39% EU south, 61% EU north).

Figure 23: Regional distribution of EU F-gas using industries' 2024-2036 compliance cost



Note: EU South: Bulgaria, Croatia, Cyprus, southern France (25% of FR population), Greece, Italy, Malta, Portugal, Romania, Spain; EU North: other EU27 MS, including 75% of the French population.

Source: AnaFgas cost modelling

In the MP alignment option, the cost distribution is found to be almost proportionate to population, with a slight shift to cost for the southern EU. In the more ambitious 'proportionate action' and maximum feasibility' options, however, the cost distribution switches significantly towards the EU north. This is mostly due to the effect that for pre-dominantly southern sectors like small stationary AC systems a strong shift away from HFC technologies to cost-efficient replacements has been assumed in the AnaF-gas scenarios underpinning those options, resulting on cost savings for operators in comparison to the baseline, both for the HFC charge and re-fill (considering rising HFC prices) and for other technical cost.

Regional patterns were also assessed for the macroeconomic indicators GDP, consumption, investment and employment. As overall effects for those indicators were found to be very small (< 0.01% changes in comparison to baseline developments, no strong regional patterns were found. When comparing the policy options, however, under the MP alignment scenario the Southern EU region preforms slightly better for GDP and investment than the Northern EU region, and slightly worse under the *proportionate action* and *maximum feasibility* scenarios. Please refer to section 10.2.7 for more detailed results.

10.2.7. Macro-economic Impacts on the EU

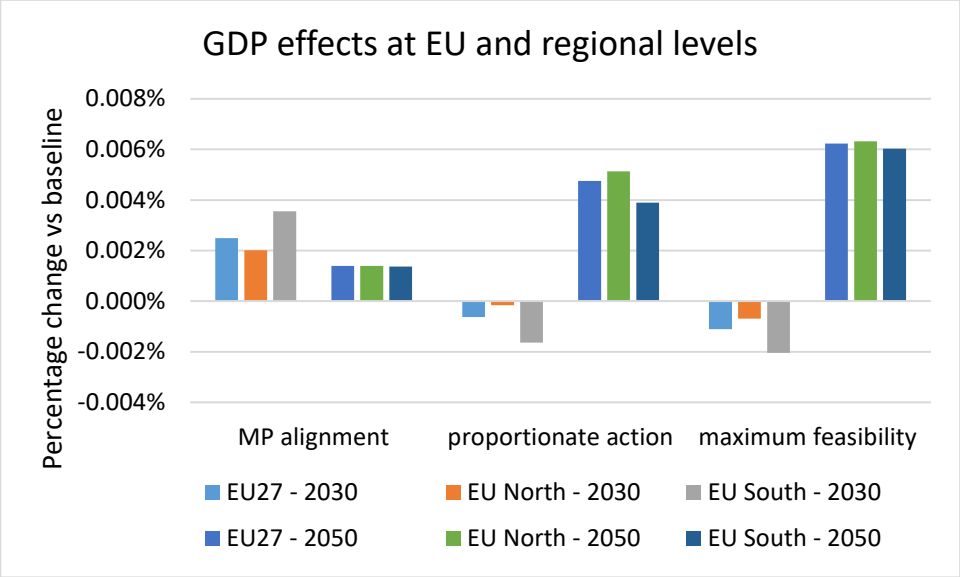
The effects of the three analysed policy options on the EU economy were modelled using the JRC-GEM-E3 model. The policy scenarios were assessed in comparison to the EU reference scenario 2020[71] which was used as the baseline. A description of the model and of the setup of the scenarios are given in Annex 4.1. Detailed sectoral results are given in Annex 4.2

[71] European Commission (2021). EU Reference Scenario 2020: Energy, transport and GHG emissions - Trends to 2050, doi: 10.2833/35750.

The impact on the macroeconomy was found to be small as the changes included in the different options concern only limited areas of the economic system. The effects on the macroeconomy follow the costs respectively savings that were found in the three policy scenarios as reflected in the results of the AnaFGas model as discussed in section 10.2.1.

Figure 24 summarises GDP changes in comparison to the baseline for all three policy options and for 2030 and 2050 time-horizons. The overall magnitude of impact on the EU GDP is small at <0.01% in all three policy options. In the *MP alignment* scenario, GDP increases at about 0.002% for 2030 and about 0.001% for 2050 were calculated. In the *proportionate action* and *maximum feasibility* scenarios, for 2030 slight negative GDP impacts at about -0.001% were calculated, however developing into positive impacts of about 0.005% by 2050, thus significantly higher than in the *MP alignment* scenario.

Figure 24: GDP effects



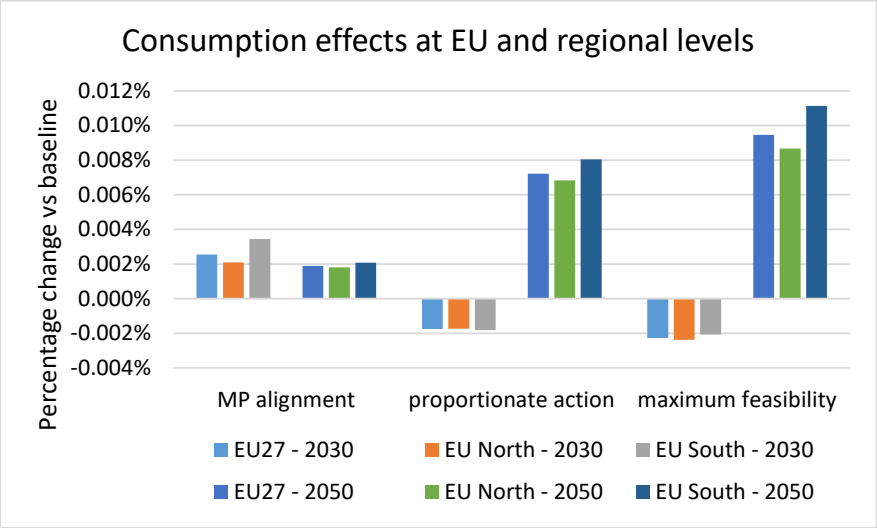
Note: EU South: Bulgaria, Croatia, Cyprus, southern France (25% of model results for France), Greece, Italy, Malta, Portugal, Romania, Spain; EU North: other EU27 MS, including 75% of model results for France.

Source: JRC-GEM-E3 modelling, based on AnaFgas cost modelling

In absolute terms, the increase in GDP identified in the GEM-E3 model results is larger than the savings in costs as determined in the AnaFGas results. For example, a GDP increase of 1.2 billion EUR in 2050 was found in the Maximum Feasibility Scenario whereas only 0.5 billion of costs savings were identified for the same year. This shows that rising HFC prices affect GDP relatively little. Cost savings lead to an increase in GDP, as the same goods can be consumed or produced with less input and thus less expenditure is needed for the same purchases. These savings can be used to purchase other goods and services, thus increasing GDP.

Changes in EU27 consumption are found to be similar to changes in GDP (Figure 25): Small positive impacts for the *MP alignment* scenario, decreasing from 2030 to 2050, and small negative 2030 impacts in the *proportionate action* and *maximum feasibility* scenarios, turning into significantly stronger positive impacts in the long-term perspective.

Figure 25: Consumption effects

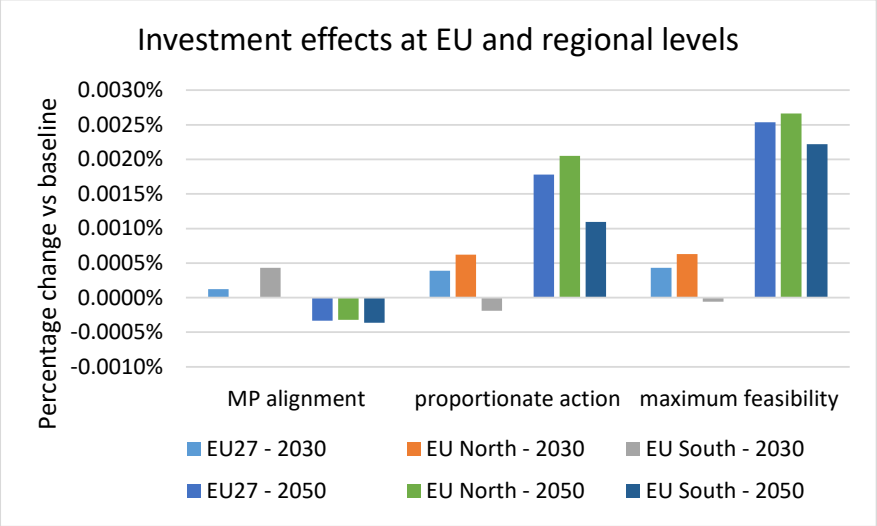


Note: EU South: Bulgaria, Croatia, Cyprus, southern France (25% of model results for France), Greece, Italy, Malta, Portugal, Romania, Spain; EU North: other EU27 MS, including 75% of model results for France.

Source: JRC-GEM-E3 modelling, based on AnaFgas cost modelling

EU27 investment (Figure 26) is changing in response to an increased GDP, but effects are relatively small; investments in the power sector decline due to lower demand for electricity, while there are increases in some other sectors (mainly equipment manufacturing) that benefit from energy savings. In the 2050 time-horizon, a very small negative investment balance (-0.0003 %) has been calculated for the *MP alignment* scenario, while the *proportionate action* and *maximum feasibility* scenarios result in small positive balances of about 0.002 %.

Figure 26: Investment effects

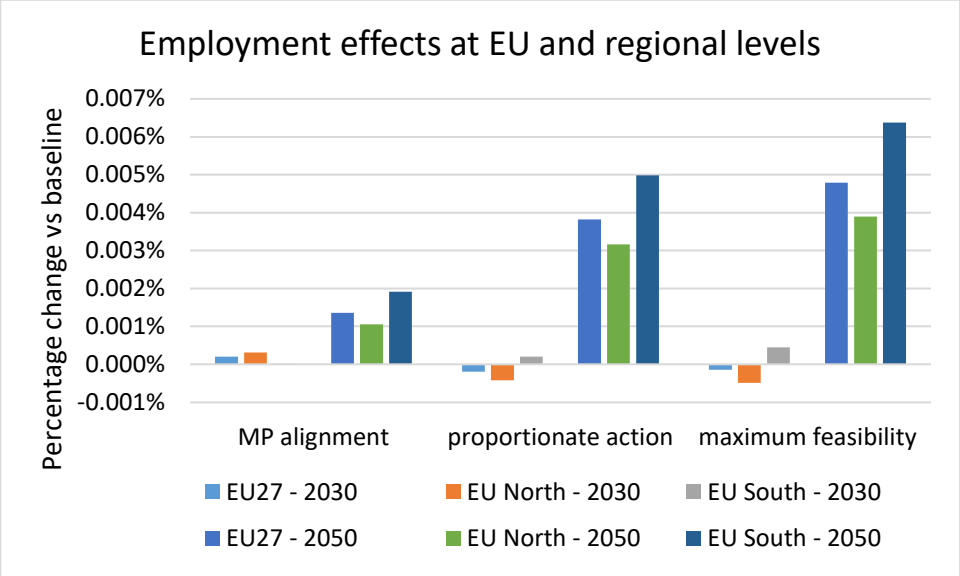


Note: EU South: Bulgaria, Croatia, Cyprus, southern France (25% of model results for France), Greece, Italy, Malta, Portugal, Romania, Spain; EU North: other EU27 MS, including 75% of model results for France.

Source: JRC-GEM-E3 modelling, based on AnaFgas cost modelling

Employment at EU27 level reacts in line with changes in GDP, increased GDP thus also leads to increases in employment (Figure 27). However, net changes at the economy level are relatively small, for example in 2050 a net gain of about 8 500 persons, or 0.005% of total baseline employment. Changes at the sectoral level (see Annex 4.2) are bigger and in line with changes in investments in those sectors. For a more detailed discussion of employment effects, please refer to section 10.3.1.

Figure 27: Employment effects



Note: EU South: Bulgaria, Croatia, Cyprus, southern France (25% of model results for France), Greece, Italy, Malta, Portugal, Romania, Spain; EU North: other EU27 MS, including 75% of model results for France.

Source: JRC-GEM-E3 modelling, based on AnaFgas cost modelling

10.2.8. Distributional effects between equipment operators and undertakings of the HFC supply chain

As discussed in section 10.2.1, the cost to F-gas using industries (equipment operators) due to HFC price increases are reflected as revenues without associated cost in the HFC supply chain.

An increase in HFC prices is the essential mechanism of the HFC phase-down to efficiently incentivise EU end-users / equipment operators to switch from high-GWP HFC-based installations to alternative installations based on low-GWP alternatives as soon as cost-efficient alternatives are available in the respective sectors. Thus, the gas producers and gas importers, i.e. the companies which place the HFCs on the EU market and get allocated the limited amounts of required quota under the HFC phase-down, increase their selling prices and thus issue a price signal to downstream actors in the HFC supply chain, and subsequently to equipment operators, reflecting the scarcity of HFCs, measured in CO_2 eq, imposed by the HFC phase-down. Where not restricted by long-term contracts, both gas distributors and, further downstream, service companies apply surcharges on their respective purchasing prices when selling to their respective customers. The price signal reflecting scarcity, finally visible to the equipment operators, i.e. those companies making the investment decisions on future use of HFCs or low-GWP substitutes, is thus higher (in terms of €/kg or €/t CO_2 eq) than in the selling prices of producers/importers placing the HFC on the EU market[72].

[72] For equipment pre-charged by OEMs (original equipment manufacturers) and then directly sold to customers (e.g. hermetic refrigeration equipment, movable AC units or vehicles containing an AC unit), the step of service companies is omitted in the supply chain at least for the first fill of such equipment.

The allocation of quota under the HFC phase-down is for free based on a grandfathering approach, complemented with a reserve for new entrants to be distributed evenly among all applicants. Unlike the EU ETS, where emission certificates are being auctioned, EU governments thus do not claim a fee which could possibly be re-distributed into the affected sectors with the aim to support the Regulation's objectives. While this approach would be maintained in the "MP alignment" policy option, the introduction of a quota allocation fee is considered in the policy options "proportionate action" and "maximum feasibility" (see section 8.7.4.3). That allocation fee is proposed to be set at 3 €/ t CO_2 eq for 2024, thus below recent market levels on HFC price increases (6 €/t CO_2 eq as OEM purchasing prices[73]) in order to avoid significant pass-through to end-users and proposed to rise in reverse proportion to the development of the EU-wide maximum quantity for HFCs to be placed on the EU market under the FGR POM phase-down.

Table 44 shows the total amount of quota allocation fees expected to be collected annually by the European Commission, based on total quota amounts foreseen for 2024 under the different options (see section 8.1). As the concept of the allocation fee measure (section 8.7.4.3) features an increase of the fee in reverse proportion to the development of the maximum quantity, the annual revenue of 130 Mio €/a in the "proportionate action" option or of 123 Mio €/a in the "maximum feasibility" option can be expected to be constant over time.

Table 44: Expected volume of quota allocation fees

	Metric	MP alignment	proportionate action	maximum feasibility
2024 Maximum quantity of HFCs	Mt CO_2 eq	49.0	41.7	41.0
Fee volume at 3 €/t CO_2 eq	Mio €/a	*	125.1	123.1

Note: * In the MP alignment option, no quota allocation fee is included. In case of such a fee, the expected revenue would amount to 147.1 Mio €/a

In the AnaFgas modelling framework it was calculated how the HFC-price related cost to equipment operators (based on assumptions for the development of HFC process as set out in section 10.2.1) can be expected to be split as revenues in the HFC supply chain between HFC producers and importers and HFC distributors on one hand, and service companies on the other hand. The allocation fee collected by the European Commission from quota holders will respectively reduce the profits calculated for HFC producers and bulk importers while avoiding that costs for end-users would be increased (Table 45).

EU27 baseline cost due to the HFC price increase in the 2024-2036 average are expected to reach about 2.1 billion €/a, thus exceeding the annual cost found in the evaluation of the 2014 FGR Revision for the 2015-2019 period (1.7 billion €/a for the EU28). In the 2050 time-horizon, however, HFC-price-induced cost to equipment operators is expected to decline to 1,4 billion €/a.

In the *MP alignment* scenario, total end-users' cost for HFC prices in the would rise above the baseline by 10% in 2024-2036 time-horizon and by 8 % by 2050. In the *proportionate action* scenario the cost for HFC prices are 19 % (2024-2036) sinking to 12 % (2050), in the *maximum feasibility* scenario 21 % (2024-2036) to 10 % (2050). Note that total end-users cost do not develop proportionally to the assumption on bulk HFC prices as deviations in HFC demand and sector-specific spread between bulk gas process and gas prices at user level need to be considered.

Given in particular the HFC price assumptions (Table 33) the quota allocation fee measure (contained in the *proportionate action* and *maximum feasibility* policy options) would cut the profits calculated for bulk importers and distributors by roughly 10%. Still, bulk importers and distributors would gain roughly

[73] Source: Öko-Recherche HFC price monitoring on behalf of the European Commission

two thirds of the overall profits of the HFC supply chain in all policy scenarios. Service companies' profits from HFC price increases may actually decrease below baseline levels by 2050.

Table 45: Profits in the HFC supply chain

Cost / income category	Time horizon	Baseline: Continuation of 2014 FGR beyond 2030	MP alignment option		Proportionate action option		Maximum feasibility option	
			Additional to baseline	Absolute *	Additional to baseline	Absolute *	Additional to baseline	Absolute *
		Mio €/ a	Mio €/ a	Mio €/ a	Mio €/ a	Mio €/ a	Mio €/ a	Mio €/ a
HFC-price induced additional cost to end-users	**2024-2036 average**	**2 101**	**210**	**2 311**	**407**	**2 507**	**442**	**2 543**
gained by service companies	2024-2036 average	863	8	872	137	1 000	147	1 011
gained by bulk importers / quota holders and distributers	2024-2036 average	1 237	202	1 439	145	1 382	172	1 409
charged by the European Commission as quota allocation fee	2024-2036 average	0	0	0	125	125	123	123
HFC-price induced additional cost to end-users	**2050**	**1 381**	**115**	**1 496**	**170**	**1 551**	**142**	**1 523**
gained by service companies	2050	470	1	471	-81	389	-128	342
gained by bulk importers / quota holders and distributers	2050	911	113	1 025	125	1 037	147	1 058
charged by the European Commission as quota allocation fee	2050	0	0	0	125	125	123	123

Note: * 'absolute' amounts are additional to the counterfactual scenario assuming no HFC phase-down at all as set out in the 2014 FGR revision

Source: AnaFgas cost modelling

10.2.9. Impact on consumer prices

Effects on consumer prices depend on the extent that the operators of F-gas using equipment pass through any additional costs they may experience. In few sub-sectors the equipment operators mostly coincide with private consumers (e.g. domestic refrigeration, moveable AC units, mobile AC in passenger cars). In most sub-sectors, however, the operators of equipment are companies which use such equipment in order to provide other goods or services to consumers, e.g. refrigerated products, air-conditioned office space or transport or IT services relying on fire-protected server farms.

Potential effects on consumer prices can be assessed based on equipment operators' relative compliance cost (i.e. the difference between cost calculated in the policy option scenarios and the baseline scenario, see section 10.2.1 or Annex 3.2 on a more disaggregated level). Those relative compliance cost give an indication how much the baseline operative cost of the respective equipment would change due to an amendment of FGR according to any of the discussed policy options. For those sectors that exhibit negative relative compliance costs no effects, or even positive effects on consumer prices through reduced prices can be assumed. In the ***"MP alignment" policy option***, this would affect mostly those sub-sectors that particularly benefit from the reduced increase in HFC prices expected under that option in the 2024-2036 time-horizon, compared to the baseline, i.e. commercial and industrial refrigeration systems and AC systems in vehicles. However, almost all of those sub-sectors hardly have direct links to consumer prices. In the ***"proportionate action" and "maximum feasibility" policy options***, however, this would affect rather those sub-sectors where additional cost-effective technological change in comparison to the baseline would be incentivized, in particular small stationary AC systems.

Effects on consumer prices in sub-sectors facing low but positive relative compliance costs will likely be comparable to those that are caused by volatile input prices anyway (e.g. for HFC-gases). With prices for HFC fluctuating strongly in the past, equipment operators continuously needed to adapt their cost calculation and decision on cost pass-through. The same rationale can be assumed to hold for low additional costs due in response to an upcoming amendment of the Regulation. In the ***"MP alignment" policy option***, the calculated relative compliance cost was below 1 % for all sub-sectors in the 2024-2036 time-horizon. In the ***"proportionate action" and "maximum feasibility" policy options***, this was the case for the majority of sub-sectors (see the Annex 3.2).

For sub-sectors with higher relative compliance costs, the situation may differ. To recover their additional costs, affected entities may need to adjust consumer prices. However, such an adjustment process (i.e. the actual pass-through rate) depends on a variety of economic factors, such as the position in the market, competitiveness, profit margins. Moreover, the additional costs that are passed through to consumers may represent only a very small cost share in overall production costs. For example, additional costs for refrigeration or air conditioning on ships are small compared to other operative costs for such vessels. Likewise, additional costs for large scale commercial refrigeration in supermarkets may be distributed among a large range of products and services and thus be negligible. Therefore, the overall/average cost effect per sector may be balanced and no cost pass-through initiated.

The relative compliance costs 2024-2036 in the ***"proportionate action" and "maximum feasibility" policy options*** are expected to be highest fire protection sub-sector and for AC systems on ships. For fire protection, it should be noted that not the complete EU sectors were covered in the analysis but rather only those niche applications of the overall EU fire protection sectors which used to rely on fluorinated gases as blowing agent or suppression agent. For the fire-protection sector, HFC-based installations are usually used to protect particularly sensitive goods and high values. For ship AC systems, a cost pass-through to consumers is unlikely given the low proportion of AC system-related cost to other operative cost of vessels.

Furthermore, the analysis of policy option using the JRC-GEM-E3 model (see Annex 4) was used to assess effect on consumption prices at sectoral level (see Annex 4.2). For all policy scenarios, some consumption price increases for the 'medical care and health' sector were calculated at about 0.04 % -

0.05 % for 2030, compared to the baseline, for 2050 at about 0.03 %. These are due to the expected cost related to lifting the MDI exemption in all three policy scenarios.

In summary, it can be concluded that the overall effect of the amended Regulation on consumer prices would not be significant under all policy options.

10.2.10. Impact on trade flows (imports and exports)

Exports

As relates to export of bulk F-gases, in particular bulk HFCs, the baseline to assess the policy against does include an implementation of the HFC production phase-down schemes under the Montreal Protocol individually by the EU Member States. The proposed settings for the EU-wide HFC-production phase-down measure (see section 8.6.3) contained in all three policy options, do safeguard that the EU HFC production phase-down scheme would not limit EU HFC production, and thus possibly connected HFC exports, more than in the case of individual regulation by Member States. Thus, no negative effects on bulk HFC exports are to be expected in all three policy options as a result of an EU-wide system. However, as part of the baseline, the MP may lead to lower future export levels as production will have to decline compared to historic 2011-2013 levels as internationally agreed.

For bulk SF_6 exports, no restrictions apply in all three policy options. Manufacture and exports of electrical switchgear containing SF_6 would not be restricted, neither, in any of the policy options, as the respective ban measures for SF_6 equipment under the ***"proportionate action" and "maximum feasibility" policy options*** apply for placing on the EU market only.

However, exports of products and equipment containing HFCs may be negatively affected under the ***"proportionate action" and "maximum feasibility" policy options*** as under those policy options significantly higher HFC prices are to be expected compared to the baseline or the "MP alignment" option (see section 10.2.1). This would affect those EU equipment manufacturers and exporters which would not be able to organize their business in a way to rely on HFCs imported under the inward processing customs procedure and subsequently re-export the HFCs inside the equipment without ever having them placed on the EU market.

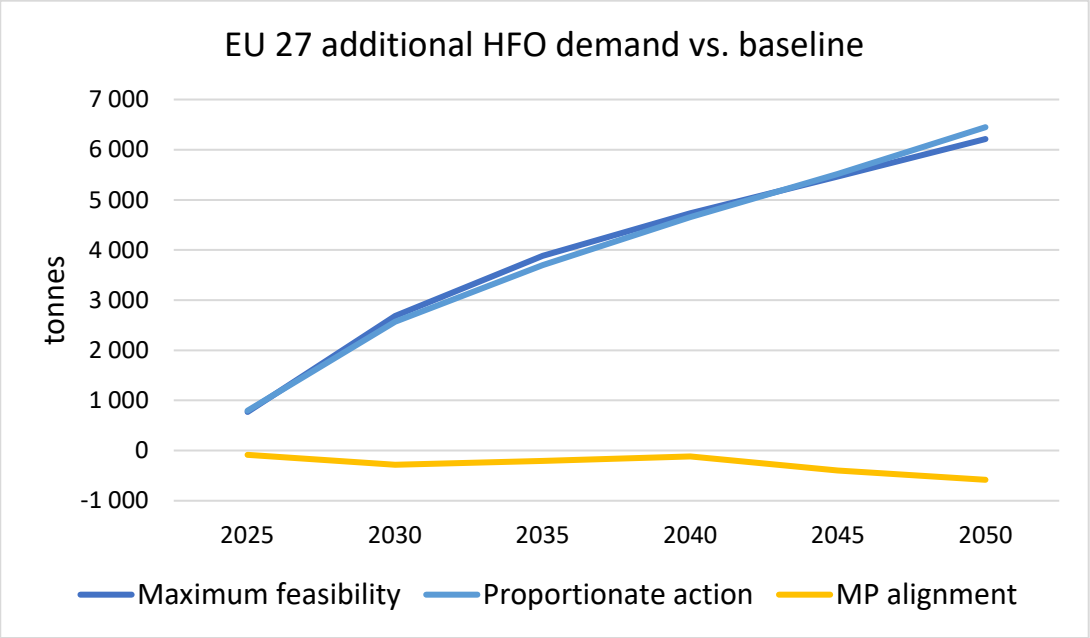
These expectations are supported by the JRC-GEM-E3 analysis, which concludes for the "proportionate action" and "maximum feasibility" policy options in slight export losses in the 'other equipment goods' sector of 0.024 %-0.030 % by 2030 and 0.132 %-0.144 % by 2050 (see section 10.2.12 and detailed tables in Annex 4.2). In the "MP alignment" scenario, export effects for the 'other equipment goods' have been calculated as below +/- 0.01%. However, the total balance on exports across sectors was assessed as slightly positive (<0.01 %) for all policy options, both for 2030 and for 2050.

Statistical information on the past quantity of exports of HFC-containing products and equipment is not available. The "maximum feasibility" policy option does include a measure to introduce a dedicated reporting scheme.

Imports

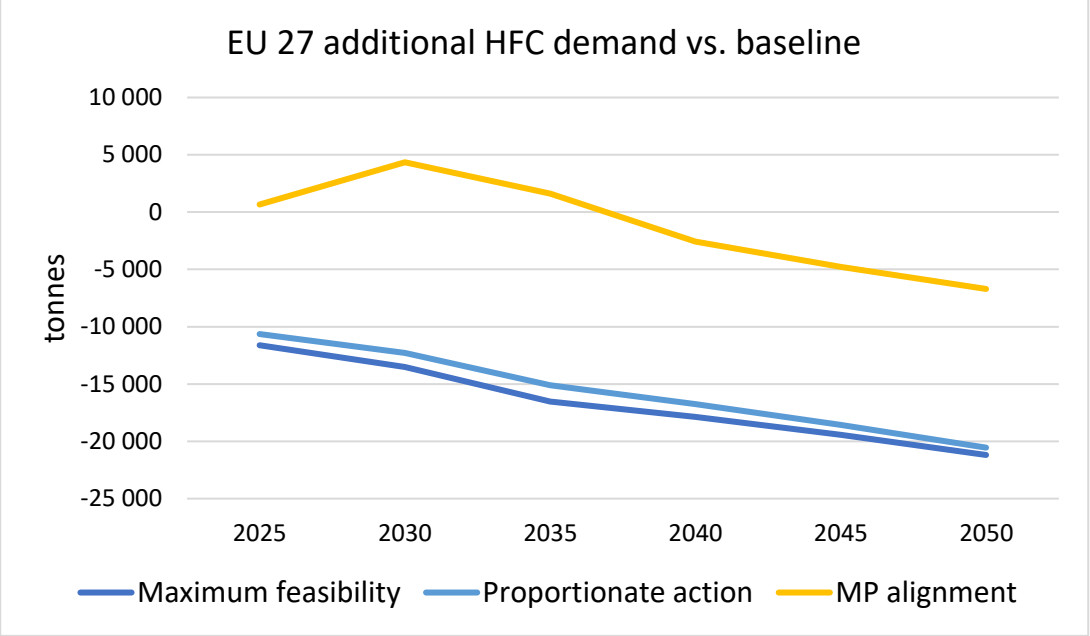
Changes in trade/import patterns for fluorinated gases under the different policy options can be deducted from modelled HFO and HFC demand as given in Figure 28 and Figure 29: Given that EU gas production and exports do not vary between the options, changes in demand directly translate into changes in imports.

Figure 28: Additional HFO demand in policy scenarios vs baseline (tonnes)



Source: AnaFgas

Figure 29: Additional HFC demand in policy scenarios vs baseline (tonnes)



Source: AnaFgas

Under the *proportionate action* and *maximum feasibility* policy options, avoided imports of HFCs, measured in tonnes, amount to about 20,000 tonnes per year in 2050, thus approximately three times the amount of additional HFO imports under those options (~6,500 t/a in 2050). Under the *MP alignment* scenario, HFO demand is remains slightly below the baseline for the whole 2025-2050 time period, while HFC demand is above the baseline until the mid-2030s and also below the baseline afterwards.

A conversion into monetary units can be provided by means of the JRC-GEM-E3 model: Those changes in import patterns under the *proportionate action* and *maximum feasibility* policy options translate for chemical products into additional imports of about 9 Mio €/a in 2030 increasing to about 15 Mio €/a in 2050. Under the *MP alignment* option, imports of chemical products were calculated to be about 4 Mio €/a below the baseline, both for 2030 and 2050 (see detailed background tables on imports in Annex 4.2).

However, in the JRC-GEM-E3 results, increased value of imports in the 'other equipment goods' sector (comprising RAC equipment) is far more relevant than the import trends for fluorinated gases discussed above. The import share enhanced EU demand for such equipment under the *proportionate action* and *maximum feasibility* policy options is worth about four times the increased value of gas imports (see detailed background tables on imports in Annex 4.2). However such increases in imports of equipment are far less relevant than the modelled increase in output for the EU sector, which is about 9 times higher in 2030, or 5 times higher in 2050 (see Table 46 in section 10.2.12 on competitiveness).

10.2.11. Impact on R&D and innovation

The evaluation of the 2014 FGR revision did find that R&D and innovation were fostered in reaction to the bans and rising HFC prices, in particular in the refrigeration and air conditioning equipment manufacturing sector. Likewise, further incentives for investment in R&D & innovation are to be expected in particular for the *proportionate action* and *maximum feasibility* policy options featuring significant reductions in the maximum admissible HFC quantities, compared to the baseline (see section 8.1). For the *MP alignment* policy option, however, little additional impact on R&D ad innovation is to be expected.

These deliberations are supported by the JRC-GEM-E3 modelling results pointing to additional investment in particular in the 'other equipment goods sector' in the *proportionate action* and *maximum feasibility* scenarios (approximately +0.15% in 2030, and + 0.2% in 2050, for background data see detailed tables in Annex 4.2).

10.2.12. Impact on competitiveness

Competitiveness of producers of gases where the demand is affected by the policy options, in particular HFCs, HFOs and SF6.

While the production of HFCs will need to be phase-down under the Montreal Protocol, this does not specifically affect any of the policy options as respective limitations are also part of the baseline as enforcement action on Member State level (if no EU-wide production phase-down scheme, see section 8.6.3, will be implemented).

The SF_6 bans for electrical switchgear (see section 8.2.1.5) foreseen in the *proportionate action* and *maximum feasibility* policy options would not disadvantage EU gas producers in comparison to non-EU producers, neither. Thus, no negative effect on competitiveness can be concluded for EU gas producers.

Competitiveness of businesses active in the manufacture and maintenance of equipment that operates based on F-gases or low-GWP alternatives

As discussed in section 10.2.11, the *proportionate action* and *maximum feasibility* policy options are likely to incentivise R&D and innovation related to equipment operating with low-GWP alternatives. This is likely to increase export opportunities, in particular, considering the Kigali Amendment to the Montreal Protocol, which will lead to a world-wide increase in demand in such technologies, however in a scheduled delayed to the EU HFC phase-down. For those undertakings in the EU equipment manufacturing sector which do manufacture pre-charged refrigeration, air-conditioning and heat pump (RACHP) equipment a level playing field in relation to non-EU competitors is effectively provided under the Regulation

by means of the inclusion imports of such equipment in the HFC phase-down under Article 14. Equipment not covered by Article 14 is hardly traded, as confirmed by the reporting data collected under Article 19. All of this points towards positive effects for competitiveness of EU manufacturers under the *proportionate action* and *maximum feasibility* policy options.

This is supported by JRC-GEM-E3 modelling results: Output of the 'other equipment goods' sector (which incorporates in GEM-E3 the RAC equipment manufacture) increases by 0.1% to 0.2% under those policy options (Table 46).

Table 46: Effects for the 'other equipment goods' sector, policy scenarios in comparison to the baseline

Indicator	Time horizon	Baseline		Percentage change vs baseline		
				MP scenario	PA scenario	MF scenario
Output	2030	714.5	bn USD 2014	-0.14%	0.13%	0.15%
Imports	2030	55.5	bn USD 2014	-0.19%	0.19%	0.22%
Exports	2030	83.7	bn USD 2014	0.01%	-0.02%	-0.03%
Investment	2030	33.9	bn USD 2014	-0.14%	0.13%	0.15%
Employment	2030	5 335	thousand persons	-0.14%	0.12%	0.15%
Output	2050	924.1	bn USD 2014	0.09%	0.19%	0.20%
Imports	2050	81.8	bn USD 2014	0.13%	0.44%	0.46%
Exports	2050	134.7	bn USD 2014	0.00%	-0.13%	-0.14%
Investment	2050	43.3	bn USD 2014	0.09%	0.20%	0.20%
Employment	2050	4 786	thousand persons	0.09%	0.19%	0.19%

Note: MPA: MP alignment; PA: proportionate action; MF: maximum feasibility
Source: JRC-GEM-E3 modelling, based on AnaFgas cost modelling

However, the competitiveness of export-oriented EU businesses could possibly be negatively affected in cases where EU manufactures rely on HFCs to be charged into products or equipment to be exported: In case such EU manufacturers rely on HFCs which were placed on the EU market and are thus subject to the quota limitation and rising HFC prices under the *proportionate action* and *maximum feasibility* policy options, which could imply a competitive disadvantage on the non-EU markets in comparison to non-EU competitors with access to lower-priced HFCs. Also, JRC modelling results indicate losses in exports from the 'other equipment goods' sector (Table 46).

However, JRC-GEM-E3 modelling results (Table 46) show that in monetary units gains in output to be expected under the *proportionate action* and *maximum feasibility* policy options are by far larger than the losses in exports.

10.3. Social impacts

10.3.1. Employment effects

Table 47 summarises sectoral employment effects as calculated for 2030 and 2050 by the JRC-GEM-E3 model for all policy options in comparison to the baseline. For more details, please refer to the tables in Annex 4.2. Mostly affected sectors are electricity, 'other' equipment goods, and services. The net balance across all sectors in the 2030 time horizon is slightly positive (~ 400 persons) in the *MP alignment* scenario, and slightly negative (~300-400 persons) in the *proportionate action* and *maximum feasibility* scenarios. In the 2050 time horizon, positive employments were calculated for all policy options, ranging from ~2,400 in the *MP alignment* scenario to ~6,800 in the *proportionate action* scenario and ~ 8,500 in the *maximum feasibility* scenario.

Table 47: Sectoral employment effects, policy scenarios in comparison to the baseline

	2030			2050		
	MP scenario	PA scenario	MF scenario	MP scenario	PA scenario	MF scenario
	Unit: 1 000 persons					
Agriculture	0.2	0.6	0.5	-0.1	-0.2	-0.3
Fossil Fuel Supply	0.0	-0.1	-0.2	0.0	-0.1	-0.2
Electricity	1.8	-3.6	-4.1	-1.8	-6.8	-7.1
Ferrous Metals	-0.5	0.5	0.6	0.3	0.6	0.6
Non-ferrous Metals	-0.2	0.3	0.3	0.2	0.3	0.3
Chemical Products	-0.2	0.6	0.6	-0.3	0.7	0.6
Other ETS sectors (Non-metallic Minerals, Paper)	0.1	0.1	0.1	0.1	0.3	0.3
Electric Goods	0.2	0.7	0.6	0.3	0.5	0.5
Transport equipment	0.3	0.0	0.0	0.0	0.0	0.0
Other Equipment Goods	-7.3	6.3	7.8	4.4	8.9	9.0
Consumer Goods Industries	1.3	-1.0	-1.4	0.0	1.0	1.1
Construction	1.3	-0.8	-0.9	-0.1	-0.1	0.4
Transport (Air)	0.0	0.0	0.0	0.0	0.0	0.0
Transport (Land)	0.3	-0.6	-0.9	0.0	-0.3	0.0
Transport (Water)	0.0	-0.1	-0.1	0.0	-0.1	-0.1
Services	3.0	-3.3	-3.3	-0.5	2.0	3.5
Total	**0.4**	**-0.4**	**-0.3**	**2.4**	**6.8**	**8.5**

Note: MPA: MP alignment; PA: proportionate action; MF: maximum feasibility
Source: JRC-GEM-E3 modelling, based on AnaFgas cost modelling

However, in comparison to overall EU baseline employment, the effects are very small: 2030 effects are in the range of 0.0002 % of baseline employment, for 2050, the order of magnitude is 0.001 % (MP alignment) to 0.005 % (maximum feasibility), see Figure 27 in section 10.2.7.

10.3.2. Public health & safety and health systems

Public health may be affected by the development of emissions of greenhouse gases and of cross-media effects as discussed in section 10.1.

11. Comparing policy options and preferred policy option

In section 9 all measures were packaged to policy options, which was done with respect to their ambition to support achieving the overarching objectives for the revision.

11.1. Policy options by ambition levels

The policy options specified in section 9 are summarized in the following table.

As for the clarifications (Objective D), it is likely that all of the alignments and clarifications considered will be addressed. As such, all revisions proposed with respect to Objective D are included in each of the scenarios.

Table 48: Summary of the policy options

Policy option	Ambition level
Option 1: Align with the Montreal Protocol and low-cost measures	Low ambition: - Includes all measures to ensure long-term compliance with the Montreal Protocol. - Adjustments to the HFC phase down only to ensure that the MP consumption phase down can be met in the long-term. - Prohibitions to use F-gases in new equipment where this is straightforward from a technology and costs perspective. - Additional measures to improve control, implementation and monitoring where this can be done at minimum cost or very efficiently.
Option 2: Achieve proportionate emission savings and implementation improvements	Medium ambition: - Ensures compliance with the Montreal Protocol (i.e. includes all Option 1 measures) but also includes further measures to reduce more emissions up to the cost level required by other sectors. - Reinforced HFC phase-down: Forcing a technological transition in all sectors where this can be done proportionately according to cost levels assumed in the long-term strategy[74], i.e. at below €390/t CO_2 eq[75]. - Additional prohibitions in the electricity transmission sector using SF_6 in switchgear, for smaller refrigeration equipment, personal care products and inhalation anaesthetics. Recovery is extended to foam products at EoL - Additional measures to improve control and implementation which might partly result in moderate costs to businesses or authorities. - Includes introduction of a quota allocation fee to limit the market participants to serious traders and to avoid costs on the end-users. - Some further labelling requirements. - Monitoring and reporting: Further reporting obligations, adjustments of verification requirements.
Option 3: Maximum feasibility and implementation improvements	High ambition: - All measures of Option 1 and Option 2 are included. - Intends to achieve maximum GHG emission reductions based on technical feasibility and without compromising energy efficiency and safety aspects. - All measures considered feasible to improve control, implementation and monitoring that were considered for the review and/or proposed by stakeholders. - Includes an HFC phase-down schedule based on maximum technical feasibility and without taking cost thresholds to exclude action on certain subsectors. Replacement of F-gases is assumed as soon as technically feasible even if costs are higher than €390/t CO_2 eq at a sub-sector level.

[74] Long-term low greenhouse gas emission development strategy of the EU and its Member States, https://ec.europa.eu/clima/policies/strategies/2050_en / https://unfccc.int/sites/default/files/resource/HR-03-06-2020%20EU%20Submission%20on%20Long%20term%20strategy.pdf.

[75] Updated stylised carbon value in 2050 as per the latest MIX modelling exercise for the 'Delivering the European Green Deal' policy package proposed by the Commission in July 2021, https://ec.europa.eu/energy/data-analysis/energy-modelling/policy-scenarios-delivering-european-green-deal_en

	- To further enhance compliance with the Montreal Protocol, exemptions for military equipment and semiconductors are removed. - Further measures linked to high burden are also considered, such as mandatory certification for importers, further reporting obligations, mandatory establishment of databases on sales, leakage and servicing, etc.

Table 49: Comparison of options by impacts compared to the baseline

Option 1: Align with the Montreal Protocol and low-cost measures					
	Environmental impacts (+/-/0)	Economic impacts (per year unless otherwise specified)			Indirect economic & social impacts
		Business	Member States	EC / EEA	
A1: Increase phase down ambition	N/A	N/A	2 100 days admin burden ongoing	30 days admin burden ongoing	N/A
A2: Prohibit F-gases in products or equipment	N/A	13 100 days admin burden up front	210 days admin burden ongoing	10 days admin burden ongoing	N/A
A3: Extend requirements for the prevention of F-gas emissions		N/A			N/A
A4: Recovery obligation for insulation foam blown with HFCs					N/A
B1&B2: Remove exemptions not in line with MP	Increase in total direct F-gas emissions until 2030: 4 Mt CO_2 eq; reduction until 2050: 33 Mt CO_2 eq Additional final energy use 0.9 GWh/a (2024-2036 average; ~0.1% of baseline), 2050: 2.3 GWh/a final energy savings (0.1% of baseline); additional indirect CO_2 emissions 2030 ~ 0.2 Mt CO_2/a; 2050: 0.1 Mt CO_2/a emission savings	Equipment operators' / F-gas end-users' additional compliance cost vs baseline, 2024-2036 average: 212 Mio €/a (~ 0.03% of baseline cost); 2050: 341 Mio €/a cost savings (~0.04 % of baseline cost) Additional profits in the HFC supply chain (vs baseline): 210 Mio €/a (2024-2036 average), 115 Mio €/a (2050) 100 days admin burden ongoing	100 days admin burden ongoing	26 days admin burden ongoing	GDP increase vs baseline at~0.001 – 0.002% Consumption vs baseline: ~ +0.002% Investment vs. baseline: ~+0.0001% (2030) / -0.0003% (2050) Employment vs baseline: ~+400 / 0.0002% (2030); ~+2,400 / 0.001% (2050) Competitiveness: 0 for EU F-gas producers - for EU manufacturing for domestic market & servicing of affected equipment, 2030 (+ for 2050) 0 for EU manufacturing for export
B3: Separate phase-down of production	0	0	30 days admin burden ongoing	10 days admin burden ongoing; 31 days upfront	0
B4: Disallow trade with countries that have not ratified the Kigali Amendment	N/A	0	110 days admin burden ongoing	250 days admin burden ongoing; 670 days upfront	

C1: Extend certification and training for technicians	N/A				
C2: Empower customs and surveillance authorities	N/A		2 300 days admin burden ongoing		
C3: Strengthen rules to prevent illegal activities	N/A	2 000 days admin burden ongoing	1 000 days admin burden ongoing; 250 days upfront	50 days admin burden ongoing	
C4: Limit participation in quota system to genuine gas traders	N/A	-5 400 days admin burden ongoing		-1 days admin burden ongoing	
C5		-3 900 days admin burden ongoing	-2 800 days admin burden ongoing	-34 days admin burden ongoing; 21 days upfront	
D: More comprehensive monitoring	N/A				
E: Improving clarity of measures and legal drafting	N/A	N/A	N/A	N/A	N/A
Option 2: Achieve proportionate emission savings and implementation improvements					
	Environmental impacts (+/-/0)	Economic impacts (per year unless otherwise specified)			Indirect economic & social impacts
		Business	Member States	EC / EEA	
A1: Increase phase down ambition	Decrease in total direct F-gas emissions until 2030: 27 Mt CO_2 eq; reduction until 2050: 253 Mt CO_2 eq Final energy savings 2.5 GWh/a (2024-2036 average; ~0.3% of baseline), 2050: 8.2 GWh/a savings (~0.5% of baseline) saved indirect CO_2 emissions 2030 ~ 0.3 Mt CO_2/a; 2050: ~0.3 Mt CO_2/a.	Equipment operators' / F-gas end-users' additional compliance cost vs baseline, 2024-2036 average: 429 Mio €/a (~ 0.1% of baseline cost); 2050: 839 Mio €/a cost savings (~0.1 % of baseline cost) Additional profits in the HFC supply chain (vs baseline): 407 Mio €/a (2024-2036 average), 170 Mio €/a (2050) 19 000 additional days pa; 13 100 upfront	2 100 additional days pa	28 additional days pa	GDP loss vs baseline at ~0.001 % in 2030, 2050: GDP gain at ~0.005 % of baseline Consumption vs baseline: ~ -0.002% (2030) / +0.007% (2050) Investment vs. baseline: ~+0.0004% (2030) / +0.002% (2050) Employment vs baseline: ~-400 / 0.0002% (2030); ~+6 800 / 0.004% (2050) Competitiveness: 0 for EU F-gas producers ++ for EU manufacturing for domestic market & servicing of affected equipment - for EU manufacturing for export
A2: Prohibit F-gases in products or equipment			2 700 additional days pa	45 additional days pa	
A3: Extend requirements for the prevention of F-gas emissions					
A4: Recovery obligation for insulation foam blown with HFCs					

B1&B2: Remove exemptions not in line with MP	N/A, included in A1/A2	100 additional days pa	100 additional days pa	26 additional days pa	
B3: Separate phase-down of production			30 additional days pa	10 additional days pa; 31 upfront	
B4: Disallow trade with countries that have not ratified the Kigali Amendment	N/A		110 additional days pa	250 additional days pa; 670 upfront	
C1: Extend certification and training for technicians	N/A	115 000 additional days pa	2 000 additional days pa		
C2: Empower customs and surveillance authorities	N/A		2 300 additional days pa		
C3: Strengthen rules to prevent illegal activities	N/A	2 500 additional days pa	1 100 additional days pa, 250 additional upfront days	50 additional days pa	
C4: Limit participation in quota system to genuine gas traders	N/A	125 Mio €/a quota allocation fees collected from quota holders, reducing the HFC supply chain profits given for A1 above -3 100 additional days pa		2 200 additional days pa, 2 200 additional upfront days	
C5: More comprehensive monitoring		-10 000 additional days pa	-2 000 additional days pa,	-46 additional days pa, 130 additional upfront days	
D: Improving clarity of measures and legal drafting	N/A				
Option 3: Maximum feasibility and implementation improvements					
	Environmental impacts (+/-/0)	Economic impacts (per year unless otherwise specified)			Indirect economic & social impacts
		Business	Member States	EC / EEA	
A1: Increase phase down ambition	Decrease in total direct F-gas emissions until 2030: 30 Mt CO_2 eq; reduction until 2050: 280 Mt CO_2 eq Final energy savings 3.0 GWh/a (2024-2036 average; ~0.3% of baseline), 2050: 9.1 GWh/a (0.5% of baseline) saved indirect CO_2 emissions 2030 0.4 Mt CO_2/a; 2050: 0.4 Mt CO_2/a	Equipment operators' / F-gas end-users' additional compliance cost vs baseline, 2024-2036 average: 557 Mio €/a (~ 0.1% of baseline cost); 2050: 898 Mio €/a cost savings (~0.1 % of baseline cost) Additional profits in the HFC supply chain (vs baseline): 442 Mio €/a (2024-2036 average), 142 Mio €/a (2050) 19 000 additional days pa, 13 000 additional upfront days	2 100 additional days pa	28 additional days pa	GDP loss vs baseline at ~0.001 % in 2030, 2050: GDP gain at ~0.006 % of baseline Consumption vs baseline: ~ -0.002% (2030) / +0.009% (2050) Investment vs. baseline: ~+0.0004% (2030) / +0.003% (2050) Employment vs baseline: ~-300 / 0.0001% (2030); ~+8 500 / 0.005% (2050)
A2: Prohibit F-gases in products or equipment			2 700 additional days pa	45 additional days pa	

					Competitiveness: 0 for EU F-gas producers ++ for EU manufacturing for domestic market & servicing of affected equipment - for EU manufacturing for export
A3: Extend requirements for the prevention of F-gas emissions					
A4: Recovery obligation for insulation foam blown with HFCs					
B1&B2: Remove exemptions not in line with MP	N/A, included in A1/A2	100 additional days pa	240 additional days pa	28 additional days pa	
B3: Separate phase-down of production			30 additional days pa	10 additional days pa; 31 days upfront	
B4: Disallow trade with countries that have not ratified the Kigali Amendment	N/A		110 additional days pa	250 additional days pa; 670 days upfront	
C1: Extend certification and training for technicians	N/A	115 000 additional days pa	2 000 additional days pa		
C2: Empower customs and surveillance authorities	N/A		2 300 additional days pa		
C3: Strengthen rules to prevent illegal activities	N/A	23 300 additional days pa; 3 000 days upfront	1 100 additional days pa; 250 days upfront	50 additional days pa	
C4: Limit participation in quota system to genuine gas traders	N/A	123 Mio €/a quota allocation fees collected from quota holders, reducing the HFC supply chain profits given for A1 above -3 100 additional days pa		2 200 additional days pa; 2 200 days upfront	
C5: More comprehensive monitoring		-18 500 additional days pa, 65 700 additional upfront days	3 200 additional days pa, 8 800 additional upfront days	300 additional days pa, 280 additional upfront days	
D: Improving clarity of measures and legal drafting	N/A				

11.2. Description of the preferred option

The preferred option is Option 2 which will result in proportionate emission savings and improvements of implementation. Option 1 and Option 3 are considered less suitable for a review of the F-gas Regulation: Option 1 fails to bring forward further opportunities for emission reductions where benefits outweigh costs. Option 3 results in further environmental benefits but might be too ambitious at this stage for certain applications and would hence require further market maturation to achieve further cost reductions.

The preferred Option 2 is summarized in the following tables, first the benefits of the option, then the costs.

Table 50: Overview of benefits for option 2

Overview of benefits (total for all provisions) – Preferred Option 2		
Description	***Amount***	***Comments***
Direct benefits		
Reduced climate emissions	Direct emission savings (cumulative): 27 Mt CO_2 eq by 2030, 253 Mt CO_2 by 2050 Indirect emission savings (annually): ~ 0.3 Mt CO_2/a by 2030, ~0.3 Mt CO_2/a by 2050	Driven by more ambitious HFC phase-down and placing on the market prohibitions for high-GWP F-gases
Reduction of administrative costs for businesses	Savings of €4.5m pa	Delivered by aligning thresholds for placing on the market of products and equipment (measure C5.9)
Reduction of administrative costs for authorities	Savings of 2 800 days per annum across Member State CAs, DG CLIMA and EEA.	Driven by savings to MS Cas from aligning reporting and verification thresholds and requirement for specification of 'NIL' reporting.
Reduction of costs to end-users	~839 Mio €/a by 2050	Cost savings in operative compliance cost to end-users (sum of capex & opex) in the long-term perspective, for additional cost in 2024-2036 time-horizon (triggered primarily by higher investment expenditures) see cost table below.
Collection of quota allocation fee	~125 Mio €/a	Collected fee reduces profits in HFC supply chain without increasing cost to end-users. Available for EU budget, including coverage of admin cost at EU level.
Indirect benefits		
Job creation	~400 by 2030, ~6 800 by 2050	
Research and development	+	Incentive in R&D in the EU equipment manufacturing sector
Competitiveness	+	Strengthened competitiveness of EU equipment manufacturing sector; however: drawback for export-oriented equipment manufacturing
GDP increase	+ 0.005 vs baseline by 2050	GDP increase in the long-term perspective. In 2030 horizon: GDP loss of ~0.001% of baseline

Table 51: Overview of costs for option 2

Overview of costs – Preferred option 2						
	Citizens/Consumers		Businesses		Administrations	
	One-off	Recurrent	One-off	Recurrent	One-off	Recurrent
Direct costs		Increased HFC refill cost until ~2030 for EU car owners of old vehicles (new cars not affected due to MAC Directive)	Administrative burden: €3m pa	Administrative burden: €32.9m pa Operative compliance cost to end-users (sum of capex & opex) ~429 Mio €/a (2024-2036 average), turning into cost savings of ~839 Mio €/a by 2050.	Administrative burden: 2 600 days	Administrative burden: 13 500 days pa
Indirect costs		Potential pass-through of higher compli-ance cost for businesses not significant in most sectors as (additional cost <1% of total op-erating cost).				

12. How would the actual impacts be monitored and evaluated?

The reporting on F-gas production, import, export and destruction for bulk quantities as well as contained in equipment has been performed via an online platform, the Business Data Repository (BDR; https://bdr.eionet.europa.eu/) throughout the last decade. This multilingual online platform is a password protected environment that hosts an online questionnaire for submission of the company reports under the FGR. Developed specifically to handle confidential information of companies, this reporting system ensures traceability and transparency by enabling quality checks during reporting and submission of reports, listing previously submitted reports from each company, and being assessable by all relevant stakeholders (EU Commission, EEA, and national competent authorities).

Reporters received support both for the reporting procedure and for technical questions from the EEA and the ETC/CME support team, and via manuals and additional guidance documents. The FGR sets the reporting deadline as 31 March of each year. Based on information available on companies present in the EU F-gas market, the EEA sends out invitation emails in February, reminding companies of their reporting obligations under the FGR.

The EEA is responsible for collecting, archiving, checking and aggregating information contained in these company reports. Certain data reported on production, import and export are presented to the Ozone Secretariat, so that compliance with the Montreal Protocol and progress in the implementation of the Kigali Amendment can be monitored. In addition, a confidential report on F-gas activities within the EU is drafted each year for Member State representatives and DG CLIMA. It describes the reporting process as well as reported data. A public summary report is published each year as well.

The BDR reporting platform has also been used since 2018 to facilitate companies' reporting on the verification of reported data by independent auditors, and for the submission of such verification reports.

Certain changes in reporting due to the presented and assessed policy options are expected, as the current EEA reporting systems is both very robust and can be easily adapted to additional or changing reporting requirements. Potential changes to the reporting are presented in the summary Table 22 above.