

Brief Report

Environmental Policies and Countermeasures for the Phase-Out of Ozone-Depleting Substances (ODSs) over the Last 30 Years: A Case Study in Taiwan

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Abstract: It is well established that the reaction cycles involving some halogenated alkanes (so-called ozone-depleting substances—ODSs) contribute to the depletion of ozone in the stratosphere, prompting the Montreal Protocol (initially signed in 1987), and later amendments. The Protocol called for the scheduled phase-out of ODSs, including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), carbon tetrachloride (CCl₄), halon, methyl chloroform (CH₃CCl₃), methyl chloride (CH₃Cl), and even hydrofluorocarbons (HFCs). In view of the urgent importance of ozone layer protection to the global ecological environment, the Taiwanese government has taken regulatory actions to reduce ODS consumption since 1993, through the joint venture of the central competent authorities. Under the government's regulatory requirements, and the industry's efforts to adopt both alternatives to ODSs and abatement technologies, the phase-out of some ODSs (i.e., CFCs, CCl₄, halon, and CH₃CCl₃) was achieved prior to 2010. The consumption of HCFCs and methyl chloride has significantly declined over the past three decades (1993–2022). However, HFC emissions indicated a V-type variation during this period. Due to local production and extensive use of HFCs in Taiwan, the country's emissions increased from 663 kilotons of carbon dioxide equivalents (CO_{2eq}) in 1993 to 2330 kilotons of CO_{2eq} in 2001, and then decreased to 373 kilotons of CO_{2eq} in 2011. Since then, the emissions of HFCs largely used as the alternatives to ODSs showed an upward trend, increasing to 1555 kilotons of CO_{2eq} in 2022. To be in compliance with the Kigali Amendment (KA-2015) to the Montreal Protocol for mitigating global warming, the Taiwanese government has taken regulatory actions to reduce the consumption of some HFC substances with high global warming potential (GWP) under the authorization of the Climate Change Response Act in 2023, aiming at an 80% reduction by 2045 of the baseline consumption in 2024.

Keywords: ozone-depleting substance; hydrofluorocarbon; regulatory compliance; phase-out; promotion measure



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1. Introduction

Ozone-depleting substances (ODSs), including chlorofluorocarbons (CFCs), hydrochlorofluorocarbons (HCFCs), halons, methyl bromide, carbon tetrachloride, and methyl chloroform, contribute to stratospheric ozone depletion. Due to the high stability of these compounds in the troposphere, they can be transferred into the stratosphere, where they break down under intense ultraviolet (UV), thus releasing chlorine or bromine atoms and then depleting ozone. In view of the environmental importance of the ozone layer to both the global ecological system and human health protection, the Montreal Protocol was signed in 1987 and entered into force in 1989. It is a global agreement to implement and take actions toward protecting the stratospheric ozone layer by phasing out ODS production and consumption [1]. Under the scheduled targets of the Protocol, the status of ODS production and consumption has significantly declined over the past few decades [2–4]. The parties to the Protocol reached a further agreement calling for the phase-down of

hydrofluorocarbons (HFCs) in 2015, in order to meet the Paris Agreement goal of a temperature reduction of 1.5 degrees C throughout this century. This further agreement is called the Kigali Amendment [1,5,6]. Although these HFCs do not deplete the ozone layer, they were used as replacements for ODSs eliminated by the original Montreal Protocol. More significantly, most of them are powerful greenhouse gases (GHGs) and thus contribute to global warming.

To be in compliance with the Montreal Protocol in 1987, the Taiwanese government established an inter-ministerial working group in 1989 to draw up countermeasures. The central competent authorities included the Ministry of Environment (MOENV), the Ministry of Agriculture (MOA), and the Ministry of Economic Affairs (MOEA). Thereafter, the regulatory measures were triggered by revising the Air Pollution Control Act on 19 June 2002. The central competent authority (i.e., MOENV), in consultation with relevant agencies, establish the regulations regarding the prohibition or restriction of substances controlled under international environmental protection conventions (e.g., the Montreal Protocol) that are prone to causing air pollution. Based on the authorization of the Act, the relevant regulations have been promulgated to be in accordance with the Intergovernmental Panel on Climate Change (IPCC) guidelines for national GHG inventories [7]. These regulations include the following: the “Regulation for Management of Montreal Protocol Controlled Substances”, the “Regulation for Management of HCFCs Consumption”, and the “Regulation for Management of Methyl Bromide” [8]. The relevant central agencies (e.g., MOEA) also promoted ODS and HFC emission reduction. The most important case was the banning of the domestic production of HCFC-22 (one of the refrigerants), thus reducing the emission of HFC-23 from the HCFC-22 manufacturing process [9]. Over the past three decades, a significant reduction in ODS consumption has been seen in Taiwan [10]. In addition, the Taiwanese government announced the policy (“Taiwan’s Pathway to Net-Zero Emissions in 2050”) on 30 March 2022 [11], which prompted the promulgation of the Climate Change Response Act on 15 February 2023. To be in compliance with the Kigali Amendment to the Montreal Protocol, MOENV pre-announced the draft (“Regulation for Management of Hydrofluorocarbons”) on 20 November 2023, under the authorization of the Act.

In a previous study [12], the emission trends and regulatory measures of F-gases in Taiwan, including HFCs, perfluorocarbons (PFCs), sulfur hexafluoride (SF₆), and nitrogen trifluoride (NF₃), were discussed. It focused on the semiconductor and optoelectronic industries by using the national GHG emission database [13]. To provide a regional case study of the environmental policies and countermeasures for phasing out ODSs over the last 30 years in Taiwan, this work summarized the regulatory progress on the phase-out of ODSs, and Taiwan’s current achievements regarding ODS consumption, using the official database [8,10,13,14]. In addition, this earlier study also judged the regulatory countermeasures for mitigating Taiwan’s emissions of HFCs from air-conditioning and refrigeration equipment as refrigerants and foam agents in the near future to be in line with the Kigali Amendment to the Montreal Protocol.

2. Data Mining and Methodology

In this work, the systematic methodology is depicted in Figure 1. The methodology was based on the main objectives of this case study, including the development process of the ODS phase-out in Taiwan, regulatory measures for reducing ODS emissions, and achievements for the phase-out of ODS consumption. Therefore, the official websites of the central competent authorities were accessed to mine the relevant database [13,14], focusing on the HFC emissions from the alternatives to ODSs during the period of 2001–2022 [14]. Furthermore, the data on ODS consumption and methyl bromide consumption were based on their annual amounts of import and export over the past two decades [13]. The regulatory countermeasures for the reduction in ODS emissions and consumption were extracted from the official database of the Ministry of Justice [8]. These relevant regulations were set forth in accordance with the Air Pollution Control Act and the Climate Change

Response Act. It should be noted that the latter was formerly called the Greenhouse Gas Reduction and Management Act, promulgated on 1 July 2015. However, the fundamental regulations in Taiwan for controlling the manufacture, import, export, sale, or use of ODSs were based on the Air Pollution Control Act prior to 2018 and have been based on the Climate Change Response Act since 2023. To be in accordance with the revisions of the Air Pollution Control Act and the Amendments to the Montreal Protocol, these regulations were revised several times.

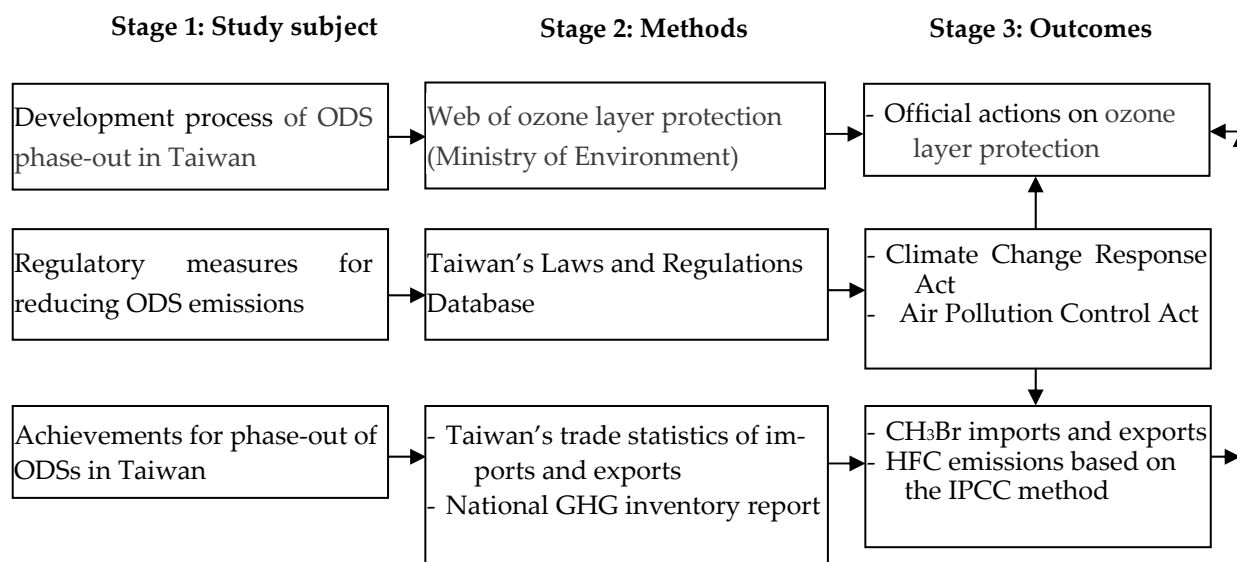


Figure 1. Framework items of this study [7,8,10,13,14].

Concerning ODS consumption, the calculation was mainly based on the database of ODS import and export, which included the trade statistics (Customs Administration, Ministry of Finance) [14]. According to the definition of ODS consumption, the net value is calculated by subtracting the value of export from the values of production and import. As mentioned above, there has been no ODS production in Taiwan since 2004. Therefore, the data on ODS consumption in Taiwan should be theoretical analysis data, not actual measurement data. Regarding the emissions of HFCs (the alternatives to ODSs) from the industrial process and product use (IPPU) sector, they were extracted from the national GHG inventory report [13], which was obtained using the IPCC methods (“2006 IPCC Guidelines for National Greenhouse Gas Inventories”) [7]. According to the Guidelines, the sub-sector of the alternatives to ODSs was coded as 2F in the IPPU sector. A further search was conducted on the achievements of the ODS phase-out [10], which was connected with the official actions on ozone layer protection and the amazing progress over the past three decades.

3. Regulatory Progress on Phase-Out of Ozone-Depleting Substances (ODSs) in Taiwan

As required under Title VI of the Clean Air Act, the US Environmental Protection Agency (EPA) is responsible for developing and implementing the relevant programs that protect the stratospheric ozone layer [15]. These regulatory programs include the ODS Phase-out Program, the Nonessential Products Ban, the Significant New Alternatives Policy (SNAP) Program, the Stationary Refrigeration and Air Conditioning Program, and the Motor Vehicle Air Conditioning Program [16]. In 1993, these ODSs were regulated for control in the “Regulation Concerning Control of Chemical Substances Listed for Control by the Montreal Protocol”, which was announced by the Industrial Development Bureau (IDB) of the Ministry of Economic Affairs (MOEA). However, the fundamental regulations in Taiwan for controlling the manufacture, import, export, sale, or use of ODSs were based on the Air Pollution Control Act prior to 2018 and have been based on the Climate Change Response Act (formerly called the “Greenhouse Gas Reduction and Management

Act”) since 2023 [8]. MOEVV, a central competent authority in Taiwan, has promulgated some relevant regulations for phasing out ODSs by setting different reduction targets and countermeasures, which include baseline level, freezing schedule, reduction percentage, and conditions for exemption. These regulatory measures will be further addressed in the following sub-sections.

3.1. CFCs, Halons, and HCFCs

To be in compliance with the Montreal Protocol, the Taiwanese government promulgated the relevant regulations for reducing the consumption of halon to zero since 1994 and reducing the consumption of chlorofluorocarbons (CFCs) to zero since 1996 under the authorization of the Air Pollution Control Act. On the other hand, the hydrochlorofluorocarbons (HCFCs) consumption baseline was set at 638.156 ozone-depleting potential (ODP) metric tons, based on the consumption amount in 1996, and has gradually been reduced to 0.5% of the HCFCs consumption baseline (i.e., 3.191 ODP metric tons) from 2020. Moreover, HCFCs were limited to the maintenance of refrigerating and air-conditioning equipment in use. These regulations are listed below:

- “Regulation for Management of Montreal Protocol Controlled Substances”

This regulation was initially promulgated on 4 May 1997 under Article 31 of the Air Pollution Control Act. HCFCs and methyl bromide (CH_3Br) were excluded from the regulated ODSs.

- “Regulation for Management of HCFCs Consumption”

Also authorized by Article 31 of the Air Pollution Control Act, this regulation became effective from 15 January 2003. In Taiwan, there was no HCFCs production. Therefore, the government has phased out most ODSs since 2006, according to the following reduction stages:

- (1) From 1 January 2004, annual HCFCs consumption shall not exceed 65% of the baseline (i.e., 414.801 ODP metric tons).
- (2) From 1 January 2010, annual HCFCs consumption shall not exceed 25% of the baseline (i.e., 159.539 ODP metric tons).
- (3) From 1 January 2015, annual HCFCs consumption shall not exceed 10% of the baseline (i.e., 63.816 ODP metric tons).
- (4) From 1 January 2020, annual HCFCs consumption shall not exceed 0.5% of the baseline (i.e., 3.191 ODP metric tons). In addition, the HCFCs consumption shall be limited to the maintenance requirements for refrigeration and air-conditioning equipment in use.
- (5) From 1 January 2030, annual HCFCs consumption shall be reduced to zero.

3.2. Methyl Bromide

It is well known that methyl bromide is a fumigant used to control pests in agriculture. In this regard, its phase-out or restricted use regulation was promulgated later. In Taiwan, the “Regulation for Management of Methyl Bromide”, also based on the authorization (Article 31) of the Air Pollution Control Act, was announced on 21 May 2004. Its use was limited to quarantine, pre-shipment purposes, or academic research. In addition, its import sources (countries/regions) must follow the requirements of the Montreal Protocol, with import sources limited to those listed in the recognition announcement of the central competent authority.

3.3. HFCs

HFCs are commonly used in a variety of commercial and industrial applications. Although HFCs are not listed in the Montreal Protocol, some of them are potent GHG substances. In response to the Kigali Amendment to the Montreal Protocol, MOENV pre-announced the draft (“Regulation for Management of Hydrofluorocarbons” on 20 November 2023 under the authorization (i.e., Article 38) of the Climate Change Response

Act. The regulated HFCs with high global warming potential (GWP) include eighteen compounds, some of which are commonly used refrigerants in Taiwan. These are summarized in Table 1 [17,18] and Table 2 [19], respectively. The data on the atmospheric lifetime and GWP (100-year time horizon) were compiled from the IPCC Report [17]. The main application fields of these HFC substances were based on the US EPA website [18]. However, HFC-32 and HFC-134a are commonly used as refrigerants because of their relatively low GWP (i.e., 771 for HFC-32 and 1530 for HFC-134a, as seen in Table 1) [20]. In this regard, the commercial refrigerants using HFC mixtures often contain HFC-32. For instance, R410A is a mixture of HFC-125 (50%) and HFC-32 (50%). Another refrigerant, R407C, is a mixture of HFC-125 (25%), HFC-134a (52%), and HFC-32 (23%). The relevant measures for phasing down their production and consumption, maximizing reclamation, and minimizing releases from in-use and exhausted equipment will be further addressed in the subsequent section. In addition, the F-gas regulation on certain fluorinated GHGs (e.g., HFCs) has been promulgated by the European Union (EU), according to the European Regulation (EC) No. 517/2014 [21]. This regulation intends to reduce the EU's F-gas emissions by two-thirds by 2030, as compared with 2014 levels. The regulatory countermeasures include the control emissions of F-gasses by requiring leak checks and proper maintenance of refrigeration equipment, recovering F-gasses at the end of life, and also introducing bans on the use of F-gasses with high GWP values. Furthermore, Regulation (EU) 2024/573 was adopted as the EU legislative revision on 7th February 2024. It came into force on 11th March 2024 and repealed the Regulation (EU) 517/2014 [22]. The target is to phase out HFCs by 2050 by limiting them in the quota system of HFCs that can be sold, produced, or imported in the EU.

Table 1. Atmospheric lifetime, global warming potential (GWP), and main applications of commonly used HFCs.

HFC	Formula	Lifetime ^a (Year)	GWP ^a	Main Applications ^b					
				Refrigerant	Solvent	Foaming	Extinguishing	Etching	Others ^c
HFC-23	CHF ₃	228	14,600	v			v	v	
HFC-32	CH ₂ F ₂	5.4	771	v					
HFC-41	CH ₃ F	2.8	135					v	
HFC-125	CHF ₂ CF ₃	30	3740	v			v		v
HFC-134	CHF ₂ CHF ₂	10	1260	v	v	v			v
HFC-134a	CH ₂ FCF ₃	14	1530	v		v			v
HFC-143	CH ₂ FCHF ₂	3.6	364	v					
HFC-143a	CH ₃ CF ₃	51	5810	v					v
HFC-152	CH ₂ FCH ₂ F	0.471	21.5	v	v	v			v
HFC-152a	CH ₃ CHF ₂	1.6	164	v		v			v
HFC-227ea	CF ₃ CHFCF ₃	36	3600	v			v		v
HFC-236cb	CH ₂ FCF ₂ CF ₃	13.4	1350	v					
HFC-236ea	CHF ₂ CHFCF ₃	11.4	1500					v	
HFC-236fa	CF ₃ CH ₂ CF ₃	213	8690	v		v	v		v
HFC-245ca	CH ₂ FCF ₂ CHF ₂	6.6	787	v					
HFC-245fa	CHF ₂ CH ₂ CF ₃	7.9	962	v		v			
HFC-365mfc	CF ₃ CH ₂ CF ₂ CH ₃	8.9	914		v	v			
HFC-41-10mee	CF ₃ CHFCF ₂ CF ₃	17	1600		v				

^a Source [17]. Herein, GWP refers to 100-year time horizon. ^b Source [18]. ^c Including dielectric gas, shielding gas (for the production of aluminum/magnesium), propellant (for the delivery of pharmaceuticals), and so on.

Table 2. Commonly used refrigerants involving HFC mixtures and their compositions.

Refrigerant HFC Mixture	GWP ^a	Composition (vol%)			
		HFC-32	HFC-125	HFC-134a	HFC-143a
R-404A	3922		44	52	4
R-407C	1774	23	25	52	
R-407F	1825	30	30	40	
R-407H	1495 ^b	32.5	15.0	52.5	
R-410A	2088	50	50		
R-507A	3985		50		50

^a Based on the US EPA website [18]. ^b Based on the website [19].

4. Achievements for Phase-Out of Ozone-Depleting Substances (ODSs) in Taiwan

As mentioned above, Taiwan always followed the Montreal Protocol to align with the international efforts of developed countries to phase out ODS production and reduce ODS consumption. Both Taiwan's government and its industries have successfully achieved the protocol's production and consumption targets by formulating regulatory reduction strategies accordingly. During the early 2000s, Taiwan only produced HCFCs in IPCC Category 1. However, the production-freezing schedule of HCFC substances in this category began in 2004, stopping the production of HCFC-141b and HCFC-142b by the only chemical manufacturer in Taiwan. In the next year (2005), the production of HCFC-22 only reached 80 ODP metric tons. All HCFC production had been terminated as of June 2005, marking the end of Taiwan's HCFC and other ODS production by 2006. It should be noted that the only HFC production in Taiwan was of HFC-23, a by-product emitted in the process of HCFC-22 manufacturing. Therefore, HFC-32 production has been stopped since 2006. However, total HFCs emissions in Taiwan reached approximately 2100 kilotons of CO_{2eq} during the early 2000s [15].

Regarding ODS consumption, the Taiwanese government and Taiwan's commercial and industrial sectors have been working closely to meet the requirements of the Montreal Protocol. The significant achievements of the consumption goals for the targeted ODSs were summarized as follows:

- Halon has been at zero consumption since 1994.
- Consumption of methyl bromide has been regulated since 1 January 1995.
- CFCs, carbon tetrachloride (CCl₄), and 1,1,1-trichloroethane (or methyl chloroform—CH₃CCl₃) have been at below-zero consumption since 1996.
- HCFC allocations became effective on 1 January 1996 in order to freeze HCFC consumption, and HCFC is set to reach zero consumption by 1 January 2030.

In Taiwan, the HCFC consumption data were obtained from the official database [10,14]. Figure 2 shows the staged declination of HCFC consumption since 1996 [14], which was based on the regulatory requirements of the Montreal Protocol, as mentioned above (Section 3.1) [10]. In addition, the variations on the theoretical HCFC consumption values in Figure 2 could be connected with the domestic demand for HCFC substances in the residential, commercial, and industrial applications, and their current HCFC prices. From the baseline level (i.e., 638.156 ODP tons), the target HCFC consumption was set at 414.801 ODP tons in 2004 (65% of the baseline level), 159.539 ODP tons in 2010 (25%), 63.816 ODP tons in 2015 (10%), and 3.191 ODP tons in 2020 (0.5%). To effectively cut down HCFC consumption, some countermeasures were performed by adopting allocations and bans for specific uses in different stages. For example, there have been regulatory bans on the following: all types of HCFCs in aerosol propellants and foaming agents in manufacturing processes, HCFC-141b in cleaning solvents in manufacturing processes, and filling HCFC coolants in the manufacture of new refrigerating or air-conditioning equipment or new construction. Figure 3 further depicts the amounts of methyl bromide imported since

2008; these data were accessed via the database of the Ministry of Finance [14]. Obviously, the imported amount of methyl bromide has significantly declined over the past decade (2014–2023). This could be attributed to the extensive use of the alternatives to methyl bromide, including phosphine and other fumigants (e.g., sulfuryl fluoride and carbonyl sulfide) [23–25]. In this regard, the import of phosphine began in 2014. Since then, its annual imports have ranged from 25 to 67 metric tons over the past decade [14]. However, phosphine is a highly toxic substance, possibly causing severe respiratory tract irritation in those who are exposed to its vapors or fumes. Although sulfuryl fluoride (SO_2F_2) is a powerful fumigant for termite control in structures and lumber, it is a potent GHG with a high 100-year GWP value (i.e., ca. 4800) [17]. In a previous study [26], this substance was also shown to pose occupational health risks as a result of exposure to it and its decomposition products (e.g., hydrogen fluoride).

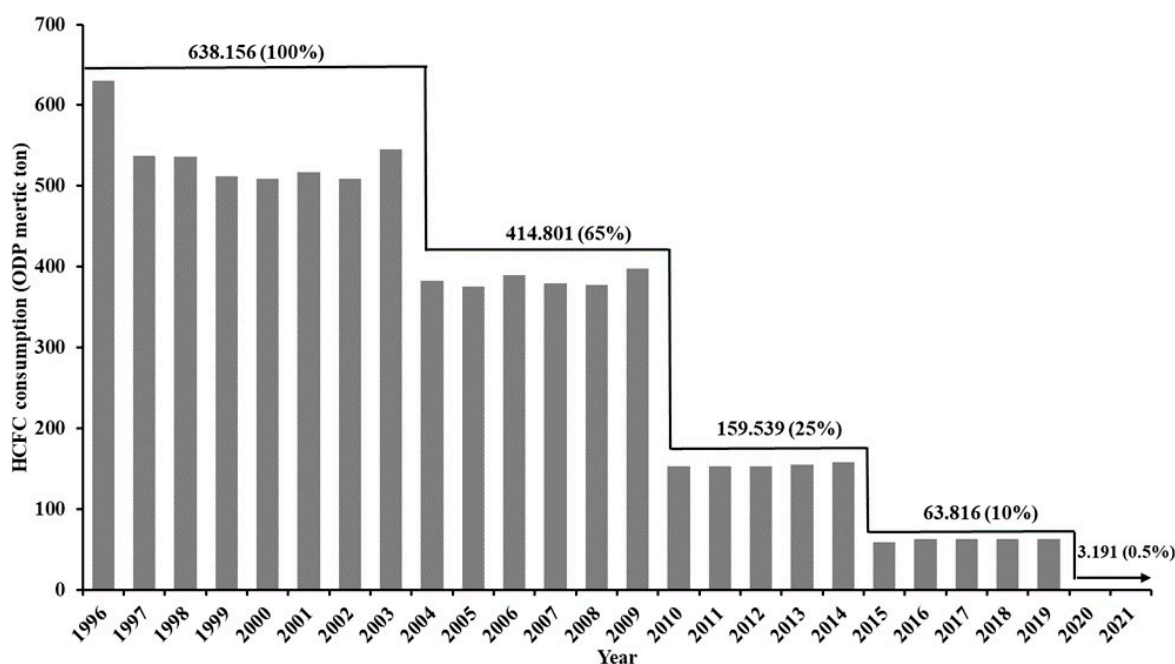


Figure 2. HCFC consumption in Taiwan since 1996 [10,14].

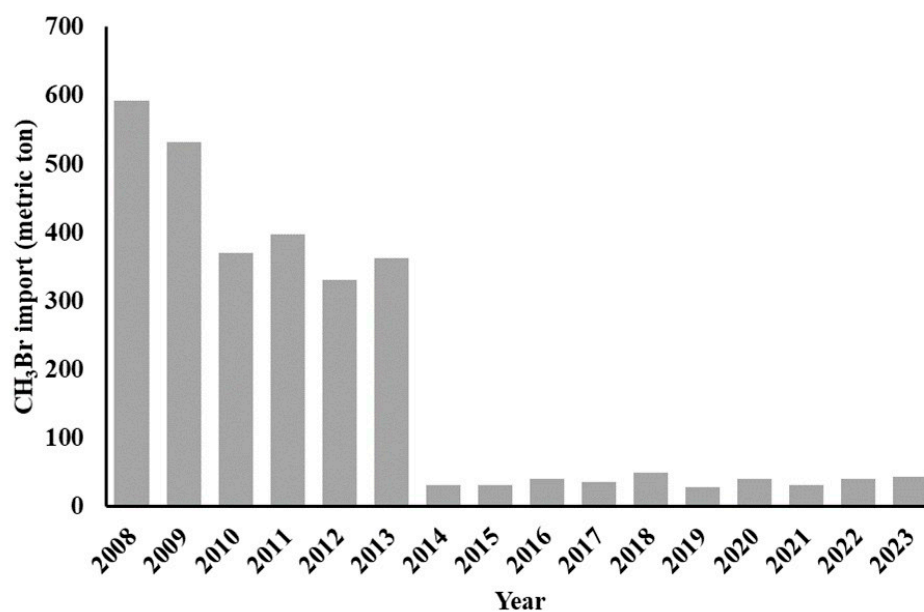


Figure 3. Amount of imported methyl bromide in Taiwan during the period of 2008–2023 [14].

5. Official Actions for Further Mitigating the Use of HFCs and Their Emissions

In a previous study [12], Taiwan's emissions of HFCs showed an increasing trend since 2011, due to the extensive use of HFCs in the fields of refrigeration, fire extinguishing, electronics cleaning, and foaming. Figure 4 depicts the HFC emissions from the alternatives to ODSs, using the database of the National Greenhouse Gas Inventory Report [14]. It shows that the major HFC emission source has been the alternatives to ODSs, accounting for about 90% of emissions in recent years. In 2022, these HFC emissions had reached 1405 kilotons of carbon dioxide equivalent ($\text{CO}_{2\text{eq}}$). In contrast, these HFC emissions in 2010 only had 226 kilotons of $\text{CO}_{2\text{eq}}$. Although HFCs are not ODSs, some of them have high GWP values (seen in Table 1), and should be included in the international agreements to gradually reduce their consumption and production due to global warming [27].

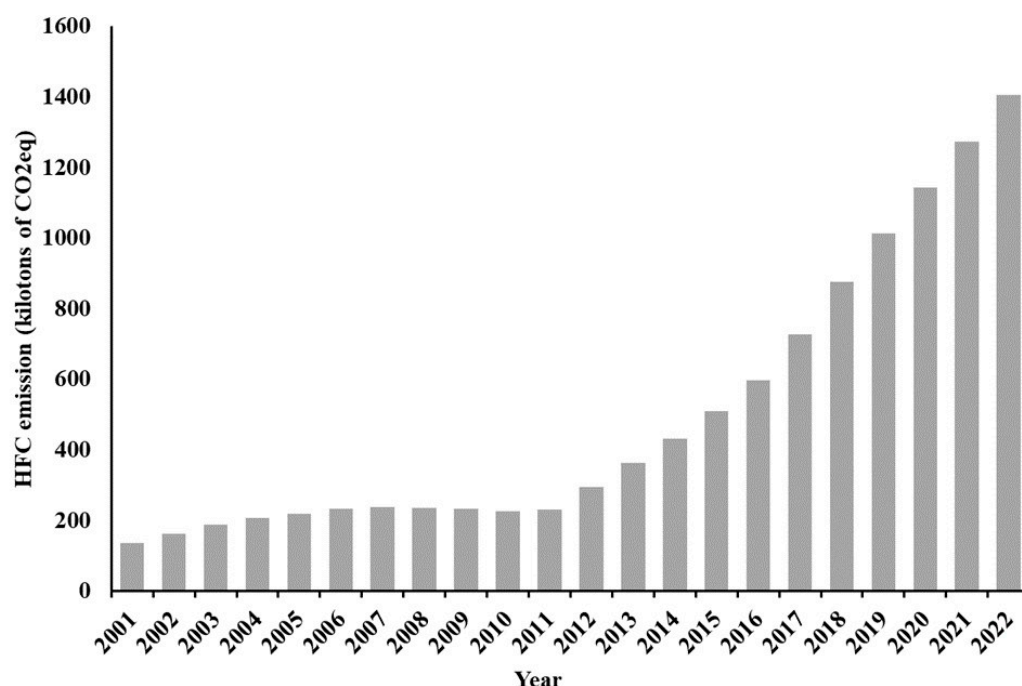


Figure 4. HFC emission in Taiwan from the alternatives to ODSs during the period of 2001–2022 [14].

To be in compliance with the Kigali Amendment (KA-2015) to the Montreal Protocol for mitigating global warming, Taiwan's government has taken further actions towards reducing the consumption of HFCs, under the authorization of the Climate Change Response Act. The Draft ("Regulations for the Management of hydrofluorocarbons"), announced on 20 November 2023, focused on prohibiting or restricting the manufacture, import, export, sale, use, or emission of HFCs with high GWP values, in addition to products that use such GHGs, which are also regulated by international environmental conventions. The mandatory measures in the Draft include the following highlights:

- Eighteen HFC substances (seen in Table 1) and their mixtures are listed in the Draft because they have been extensively used in a variety of commercial and industrial applications, especially in refrigeration equipment, and wafer etching and cleaning solvent in electronics.
- HFCs allocations became effective in the coming year in order to freeze its consumption.
- The national baseline for HFCs consumption was set at 24,523,864.2 metric tons $\text{CO}_{2\text{eq}}$. The staged consumption reduction targets were 22,071,477.8 metric tons $\text{CO}_{2\text{eq}}$ since 1 January 2029 (90% of the baseline), 17,166,704.9 metric tons $\text{CO}_{2\text{eq}}$ since 1 January 2035 (70% of the baseline), 12,261,932.1 metric tons $\text{CO}_{2\text{eq}}$ since 1 January 2040 (50% of the baseline), and 4,904,772.8 metric tons $\text{CO}_{2\text{eq}}$ since 1 January 2045 (20% of the baseline).
- Regarding the production of HFCs, it will be effective in the coming year.

- The imports and exports of HFCs will not be allowed without approval.
- The enterprises using and supplying HFCs need to file an application for approved allocation and then for a customs declaration in accordance with the import and export regulations.

6. Conclusions and Future Outlook

In this case study, the regulatory countermeasures on the production, use, and phase-out of ozone-depleting substances (ODSs), and the current achievements regarding their consumption in Taiwan, have been summarized to echo the Montreal Protocol over the period of 1993–2022. On the basis of the official database, we can see great progress over the last 30 years, especially regarding the significant reduction in emissions from the chemical and electronic industries. Under the joint-venture efforts involving newly implemented regulations and modifications to industrial technologies, the phase-out of some ODSs (i.e., CFCs, CCl₄, halon, and CH₃CCl₃) had been achieved prior to 2010. Moreover, the consumption of HCFCs and methyl chloride has significantly declined over the past three decades (1993–2022). However, the emissions of HFCs mainly used as refrigerant alternatives to ODSs have shown an upward trend, increasing from 373 kilotons carbon dioxide equivalents (CO_{2eq}) in 2011 to 1555 kilotons of CO_{2eq} in 2022.

Obviously, future efforts will focus on the emission reduction of HFCs, which are potent greenhouse gasses. According to the Kigali Amendment to the Montreal Protocol, the relevant regulations have been announced by some developed countries. The core goals are to phase down their production and consumption, maximize reclamation, minimize releases from air-conditioning and refrigeration equipment, and facilitate the transition to next-generation, environmentally friendly technologies or refrigerants. In this regard, the Taiwanese government pre-announced the regulation (“Regulations for the Management of hydrofluorocarbons”) on 20 November 2023, listing 18 HFCs and their mixtures as targets for control and also aiming at reducing baseline consumption in 2024 by 80% by 2045. As compared to the F-gas regulation by the European Union (EU), the HFC reduction schedule in Taiwan is obviously much looser. In the near future, the best way to cut HFC emissions may be to promulgate the regulations banning the production of HFCs and using the new-generation alternatives to commonly used HFC refrigerants like hydrofluoroolefins (HFOs).

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