SEMARNAT

SECRETARÍA DE MEDIO AMBIENTE
Y RECURSOS NATURALES

ROADMAP TO IMPLEMENT THE KIGALI AMENDMENT IN MEXICO

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May, 2019

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Acronyms

AC	Stationary Air Conditioning
Aer	Aerosols
BAT	Best Available Technology
BAU	Business as Usual
CC	Climate Change
CFC	Chlorofluorocarbons
CO2e	Carbon Dioxide Equivalent
COFEPRIS	Federal Commission for Protection against Sanitary Risks
CR	Commercial Refrigeration
DGGCARETC	General Direction of Air Quality Management and Pollutant Release and Transfer Register
DGGIMAR	General Direction for Management of Hazardous Materials and Activities
DR	Domestic Refrigeration
EE	Energy Efficiency
Ext	Fire Extinguishers
FIDE	Trust for Electrical Energy Savings
Foam	Foams
GCA	General Customs Administration
GDP	Gross Domestic Product
GHG	Greenhouse Gases
GWP	Global Warming Potential
HCFCs	Hydrochlorofluorocarbons
HCs	Hydrocarbons
HFCs	Hydrofluorocarbons
HFOB	Lower-GWP HFO Blends
HFOs	Hydrofluoroolefins
IR	Industrial Refrigeration
KA	Kigali Amendment
MAC	Mobile Air Conditioning
MDIs	Metered Dose Inhalers
MLF	Multilateral Fund for the Implementation of the Montreal Protocol
MOP	Meeting of the Parties to the Montreal Protocol
MP	Montreal Protocol
NOM	Official Mexican Standard
ODS	Ozone Depleting Substances
OEM	Original Equipment Manufacturer
PU	Polyurethane
RAC	Refrigeration and Air Conditioning
RISEMARNAT	SEMARNAT Internal Regulations
SEER	Season Energy Efficiency Rate
SER	Service
Sol	Solvents
TR	Transport Refrigeration

PRESENTATION

This publication was prepared by SEMARNAT as a part of the enabling activities to implement the **Kigali Amendment to the Montreal Protocol in Mexico**, through which the consumption of hydrofluorocarbons (HFCs), powerful high impact gases for the climate, will be reduced.

The document presents the **"way forward"** for Mexico to implement the Kigali Amendment and is based on the national diagnosis on use, consumption and sectoral distribution of HFCs. In addition, it considers the analysis results of the national legal framework for the control of the consumption of substances regulated by the Montreal Protocol and its amendments.

By recognizing the potential benefits that the Kigali Amendment can bring, this **Roadmap** considered instruments of public policy that promote energy efficiency in the refrigeration and air conditioning (RAC) sector, as well as the availability of environmentally friendly and high energy efficiency technologies. Likewise, it was designed with a sectoral focus, establishing short, medium and long-term actions with the aim of meeting the reduction targets which Mexico has committed to.

The implementation of the amendment will be aligned with other actions that Mexico undertakes to counteract **climate change.** The reduction of HFCs will contribute to meet the mitigation goals established as Nationally Determined Contributions in the Paris Agreement. In addition, synergies will be promoted with other agendas of national relevance, such as **energy efficiency** and **waste management.** In this way, not only will the consumption of HFCs be reduced, but also the amendment will function as a well-being platform in the country, while supporting the achievement of the **2030 Agenda for Sustainable Development** of the United Nations.

01

Chapter BACKGROUND

Photography: IISD/Kiara Worth (enb.iisd.org/ozone/resumed-oewg38-mop28/8oct.html)

BACKGROUND

1.1 HFCs in Context

Hydrofluorocarbons (HFCs) are chemicals primarily used as refrigerants in domestic, commercial and industrial **refrigeration as well as air conditioning (RAC)** systems. They are also utilized as blowing agents for the manufacture of polyurethane foams, as propellants for aerosol products and fire extinguishers, and as solvents. HFCs have, overall, ideal characteristics in their applications, except for the fact that they present a high global warming potential (GWP), which is how they contribute to **climate change.**

According to scientific studies, the reduction of HFCs could contribute to avoid the increase between 0.35 °C and 0.5 °C of the global average temperature predicted for 2100 (Xu et al., 2013).

Today, HFCs are used globally as a part of a long transition through which this class of substances have crossed around the planet since the 1950s, when chlorofluorocarbons (CFCs), which turned out to be ozone depleting substances (ODS), began to be used.

With the findings made between the seventies and the eighties, which revealed the ozone layer depletion, the international community mobilized as never before, leading to the signing of the Vienna Convention for the Protection of the Ozone Layer, and later, in 1987, the creation of the **Montreal Protocol (MP)**, a multilateral agreement designed to address the deterioration of the ozone layer by controlling the consumption and production of ODS.

By means of this Protocol, CFCs were mostly replaced by hydrochlorofluorocarbons (HCFCs), which contain fewer chlorine atoms, the main depleting element of stratospheric ozone. Mexico was the first country to sign this international instrument and historically has fulfilled its commitments in advance. Currently, the consumption of CFCs, carbon tetrachloride (CTC), halons and methyl bromide (MeBr), as well as a large part of HCFCs, has been definitively phased-out. With these actions, by 2018, 99% of the ODS were phased-out in our country.

Globally, CFCs and most HCFCs have been successfully eliminated. However, at the same time, the consumption of HFCs has increased (UNIDO, 2018e). These do not deplete the ozone layer but do contribute significantly to climate change, due to its high GWP.

In the mid-seventies, the Mexican scientist Mario Molina discovered, along with researchers Frank Sherwood Rowland and Paul Crutzen, that the release of certain industrial gases, CFCs, caused the thinning of the stratospheric ozone layer that protects the Earth from the ultraviolet rays of the sun.

In 1995, Mario Molina and his colleagues received the Nobel Prize in Chemistry for their discoveries, which have been decisive for the future of the Earth's atmosphere and life in general.

Therefore, a new replacement is necessary for alternatives of lower climate impact. Hydrofluoroolefins (HFOs), as well as other natural alternatives, which include CO2, some hydrocarbons and ammonia, stand out among those alternatives (Diagram 1).

1.2 Kigali Amendment and Mexico's Obligations

The MP is considered the most successful multilateral environmental agreement in history, due to the double positive impact it has had on the ozone layer and the mitigation of climate change. It has been adjusted and amended over time to accelerate the phase-out and phase-down schedules, introducing other control measures and updating the list of controlled substances.

As evidence of the constant dynamics of this agreement, which has universal ratification, at the XXVIII Meeting of the Parties to the Montreal Protocol (MOP), held in the city of Kigali, Rwanda, in October 2016, a historic decision was made to adopt an amendment to reduce the consumption and production of HFCs, adding them to the list of controlled substances.

The **Kigali Amendment (KA)** indicates that all countries have committed to achieving legally binding targets that require gradual reductions in HFC consumption and production. For developing countries such as Mexico, the agreement specifies that a licensing system for the import and export of HFCs should enter into force no later than January 1, 2021.

Because HFCs have an impact on global climate, the consumption reductions will be measured in terms of carbon dioxide equivalent (CO_2e), based on the GWP of each controlled substance.

The HFC phase-down schedule for Mexico establishes that the country will have to freeze its consumption in 2024, taking as a baseline the average of HFC consumption in the period from 2020 to 2022, while adding 65% of the HCFC baseline. The Table 1 below indicates the goals that Mexico must meet in order to finally phase-down 80% of the baseline before 2045:

Diagram 1

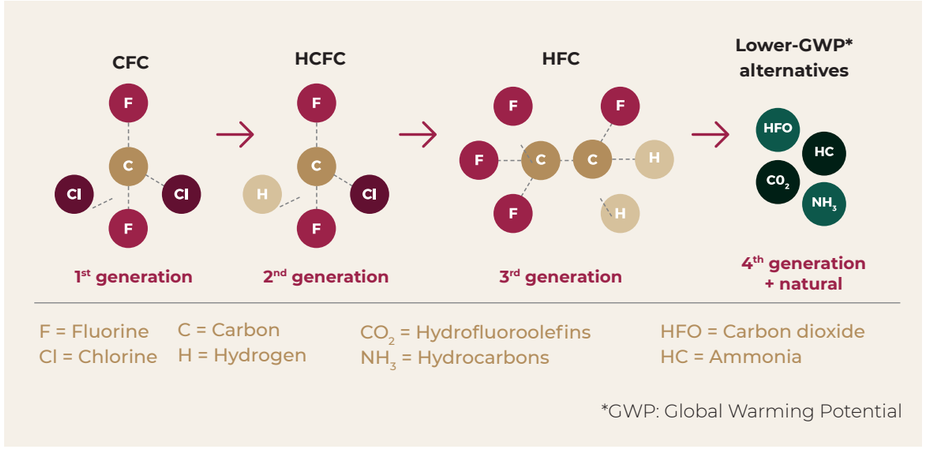


Table 1. Kigali Amendment Schedule for Mexico

KIGALI AMENDMENT SCHEDULE FOR MEXICO		
Kigali Amendment Schedule for Mexico		
HFC component	Average consumption between 2020 - 2022	
HCFC component	Plus 65% of HCFCs baseline	
Phase-down goals		
	Year	**Phase-down percentage**
Consumption freeze	2024	-
Stage 1	2029	10%
Stage 2	2035	30%
Stage 3	2040	50%
Stabilization	2045	80%

Source: Kigali Amendment

1 Kigali Amendment, Article 4B. (MOP28, 2016).

Diagram 2. Traverse Agendas in the Implementation of the Kigali Amendment

Main Instruments of the Climate Change (CC) Policies

- GENERAL LAW ON CC
- +State
- NATIONAL STRATEGY ON CC
- SPECIAL PROGRAM ON CC
- +Local
- CC FUND
- NATIONAL INVENTORY ON GREENHOUSE GASES AND COMPOUNDS
- +Local
- NATIONAL REGISTRY OF EMISSIONS (RENE)
- MEXICAN OFFICIAL STANDARDS (NOM)

GHG Nationally Determined Contributions

-22% -36%

Based on **2030** baseline

In Mexico, HFCs contribute with **1.8% of GHG emissions** (INECC, 2018).

HFC reduction will contribute to achieve the goals on **climate change mitigation.**

Existing Regulations and Guides for Management and Disposal of Used Refrigerant Banks

- WASTE MANAGEMENT AND DISPOSAL
- TRANSBOUNDARY MOVEMENT OF HAZARDOUS WASTE
- GOOD PRACTICE GUIDES FOR SERVICE
- TRANSPORTATION OF HAZARDOUS MATERIALS
- DESTRUCTION OF DISCARDED REFRIGERANTS

UNIDO (2017)

Mexico has nine refrigerant **recovery and recycling centers**, as well as two facilities authorized for **destruction** by argon plasma arc and cement kilns for co-processing.

Environmentally responsible management of refrigerants in discarded equipment and systems will be strengthened.

Main Instruments of the Energy Efficiency (EE) Policies

- ENERGY TRANSITION LAW
- SPECIAL PROGRAM ON ENERGY TRANSITION
- EE INDICATORS
- FIDE STAMP
- NATIONAL PROGRAM FOR SUSTAINABLE USE OF ENERGY
- EE STANDARDS (NOM)
- ENERGY MANAGEMENT SYSTEMS
- TRANSITION STRATEGY TO PROMOTE THE USE OF CLEANER TECHNOLOGIES AND FUELS
- FUND FOR ENERGETIC TRANSITION AND SUSTAINABLE USE OF ENERGY

It is estimated that **electricity consumption** contributes with **71% of GHG** emissions of the **RAC** sector in Mexico (UNIDO, 2018e).

Energy efficiency actions will be promoted.

Energy Efficiency Goals

-1.9% -3.7%

2016-2030 **2031-2050**

Annual average rate of energy final consumption intensity

Sustainable development Goals

The modernization of the **national industry** and the creation of better paid **jobs** for professionals in the sector will be encouraged.

1.3 **Cross-Cutting Agendas**

The implementation of the KA is aligned with the **2030 Agenda for Sustainable Development** and it will help to achieve the goals of climate action, affordable and clean energy, responsible production and consumption, decent work and economic growth, as well as industry, innovation and infrastructure. The connection with the national policy agendas is shown in Diagram 2.

The Kigali Amendment came into force globally on January 1, 2019, after the ratification of at least twenty countries. The ratification of Mexico occurred on September 25, 2018 and its promulgation decree was published in the Official Gazette of the Federation (OGF), on November 30, 2018.

02 Chapter

LEGISLATIVE ANALYSIS

LEGISLATIVE ANALYSIS

In order to identify the key elements for a successful implementation of the KA, an analysis of the legislation at all levels was carried out (UNIDO, 2019a, 2019b), including the Political Constitution of the United Mexican States and the legislation on the organization of the Federal Public Administration, as well as the laws and regulations related to the protection of the environment, which contain the obligations that individuals must fulfill regarding the Montreal Protocol, as part of the Vienna Convention. Particularly, the modifications required in the current legal framework were determined to provide the relevant authorities with attributions to comply with the obligations acquired by Mexico when signing the Kigali Amendment.

Based on the analysis of the legislative framework, two options are suggested for controlling HFCs, the first one through an extension of the current regulation to control HCFCs. Regarding these, the obligations imposed by the MP have been implemented as explained below.

In accordance with the phase-out schedule for substances controlled by the Montreal Protocol the consumption

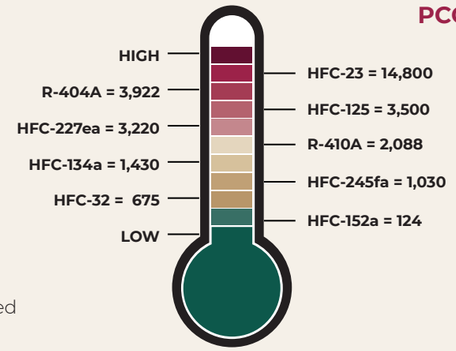
Mexico's obligations as part of the KA:

- To establish a baseline of annual consumption, expressed in tons of CO_2 equivalent. Consumption is considered as the result of the sum of domestic production plus imports, while subtracting the exports that are made in a calendar year (Diagram 3).
- To comply with the HFC consumption reduction goals established in the EK calendar (see section 1.2).
- To create a quota system which determines the maximum amount of tons CO_2 equivalent of HFCs that will be allowed to import during a calendar year.
- To impose as a regulation to entities, obtaining a permit to import HFCs as part of the quota assigned to them at the beginning of the calendar year.

2 Kigali Amendment, Article 4B. (MOP28, 2016).

Diagram 3

The level of **HFC consumption** must be established in terms of **CO_2e**, which is determied based on the HFC conspumption in metric tons and multiplied by the appropriate **Global Warming Potential** (GWP).



The HFCs at country level will be reported based on their apparent consumption:

consumption = production + imports – exports – destruction (CO_2e)

baselines of ODSs were established in a timely manner.

The obligation to establish a quota system for ODS has been fulfilled in the exercise of the attributions given to the General Direction of Air Quality Management and Pollutant Release and Transfer Register (DGGCARETC), in sections XIV and XXIX of the article 30 of SEMARNAT Internal Regulations (RISEMARNAT), currently in force. Moreover, two permits were established for the importation of regulated substances: one that must be granted by the Federal Commission for Protection Against Sanitary Risks (COFEPRIS), in compliance with the CICOPLAFEST[3], Agreement, due to the properties of hazardousness and toxicity of the substances; and another that must be issued by the General Direction for Management of Hazardous Materials and Activities (DGGIMAR), in relation to the effect of these substances on the environment.

3 Comisión Intersecretarial para el Control del Proceso y Uso de Plaguicidas, Fertilizantes y Sustancias Tóxicas.

The route of regulatory modifications to implement the KA in Mexico is presented in strict accordance with the regulatory framework for HCFC control. This would allow taking advantage of the capacities developed for its control over time and avoiding procedural complications for individuals.

To achieve this objective, sections XIV and XXIX of article 30 of the RISEMARNAT would have to be modified as follows:

> XIV.- Design and apply national policies and regulations arising from the provisions of the Montreal Protocol, as well as any other international treaty or treaty that regulates ozone-depleting substances, substances with global warming potential and, in general, gases harmful to the environment. environment and the respective amendments;
>
> XXIX.- Assign quotas for the import of substances controlled by the Montreal Protocol, as well as any other international treaty or treaty that regulates ozone-depleting substances, substances with global warming potential and, in general, gases harmful to the environment and request information on the use of these substances;

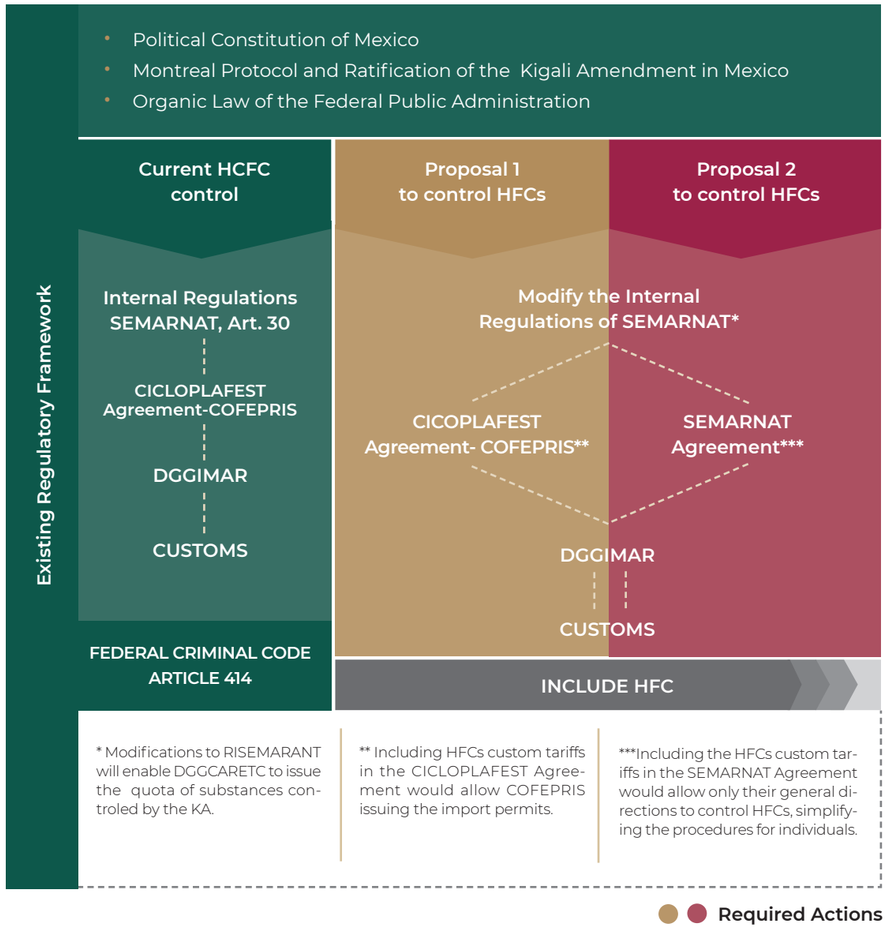
Subsequently, the tariff fractions that control the import and export of HFCs in Mexico should be added to the CICOPLAFEST Agreement. This modification would be reflected in the Law on General Import and Export Taxes and would allow the General Customs Administration (GCA) to exercise its verification attribution. Likewise, the DGGIMAR of SEMARNAT would continue issuing the import authorization, based on section X of article 29 of the RISEMARNAT, as they are hazardous materials.

The second option for the control of HFCs works through the "Agreement that establishes the classification and codification of goods whose import and export is subject to regulation by SEMARNAT", for the control of certain substances that due to their properties may have sensitive effects on the environment. Considering the possibility of simplifying the procedures for individuals, substances controlled by the KA could be added to this agreement. Thus, only SEMARNAT, through its general directorates, would authorize annual quotas and imports of HFCs. This alternative would require the RISEMARNAT modifications already proposed but would avoid the inclusion of HFCs in the CICOPLAFEST Agreement.

In Diagram 4, the two proposed options are presented in a schematic manner. Both would allow complying with the obligations included in the MP and the KA, with reliable control mechanisms for the country.

Regardless of the route to be followed, the amendment to article 414 of the Federal Criminal Code must be considered.

Diagram 4



03 Chapter DIAGNOSIS

DIAGNOSIS

The consumption of HFCs in Mexico has grown from 2007 to 2017 with an average annual growth rate of 14.5%, going from 12.75 million tons of carbon dioxide equivalent ($MtCO_2e$) to 49.43 $MtCO_2e$ during this period (Figure 1). This is the result of the significant phase-out of HCFCs following the implementation of the National HCFC Phase-out Plan (HPMP), as well as the growing demand for domestic, residential and industrial RAC systems (UNIDO, 2019c).

In 2017, the pure HFCs and blends most consumed in Mexico were:

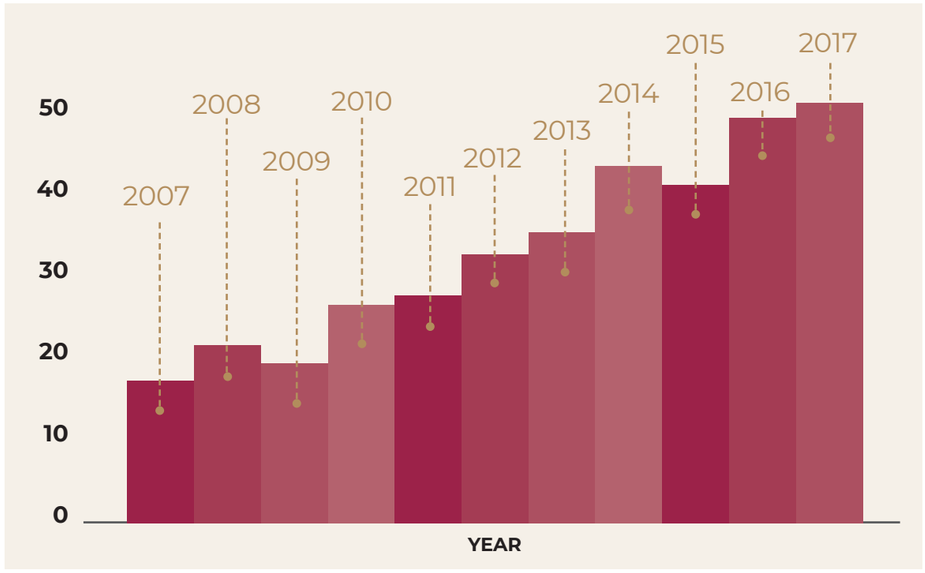
R-410A (22.75 $MtCO_2e$), used mainly in the stationary air conditioning sector (AC).

HFC-134a (11.84 $MtCO_2e$), used mainly in the mobile air conditioning (MAC) and in domestic refrigeration.

R-404A (7.16 $MtCO_2e$), consumed in the commercial refrigeration sector.

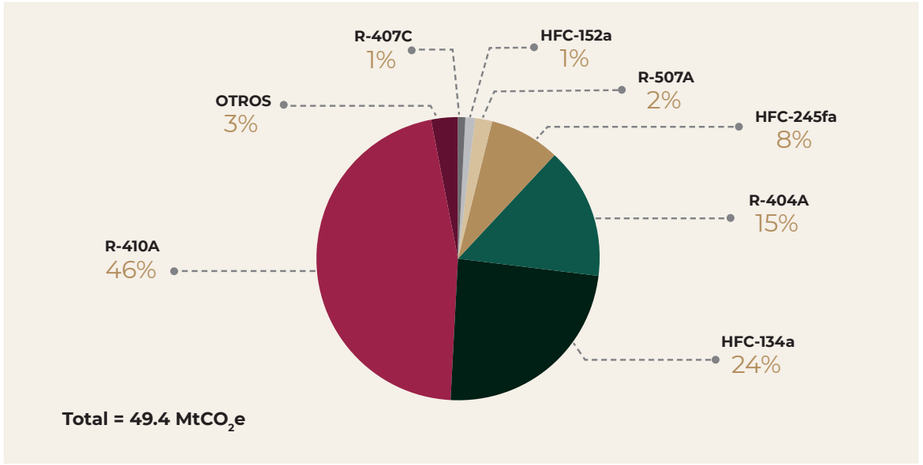
HFC-245fa (4.52 $MtCO_2e$), consumed in the manufacture of polyurethane (PU) rigid foams.

Figure 1. HFC Consumption Trend in Mexico 2007-2017



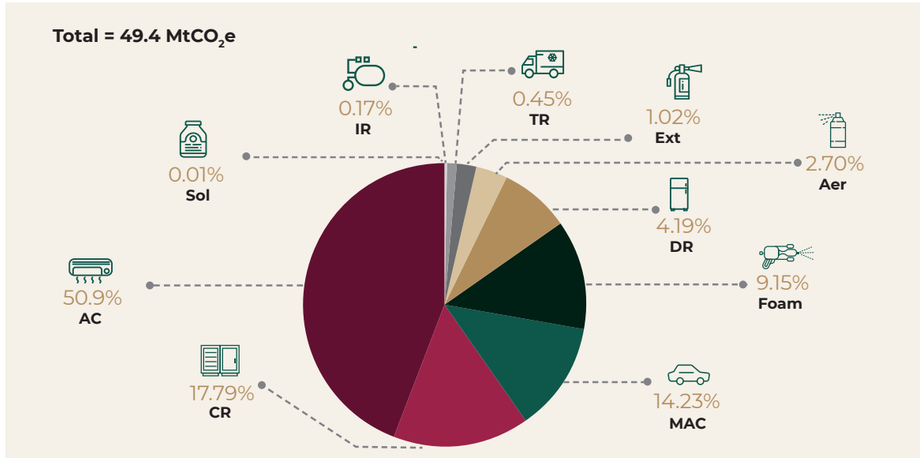
Source: UNIDO (2019c), based on Customs information.

Figure 2. Consumption Distribution of the Main HFCs in 2017



Source: UNIDO (2019c), based on Customs information.

Figure 3. Consumption Distribution of HFCs by Sectors in 2017



AC: Stationary Air Conditioning, CR: Commercial Refrigeration; MAC, Mobile Air Conditioning, Foam: Foams, DR: Domestic Refrigeration, Aer: Aerosols, Ext: Fire extinguishers, TR: Transport Refrigeration, IR: Industrial Refrigeration, Sol: Solvents.

Source: UNIDO (2019c), based on Customs and industry information.

Diagrama 5. Location of original equipment manufacturing plants and new products using HFC

These four substances represent around 93% of the national consumption and are, therefore, a priority in the implementation of the Kigali Amendment (Figure 2).

In Mexico, HFCs are mainly consumed in two market segments, as refrigerants in RAC systems and a set of industrial applications, which include blowing agents for foams, propellants for aerosol products and fire protection, as well as solvents.

The main sectors that consume HFCs are AC, commercial refrigeration, MAC and foams, which in total represent 91% of the total national HFC consumption. The complete sectoral distribution is detailed in Figure 3.

Mexico is a global leader in the manufacture of original equipment (OEM), as well as various products that use HFCs. In Diagram 5, the regional distribution of the main sectors is shown.

The analysis of consumption in 2017 for each sector that consumes HFCs is presented in the following subsections. In case of those related to the RAC sectors, the sectoral categorization of the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) was used (UNEP, 2015).

3.1 Stationary Air Conditioning (AC)

The AC sector represents the largest consumption of HFCs nationwide, with 24.85 $MtCO_2e$ during 2017. The most consumed substance in this sector is R-410A (92% of the sector), followed by HFC-134a (6%) and R-407C (2%).

The consumption of this sector is attributable to the vast number of OEM companies, in particular of package type equipment and duct systems, as well as air conditioning chillers, all charged mainly with R-410A. The foregoing is reflected in the fact that Mexico is the third largest exporter of air conditioning systems worldwide (OEC, 2017).

There are at least ten companies in the sector that have several air conditioning systems manufacturing plants. They are mostly of foreign capital, except for one that is dedicated to the production of chillers. The rest of them mainly manufacture split, package and duct systems, which are mostly exported to the United States, as well as to other parts of the world. These companies are located in Nuevo Leon, Coahuila, Tamaulipas, Baja California and San Luis Potosi.

Table 2 shows the consumption of AC by subsector, for OEMs and services, during 2017.

Average age: 4 years

4.9 million households have air conditioning (15% total)[a].

56% have **NOM-ENER** label[a].

Mexico is the **3rd largest exporter** of air conditioners (9% of the total worldwide)[b].

a) INEGI (2018), ENCEVI
b) OEC (2017)

Table 2. Estimated Consumption of HFCs in the AC Sector During 2017

SECTOR	SUBSECTOR	OEM	Service
		$MtCO_2e$	
Stationary air conditioning (AC)	Package and duct systems	18.89	1.09
	AC chillers	2.48	1.66
	Mini-splits	-	0.48
	Window	-	0.25
	TOTAL	**21.37**	**3.48**

Source: UNIDO (2019c).

Trends of Energy Efficiency in the AC Sector

The air conditioning systems with the best performance in the Mexican market are those that have incorporated the frequency inverter. In case of the mini-split inverter equipment, their SEER [4] is around 7-1 Wt/We [5]. The centralized systems with chillers and whose performance is based on the type of compressor generally exceed Wt/We, while the VRF multi-split systems reach a SEER of 6.4 Wt/We; in these systems, refrigerants with lower GWP have also been incorporated. Window type equipment, rooftop package and ducted split have had les technological evolution, so their efficiencies are lower and still use conventional refrigerants (UNIDO, 2018a, 2018b). Table 3 describes the efficiency characteristics systems in Mexico.

4 SEER: seasonal energy efficiency rate.
5 Wt/We: termal watt per electric watt.

Table 3. Analysis of Energy Efficiency in AC Systems

SYSTEM	EFFICIENCY (WT/WE)		CONVENTIONAL REFRIGERANTS	ALTERNATIVE REFRIGERANTS	CAPACITY KWT (TR)
	AVERAGE RANGE	BAT[6] MÉXICO			
Window	2.3-3	3	R-410A, R-22, R-407C	R-290, R-32 ▲	2 a 7 (0.5 a 2)
Residential Mini-split (includes inverter)	3.8-4.1	7.2	R-410A, R-22, R-407C	R-290, R-32, R-1270 ▲	2 a 12 (0.5 a 3.4)
Commercial Mini-split	3.2-3.8	6.3	R-410A, R-22, R-407C	R-290, R-32, R-1270 ▼	12 a 19 (3.4 a 5.4)
Residential Ducted split	2.9-3.3	5.1	R -410A	R-290, R-32, R-1270 ▼	5.3 a 17.6 (1.5 a 5)
Commercial Ducted split	2.9-3.3	5.1	R-410A	R-290, R-32, R-1270 ▼	9 a 71 (2.5 a 20.2)
Package rooftop	2.9-3.3	3.8	R-410A, R-407C	(Tested in laboratory) ▼	Small businesses: 18 to 88 (5 to 25) Large businesses: 263 a 703 (75 a 150)
Multi-splits (includes VRF)	2.9-3.3	6.44	R-410A, R-407C	R-32, other ►	
AC chillers (small businesses)	2.9-4.7	6.5	R-410A, R-407C	R-290, R-32, R-452B ▲	50 a 750 (14 a 213)
***Chillers* AC grandes comercios**	2.9-4.7	6.5	HFC-134a R-134A, R-123	R-1234yf, R-1234ze, R-513A, R-1336mzz(z) ▲	>750 (>213)

Status: ▲Commercially available in some markets, ► In development, ▼ Tested in laboratory
Source: UNIDO (2018a, b).

6 Best Available Technology

3.2 Commercial Refrigeration (CR)

CR is the second most important sector within the national consumption of HFCs, with around 8.79 MtCO2e in 2017. The R-404A is the most consumed substance in commercial refrigeration (with 80%), followed by the R-507A (13%) and HFC-134a (4%).

The three subsectors that use HFCs are centralized systems (for supermarkets), condensing units (for various businesses and industries) and stand-alone equipment (such as freezers, showcases and plug-in beverage coolers). R-404A is used in the three subsectors mentioned. R-507A is mainly used as a substitute for HCFC-22 in centralized systems, while HFC-134a is used in condensing units and stand-alone equipment.

In Mexico, there are three manufacturing companies of centralized systems and condensing units, of which only one is national. In the case of stand-alone equipment, there are several Mexican companies of great commercial presence, as well as two of foreign capital. These companies are located in Nuevo Leon, Queretaro, Guanajuato, Yucatan and Mexico City.

Table 4 shows the HFC consumption in 2017 for the commercial refrigeration subsectors.

In this section it is important to notice the high consumption for the service of centralized commercial refrigeration systems. There are several factors that influence the use of refrigerants in this sector, including the size of the systems, the number of pipes and ducts that compose them, the age of the equipment, the lack of preventive maintenance and the lack of refrigerant recovery.

Table 4. Estimated Consumption of HFCs in the Commercial Refrigeration Sector During 2017

SECTOR	SUBSECTOR	OEM	SERVICE*
		($MtCO_2e$)	
Commercial refrigeration (CR)	Centralized systems	-	6.62
	Condensing units	-	1.79
	Stand-alone equipment	0.27	0.11
	TOTAL	**0.27**	**8.52**

* The term "Service" includes the consumption for initial charge of centralized systems and condensing units, which are not pre-charged during their manufacturing, but until their installation. Source: UNIDO (2019c).

Table 5. Analysis of Energy Efficiency in Stand-Alone Equipment

SYSTEM	CAPACITY (L)	BAT - FIDE MÁX. MAX DAILY CONSUMPTION (WH/L)	CONVENTIONAL REFRIGERANT	ALTERNATIVE REFRIGERANT
Vertical freezer with solid door and cold plate	352.70	12.50	R-22, HFC-134a, R-404A	R-290, R-744, R-600a ▲
Horizontal freezer with glass door (includes medical use)	643.10	5.50		
Horizontal freezer with solid door (includes medical use)	394.00	7.84		
Vertical freezer with glass door and forced air circulation	404.70	28.30		
Vertical freezer with glass door and cold plate	278.40	20.72		
Ice bags preserver	1,652.70	3.18		
Vertical cooler with forced air circulation	1,080.00	3.66		
Closed cabinet of medium temperature	698.10	10.08		

Status: ▲ Commercially available in some markets, ► In development, ▼ Tested in laboratory
Source: UNIDO (2018a, b).

Trends of Energy Efficiency in the Commercial Refrigeration Sector (stand-alone units)

The efficiency of stand-alone commercial refrigeration equipment is expressed in terms of the maximum daily electricity consumption (Wh/l-d), which depends on the type of technology and its application. The high-performance reference for these devices is the FIDE 4117 stamp, which comprises the best equipment. The lowest consumption per liter is a conservator of ice bags followed by a vertical cooler with forced circulation. The refrigerant HFC-134a is still very common, but the alternative refrigerants R-290, R-744 and R-600a are becoming more common in the market (UNIDO, 2018a, 2018b). Table 5 describes the efficiency characteristics of the stand-alone equipment subsector.

Table 6. Technologies in Centralized Systems and Condensing Units

SYSTEM	CONVENTIONAL REFRIGERANTS	ALTERNATIVE REFRIGERANTS
Condensing units, cold rooms	R-404A, R-507A, HFC-134a, R-413A,	R-290, R-744, R-1270 ►
Centralized systems	R-404A, R-507A, HFC-134a, R-413A,	R-290, R-744, R-1270, R-1234yf, R-1234zd ►

Status: ▲ Commercially available in some markets, ► In development, ▼ Tested in laboratory
Source: UNIDO (2018a, b).

Technology trend in condensing units and centralized systems

The use of alternative refrigerants in condensing units, typical of refrigeration and freezing rooms has not yet been extended, on account of the incorporation of those refrigerants continues in development. The efficiency of the condensing units depends on the cooling capacity and application of the technology (medium or low temperature), so an efficiency is considered for the condenser and another greater for the evaporator (UNIDO, 2018a, 2018b). Table 6 identifies the technological characteristics of condensing units and centralized systems.

3.3 Mobile Air Conditioning (MAC)

The MAC sector appears in third place of HFC consumption nationwide. In 2017, 7.04 MtCO2e of HFC-134a were used, which completely displaced CFC-12, previously used in the automotive sector. The subsector of light vehicles is the one with the highest demand of HFCs in MAC, both for OEM and the service.

It is estimated that between 2010 and 2017 the gross domestic product (GDP) of the cars and trucks manufacture registered an average annual growth of 12.9%, while the one of automotive parts was 11.9%. Overall, the Mexican automotive industry grew 12.3% each year, which indicates a momentum for this sector (AMIA-INEGI, 2018). This growth is consistent with the one replicated in the national demand of HFC-134a in MAC.

There are several manufacturing plants of light vehicles distributed along the country which belong to eleven companies, all of them being foreign. Regarding heavy vehicles, such as buses and tractors, at least seven companies have been identified, only one being national.

From the national production of light and heavy vehicles, 97.5% concentrates in ten states, with Sonora (16.2%), Coahuila (15.9%) and Puebla (13.6%) recording the highest levels of production (AMIA-INEGI, 2018).

Table 7 shows the estimated consumption of HFCs in the MAC subsectors. 46% of this corresponds to the manufacture of new vehicles, while the remaining 54% is for service and maintenance. These figures are consistent with the high levels of leakage in the air conditioning systems of motor vehicles and the continuous maintenance they require, particularly in regions of the country with extreme climatic conditions.

Domestic production: **3.3 million**[a]

Imports: **0.9 million**[a]

Exports: **2.8 millon**[a]

Vehicle fleet: **24.4 million**[b]

a) AMIA (2017),
b) INEGI (2017). INEGYCEI 2015. (2017)

Table 7. Estimated Consumption of HFCs in MAC Sector During 2017

SECTOR	SUBSECTOR	OEM	SERVICE
		$MtCO_2e$	$MtCO_2e$
Mobile air conditioning (MAC)	Light vehicles	3.27	3.69
	Buses and trucks	0.02	0.06
	TOTAL	**3.29**	**3.75**

Source: UNIDO (2019c)..

In terms of regulation, the draft amendment of the **NOM-163-SEMARNAT-ENER-SCFI-2013**, referring to the maximum of CO_2 emissions from the exhaust and its equivalence in fuel efficiency, applicable to light vehicles and new trucks, will allow obtaining credits to achieve the required emissions goal in gCO2/km, derived from technological developments for air conditioning systems, based on the improvements in efficiency, increased hermeticity and use of refrigerants with lower global warming potential (UNIDO, 2018a, 2018b).

3.4 **Foams (Foam)**

The foam sector is the fourth largest consumer of HFCs in Mexico, with 4.52 $MtCO_2e$ estimated in 2017. HFC-245fa represents 92% of this amount, which is used primarily in the manufacture of PU foams for insulation of domestic refrigerators, followed by HFC-365mfc/227ea (7%) and HFC-134a (1%).

In this sector the largest users standing out are the companies dedicated to the manufacture of refrigerators (sections 3.2, 3.5), as well as a series of companies that are dedicated to the formulation of systems for the preparation of polyurethane foams. The total consumption in this sector is presented in Table 8.

Table 8. Estimated Consumption of HFCs in the PU Foams Sector During 2017

SECTOR	SUBSECTOR	CONSUMPTION ($MtCO_2e$)
Foams (Esp)	Rigid PU foams	4.52

Source: UNIDO (2019c).

3.5 **Domestic Refrigeration (DR)**

The domestic refrigeration sector ranks fifth in the national consumption of HFCs, with 2.07 $MtCO_2e$ estimated in 2017. The only refrigerant used currently in this sector is HFC-134a.

Mexico is an important exporter in the appliance industry, being the main country in Latin America and the sixth worldwide, above other relevant countries of the industry, such as South Korea, Turkey and France (Secretaría de Economía, 2015).

In addition, it is the main exporter of refrigerators with freezer. In this sector, nine OEM plants have been identified within the country, which belong to seven corporate groups, of which one of the main ones is Mexican.

Average age: 7 years

28.9 million households have a refrigerator (87% of total)[a].

72% have NOM-ENER label[a].

Mexico is the **1st exporter** of two-doors refrigerators (25% of the total worldwide)[b].

a) INEGI (2018) ENCEVI,
b) OEC (2017)

In this sector, most of the consumption (92%, approximately) is intended for the manufacture of new equipment, while only 8% is used in service, due to the low rate of leakage featured by this type of equipment.

Tabla 9. Estimated Consumption of HFCs in the Domestic Refrigeration Sector during 2017

SECTOR	SUBSECTOR	OEM ($MtCO_2e$)	SERVICE ($MtCO_2e$)
Domestic refrigeration (DR)	Domestic refrigerators	1.92	0.15
	TOTAL	**1.92**	**0.15**

Source: UNIDO (2019c).

The increase in per capita income, urbanization and the growth of the middle class in emerging countries, such as Mexico, have triggered a change in consumption patterns, which is reflected in the increase of demand for household appliances such as refrigerators.

In addition, the production of refrigerators has evolved in recent decades. While in the past this equipment used CFCs as a refrigerant, it currently uses HFC-134a, although some companies already have begun to decrease their consumption.

Trends of Energy Efficiency in the Domestic Refrigeration Sector

The domestic refrigerators that prevail in Mexico are of 9 to 16 cubic feet of capacity and use mostly HFC-134a refrigerant, although equipment with R-600a is already available. The energy efficiency of these appliances is expressed by the maximum annual consumption (kwh/year), so the lower the annual consumption, the more efficient the refrigerator is. The units that provide the best performance are those registered under the FIDE 4111 label. In general, equipment with capacities of 9 and 11 cubic feet consume less energy and comply with the recently updated NOM-015-ENER-2018 standard. In larger systems, it is still necessary to carry out technological improvements to comply with the values of the NOM (UNIDO, 2018a, 2018b) standard. Table 10 describes the characteristics of these devices.

Table 10. Analysis of Energy Efficiency in the Domestic Refrigeration Sector

SYSTEM	CAPACITY L (ft^3)	EFFICIENCY (KWH / YEAR)		CONVENTIONAL REFRIGERANTS	CONVENTIONAL REFRIGERANTS
		BAT FIDE	NOM-015-ENER-2018		
Domestic refrigerator	255 (9)	280	306	HFC-134a	R-600a▲
	314 (11)	313	323		
	364 (13)	399	337		
	396 (14)	375	347		
	446 (16)	389	360		

Status: ▲ Commercially available in some markets, ► In development, ▼ Tested in laboratory
Source: UNIDO (2018a, 2018b).

3.6 Aerosols (Aer)

The aerosol sector is the next in terms of HFC consumption at the national level, with 1.33 MtCO2e, where HFC-134a and HFC-152a are the most commonly used substances, with 61% and 35% of the total HFC consumption in this sector, respectively.

Regarding technical aerosols, HFC-134a and HFC-152a were also the most used substances in 2017. There are several national companies belonging to this subsector in the country.

HFC-152a is used primarily as a propellant in several household aerosols. Several companies, both foreign and national, are involved in the manufacturing of this kind of aerosols.

Due to the possibility of purifying HFC-134a to a medicinal degree, it can be widely used as a propellant for metered dose inhalers (MDI). Several laboratories producing this type of products have been identified.

In the health sector, the use of HFCs is considered of essential use, so its consumption is not subject to the phase-down plan. Therefore, the available 20% reserve of consumption will cover the demand of this sector.

The distribution of HFC consumption in 2017 for the aerosol sector is presented in Table 11.

Table 11. Estimated Consumption of HFCs in the Aerosols Sector During 2017

SECTOR	SUBSECTOR	CONSUMPTION ($MTCO_2e$)
Aerosols (Aer)	Technical aerosols	0.69
	Domestic aerosols	0.42
	Metered dose inhalers (MDI)	0.22
	TOTAL	**1.33**

Source: UNIDO (2019c).

3.7 Fire Extinguishers (Ext)

There is little consumption of HFCs dedicated to fire protection. In 2017, this sector consumed around 0.49 MtCO2e.

HFC-125, HFC-236fa and HFC-227ea are chemical compounds that suppress class A, B and C fires without water or harmful chemical residues. Therefore, they continue to be the main substances used in Mexico for portable fire extinguishers and pressure fire suppression systems.

In 2017, HFC-236fa had the highest consumption (around 0.17 MtCO2e), followed by HFC-227ea and HFC-125, with 0.16 MtCO2e each.

Table 12. Estimated Consumption of HFCs in the Fire Extinguishers Sector During 2017

SECTOR	CONSUMPTION ($MtCO_2e$)
Fire extinguishers (Ext)	**0.49**
TOTAL	**0.49**

Source: UNIDO (2019c).

3.8 Transport Refrigeration (TR)

The systems used in transport refrigeration are mainly imported by some companies with international presence, although there is also a Mexican company that manufactures them. This sector includes both small and large vehicles, used mainly for distribution of food over short distances, and intermodal containers that are transported by rail or road.

It is estimated that in 2017, the TR sector used approximately 0.22 $MtCO_2e$, of which 63% corresponded to the consumption of HFC-134a and 37% to R-404A.

The estimated consumption for this sector, which is all comprised for services, is presented in Table 13.

Table 13. Estimated Consumption of HFCs in the Transport Refrigeration Sector During 2017

SECTOR	SERVICE ($MtCO_2e$)
Transport refrigeration (TR)	0.22
TOTAL	**0.22**

Source: UNIDO (2019c).

In this regard, it is important to highlight the relevance of the TR in the cold chain of food and pharmaceutical products, which is vital to extend the lifetime of fresh and frozen products to the maximum, in order to meet the consumer demands.

3.9 Industrial Refrigeration (IR)

Most of the systems that belong to the industrial refrigeration sector operate with ammonia (NH_3) due to their size and cooling capacity. However, it has been identified that a small part of the national HFC consumption (0.08 $MtCO_2e$ in 2017) is used in this sector for service and maintenance of process chillers, which are mostly imported. In 2017, HFC-134a (69%) and R-404A (31%) were the most consumed substances regarding service of industrial chillers.

Table 14. Estimated Consumption of HFCs in the Industrial Refrigeration Sector During 2017

SECTOR	SUBSECTOR	SERVICE ($MtCO_2e$)
Industrial refrigeration (RI)	Process chillers	0.08
	TOTAL	**0.08**

Source: UNIDO (2019c).

3.10 Solvents (Sol)

The sector of lowest HFC consumption is solvents, with a little more than 7,000 tons of CO2e consumed in 2017. The identified HFC used in this sector is HFC-43-10mee, although in recent years the introduction of HFC-365mfc has been registered (Table 15).

These HFCs are used mainly in precision cleaning applications of metals and electronic components, in which solvents are used in blends with alcohols and/or chlorocarbons that improve cleaning performance and reduce overall costs.

Table 15. Estimated Consumption of HFCs in the Solvents Sector During 2017

SECTOR	CONSUMPTION ($MtCO_2e$)
Solvents (Sol)	0.007
TOTAL	**0.007**

Source: UNIDO (2019c).

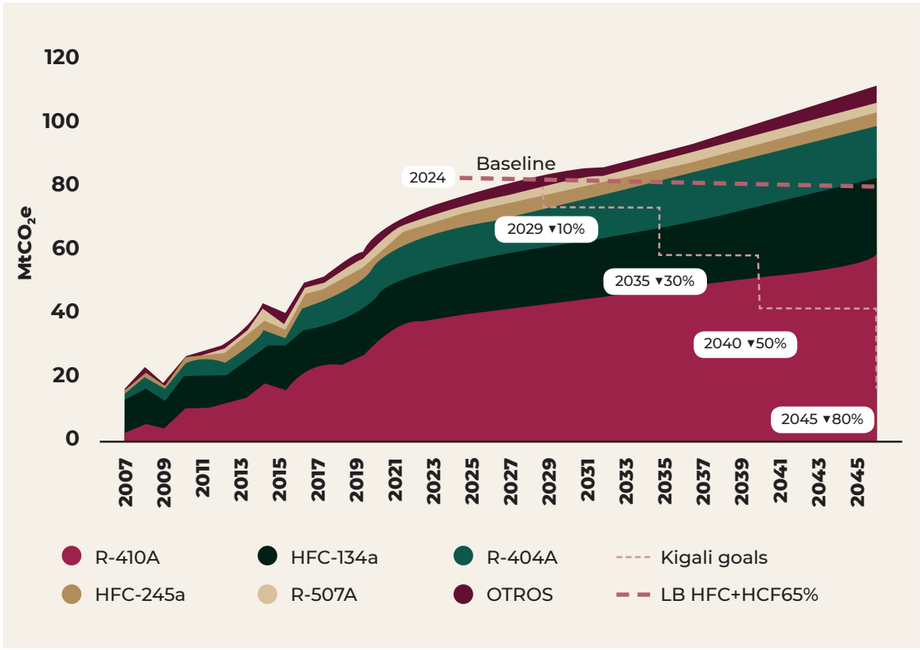
3.11 Demand Projection Towards 2045

In order to know the level of phase-down to which the HFC consuming sectors will have to adjust to, it is necessary to determine the expected demand in the coming decades according to a Business-as-usual (BAU) scenario. The main criteria for estimating this scenario are the following (UNIDO, 2019c, 2019d):

- Current consumption and sectoral distribution
- HCFC phase-out impact
- Expected GDP behavior
- Substances growth trend
- Production projections of new equipment and units

Mexico's baseline was estimated based on the projected consumption between 2020 and 2022, which according to the KA will set the consumption level from 2024 onwards and will be, simultaneously, the reference for the phase-down required according to the EK schedule. Figure 4 shows that the BAU scenario would reach around 110 $MtCO_2e$ in 2045 if no control measures are undertaken, while the baseline is estimated at around 80 $MtCO_2e$.

Figure 4. BAU Scenario of HFC Demand Towards 2045 and Baseline



Source: UNIDO (2019c, 2019d).

04 Chapter

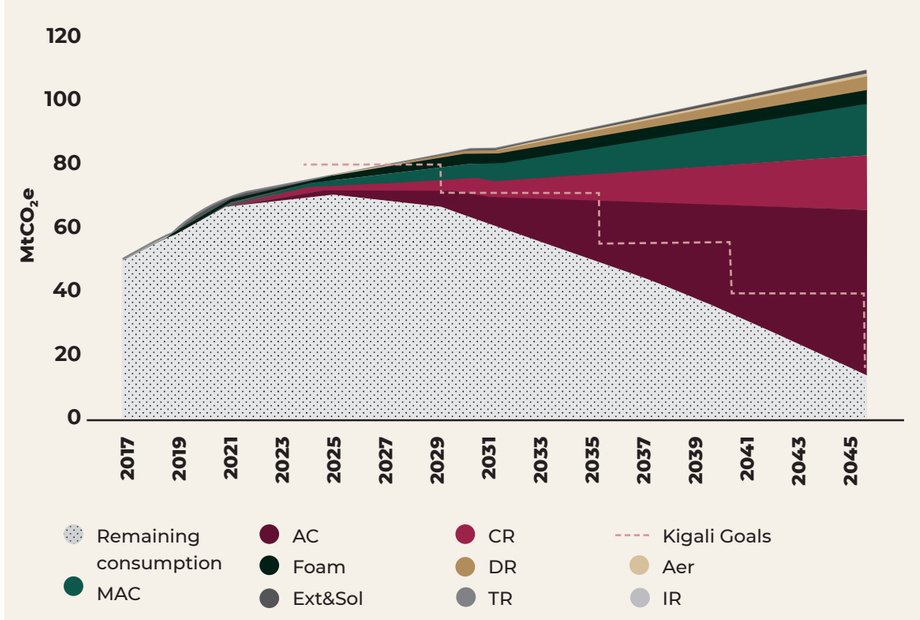
PHASE-DOWN SCENARIOS

PHASE-DOWN SCENARIOS

Based on the analysis of lower climate impact alternatives that could be adopted in Mexico according to their technical, economic and regulatory feasibility, the following transition path at short, medium and long term is proposed for the sectors that consume HFCs (Diagram 6):

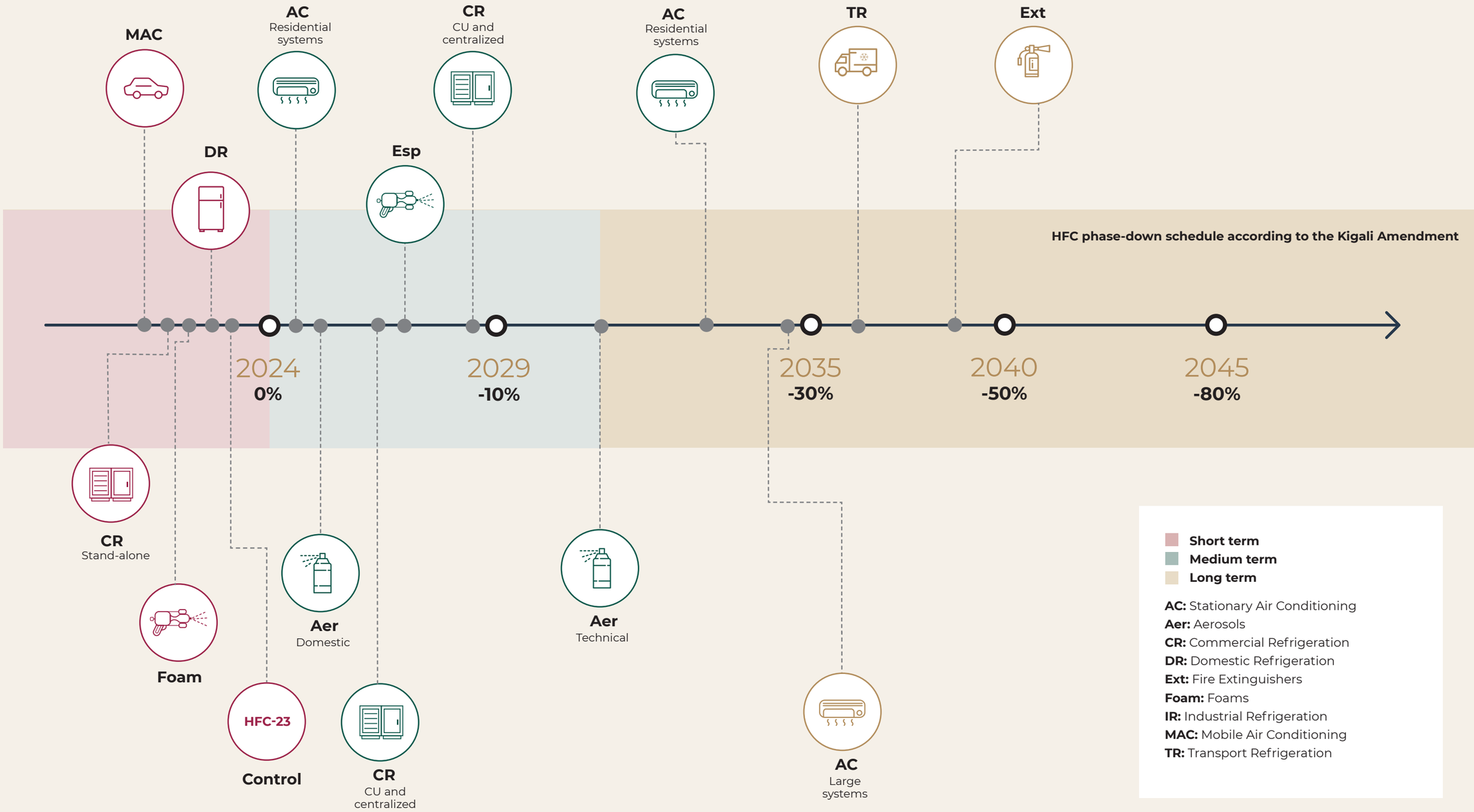
Figure 5 shows the HFC reduction scenarios which demonstrate compliance with the KA goals for Mexico. These were determined considering the characteristics of the alternatives in terms of GWP reduction, charge reduction, availability and potential market penetration (UNIDO, 2019e).

Figure 5. Sectoral HFCs Phase-Down Scenarios to Comply with KA



Source: UNIDO (2019e).

Transition of the sectors that consume HFCs



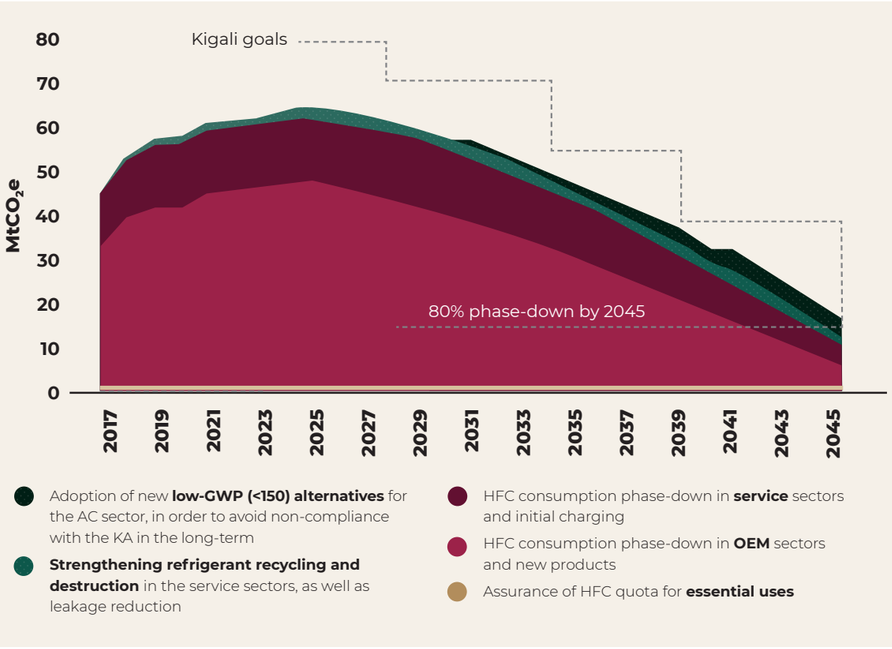
As it can be seen, the contribution of AC, MAC, CR and Foam sectors are critical to accomplish a phase-down scenario.

Although there are priority measures in each sector, the overall actions that are crucial for Mexico to comply with its obligations are the following:

- Adopting **low-GWP (<150) alternatives**, which is especially relevant for the AC sector, due to its contribution to the national consumption.
- Strengthening regulatory programs to **train technicians, recover, recycle and dispose refrigerants**, along with the promotion of the extended responsibility of the producer in the handling of discarded RAC equipment.
- Promoting the **leakage control** of refrigerants, especially in the CR sector. This should be addressed along with energy efficiency measures.
- Analyzing the possibility of avoiding the pre-charge of **exported equipment** that uses high-GWP HFCs.

The impact of the main HFC reduction measures is illustrated in Figure 6.

Figure 6. Impact of the Main Control Measures to Reduce HFCs in Mexico



Source: UNIDO (2019e).

05 Chapter

ROADMAP TO REDUCE HFC

ROADMAP TO REDUCE HFC

5.1 Methodology

The Roadmap was structured with the aim of obtaining a diagnosis of the HFC consumption among the different user sectors at a national level, as well as of the existing regulatory framework for the management of these substances. An analysis of the policies and regulations to promote energy efficiency was also addressed, as well as an evaluation of the commercially available technologies in Mexico for the RAC sector.

Based on the stated above, a projection of the consumption of the different HFCs in each sector and subsector was made to estimate the baseline of consumption according to the schedule established in the Kigali Amendment. In accordance to the needs of transition to alternatives with lower climate impact, public policy actions were prioritized to be executed in the short, medium and long term. Specific actions were established for each sector within the Roadmap. Finally, a consultation was carried out among relevant government entities.

STEP 1. BACKGROUND

- Preliminary studies
- Identification of HFCs consumed in Mexico
  - Identification of imported/consumed HFCs and their supply chain
  - Identification of industries using HFCs
- Assessment of the institutions involved in the HFC management in Mexico
- Compilation of information about industrial associations, academia and specialists

STEP 2. NATIONAL POLICIES

- Regulations to control the Montreal Protocol substances
  - Quota and import and export licensing systems
  - Customs controls
- Regulations to control Greenhouse gases
  - LGEEPA
  - LGCC
  - ENCC
  - PECC
  - NDCs
- Standards to use HFCs and alternatives
  - Energy efficiency
  - Safety
  - Handling and disposal

STEP 3. DATA COMPILATION AND SURVEYS

- Data compilation
  - Customs imports and exports registries from 2012 to 2017
  - Suppliers imports and exports registries
  - Identification of user sectors and subsectors
  - Sectoral consumption distribution for original equipment manufacturers and services
- Surveys
  - Design and application of surveys for companies
  - Interviews and site visits with the industry and chemical suppliers
  - Consultation of specialists, government officials and academy

STEP 4. DATA MANAGEMENT

- Quality control
  - Information cross-check among sources
  - Internal and external consultation processes
  - Verification against national and international publications

STEP 5. DEMAND PROJECTION

- Considerations
  - HFCs growth rates
  - HPMP implementation impact
  - Manufacturing growth
  - Gross domestic product previsions
  - Installed capacity expansion of new manufacturing plants
  - Population growth

STEP 6. TRANSITION TO LOW CLIMATE IMPACT SCENARIOS

- Phase-down obligations
  - Identification of alternatives by sector and subsectors
  - Determination of commercial and technological availability
  - Analysis of scenarios to comply with the KA

STEP 7. TECHNOLOGY DIAGNOSIS OF ENERGY EFFICIENCY

- Revision of RAC technologies state-of-the-art
- Analysis of EE regulations and standards in Mexico, US, Europe and Japan
- Comparison of the best standards and technologies in Mexico and the world

STEP 8. DESIGN OF THE ROADMAP

- Prioritization of sectors and substances based on the previous steps
- Identification of key interventions by sector and substance, and of priority actions in the short (2019-2023), medium (2024-2028) and long term (2029-2045)
- Determination of public policy pillars necessary for a successful implementation of KA in Mexico
- Consultation and validation from government agencies
- Presentation of the Roadmap at a national level

5.2 **Policy Pillars**

The pillars of public policy on which the phase-down of HFC consumption will be sustained in Mexico during the next decades are: 1) regulation, 2) strategic planning, 3) implementation, and 4) reporting and verification (Diagram 7).

Regulation

A series of modifications will be made to the current regulatory framework that will be focused on allowing Mexico's compliance with the Montreal Protocol and the KA obligations, including the implementation of licensing and authorization systems for the import and export of HFCs, as well as the import quota assignation attributions.

On the other hand, regulations and standards that would allow a harmonious transition towards lower-impact climate alternatives will be updated or created, including safety issues in the handling of flammable refrigerants and the promotion of energy efficiency in the various RAC sectors. Moreover, HFC control actions within the framework of Mexico's climate change policies and instruments will be harmonized.

Strategic Planning

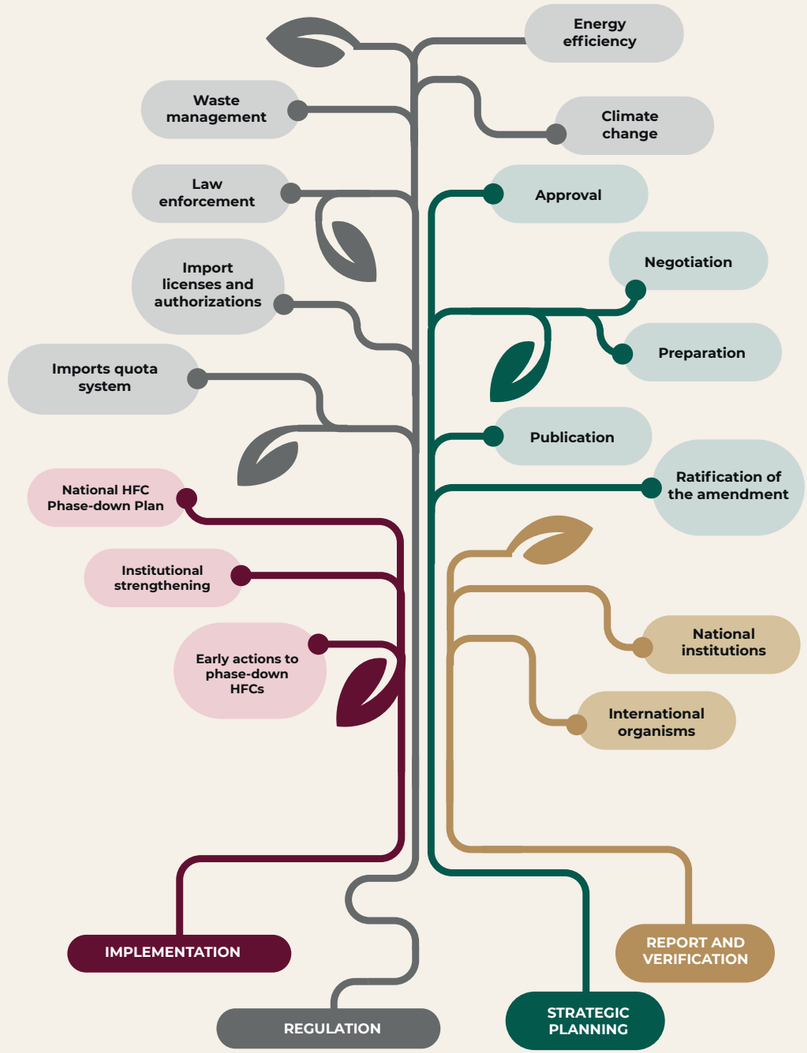
The HFC Phase-Down Plan in Mexico, in which the actors involved in the control of these substances will participate, will be prepared, parting from the presentation of this Roadmap. The negotiation of this plan with the MLF of the Montreal Protocol will allow Mexico to access international financing to implement the HFC consumption reduction actions described in this document.

Implementation

Institutional strengthening actions will be implemented to create the capacities required for the implementation of projects and programs to reduce HFCs consumption, including the execution of early phase-down actions. The implementation of the plan will be based on three action lines: 1) technological conversion projects and adoption of climate-friendly alternatives, 2) technical assistance and training to support the adoption of alternatives, and 3) dissemination of activities to reduce HFCs.

Report and Verification

The compliance certification of Mexico's commitments will be carried out based on the report and verification against international organizations and national institutions, through their respective platforms and mechanisms.
The action lines required for the construction of the four policy pillars are detailed in the next diagram:



MISSION:

To transit harmoniously towards the adoption of lower climate impact alternatives, while promoting the modernization of the industry and the creation of better jobs.

VISION:

Mexico has achieved 80% of HFCs consumption phase-down goal by 2045 in a sustainable, efficient and safe manner, contributing to the development of the region.

Diagram 8. Pillars for the Implementation of the Kigali Amendment in Mexico

PILLARS	ACTIONS	SHORT TERM (2019-2023)	MEDIUM TERM (2024-2028)	LONG TERM (2029-2045)
REGULATION	**Imports quota system**	• To modify the RISEMARNAT in order to include HFCs as substances regulated by the Montreal Protocol (MP). • To design and publish the quota allocation rules to import HFCs.	• To operate the HFC import quota system.	
	Import licenses and authorizations	• To include the HFCs custom tariffs in the CICLOPLAFEST Agreement; or • To include the HFCs custom tariffs in the SEMARNAT Agreement (See section 2).	• To apply the license system.	
	Law enforcement	• To include HFCs as substances regulated by the MP, by modifying the article 414 of the Federal Criminal Code.	• To strengthen the HFCs inspection capacities of the General Prosecutor and PROFEPA.	
	Waste management	• To elaborate a regulation proposal to strengthen the environmentally-sound handling and disposal of HFCs.	• To boost the publication of the regulations.	• To encourage the application of regulations.
	Climate change	• To promote HFCs control actions in the framework of the national climate change policies. • Promote the regulation and control of precharged equipment. Review import tariff fractions and labeling alternatives.		
	Energy efficiency	• To foster regulations and actions to promote energy efficiency in the residential, commercial and industrial RAC sectors. • To elaborate a national plan of efficient cooling that considers the assessment of technologies, minimum standards, labeling, capacities and economic feasibility for energy savings.		

PILLARS	ACTIONS	SHORT TERM (2019-2023)	MEDIUM TERM (2024-2028)	LONG TERM (2029-2045)
STRATEGIC PLANNING	**Ratification of the amendment**	• To present, at a national level, the commitments established in the KA (Roadmap to implement the Kigali Amendment in Mexico).		
	Preparation	• To prepare diagnosis and roadmaps. • To conduct workshops with the user sectors. • To design the National HFC Phase-Down Plan in Mexico.		
	Negotiation	• To submit and negotiate the plan to the executive committee of the MLF of the MP.		
	Approval	• To obtain MLF financing for the execution of the first step of the plan.	• To obtain financing for the following steps of the plan.	
	Publication		• To publish the phase-down calendar in the OGF.	• To publish any amendments to the calendar in the OGF.
IMPLEMENTATION	**Institutional strengthening**	• To create additional capacities in the National Ozone Unit (NOU). • Coordination of the UPO with the Government of Mexico for the development of studies and projects that lead to compliance with the commitments established in the MP.		

PILLARS	ACTIONS	SHORT TERM (2019-2023)	MEDIUM TERM (2024-2028)	LONG TERM (2029-2045)
IMPLEMENTATION	**Early actions to phase-down HFCs**	• To prepare a sectoral diagnostic and roadmap.		
		• To implement pilot projects for conversion of production lines in domestic and commercial refrigeration sectors. • To establish energy efficiency pilot programs. • To conduct studies on the life cycle of refrigerators and air conditioners. • To prepare a proposal of a national strategy to mitigate HFC emissions.		
	National HFC Phase-down Plan		• To execute technological conversion projects and of adoption of climate friendly alternatives.	
			• To provide technical assistance and training for the adoption of alternatives with lower climate impact.	
			• To execute HFCs recovery, recycling and destruction projects.	
			• To disseminate HFCs reduction activities.	

PILLARS	ACTIONS	SHORT TERM (2019-2023)	MEDIUM TERM (2024-2028)	LONG TERM (2029-2045)
REPORT AND VERIFICATION	**International organisms**	• To present country reports to the MLF.		
		• To present verification audits of annual consumption to the MLF.		
		• To present compliance reports to the Ozone Secretariat of UN Environment.		
	National institutions	• To present annual consumption reports to the SEMARNAT BADESIARN system.		
		• To present HFC emissions inventories to INECC.		
		• To present reports on environmental indicators to INEGI.		

5.3 Sectoral Actions

Based on the analysis carried out, the priority actions identified in the short, medium and long term are described for each HFCs user sector regarding their transition towards the adoption of alternatives with lower climate impact.

PRIORITIZATION OF ACTIONS	
Short term	2019-2023
Medium term	2024-2028
Long term	2029-2945

TYPES OF FINAL USES	
OEM / New	Original Equipment Manufacturing (OEM) or New products
Service / Initial charge	Service (SER) or Initial charge

CATEGORIES OF LOWER-GWP ALTERNATIVES			
HFO	Pure Hydrofluoroolefins (HFOs)	**CO_2**	Carbon dioxide (CO_2) or R-744
HFOB ↓	Lower-GWP blends based on HFOs	**HC**	Hydrocarbons (HCs)
HFC ↓	Lower-GWP HFCs	**Other**	Other

Status: ▲ Prioritization of Actions, ▸ Limited availability, ▾ Under development

5.3.1 Stationary Air Conditioning

The AC sector is the **main consumer of HFCs in Mexico**, specifically for the manufacture of original equipment. Alternatives for its subsectors include lower-GWP HFCs (HFC-32, GWP: 675), hydrocarbons (R-290, GWP: 4), lower-GWP blends based on HFOs, pure HFOs (HFO-1234ze, GWP <1) for AC chillers, as well as new chemical developments, such as fluoroiodocarbons. Due to its contribution to Mexico's consumption, it is essential to promote the research and development on new lower-GWP (<150) alternatives that allow the country to meet its reduction goals. Training and certification will be key factors in the adoption of new alternatives, as well as the promotion of higher energy efficiency requirements, along with equipment substitution programs.

SECTOR	STATIONARY AIR CONDITIONING	
SUBSECTORS	PHASED-DOWN HFCS	AVAILABLE ALTERNATIVES
Window, Split, Ducted, Packaged, VRF systems and chillers	R-410A, R-407C, HFC 134-a	HFC 32 ▲, HFOB ↓ ▸, Otros ▾, R-290 ▸, HFO ▸

Short term	OEM, SER	• To conduct a diagnostic study on the regulation to handle flammable refrigerants in the sector. • To prepare a technical-economic analysis on lower climate impact alternatives for the sector.
Medium term	OEM	• To promote in the medium and long term the technological conversion of multinational companies located in the country. • To encourage the development and adoption of new lower-GWP alternatives for the sector. • To formulate and execute a pilot project for the phase-down of R-410A in the manufacture of chillers of a national company.
Long term	SER	• To design a training and certification program for service technicians in the sector. • To provide equipment to service technicians. • To promote the approval and application of standards for the handling of flammable refrigerants. • To promote the implementation of large-scale programs to replace inefficient air conditioners. • To promote the regulation of end of life equipment management.
Energy efficiency	EE	• To promote the application and update of energy efficiency standards for air conditioning systems and their respective FIDE labels. • To promote the creation of new test laboratories for the sector. • To promote energy efficiency in end uses through better operational practices in businesses and industries.

5.3.2 **Commercial Refrigeration**

In the CR **stand-alone equipment** subsector, the main alternative available is hydrocarbons, especially propane or R-290 (GWP: 3), which, in fact, is already used today in the manufacture of new equipment. Due to the flammability characteristics of this refrigerant (A3), the main actions to assume will result in the strengthening of capacities (training, regulation and certification) in the handling of flammable refrigerants.

SECTOR		COMMERCIAL REFRIGERATION	
SUBSECTORS		PHASED-DOWN HFCS	AVAILABLE ALTERNATIVES
Stand-alone equipment		HFC 134-a	R-290 ▲ R-744 ▶
Short term	OEM	• To implement a conversion project from HFC-134a to R-290 in the manufacture of stand-alone equipment in a national company. • To formulate an umbrella project with national manufacturers of stand-alone equipment to phase-down HFC-134a.	
	SER	• To implement a training project for technicians of the sector. • To prepare a diagnosis on the regulation to handle flammable refrigerants in the sector, with emphasis on hydrocarbons. • To evaluate the feasibility of regulating the management of end of life equipment in schemes of extended responsibility of the producer. • To implement a pilot project for the replacement of 8,000 stand-alone equipment units.	
Medium term Long term	OEM	• To expand training programs of service technicians nationwide. • To provide equipment to service technicians. • To promote the approval and application of regulations for the management of flammable refrigerants, with emphasis on hydrocarbons.	
	SER	• To promote the implementation of large-scale programs to replace inefficient equipment. • To promote regulations for the management of equipment at the end of its useful life. • To promote the regulation of end of life equipment management. • To strengthen the HFC Recovery and Recycling Center Network.	
Energy efficiency	EE	• To promote the application of NOM-022-ENER/SCFI-2014 and its update in the medium and long term. • To promote the updating of FIDE 4117 label requirements.	

In the subsectors of **condensing units and centralized systems for supermarkets** of the CR, there are several lower-GWP alternatives that could be adopted. Among these, the ones which stand out are the lower-GWP blends based on HFOs already commercially available, CO2 (R-744; GWP: 1) trans-critical and cascade of systems, and direct and indirect hydrocarbon systems. Leakage minimization and energy efficiency issues are critical for a successful transition within these subsectors. Moreover, it is essential to promote the professionalization of the sector, as well as to highlight the benefits of an early transition.

SECTOR		COMMERCIAL REFRIGERATION	
SUBSECTORS		PHASED-DOWN HFCS	AVAILABLE ALTERNATIVES
Condensing units and centralized systems		R-404A R-507A	HFOB ↓ R-744 ▲ HC ▶
Short term	OEM	• To prepare a dissemination workshop among manufacturers and contractors on the use of alternatives with lower climate impact.	
	SER	• To promote pilot projects in the use of alternatives and disseminate their benefits. • To encourage the leakage reduction in the sector and promote the verification standard of GHG emissions in relation to the National Registry of Emissions.	
Medium term Long term	OEM	• To promote the use of alternatives with lower climate impact among end users.	
	SER	• To design and execute a demonstration project for supermarkets. • To design and implement a training program and equipment provisioning for service technicians • To promote the proper handling of HFCs in service activities. • To design and implement a pilot program for HFC destruction.	
Energy efficiency	EE	• To promote the publication and application of NOM-012-ENER, as well as the revision of the scope of refrigerants included. • In the short term, to prepare an energy efficiency roadmap for the commercial sector. • To promote the creation of national testing laboratories for condensing units. • To encourage the creation of a FIDE label for condensing and evaporating units. • To conduct a diagnostic study to characterize the systems of the sector and, in the medium term, to promote the creation of a national inventory of facilities.	

5.3.3 **Mobile Air Conditioning**

In **MAC**, the alternative HFO-1234yf (GWP <1) is fully available and its use in the manufacture of new vehicles increases gradually. The actions that Mexico requires in this sector are focused on promoting the replacement of HFC-134a in new vehicles commercialized in the country, as well as training and equipment provisioning for service technicians to use the new alternative, which is slightly flammable (A2L).

SECTOR	MOBILE AIR CONDITIONING		
SUBSECTORS	PHASED-DOWN HFCS	AVAILABLE ALTERNATIVES	
Vehículos ligeros Vehiculos pesados	HFC 134-a	HFO-1234yf ▲	HFC-152a R-744 ▸
Short term	OEM SER	• To promote the approval of the standard project NOM-163-SEMARNAT-ENER-SCFI-2013 on CO_2 emissions in light vehicles regarding the refrigerants used. • To formulate a training program and equipment provisioning for service technicians (recovery, recycling and reuse of refrigerants).	
Medium term	SER	• To implement a national training program. • To provide equipment to service technicians in the sector. • To strengthen the HFC Recovery and Recycling Center Network.	
Long term			

5.3.4 **Foams**

In the **Foam sector**, the only HFCs that are still used significantly are HFC-245fa and HFC-365mfc, for the manufacture of PU rigid foams, in addition to HCFC-141b, which is used in a fraction of the production of insulating foams in domestic refrigeration. Today, several lower-GWP alternatives are already widely used, among them, hydrocarbons such as cyclopentane (GWP: 5) stand out. The expectation is that system houses that have not yet phased-put these HFCs will migrate to hydrocarbons in the short and medium term, except for those applications that require high thermal insulation, where the use of pure HFOs, such as HFO-1234ze, predominate (GWP<1). Mexico will be able to provide technical and financial assistance to domestic companies through the MLF.

SECTOR	FOAMS			
SUBSECTORS	PHASED-DOWN HFCS		AVAILABLE ALTERNATIVES	
Rigid PU foams	HFC 245fa	HFC-365mfc	HC	HFO ▲
Short term	NEW	• Prepare a project to phase-down HFC-245fa and HFC-365mfc in national systems houses		
Medium term	NEW	• Implement the project to phase-down HFC-245fa and HFC-365mfc from national systems houses		
Long term				

5.3.5 Domestic Refrigeration

In the **DR** sector, the main alternative is isobutane, or R-600a (GWP: 4), which is scheduled to be adopted in the short and medium term. It is fully available for the manufacture of new equipment and services and offers mostly an optimum performance. Its only disadvantage is the high flammability (A3), so the most important actions that Mexico requires are focused on capacity building (training, regulation and certification) in the handling of flammable refrigerants. Since Mexico is one of the main manufacturers of domestic refrigerators worldwide, the technological conversion of national and multinational companies should also be promoted through specific mechanisms.

SECTOR		DOMESTIC REFRIGERATION	
SUBSECTORS		PHASED-DOWN HFCS	AVAILABLE ALTERNATIVES
Domestic refrigerators		HFC 134-a	R-600a ▲ HFO 1234yf ▸
Short term	OEM	• To implement a conversion project from HFC-134a to R-600a for the manufacture of new equipment in a national company. • To promote the technological conversion of multinational companies located in the country.	
	SER	• To implement a training project for service technicians in the sector. • To prepare a diagnostic study on the regulations to handle flammable refrigerants in the sector. • To encourage the implementation of pilot programs in order to replace inefficient refrigerators. • To assess the feasibility of regulating the management of end of life equipment in schemes of extended responsibility of the producer.	
Medium term	OEM	• To continue with the support of the technological conversion of multinational companies located in the country. • To expand the training programs for service technicians nationwide. • To provide equipment to service technicians in the sector. • To promote the approval and application of regulations to handle flammable refrigerants. • To promote the implementation of large-scale programs to replace inefficient refrigerators. • To promote regulations for the management of equipment at the end of its useful life. • To strengthen the HFC Recovery and Recycling Center Network.	
	SER		
Long term			
Energy Efficiency	EE	• To promote the application of the standard NOM-015-ENER-2018 and its update in the medium and long term. • To promote the update of the FIDE 4111 label requirements.	

5.3.6 Other RAC (Transport Refrigeration and Industrial Refrigeration)

The TR and IR sectors have a relatively lower participation than other RAC sectors; however, they are crucial in the cold chain for consumer products. In **TR**, its transition is based mainly on the replacement of R-404A by lower-GWP blends based on HFOs, such as R-452A, despite its GWP (1945), although even lower climate impact substances could be expected in the medium and long term. In the case of **IR**, although most of it is already based on natural alternatives, such as the R-744 and R-717, process chillers that mostly use HFC-134a could transit to systems that use pure HFOs of nearly zero GWP, which are already commercially available. It is also expected that various direct and indirect arrangements based on R-744, R-717 and hydrocarbons will be incorporated, in order to reduce the charge of ammonia —which is toxic— and have safer facilities with higher energy performance.

SECTORS AND SUBSECTORS		TRANSPORT REFRIGERATION AND INDUSTRIAL REFRIGERATION	
		PHASED-DOWN HFCS	AVAILABLE ALTERNATIVES
Transport refrigeration Industrial refrigeration		R-404A HFC 134-a	HFOB ↓ ▲ R-744 ▸ R-717 ▲ R-744 ▸ HFO ▲ HC ▸
Short term	OEM	• To prepare a dissemination workshop among manufacturers and contractors on the use of alternatives with lower climate impact. • To promote pilot projects in the industry in the use of alternatives and disseminate their benefits. • To encourage the leakage reduction in the industrial sector and promote the verification standard of GHG emissions in relation to the National Registry of Emissions.	
	SER		
Medium term	OEM	• To promote the use of lower climate impact alternatives among users of the cold chain. • To design and implement training programs and equipment provisioning for service technicians. • To promote the proper handling of HFCs in service activities. • To design and implement a pilot program for HFC destruction.	
	SER		
Long term			
Energy Efficiency	EE	• To promote the application of good practices for energy saving in the industry. • To promote the implementation of energy management systems.	

5.3.7 Aerosols, Solvents and Fire Extinguishers

Among the sectors in which HFCs are used as a propellant, the most relevant is that of **aerosol** products (technical, domestic and pharmaceutical). For technical aerosols, the trend is for them to introduce HFO-1234ze (GWP <1), with the possibility that some adopt HFC-152a (GWP: 124). In domestic aerosols, which already use hydrocarbons in large proportion, the trend would continue. For MDIs, although there are alternatives such as powder dispensers, it is proposed to ensure long-term consumption of pharmaceutical grade HFC-134a within the quotas that Mexico grants. The **Sol** and **Ext** sectors have a low consumption of HFC and there are alternatives such as hydrofluoroethers (HFE) and FK 5-1-12, respectively, that Mexico could adopt in the long term, since their phase-down is not a priority right now.

SECTORS Y SUBSECTORS	AEROSOLS, SOLVENTS AND EXTINGUISHERS	
	PHASED-DOWN HFCS	AVAILABLE ALTERNATIVES
Aerosol sector: • Technical • Domestic • MDIs Solvents sector Extinguishers sector	HFC 134-a, HFC 152-a, HFC 365mfm, HFC-43 10me, HFC-125, HFC-227ea	HC, HFO ▲, R-717 ►, R-717 ►
Medium term (NEW)	• To prepare a diagnostic study on alternatives to HFC-134a as a propellant. • To prepare a diagnostic study on the impact of HFC-152a in the national HFC consumption.	
Long term	• To undertake support actions to reduce the consumption of HFC-134a. • To undertake support actions to reduce the consumption of HFC-152a.	

5.3.8 HFC-23 Emissions in the Production of HCFC-22

Mexico has an HCFC-22 manufacturing plant, whose production was 6,000 tons in 2017. In this process, HFC-23 (GWP: 14,000) is generated as a by-product. As part of the Kigali Amendment, Mexico has committed to control the emissions of this gas in the short term. Currently, the most effective methods for its control are being analyzed (UNIDO, 2018h).

SECTOR	HFC-23	
	PHASED-DOWN HFCS	AVAILABLE ALTERNATIVES
	HFC-23	To control the HFC-23 emissions
Short term		• To prepare a diagnostic study of the alternatives to control HFC-23 emissions. • To design and execute the project to control HFC-23 emissions. • To monitor and verify the destruction of HFC-23.
Medium term		• To monitor and verify the destruction of HFC-23.
Large term		

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