2.15 Food and Drink

Introduction

NMVOCs are emitted during the production of alcoholic beverages, breadmaking and other food products.

Data Sources

The emission estimates are based on the total annual production of the particular food manufacturing process. National production statistics for alcoholic beverages broken down into a minimum of wine, beer and spirits are required. The Standard Nomenclature for Air Pollution (SNAP) numbers for food and drink are: alcoholic beverages (40606 - 40608) and breadmaking and other food products (40605).

For the breadmaking and other food production, national production statistics broken down into the categories listed in Table 2-26 are required.

BIOLOGICAL CARBON

Carbon dioxide emitted during certain operations in the production of food and drink, including vegetable oil extraction and tobacco are not counted here. They are from the use of biological carbon which, for the purposes of this chapter, is considered not to lead to net CO_2 emissions.

2.15.1 Methodology for Estimating Emissions of NMVOC from Alcoholic Beverages

NMVOCs are produced during the processing of cereals and fruits in preparation for the fermentation processes. The emission factors shown below in Table 2-25 are taken from in the EMEP/CORINAIR Guidebook and are based on the total annual production of an individual beverage.

TABLE 2-25
EMISSION FACTORS FOR NMVOC FROM ALCOHOLIC BEVERAGE PRODUCTION
(KG/HL BEVERAGE)

Beverage	Emission Factor
Wine	0.08
Red wine	0.08
White wine	0.035
Beer	0.035
Spirits (unspecified)	15
Malt whiskey	15
Grain whiskey	7.5
Brandy	3.5

Note: hl = 100 litres

The emission factors and sources used here are derived for Europe. If more region specific data are available, these should be used. There may be different processes and emission factors in other parts of the world. Please note that if the breakdown of red and white wine and spirits is known, use the specific emission factor.

2.15.2 Methodology for Estimating Emissions of NMVOC from Bread Making and Other Food

NMVOC are released during the heating of fats and oils and foodstuffs containing them, the baking of cereals, flour and beans, fermentation in bread making, the cooking of vegetables and meats, and the drying of residues. Food production is divided into seven categories, each with its own emission factor. The emission factors given in the EMEP/CORINAIR Guidebook are shown in Table 2-26.

TABLE 2-26
EMISSION FACTORS FOR NMVOC FROM BREAD AND OTHER FOOD PRODUCTION
(KG/TONNE)

Food Production Process	Emission Factor
Meat, fish and poultry	0.3
Sugar	10
Margarine and solid cooking fats	10
Cakes, biscuits and breakfast cereals	1
Bread	8
Animal feed	1
Coffee roasting	0.55

The emission factors and sources used here are derived for Europe. There may be different processes and emission factors in other parts of the world.

Completing the Worksheet

Use WORKSHEET 2-13 ALCOHOLIC BEVERAGE PRODUCTION to enter data for this submodule.

USING THE WORKSHEET

- Copy the Worksheet at the end of this section to complete the inventory.
- Keep the original of the Worksheet blank so you can make further copies if necessary.

STEP 1 ESTIMATING NMVOC EMITTED FROM ALCOHOLIC BEVERAGES

1 Estimate total annual Quantity of Alcoholic Beverage Produced in hectolitres (hl), broken down into categories of beverages listed in Table 2-25 and enter this value in column A.

2 Enter the corresponding Emission Factor, in kilograms NMVOC per hectolitre of beverage produced, in column B.

3 Multiply column A by column B to obtain NMVOC Emitted in kilograms and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams NMVOC and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of that column to obtain the total NMVOC emitted.

STEP 2 ESTIMATING NMVOC EMITTED FROM BREAD MAKING AND OTHER FOOD

1 Estimate total annual Quantity of Food Produced, in tonnes, broken down into categories of food manufacturing processes listed in Table 2-26 and enter into column A.

2 Enter the corresponding Emission Factor, in kilograms NMVOC per tonne of food produced, in column B.

3 Multiply column A by column B to obtain NMVOC Emitted in kilograms and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams NMVOC and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of that column to obtain the total NMVOC Emitted.

2.16 Emissions Related to Production of Halocarbons (HFCs, PFCs) and Sulphur Hexafluoride (SF_6)

Introduction

Atmospheric release of materials may be the result of by-product emissions during manufacture or from fugitive releases. A fugitive emission is an emission that is not controlled or contained, such as a leak from a flange or coupling.

Data Sources

The type of data required depends on the level of effort that is to be expended and the accuracy required. For the simpler methodology that uses an emission factor, data on production should be available from chemical companies. For the more detailed approach, plant specific emission information is required.

2.16.1 Methodology for Estimating Emissions of By-Products

It is estimated that the HFC-23 released, as a by-product during manufacture of HCFC-22, is currently equivalent to 4 per cent of the production of HCFC-22 assuming no abatement measures, although lower figures have been suggested.

This factor, or a similar number derived for the particular country's circumstances, can be used to estimate national emissions of HFC-23 from the total national HCFC-22 production (for both potentially dispersive and feedstock end-uses).

The Reference Manual (Section 2.16.1) describes a Tier 2 methodology but no worksheets are provided here.

2.16.2 Methodology for Estimating Fugitive Emissions

Fugitive emissions of a chemical may occur both during the production and the distribution of a chemical. For this section, fugitive emissions associated with use are not addressed as they are covered in the section related to consumption (see Section 2.17). In the case of fluorocarbon processes, fugitive emissions have been estimated to be approximately 0.5 per cent of the total production of each compound (UNEP, 1994).

This factor, or a similar number derived for the particular country's circumstances, can be used to estimate national fugitive emissions of individual HFCs and PFCs associated with national production.

The Reference Manual (Section 2.16.2) describes a Tier 2 methodology but no worksheets are provided here.

Completing the Worksheet

Use WORKSHEET 2-14 PRODUCTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE - BY-PRODUCTS - HFCS AND PFCS to enter data for this submodule.

Note that only a Tier 1 method is presented. If data exist, the Tier 2 method described above is preferable.

STEP 1 ESTIMATING HFCS AND PFCS EMITTED

1 Estimate the total annual Quantity of Halocarbon Produced in tonnes of the specific halocarbon in question and enter into the appropriate column A.

2 Enter the corresponding Emission Factor, in kilograms of pollutant (HFCs or PFCs) per tonnes of halocarbon, in column B.

3 Multiply column A by column B to obtain Halocarbon Emitted in kilograms and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams HFCs or PFCs and enter this value in column D.

STEP 2 ESTIMATING HFCS AND PFCS EMITTED

1 Estimate the total annual Quantity of Halocarbon Produced in tonnes of the specific pollutant in question and enter it into the appropriate column A.

2 Enter the corresponding Emission Factor, in kilograms of pollutant (HFCs or PFCs) per tonnes of halocarbon produced, in column B.

3 Multiply column A by column B to obtain Halocarbon Emitted in kilograms and enter this value in column C.

4 Divide column C by 10^6 to convert to units of gigagrams HFCs or PFCs and enter this value in column D.

2.17 Emissions Related to Consumption of Halocarbons (HFCs, PFCs) and Sulphur Hexafluoride (SF_6)

Introduction

The chemicals (HFCs, PFCs, SF_6) are of concern, because they have high global warming potentials and long atmospheric residence times.

Current and expected application areas of HFCs and PFCs include:

- refrigeration and air conditioning
- fire suppression and explosion protection
- aerosols
- solvent cleaning
- foam blowing
- other applications[1]

Primary uses of SF_6 include:

- gas insulated switch gear and circuit breakers
- fire suppression and explosion protection
- other applications[2]

THE MONTREAL PROTOCOL

Partially and fully fluorinated hydrocarbons, HFCs and PFCs, are not controlled by the Montreal Protocol because they do not contribute to depletion of the stratospheric ozone layer.

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[1] HFCs and PFCs may be used in sterilisation equipment, for tobacco expansion applications, and as solvents in the manufacture of adhesives, coating, and inks.

[2] SF_6 may be used as an insulating medium, a tracer, in leak detectors, and in various electronic applications. For SF_6 consumption in magnesium and aluminium foundries, see Section 2.13.6.1.

Table 2-26 *(Reference Manual)* gives an overview of the most important HFCs and PFCs including application area and GWP relative to CO_2 (100 year integration time).

Data Sources

HFCS, PFCS AND SF_6

HFCs are chemicals containing only hydrogen, carbon, and fluorine. PFCs are chemicals containing only carbon and fluorine. SF_6 is a particularly potent GHG with a 100-year GWP of 23,900 and an estimated lifetime of about 3,200 years.

The type of data required depends on the level of effort that is to be expended and the accuracy required. At a minimum, quantities of halocarbons and SF_6 imported and exported in bulk and national production are required. For the next level, the quantities of these materials contained in products imported and exported are required. Data on production and exports of chemicals in bulk should be available from chemical companies and/or national production statistics. Information on imports of chemicals in bulk and in products may be available from Customs and Duty records. National environmental protection authorities may keep records of HFCs/PFCs destroyed, if any.

General Methodology

POTENTIAL AND ACTUAL EMISSIONS

Emissions from industrial processes can be estimated in two ways; as potential emissions, Tier 1 (a and b), and as actual emissions, Tier 2. Tier 1b is preferred to the Tier 1a methodology.

In Tier 1 (a and b) methodology, potential emissions of a certain chemical are equal to the amount of virgin chemical consumed in the country minus the amount of chemical recovered for destruction or exported in the year under consideration. All chemicals consumed will eventually be emitted to the atmosphere over time if not destroyed, and in the long term (e.g., 50 yr), potential emissions will equal actual emissions.

In the Tier 2 methodology, actual emission estimates take into account the time lag between consumption and emission, which may be considerable in some application areas, e.g., closed cell foams, refrigeration and fire extinguishing equipment. Time lags result from the fact that a chemical is placed in new products and then slowly leaks out over time.

Actual emissions estimates are the most accurate with respect to emissions in individual years, provided that the necessary information is available for their calculation. If essential data are not available, the potential emission calculations provide a simpler approach for reasonable emission estimates.

The following procedures described for HFCs/PFCs are applicable for SF_6 as well.

2.17.1 Methodology for Estimating Emissions for Tier 1a and Tier 1b

Since net consumption of a chemical equals production plus imports minus exports, the calculation formula for the basic method (Tier 1) is as follows:

Potential Emissions = Production + Imports - Exports - Destruction

By-product emissions during HFC/PFC production and fugitive emissions related to production and distribution have to be calculated separately, as described in Section 2.16.

Production refers to production of new chemical only and not the reprocessing of recovered fluid.

There are two versions of Tier 1 (a and b) depending upon whether HFCs/PFCs in products are taken into account. Two versions are presented because it is expected that there may be difficulties in many countries with the availability of data regarding imports and exports of HFCs/PFCs in products, at least in the short term. The Tier 1b methodology is preferred if the relevant data are available.

Tier 1a

In Tier 1a, only chemicals imported or exported in bulk are considered in the calculation of potential emissions. The following definitions apply:

Imports	=	Imported HFC/PFC in bulk
Exports	=	Exported HFC/PFC in bulk

REFRIGERATION, FIRE EXTINGUISHERS AND SOLVENTS

Refrigeration units, fire extinguishers and solvents will normally contain HFC/PFC mixtures. The fraction of each chemical must be considered separately. Refrigeration units may be refrigerators, ice machines, AC window units, split-units, chillers, etc.

The application of Tier 1a may lead to an under-estimation or an over-estimation of potential emissions, depending on whether the majority of HFC/PFC-containing products is being imported or exported.

Tier 1b

Tier 1b is an extension of Tier 1a and includes HFCs/PFCs contained in various products which are imported and exported. The following definitions apply:

Imports	=	Imported chemical in bulk + quantity of chemical imported in HFC/PFC containing products
Exports	=	Exported chemical in bulk + quantity of chemical exported in HFC/PFC containing products

FOAM PRODUCTS

Foam products include insulating and non-insulating foams in a variety of products, like refrigerators, insulation panels, pour-in-place sprays, car seats, furniture, bedding, packaging material, etc.

The product types that should be considered are

- refrigeration and air conditioning units
- foam products
- fire extinguishers
- solvents
- aerosol cans

Most of these items will use mixtures of halocarbons that must be assessed separately due to their vastly different global warming potentials.

2.17.2 Tier 2: Advanced Methodology for Estimating Emissions

The advanced method, Tier 2, contains *actual emission calculations for each individual chemical.* This is the preferred method if input data are available. It is recommended that routines are established to report HFC/PFC emissions according to Tier 2.

To use this methodology one must employ a "bottom-up" approach or a "top-down" approach. In a "bottom-up" approach, one calculates or estimates the consumption of each individual HFC and PFC chemical based on the number of pieces of equipment or uses at a detailed level, e.g., refrigerators, other stationary refrigeration/AC equipment, soft foam, hard foam etc., to establish the volume basis for emission calculations. A "top-down" approach estimates emissions on the basis of the consumption distribution and emission characteristics related to various processes and equipment, also taking current service and recovery practices into account.

Table 2-27 gives examples of current distribution of HFC/PFC use among various application areas in certain countries. Since HFCs and PFCs have only recently entered the market, the relative size of each area will change over time and will have to be updated.

TABLE 2-27
EXAMPLE DISTRIBUTION OF HFC/PFC USE BY APPLICATION AREA (1994)

Country	Refrigeration Air Conditioning	Foam Blowing	Solvent	Fire Extinguishing	Aerosol Propellant	Other Applications
Norway	99%	<1%	0%	<1%	0%	0%
Sweden	90%	5%	0%	0%	5%	0%
United Kingdom	76%	12%	0%	7%	5%	0%

See the *Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories Reference Manual* for sources.

Any given application area may employ several types of HFC/PFC fluid. Consumption figures should be collected or estimated and the type of HFC/PFC used should be identified.

A) *Refrigeration and Air Conditioning Equipment*

For the purposes of emission estimation, refrigeration and air-conditioning systems are classified into three categories, according to their emission characteristics:

i) Household refrigerators and freezers;

ii) Other stationary refrigeration and air conditioning equipment, including:

- cold storage warehouses;

- retail food refrigeration;
- industrial process refrigeration;
- commercial and industrial appliances such as refrigerated vending machines, ice machines, dehumidifiers, and water coolers;
- refrigerated transport including trucks, trains, and ships with refrigerated compartments; and
- commercial and residential air conditioning including chillers, heat pumps, window air conditioners, central air conditioners.

iii) Mobile air conditioners used to cool the passenger compartment of automobiles, trucks, buses, and trains.

Methods for estimating average emission rates for the above-uses sectors are outlined below.

The *quantity of refrigerant emitted during system assembly* is related to the amount charged by the following empirical formula:

EQUATION 1

$$E_{assembly,\ t} = E_{charged,\ t} \bullet (k/100)$$

where:

$E_{assembly,t}$ = emissions during system manufacture/assembly in year t

$E_{charged,t}$ = amount of refrigerant charged into new systems in year t

k = assembly losses in per cent of the amount charged

The amount charged ($E_{charged,t}$) should include all systems which are charged in the country, including those which are made for export. Systems that are imported precharged should not be considered.

Annual leakage from the stock, including venting during service, is given by :

EQUATION 2

$$E_{operation,\ t} = E_{stock,\ t} \bullet (x/100)$$

where:

$E_{operation,t}$ = amount of HFC/PFC emitted during system operation in year t

$E_{stock,t}$ = amount of HFC/PFC stocked in existing systems in year t

x = annual leakage rate in per cent of total HFC/PFC charge in the stock, per cent.

HFC USE IN REFRIGERANTS

HFC-134a is the primary fluorocarbon substitute for CFC-12 in many refrigeration and air-conditioning applications including refrigerators, chillers, and mobile air conditioners. Other HFCs may also be used in refrigeration applications, particularly as components of blends. These include HFC-23, HFC-32, HFC-125, HFC-143a, and HFC-152a.

PFC USE IN REFRIGERANTS

PFC-218 is used as a component in refrigerant blends. PFC-116 may be used in a blend as a substitute for R-503.

In calculating the refrigerant "bank" ($E_{stock,t}$) all systems in operation in the country (home-made and imported) have to be considered.

The amount of refrigerant released from scrapped systems depends upon the amount of refrigerant left at the time of disposal, and the portion recovered.

To estimate emissions at system disposal, the following calculation formula is applicable:

EQUATION 3

$$E_{disposal,\ t} = Ei_{charge,\ (t-n)} \bullet (y/100) \bullet (100 - z)/100$$

or

$$E_{disposal,\ t} = E_{i\ charge,\ (t-n)} \bullet Q$$

where:

$E_{disposal,t}$	=	amount of HFC/PFC emitted at system disposal in year t
$Ei_{charge;\ (t-n)}$	=	amount of HFC/PFC initially charged into new systems installed in year (t-n)
n	=	average equipment lifetime, years
y	=	amount of HFC/PFC in systems at time of disposal in per cent of initial charge, per cent
z	=	amount of HFC/PFC recovered in per cent of actual charge ("recovery efficiency"), per cent
Q	=	amount of HFC/PFC emitted at system disposal in per cent of the quantity of chemical originally charged into the system, per cent (Q = y(100-z)/100)

In estimating the amount of refrigerant initially charged into the systems ($Ei_{i,\ charged\ (t-n)}$), both systems charged in the country (for home market) and systems imported precharged should be taken into account. The first charge into systems made for export should not be considered. For example, if calculating emissions for 1995 with equipment that has a 15-year lifetime, then information on quantity of HFC/PFC charged in 1980 (1995-15) is required. Total emissions in year t will then be found as the sum of emissions at assembly, during operational life and at disposal:

EQUATION 4

$$E_{total,\ t} = E_{assembly,\ t} + E_{operation,\ t} + E_{disposal,\ t}$$

See Section 2.17.4.2 in the *Reference Manual* for more information on the "top-down" and "bottom-up" approaches and on the derivation of the factors used in Equations 1 to 4.

i) Household Refrigerators and Freezers

TABLE 2-28
HOUSEHOLD REFRIGERATORS AND FREEZERS INPUT PARAMETERS

Input	Definition	Default Value	Comment
k	assembly losses in % of amount charged	2%	range 2-5%
x	annual leakage rate in % of the total HFC/PFC charge in the stock	1%	
n	average equipment lifetime	15 yr	
y	amount of HFC/PFC in systems at time of disposal in % of initial charge	90%	
z	amount of HFC/PFC recovered in % of actual charge ("recovery efficiency")	50%	0% if no recovery practices

REFRIGERANT ACTIVITY DATA

Reasonable estimates for the number of refrigerators and freezers manufactured are generally available, as well as the number of imported and exported units and the total stock. The amount of refrigerant banked in the stock can be estimated by multiplying the number of units by the average charge size.

These values are typical of industrialised countries and may be different for developing countries.

ii) Other Stationary Refrigeration and Air Conditioning Equipment

TABLE 2-29
OTHER STATIONARY REFRIGERATION AND AIR CONDITIONING EQUIPMENT INPUT PARAMETERS

Input	Definition	Default Value	Comment
k	assembly losses in % of amount charged	2-5%	2-3% for factory built 4-5% for site built
x	annual leakage rate in % of the total HFC/PFC charge in the stock	17%	3% if improved valves and fittings are used
n	average equipment lifetime	15 yr	
y	amount of HFC/PFC in systems at time of disposal in % of initial charge	90%	
z	amount of HFC/PFC recovered in % of actual charge ("recovery efficiency")	0%	80% if use recovery practices

Refrigerant charge may vary over a wide range, depending upon system size and design. The following range may indicate orders of magnitude.

- Residential air conditioning: 2 to 3 kg
- Transport Refrigeration: 8 kg
- Retail Food Refrigeration: 10 to 230 kg
- Chillers: 75 to 900 kg
- Industrial Process Refrigeration: 340 to 9100 kg
- Commercial and industrial appliances: 0.10 to 0.50 kg

To apply the bottom-up approach, reliable average values for system charge sizes valid for each country will be required to develop useful estimates.

iii) Mobile Air Conditioning (MAC) Equipment

TABLE 2-30
MOBILE AIR CONDITIONING (MAC) EQUIPMENT INPUT PARAMETERS

Input	Definition	Default Value	Comment
k	assembly losses in % of amount charged	4-5%	
x	annual leakage rate in % of the total HFC/PFC charge in the stock	30%	10% with improved seals fittings and hosing
n	average equipment lifetime	12 yr	11 yr (small cars) to 15 yr (trucks)
y	amount of HFC/PFC in systems at time of disposal in % of initial charge	75%	
z	amount of HFC/PFC recovered in % of actual charge ("recovery efficiency")	0%	80% if use recovery practices

Typical refrigerant charges in mobile air conditioners are 1.2 kg/unit for cars and 1.5 kg/unit for trucks. MACs in newer cars may have a lower charge, e.g., 800 g which is typical for Japanese passenger cars.

B) Foam Blowing

i) Open Cell Foam

For open cell foams, HFC and PFC emissions occur at the time of manufacture and are equal to 100 per cent of the total quantity of chemical used as the blowing agent. As a result total HFC or PFC emissions in year t for open cell foam can be calculated as follows:

> Emissions of HFCs or PFCs in year t = 100% of the quantity of HFCs or PFCs sold for blowing open cell foam in year t

ii) Closed Cell Foam

For closed cell foams, only about 10 per cent of the blowing agent is released during the blowing of the foam, while the remaining chemical is contained in the insulation. This quantity remaining in the foam is slowly released over the 20 to 25 year lifetime of the foam. HFC or PFC emissions from insulating foam in year t are therefore calculated as follows:

Emissions of HFCs or PFCs in year t = 10 per cent of the total quantity of HFC or PFC used in manufacturing new insulating foam in year t + 4.5 per cent of the quantity of original HFC or PFC charge blown into the insulated foam manufactured between year t and year t-20

The total quantity of HFC or PFC contained in the existing stock of insulating foam can be calculated as the product of the total quantity of insulating foam in use in year t and the average charge of chemical contained in each tonne of such installed insulating foam.

If action is taken to control emissions from foam blowing by recycling or leakage control then an alternative formula may be applicable. See *Reference Manual*, Section 2.17.4.3.

C) *Fire Extinguishers*

Total halon emissions can be estimated as 60 per cent of total halon 1211 contained in new portable halon fire extinguishers installed each year, and as 35 per cent of total Halon 1301 contained in new total flooding equipment installed each year. The remaining amounts of chemical, 40 per cent for portable fire extinguishers and 65 per cent for total flooding equipment respectively, adds to the bank of fire extinguishing chemicals. As halons are replaced, emissions of HFCs and PFCs may be calculated:

Emissions of HFCs or PFCs in year t = 60 per cent of the total quantity of HFC or PFC used in new portable halocarbon fire extinguishing equipment installed in year t

HFC AND PFC USE IN FIRE EXTINGUISHERS

HFCs and PFCs are potential replacements for Halon 1211 in portable fire extinguishers and Halon 1301 in total flooding fixed fire extinguishing systems. Potential substitutes include HFC-23, HFC-125, HFC-227ea, PFC-410, and PFC-614.

Similarly, emissions estimates in year t for total flooding equipment can be calculated as:

Emissions of HFCs or PFCs in year t = 35 per cent of the total quantity of HFC or PFC used new fixed halocarbon fire extinguishing equipment installed in year t

SF_6 USE IN FIRE EXTINGUISHERS

Some of the new substitutes for halon in fire extinguishing equipment contain sulphur hexafluoride, SF_6, probably in blends with HFC. If the products contain SF_6, it is emitted to the atmosphere in the same manner as HFC or PFC. The equations for the estimation of HFC and PFC emissions from fire extinguishing equipment are therefore also valid for SF_6, since they have to be adjusted for the proportion of the SF_6 in the original blend. Emissions of SF_6 are to be calculated according to the proportion of this chemical in the blend.

D) *Aerosols*

Emissions from aerosols are modelled by the following equation :

Emissions of HFCs in year t = 50% of the quantity of HFCs contained in aerosols sold in year t + 50% of the quantity of HFC contained in aerosols sold in year t-1

This calculation accounts for the six-month lag from purchase to use.

E) Solvents

HFC AND PFC USE AS SOLVENTS

HFCs and PFCs may be used as replacements for CFC-113 in metal cleaning, electronics, and precision cleaning applications and as replacements for aerosol cleaning. The compounds that may be used include HFC-43-10, PFC-614, PFC-512, PFC-612, PFC-716, and PFC-819.

Chemicals used as cleaning agents are emitted during, or shortly after, use and are typically 100 per cent of total use. This methodology assumes that solvents, on average, are used six months after they are sold.

Emissions of HFCs or PFCs in year t
=
50% of the quantity of HFCs or PFC
sold for use in solvent applications in year t
+
50% of the quantity of HFCs
sold for use in solvent applications in year t-1

F) Other Applications

OTHER HFC AND PFC USE

Other applications in which HFCs and PFCs may replace CFC and HCFC include sterilisation equipment, tobacco expansion applications, and as solvents in the manufacture of adhesives, coatings and inks. The specific compounds include HFC-125, HFC-134a, and HFC-227 ea.

For other applications, it is assumed that all HFCs and PFC are released within 6 months after production. Emissions in the year t can be calculated as follows:

Emissions of HFCs or PFCs in year t
=
50% of the quantity of HFCs/PFCs sold for other applications in year t
+
50% of the quantity of HFCs/PFCs sold in year t-1

Sulphur Hexafluoride (SF_6) Emissions

SF_6 is used as an insulation medium in high tension electrical equipment including gas insulated switchgear (GIS) and circuit breakers.

The use of SF_6 in production of aluminium and magnesium is covered under *Reference Manual*, Section 2.13.8.

Total annual emissions of SF_6 used in GIS applications and circuit breakers can be assumed to be approximately 1 per cent of the total quantity of SF_6 contained in equipment. In addition, if it is assumed that GIS has a lifetime of 30 years, then approximately 70 per cent of the SF_6 will remain in the equipment upon retirement and will then be released upon disposal of the equipment. Total emissions from GIS applications can therefore be estimated as:

Emissions of SF_6 in year t = 1% of the total charge of SF_6 contained in the existing stock of equipment in year t + 70% of the quantity in equipment manufactured in year t-30.

Completing the Worksheet

Use WORKSHEETS 2-15 CONSUMPTION OF HALOCARBONS AND SULPHUR HEXAFLUORIDE - TIER 1a AND TIER 1b to enter data for this submodule. Each individual compound must be assessed separately.

USING THE WORKSHEET

- Copy the Worksheet at the end of this section to complete the inventory.
- Keep the original of the Worksheet blank so you can make further copies if necessary.

STEP 1 ESTIMATING HFCs AND PFCs EMITTED - TIER 1a AND TIER 1b

1 Estimate the total annual Quantity of Halocarbon Produced in tonnes of the specific halocarbon in question and enter it into column A.

2 Estimate the total annual Quantity of Halocarbon Imported and Exported in Bulk, into and out of the country, in tonnes of the specific halocarbon in question, and enter these values into columns B and C, respectively.

3 Estimate the total annual Quantity of Halocarbon Destroyed in tonnes of the specific halocarbon in question that was destroyed and enter it into column D.

4 Add column A to column B, subtract column C, subtract column D and enter the result in column E to obtain the Potential Bulk Halocarbon Emissions.

STEP 2 ESTIMATING HFCs AND PFCs EMITTED - TIER 1b

1 Estimate the total annual Number of Units of Imported (as positive numbers) or Exported (as negative numbers) of individual product types, containing the specific halocarbon in question, and enter these into column F.

2 Estimate the total Quantity of Material per Unit for each individual product type in kg and the fraction of halocarbon in material (%100) of the specific halocarbon in question and enter these into columns G and H, respectively.

3 Multiply column F, G and H to calculate kg of each halocarbon, convert to tonnes by dividing by 10^3 and enter this value in column I to obtain Potential Product Halocarbon Emissions.

4 Sum the values in column I and enter the result in the bottom of that column to obtain the total Potential Product Halocarbon Emissions.

STEP 3 SUMMARY OF HFCS AND PFCS EMITTED - TIER 1a AND TIER 1b

1 Enter the totals from columns E and I repectively in the appropriate columns J and K and sum these two columns and enter result in column L.

2 Divide column L by 10^3 to convert to units of gigagrams HFCs or PFCs and enter this value in column M to obtain the Total Potential Halocarbon Emissions.

WORKSHEET

The same worksheet can be used for home refrigeration and freezers, other stationary refrigeration and air conditioning equipment and mobile air conditioning. Each worksheet must be duplicated for every HFC and PFC under assessment.

STEP 4 ESTIMATING HFCS AND PFCS EMITTED- REFRIGERATION ASSEMBLY TIER 2

1 Estimate the Amount of HFC/PFC Charged into New Systems in Year t (inventory year) in tonnes and enter in column A.

2 Enter appropriate value of k Assembly Losses in amount charged in per cent into column B.

3 Multiply column A by column B (see Equation 1), and enter result in column C.

4 Divide the result in column C by 10^3 and enter the result in column D.

STEP 5 ESTIMATING HFCS AND PFCS EMITTED - REFRIGERATION OPERATION- TIER 2

1 Estimate the total Amount of HFC/PFC Stocked in Existing Systems in Year t (inventory year) in tonnes, and enter in column E.

2 Enter appropriate value of x, Annual Leakage Rate, in per cent, into column F.

3 Estimate the Halocarbon Emitted in tonnes using Equation 2 as shown in Column G. Enter result in column G.

4 Divide the result in column G by 10^3 and enter the result in column H.

STEP 6 ESTIMATING HFCS AND PFCS EMITTED - REFRIGERATION DISPOSAL- TIER 2

1 Estimate the total Amount of HFC/PFC Charged into New Systems in Year t-n in tonnes and enter in column I.

2 Enter appropriate values of n, Average Equipment Lifetime in years into column J.

3 Enter appropriate values of y, Amount of HFC/PFC in Systems at Time of Disposal in Per Cent of Original Charge into column K.

4 Enter appropriate values of z, Amount of HFC/PFC Recovered in Per Cent of Actual Charge into column L.

5 Calculate Halocarbon Emitted during disposal by using Equation 3 as shown in Column M. Enter the result in column M.

6 Divide the value in column M by 10^3 and enter the result in column N.

STEP 7 ESTIMATING HFCS AND PFCS EMITTED-SUMMARY - TIER 2

1 Transfer sums of columns D, H and N for emissions during Assembly, Operation and Disposal respectively into appropriate columns O, P and Q.

2 Sum the values in columns O, P and Q and enter the result in column R to obtain the Total Halocarbon Emissions.

STEP 8 ESTIMATING HFCS AND PFCS EMITTED FROM FOAM PRODUCTS- TIER 2

This worksheet contains both open cell and closed cell foams. Each worksheet must be duplicated for every HFC and PFC under assessment.

Open Cell

1 Estimate the Quantity of HFCs/PFCs Used in open cell foam for the year under study, in tonnes, and enter it in column A.

2 Enter the appropriate Fraction Loss during Production for open cell foam in per cent (100% if no recovery) in column C.

3 Calculate HFC/PFC Emitted during production by multiplying column A by column C and enter result in tonnes into column E.

4 Divide column E by 10^3 to convert to units of gigagrams HFCs or PFCs and enter this value in column F

HFC AND HCFC USE IN FOAM

HFCs are potential replacements for CFCs and HCFCs in the manufacture of insulating, cushioning, and packaging foams. The specific compounds that may be used include HFC-125, HFC-134a, HFC-143a, and HFC-152a.

Closed Cell Foam

RECYCLING

Approximately 55 per cent of the HFC or PFC used as a blowing agent in the manufacture of open cell foams could potentially be recycled. If such recycling occurs, total emissions from open cell foam manufacture would still be 100 per cent of the chemical *sold* for foam blowing purposes. The quantity required, however, would be reduced since the gas used for the blowing process will be a mixture of 45 per cent virgin chemical and 55 per cent recycled chemical.

1 Estimate the Quantity of HFC/PFC Used in closed cell foam for the year under study, in tonnes, and enter it in column A.

2 Estimate the Quantity of HFC/PFC in Use contained in existing stock of insulating foam for the year under study in tonnes and enter this value in column B.

3 Enter the appropriate Fraction Loss during Production (closed cell) in per cent (100% if no recovery) in columnC.

4 Enter the Fraction Loss during Use in per cent in column D.

5 Multiply column A by column C and add this value to the result of column B times column D. Enter the result in tonnes in column E.

6 Divide column E by 10^3 to convert to units of gigagrams HFCs or PFCs and enter this value in column F.

STEP 9 ESTIMATING HFCs, PFCs AND SF6 EMITTED FROM FIRE EXTINGUISHERS - TIER 2

USING THE WORKSHEET

- Copy the Worksheet at the end of this section to complete the inventory.
- Keep the original of the Worksheet blank so you can make further copies if necessary.
- Each worksheet must be duplicated for every HFC, PFC and SF_6 under assessment.

Portable and Fixed Fire Extinguishers

1 Estimate the Total Quantity of HFC/PFC/SF_6 Used in New Extinguishers in tonnes, broken down into portable and fixed, systems for the year under study and enter this value into column A.

2 Enter appropriate Fractional Loss Factor for portable and fixed fire extinguishers in per cent into column B.

3 Calculate HFC/PFC/SF_6 Emitted by multiplying column A by column B and enter result, in tonnes, in column C.

4 Divide column C by 10^3 to convert to units of gigagrams HFCs, PFCs or SF_6 and enter this value in column D.

5 Sum the values in column D and enter the result in the bottom of column to obtain the Total HFC/PFC/SF_6 Emitted.

HFC USE IN AEROSOLS

HFCs may be used as replacements for CFCs in aerosol propellants in industrial and technical applications, and household, medical and personal care products. The HFCs that may be used include HFC-125, HFC-134a, 152a, and HFC-227ea.

STEP 10 ESTIMATING HFCs, PFCs AND SF_6 EMITTED FROM AEROSOLS - TIER 2

1 Estimate the Use of HFCs or PFCs for Aerosols in Inventory Year in tonnes, and enter this number in column A.

2 Estimate the Use of HFCs/PFCs for Aerosols in Prior Year in tonnes and enter this number in column B.

3 Enter the appropriate factor of Loss of Current Year's Use for the year under inventory in column C in per cent divided by 100. A default of 0.5 can be used.

4 Calculate the Emission of HFCs/PFCs from Aerosols by multiplying column A by column C and adding the result to the multiplication of column B times (1-column C). Enter the result into column D.

5 Divide column D by 103 to convert to units of gigagrams HFC or PFCs and enter this value in column E.

STEP 11 ESTIMATING HFCS, PFCS AND SF_6 EMITTED FROM SOLVENTS - TIER 2

1 Estimate the Use of HFCs or PFCs for Solvents in Inventory Year in tonnes, and enter this number in column A.

2 Estimate the Use of HFCs/PFCs for Solvents in Prior Year in tonnes and enter this number in column B.

3 Enter the appropriate factor of Loss of Current Year's Use for the year under study in column C in per cent divided by 100. A default value of 0.5 can be used.

4 Calculate the Emission of HFCs/PFCs from Solvents by multiplying column A by column C and adding the result to the multiplication of column B times (1-column C). Enter the result into column D.

5 Divide column D by 103 to convert to units of gigagrams HFC or PFCs and enter this value in column E.

STEP 12 ESTIMATING HFCS, PFCS AND SF_6 EMITTED FROM OTHER APPLICATIONS - TIER 2

1 Estimate the Use of HFCs or PFCs for Other Applications in Inventory Year in tonnes, and enter this number in column A.

2 Estimate the Use of HFCs/PFCs for Other Applications in Prior Year in tonnes and enter this number in column B.

3 Enter the appropriate factor of Loss of Current Year's Use for the year under study in column C in per cent divided by 100. A default value of 0.5 can be used.

4 Calculate the Emission of HFCs/PFCs from Other Applications by multiplying column A by column C and adding the result to the multiplication of column B times (1-column C). Enter the result into column D.

5 Divide column D by 103 to convert to units of gigagrams HFC or PFCs and enter this value in column E.

STEP 13 ESTIMATING SF_6 EMITTED

SF_6 ACTIVITY DATA

The total charge of SF_6 contained in equipment can be estimated as the product of the total quantity of equipment in operation and the typical charge size. Charge sizes for GIS equipment rated to 50 kV or more can range from hundreds to thousands of kilograms per installation, and for low-voltage switches contain 1-2 kg per installation. If data on the total stock of GIS are unavailable, it should be assumed that emissions equal consumption.

This worksheet is for SF_6 used in GIS and circuit breakers.

1 Estimate the Quantity of SF_6 in Use in Inventory Year, in tonnes, in GIS and circuit breakers and enter this value in column A.

2 Enter the appropriate Loss Factor for SF_6 in Use for the year under study, in column B, in per cent divided by 100.

3 Estimate the Quantity of SF_6 in Use 30 years Prior to the Inventory Year in tonnes, in GIS and circuit breakers and enter this in column C.

4 Enter the appropriate Fraction Remaining in SF_6 Equipment at Time of Disposal, in column D, in per cent divided by 100.

5 Calculate SF_6 Emitted by multiplying column A by column B, and adding it to the result of multiplying column C by column D. Enter the result into column E.

6 Divide column E by 10^3 to convert to units of gigagrams SF_6 Emitted and enter this value in column F.