

Chapter 3

Industrial Processes

3.1 Introduction

New Zealand's industrial processes sector represented approximately 5% of all greenhouse gas emissions in 2001 and there was an increase of 4% from 2000. Emissions are now 6.4% above the 1990 baseline in this sector.

Emissions included under industrial processes arise from the chemical transformation of materials from one substance to another. Although fuel is also often combusted in the course of these processes, emissions arising from this combustion are included in the energy sector emissions.

Process emissions related to energy production are also considered within the energy sector. These include, for example, refining crude oil and producing synthetic petrol from natural gas.

3.2 Country-specific approaches different from the IPCC methodology

Estimates of emissions from industrial processes are mostly based on industry-supplied information. Many of the emission factors are New Zealand specific and supplied by industry.

3.3 Emissions calculation methodologies

New Zealand has a relatively small number of plants emitting non-energy-related greenhouse gases from industrial processes. This allows us to use a high level of New Zealand-specific information.

Emissions of CO₂ from industrial processes were compiled by the Ministry of Economic Development and reported in *New Zealand Energy Greenhouse Gas Emissions 1990-2001* (Ministry of Economic Development, 2002). Production and emissions data are provided by industry and emission factors are derived from these.

Data on non-CO₂ emissions was primarily gathered through a questionnaire distributed directly to companies by consultants. It requested information on emissions and production, as well as on any relationship the companies had established between the two. This was supplemented by information from a variety of industry groups and other statistical sources. IPCC default emission factors were applied to supplied production data where no local information on emissions was available.

Estimates of actual emissions of HFCs and PFCs are included in the inventory, using the methodology provided in *IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories* (IPCC, 2000). Emissions of two PFCs from the

production of aluminium, CF₄ and C₂F₆, are supplied by Comalco New Zealand (the operator of New Zealand's sole aluminium smelter). These emissions from aluminium smelting are calculated using the IPCC (2000) Tier 2 method and the default coefficients for Centre Worked Pre Bake technology.

Actual and potential emissions of SF₆ resulting primarily from the use of SF₆ in electrical switchgear are reported using the IPCC (2000) Tier 2b methodology.

Montgomery Watson (2002) contains information on the estimates of non-CO₂ emissions, including descriptions of the industrial processes found in New Zealand and the information sources used.

Worksheets are included at the end of the chapter showing activity data and emission factors for the industrial processes sector. A full-time series of activity data and emissions is provided for HFCs, PFCs and SF₆.

3.4 Changes since the last inventory submission

New Zealand Energy Greenhouse Gas Emissions 1990-2001 (Ministry of Economic Development, 2002), the source document for CO₂ emissions from industrial processing, has been added to the references for this section.

3.5 Uncertainty

The number of companies in New Zealand producing CO₂ from industrial processes is small. The emission estimates they have supplied are considered to be accurate to within ±5%.

The uncertainty surrounding estimates of non-CO₂ emissions is greater. The combination of uncertainty in the activity data and in the emission factors are considered to be approximately as shown in Table 8. Montgomery Watson (2002) provides further information on this.

Table 8: Uncertainty ranges for industrial process emissions

Gas	Uncertainty
CO ₂	±5%
CH ₄	±80%
HFCs	see below
PFCs ¹	±27%
SF ₆	±10%
SO ₂	±9%
NO _x	±30%
CO	±33%
NMVOG	±53%

1. From aluminium smelting only.

Discussion of the uncertainties surrounding estimates of actual emissions from the use of HFCs and PFCs is included in Montgomery Watson, 2002. The level of uncertainty varies with each application. For example, for aerosols, emission data could be over- or under-estimated by a factor between one third and three times; for mobile air conditioning, the top-down approach provides an upper bound so it is unlikely that the true emissions value will exceed the calculated top-down approach; and for fire protection, only one company is involved in the administration of the installed chemical and therefore the uncertainty associated with its emissions is considered to be low.

3.6 References

Intergovernmental Panel on Climate Change, 2000, *Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories*, IPCC National Greenhouse Gas Inventories Programme.

Ministry of Economic Development, 2002, *New Zealand Energy Greenhouse Gas Emissions 1990-2001*, Wellington, New Zealand.

Montgomery Watson, 2002, *Inventory of Non-CO₂ Greenhouse Gas Emissions from Industrial Sources and Solvent and Other Product Use, HFCs and PFCs and SF₆*, report to the Ministry for the Environment, New Zealand, April 2002.

Appendix to Chapter 3:
Industrial Process calculation tables 2001
HFC, PFC and SF₆ calculation tables 1990 to 2001

Module 2001 Industrial process (New Zealand)
Worksheet NZ 2a
Sheet CO₂ emissions

Source category	Production Quantity (t)	CO ₂ emissions (Gg)	CO ₂ emis factor (t/t)
Total industrial processes		2,875.54	
Cement ¹	1,088,130	523.98	0.48
Lime ¹	144,200	103.66	0.72
Hydrogen ¹	29,950	182.89	6.11
Iron and steel ¹	800,790	1,560.68	1.95
Aluminium ¹	324,110	504.34	1.56

1 Production and emissions data provided by industry and reported in Ministry of Economic Development (2002):

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. Aerosol 1 of 2
Sheet HFCs from aerosols (based on equation 3.35¹)

Year	Quantity HFC 134a contained in aerosol products sold in year t (tonnes) ²	Emission factor	Quantity HFC 134a contained in aerosol products sold in year t-1 (tonnes)	Emission of HFC 134a (tonnes)
1992	5.5	0.5	6.7	6.1
1993	6.7	0.5	9.9	8.3
1994	9.9	0.5	20.3	15.1
1995	20.3	0.5	28.5	24.4
1996	28.5	0.5	34.7	31.6
1997	34.7	0.5	34.7	34.7
1998	34.7	0.5	33.8	34.3
1999	33.8	0.5	37.0	35.4
2000	37.0	0.5	38.6	37.8
2001	38.6	0.5	40.3	39.5

1. IPCC (2001) Equation 3.35
2. Only HFCs used in aerosols is HFC 134a

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. Aerosols 2 of 2
Sheet Imports and domestic production of aerosols

Year of import	Aerosol imports (all)		Domestic loading HFC (tonnes)	Total HFC contained in products (tonnes)
	Number of Units	HFC ¹ (tonnes)		
1992	3,300,000	5.54	0.0	5.5
1993	4,000,000	6.72	0.0	6.7
1994	5,400,000	9.07	0.8	9.9
1995	8,700,000	14.62	5.7	20.3
1996	13,100,000	22.01	6.5	28.5
1997	16,800,000	28.22	6.5	34.7
1998	17,400,000	29.23	5.5	34.7
1999	17,500,000	29.40	4.4	33.8
2000	18,848,536	31.67	5.3	37.0
2001	19,773,731	33.22	5.4	38.6

1. Assumes average propellant charge =84 grams, 2% of all imported aerosols contain HFCs

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 1 of 4
Sheet Stationary Refrigeration and Air Conditioning - annual sales of refrigerant (input to equation 3.4¹)

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MDIs 1 of 1
Sheet HFCs from metered dose inhalers

Year ¹	Estimated no. of doses (millions)	Weighted average propellant/dose (g/dose)	Total propellant (tonnes)	HFC doses	Emission of HFC 134a (tonnes) ²
1995	350.0	0.032	11.2	1%	0.1
1996	350.0	0.032	11.2	5%	0.6
1997	350.0	0.032	11.2	10%	1.1
1998	361.9	0.032	11.6	10%	1.2
1999	360.7	0.032	11.5	10%	1.2
2000	397.2	0.032	12.7	13%	1.7
2001	457.7	0.032	14.6	70%	10.3

1. HFC 134a not used in MDIs before 1995
2. Only HFC used in MDIs is HFC 134a

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. Fire protection 1 of 1
Sheet Annual emissions from the fire protection industry

Year ¹	Total HFC 227a installed (tonnes)		Emission rate	Emissions of HFC 227a (tonnes)
	Streaming	Portable		
1994	1.6	—	0.0133	0.02
1995	3.2	—	0.0133	0.04
1996	4.8	—	0.0133	0.06
1997	6.4	—	0.0133	0.09
1998	8.0	—	0.0133	0.11
1999	10.0	—	0.0133	0.13
2000	11.0	—	0.0133	0.15
2001	12.0	—	0.0133	0.16

1. Use of HFC 227a in fire protection industry not occurring before 1994

Year	Domestically manufactured chemical	Imported bulk chemical	Exported bulk chemical	Chemical in imported equipment	Chemical in exported equipment	Annual sales (tonnes)
1990	0	0.0	0	0	0.0	0.0
1991	0	0.0	0	0	0.0	0.0
1992	0	0.0	0	3.9	0.3	3.6
1993	0	6.0	0	6.4	2.0	10.4
1994	0	53.0	0	6.8	10.5	49.3
1995	0	105.4	0	8.4	16.6	97.2
1996	0	152.3	0	10.6	15.9	147.0
1997	0	88.5	0	10.5	14.9	84.1
1998	0	192.9	0	9.9	16.8	186.0
1999	0	170.1	0	12.6	17.8	165.0
2000	0	134.0	0	11.9	19.0	126.9
2001	0	184.9	0	11.5	18.9	177.5

1. IPCC (2001) Equation 3.4

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 2 of 4
Sheet Stationary Refrigeration and Air Conditioning - total charge of new equipment (input to equation 3.4¹)

Year	Chemical to charge domestically manufactured equipment	Chemical to charge imported equipment	Chemical contained in factory charged imported equipment	Chemical contained in factory charged exported equip	Total charge of new equipment (tonnes)
1990	0.0	0	0	0.0	0.0
1991	0.0	0	0	0.0	0.0
1992	0.2	0	3.9	0.3	3.8
1993	4.9	0	6.4	2.0	9.3
1994	38.4	0	6.8	10.5	34.7
1995	74.3	0	8.4	16.6	66.1
1996	102.1	0	10.6	15.9	96.8
1997	63.6	0	10.5	14.9	59.2
1998	127.1	0	9.9	16.8	120.2
1999	112.3	0	12.6	17.8	107.1
2000	94.1	0	11.9	19.0	87.0
2001	140.4	0	11.5	18.9	133.1

1. IPCC (2001) Equation 3.4

2. Chemical to charge imported equipment that is not factory charged

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 3 of 4
Sheet All HFC and PFC emissions from stationary refrigeration Equation 3.4¹

Year	Annual sales of new refrigerant	Total charge of new equipment	Original charge of retiring equipment	Amount of intentional destruction	Emissions ² (tonnes)
1990	0.0	0.0	0	0	0.0
1991	0.0	0.0	0	0	0.0
1992	3.6	3.8	0	0	0.0
1993	10.4	9.3	0	0	1.1
1994	49.3	34.7	0	0	14.6
1995	97.2	66.1	0	0	31.1
1996	147.0	96.8	0	0	50.1
1997	84.1	59.2	0	0	24.8
1998	186.0	120.2	0	0	65.8
1999	165.0	107.1	0	0	57.8
2000	126.9	87.0	0	0	39.9
2001	177.5	133.1	0	0	44.5

1. IPCC (2001) Equation 3.4

2. The methodology produces a negative number for 1992, thus 0 has been entered for this year.

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MAC 1 of 4
Sheet Mobile air conditioning Equation 3.45¹ (input to equation 3.44¹)

Year ²	Total virgin HFC 134a ³ in first-fill MAC systems (tonnes)	Emission factor	First-fill emissions HFC 134a (tonnes)
1994	4.0	0.005	0.020
1995	13.4	0.005	0.067
1996	13.1	0.005	0.065
1997	11.7	0.005	0.058
1998	10.8	0.005	0.054
1999	10.8	0.005	0.054
2000	11.2	0.005	0.056
2001	9.1	0.005	0.045

1. IPCC (2001) Equations 3.44 and 3.45
2. No use recorded before 1994
3. HFC 134a the only HFC used in MAC

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MAC 3 of 4 (IPCC (2000) equation 3.47)
Sheet HFC 134a emissions from mobile air conditioning (equation 3.44¹)

Year	Annual scrap rate of vehicles with MACs using HFC-134a	Number of vehicles with MACs using HFC-134a	Average HFC-134a charge per vehicle (kg)	Destruction (tonnes)	Disposal emissions (tonnes)
1994	0.0108	39,805	0.81	0	0.35
1995	0.0115	91,301	0.81	0	0.85
1996	0.0069	143,987	0.81	0	0.80
1997	0.0052	199,857	0.81	0	0.84
1998	0.0037	257,314	0.81	0	0.77
1999	0.0034	331,757	0.81	0	0.91
2000					
2001					

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MAC 2 of 4
Sheet Mobile air conditioning Equation 3.46¹ (input to equation 3.44¹)

Year ²	Total annual virgin HFC 134a	Annual virgin HFC in first-fill MAC systems					Operation emissions HFC 134a (tonnes)
		Buses	Trucks	Cars	Cars (new)	Total	
1994	3.2	0.0	0.7	2.6	0.7	4.0	-0.8
1995	20.8	0.2	3.3	7.4	2.5	13.4	7.4
1996	37.5	0.3	3.4	7.0	2.4	13.1	24.4
1997	12.9	0.3	3.2	6.8	1.4	11.7	1.2
1998	54.6	0.3	3.0	6.8	0.7	10.8	43.8
1999	27.4	0.4	3.7	6.7	0.0	10.8	16.6
2000	44.1	0.3	4.4	6.5	0.0	11.2	32.9
2001	46.3	0.2	2.9	6.0	0.0	9.1	37.2

1. IPCC (2001) Equations 3.44 and 3.45
2. No use recorded before 1994

Module 1990 - 2001 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. MAC 4 of 4
Sheet HFC 134a emissions from mobile air conditioning (equation 3.44¹)

Year ²	First-fill emissions (tonnes)	Operation emissions	Disposal emissions ³	Intentional destruction	Annual emissions of HFC 134a (tonnes)
1994	0.020	-0.8	0.35	0	-0.5
1995	0.067	7.4	0.85	0	8.3
1996	0.065	24.4	0.80	0	25.3
1997	0.058	1.2	0.84	0	2.1
1998	0.054	43.8	0.77	0	44.6
1999	0.054	16.6	0.91	0	17.5
2000	0.056	32.9	2.16	0	35.1
2001	0.045	37.2	2.91	0	40.2

1. IPCC (2001) Equation 3.44
2. No use recorded before 1994
3. Calculated using IPCC (2000) equation 3.47

Module 1990 - 2000 Consumption of halocarbons (New Zealand)
Worksheet Supplementary 2.F. RAC 4 of 4
Sheet All HFC and PFC emissions from stationary refrigeration

Year	Bulk emissions (tonnes)	HFC 32 (tonnes)	HFC 125 (tonnes)	HFC 134a (tonnes)	HFC 143a (tonnes)	HFC 152 (tonnes)	PFC 218 (tonnes)
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1991	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1992	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1993	1.1	0.0	0.0	1.1	0.0	0.0	0.0
1994	14.6	0.0	1.2	11.3	0.4	0.4	0.0
1995	31.1	0.4	0.5	18.2	7.9	1.2	0.8
1996	50.1	0.0	6.7	28.3	7.1	0.4	4.8
1997	24.8	0.0	10.5	3.6	9.3	0.2	0.3
1998	65.8	0.0	9.5	35.2	9.4	0.4	8.0
1999	57.8	7.4	10.4	23.0	11.0	1.7	0.0
2000	39.9	0.0	4.1	29.3	6.4	0.0	0.0
2001	44.5	0.1	12.8	16.6	14.9	0.0	0.0

Module 1990 - 2001 Emissions of Sulphur Hexafluoride (New Zealand)

Worksheet

Sheet SF₆ from Electrical Equipment and Other Sources (based on equation 3.18, 3.17 and 3.22)

Year	Potential SF ₆ Emissions (kgs) ¹	Emissions from Electical Equipment (kgs) ²	Emission from Other Sources ⁴ (kgs) ³	Actual SF ₆ Emissions (kgs)
1990		396.2	120.0	516.2
1991	2256.0	409.0	131.0	540.0
1992	1392.8	422.9	147.0	569.9
1993	2026.4	435.4	153.0	588.4
1994	1842.0	448.5	155.0	603.5
1995	1566.0	466.0	162.0	628.0
1996	2240.0	484.7	134.0	618.7
1997	2354.0	505.4	135.0	640.4
1998				
1999				
2000	1752.6	671.6	15.0	686.6
2001	1483.5	690.4	15.0	705.4

1. IPCC (2001) Equation 3.18

2. IPCC (2001) Equation 3.17

3. IPCC (2001) Equation 3.22

4. SF₆ use in magnesium casting ceased in 1998

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2001 Industrial process (New Zealand)
NZ 2b part 1
Non-CO₂ emissions

Source Categories	ACTIVITY DATA	Emission Estimates										Aggregate Emission Factor									
	A Production Quantity (kt)	B										C									
		Full Mass of Pollutants										Tonne of pollutant per tonne of product									
		(Gg) Tonnes x 1000										(t/t)									
	CO	CH4	N2O	NOx	NMVOc	HFC	PFC	SF6	SO2	CO	CH4	N2O	NOx	NMVOc	HFC	PFC	SF6	SO2			
A Iron and Steel	800.79	0.2300			0.9287																
Fletcher Challenge	189.00	0.0006			0.0110					0.000003			0.00006								
BHP Steel	611.79	0.2294			0.9177				0.7036	0.000375			0.00150						0.001150		
B Non-Ferrous Metals																					
Aluminium Production	324.11						0.0087														
Other (Magnesium)																					
C Inorganic Chemicals (excepting solvent use)																					
Nitric Acid																					
Fertiliser Production	593.87																				
Ballance (Mount)	157.07								0.5497										0.003500		
Ballance (Invercargill)	70.80								1.2036										0.017000		
Ravensdowne Fertiliser	366.00								3.7332										0.010200		
Other																					
Ammonia/ Urea (Ballance)	163.21		0.1142									0.000700									
D Organic Chemicals																					
Adipic Acid																					
Other																					
Orica Adhesives and resins (Formaldehyde)	20.13	0.0503	0.0503			0.1550				0.002500	0.002500			0.007700							
Methanex (Methanol)	2132.33					10.6616								0.005000							
E Non-Metallic Mineral Products																					
Cement (total)	1063.95				3.8302				1.1916				0.003600						0.001120		
Golden Bay Cement																					
Milburn Cement	462.58																				
Lime (total)	141.00								0.0050												
Websters Hydrated Lime	7.00								0.0006										0.000080		
McDonalds Lime	134.00								0.0044										0.000033		
Other																					
Asphalt Roofing (Emoleum)	0.00																				
The New Zealand Refining Company	4700.00					0.0000								0.000500							
Road Paving (Bitumen Contractors Assoc)	105.00	0.0037			0.0088	2.5200			0.0126	0.000035			0.000084	0.024000					0.000120		
						0.0000								0.023000							
Giass	57.54					0.2589								0.004500							
F Other (ISIC)																					
Paper and Pulp	1501.00	4.0902			1.0956	2.7024			5.1127	0.002725			0.000730	0.001800					0.003406		
Winstone Pulp International	150.00																				
Pan Pac Forest Products	241.40																				
Fletcher Challenge																					
Carter Holt Harvey																					
Panel Products	84.00																				
Carter Holt Harvey Panels	84.00					0.0089								0.000106							
Nelson Pine Industries																					

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2001 Industrial process (New Zealand)
NZ 2b part 2
Non-CO₂ emissions

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2001 Industrial process (New Zealand)
NZ 2b part 2
Non-CO₂ emissions

Source Categories	ACTIVITY DATA	Emission Estimates										Aggregate Emission Factor									
	A	B										C									
	Production Quantity (kt)	Full Mass of Pollutants										Tonne of pollutant per tonne of product									
		(Gg) Tonnes x 1000										(t/t)									
	CO	CH4	N2O	NOx	NMVOc	HFC	PFC	SF6	SO2	CO	CH4	N2O	NOx	NMVOc	HFC	PFC	SF6	SO2			
Food and drink production	3110.3469																				
Wine (million litres)	53.30				0.0043									0.000080							
Beer (million litres)	307.00				0.0107									0.000035							
Spirits (million litres)	0.18				0.0027									0.015000							
Meat	1200.80				0.3602									0.000300							
Fish	283.29				0.0850									0.000300							
Poultry	115.79				0.0347									0.000300							
Sugar	223.32				2.2332									0.010000							
Margarine and solid cooking fats					0.0000									0.010000							
Cakes, biscuits and breakfast cereals	23.89				0.0239									0.001000							
Bread	117.00				0.9360									0.008000							
Animal feed	780.64				0.7806									0.001000							
Coffee roasting	5.14				0.0028									0.000550							

TOTAL 4.6041 0.1646 0.0000 6.7920 25.2553 0.0087 12.5170

Note: Use of halocarbons and SF6 covered in separate tables

Note: Total SO2 emissions from fertiliser production is 5.4865 Gg