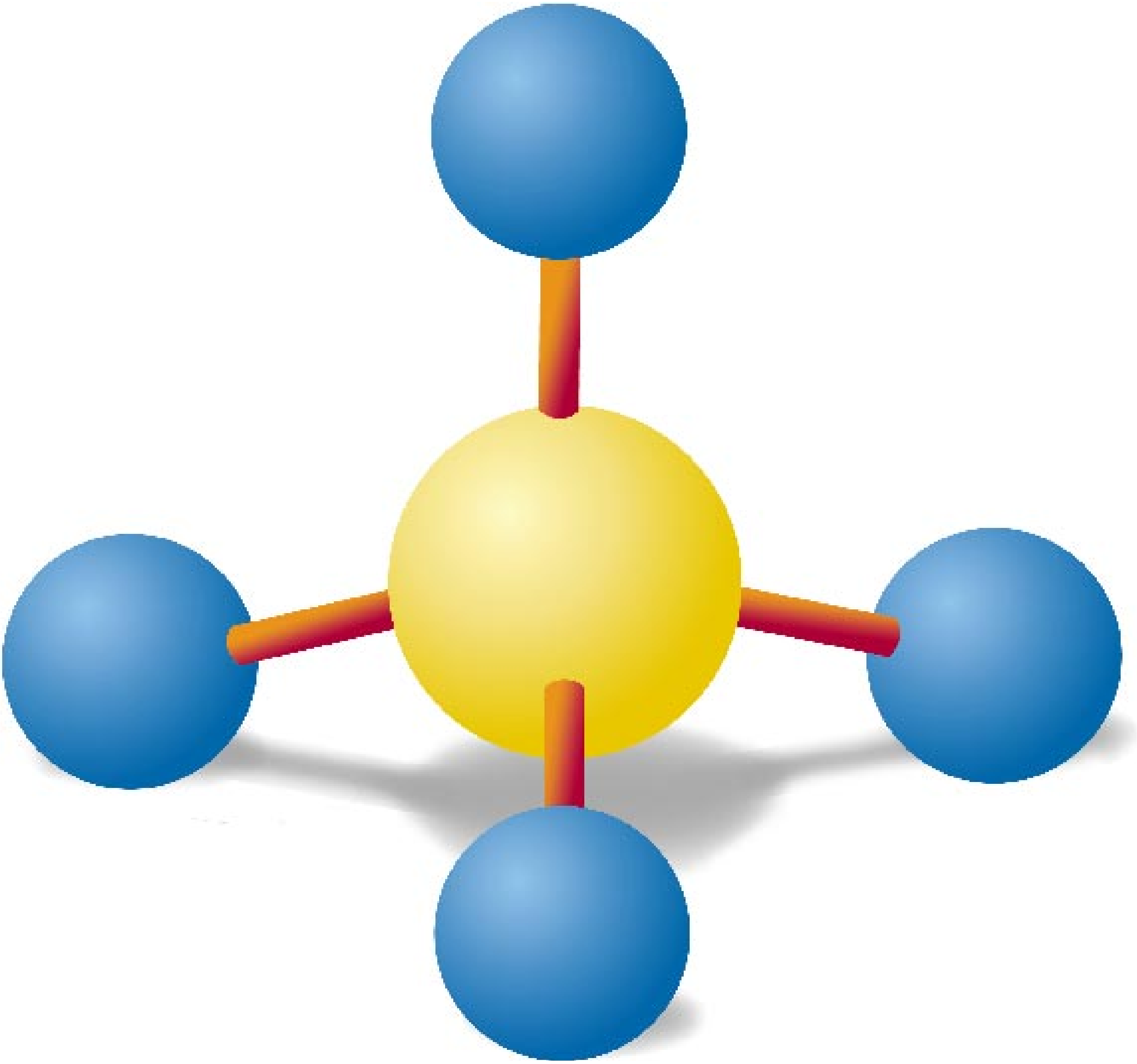
PERFLUOROCARBON EMISSIONS REDUCTION PROGRAMME 1990-2000



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The Information contained in this report is based upon data submitted by the operating companies which have participated in the survey and has not been verified by the IAI.

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1.0 INTRODUCTION AND SUMMARY

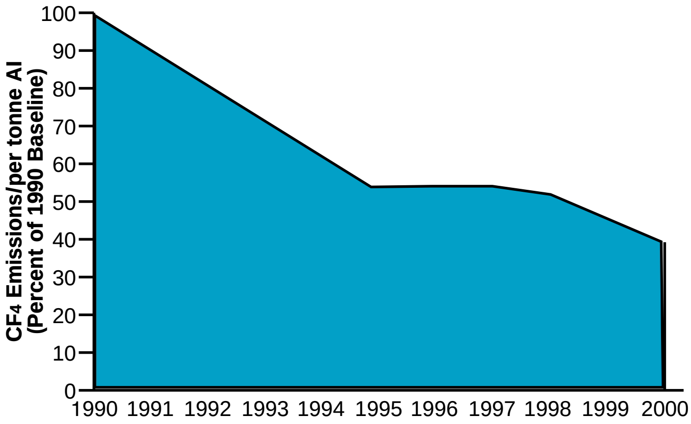
Primary aluminium production has been identified as a major man made source of emissions of two perfluorocarbon compounds (PFCs), tetrafluoromethane (CF_4) and hexafluoroethane (C_2F_6). These compounds are potent global warming gases as compared to carbon dioxide (CO_2) and have long atmospheric lifetimes. The two PFCs, CF_4 and C_2F_6, have the equivalent greenhouse gas warming potentials of 6,500 and 9,200 times that of CO_2, respectively. During normal operating conditions in an electrolytic cell used to produce aluminium, no measurable amounts of PFCs are generated. They are only produced during brief upset conditions known as "anode effects". These conditions occur when the level of aluminium oxide (the raw material for primary aluminium) drops too low and the electrolytic bath itself begins to undergo electrolysis. Since the aluminium oxide level in the electrolytic bath cannot be directly measured, surrogates such as cell electrical resistance or voltage are most often used in modern facilities to ensure that the alumina in the electrolytic bath is maintained at the correct level.

The industrial processes of the primary aluminium industry were directly responsible in 2000 for emitting a combined total of 92 million tonnes of CO_2 equivalents. This total was made up of 53 million tonnes (58%) of CO_2 equivalents from the two perfluorocarbon compounds (PFCs) and 39 million tonnes (42%) of CO_2 itself from the electrolysis reaction of the carbon anodes. In 1990 the combined total emissions were 117 million tonnes of CO_2 equivalents of which 86 million tonnes (73%) came from the PFCs emissions and 31 million tonnes (27%) of CO_2 itself from the electrolysis process.

The Institute carries out annual surveys of PFC emissions and sends out benchmarking reports, so individual plants can compare their performance with other de-identified plants using the same technology. The data from the 63% of world aluminium production that participated in these surveys shows that the specific emission rate (per unit weight of aluminium production) for CF_4 was reduced by 60% over the 1990 to 2000 time period while the specific emission rate for C_2F_6 was reduced by 62% over the same period.

Aluminium production has increased by around 24% since 1990 and yet there has still been an overall reduction in the total annual emissions of PFCs. This is one of the few

PFC Emissions Reduction from the IAI Survey



examples of where the global emissions of a greenhouse gas from an industry sector are actually in decline.

The Industry has appointed a PFC Consultant to hold seminars and carry out measurement programmes to encourage the wider adoption of good operating practices. The Surveys show that individual smelters in the developing world are performing as well if not better than some plants in Europe or North America. Voluntary agreements, between government and industry have played a significant role in encouraging this reduction in PFC emissions in many countries, such as USA, Australia, Bahrain, Brazil, Canada, France, Germany, New Zealand, Norway and the UK. Together they represent around half of world production.

The 2000 PFC Survey highlighted the considerable variation in performance between smelters using different types of technology and even between smelters using the same technology, so there is still considerable potential for improvement. The reduction in the frequency and duration of anode effects has dual benefits. It reduces PFC emissions and optimizes process efficiency.

The IAI's PFC Reduction Initiative involves;

- Surveying producers for anode effect data;
- Publishing reports that serve as a data source on PFCs from aluminium production;
- Providing advice on good practices for PFC measurement procedures;
- Conducting workshops for benchmarking and good practices for reduction of Anode effects;
- Collaborating with national regulatory agencies, and supports international bodies like the United Nations Framework Convention on Climate Change (UNFCCC), Intergovernmental Panel on Climate Change (IPCC) and international business groups and member companies to develop better PFC inventories;

- Sponsoring fundamental atmospheric research to understand better how PFCs affect climate change;
- Sponsoring measurements of PFCs in historical air samples to establish the relationship with aluminium production.

The IAI has introduced a benchmarking programme. Each reporting smelter receives a performance graph showing where it ranks in relation to the performance of other de-identified plants with similar technology. A series of regional workshops are being organised to promote the spread of good practice throughout the industry. Companies are being encouraged, and, where appropriate, assisted to carry out actual sample measurements at the aluminium production facilities. The measurement results can then be used to improve the accuracy of inventory results calculated by using technology average slope factor calculations. This also helps to provide a solid base for constructing the inventory back to 1990, which would be suitable for third party verification.

In the future the introduction of inert anodes and the replacement over time of carbon anodes could eventually eliminate PFC emissions as well as the carbon dioxide emissions that result from the electrolysis reaction of aluminium oxide.

2.0 DETAIL

Primary aluminium producers believe that the availability of reliable data on PFCs is essential both for the development of individual producer responses to global warming concerns and to inform policy development by governments. As a result, this overview of the Industry's voluntary response to reductions in the emission of CF_4 and C_2F_6 has been compiled. This overview shows the progress that has been made between the baseline year of 1990 and 2000. In its initial data collection effort for the period 1990 to 1993, the IAI was only able to obtain a 27% participation rate for 1990 based on that year's world production volume. As a part of the data collection effort for the period 1998 to 2000, respondents were asked to provide data for 1990 as well in an effort to improve the 1990 base year participation rate. The most recent 1998-2000 survey questionnaire was sent to IAI correspondents representing 104 facilities that produce about 75% of world primary aluminium production for 2000. The survey was unable to cover producers in Azerbaijan, Bosnia-Herzegovina, China, Croatia, Iran, Korea, Poland, Romania, Russian Federation, Tadzhikistan and the Ukraine.

The participation of the global aluminium industry in this 1998 to 2000 survey is summarized in the following table together with the participation rate for the updated 1990 baseline year.

Production Based Participation in PFC Surveys

Year	Responses	Participating Production (Tonnes)	World Production (Tonnes)	Percentage of World Production Participating
1990	98	11,830,375	19,500,195	61%
1998	112	15,368,475	22,708,340	68%
1999	117	16,312,720	23,715,946	69%
2000	115	16,079,066	24,253,659	66%

A further breakdown of the participation data by smelter technology type is provided in the following table;

Survey Participation Statistics
Breakdown by Technology Type

Tech. Type	Year	Reporting Production (Tonnes)	World Production (Tonnes)	Percent Participation
CWPB	1990	2,626,117	3,277,019	80%
	1998	1,379,218	2,310,195	60%
	1999	1,349,110	2,163,613	62%
	2000	1,139,568	2,079,163	56%
PFPB	1990	5,066,427	6,174,602	82%
	1998	10,242,354	10,994,435	93%
	1999	10,997,111	12,036,318	91%
	2000	11,362,665	13,032,758	87%
SWPB	1990	1,446,781	2,875,891	50%
	1998	1,108,272	1,981,009	56%
	1999	1,056,762	1,996,678	53%
	2000	873,797	1,861,262	47%
VSS	1990	1,827,760	4,687,694	39%
	1998	2,250,236	4,653,137	48%
	1999	2,246,337	4,673,977	48%
	2000	2,231,019	4,531,297	49%
HSS	1990	863,290	2,484,989	35%
	1998	388,395	2,769,564	14%
	1999	663,400	2,845,360	23%
	2000	472,017	2,749,179	17%

The Intergovernmental Panel on Climate Change (IPCC) has a recommended good practice guidance for inventorying PFC emissions from primary aluminium production as a part of the IPCC / OECD / IEA Programme for National Greenhouse Gas Inventories. A copy of this good practice guideline can be obtained from the IPCC web site (www.ipcc.ch). These IPCC guidelines served as the calculation method for specific emission rates using the survey data. As is stated in the guidance, the key process parameters that are required for estimating specific emission rates are either the anode effect frequency and duration or the anode effect over-voltage. Using the IPCC Tier 2 good practice guidelines, specific emission rates (kg CF_4 per tonne of aluminium produced) were calculated for the facilities providing data for the period 1990 to 2000 survey and are given in the following tables. The data show that taking into account only the production that has participated in this survey, a further 15% reduction in the specific emission rate for CF_4 has occurred over the 1998 to 2000 time period from the 1990 baseline. For the decade 1990 to 2000 a 60% reduction in the specific emission rate for CF_4 and a 62% reduction in the specific emission rate for C_2F_6 has been achieved.

The following tables show a breakdown of the PFC emissions by technology type. Each of the calculated annual technology specific emission rates (kilograms of CF_4 per tonne of aluminium produced) is a production weighted average.

Kilograms CF_4 per Tonne of Aluminium Produced (Production Weighted Average)

Category	1990	1998	1999	2000
All Reporting Production	0.54	0.28	0.26	0.22

Kilograms C_2F_6 per Tonne of Aluminium Produced (Production Weighted Average)

Category	1990	1998	1999	2000
All Reporting Production	0.057	0.032	0.025	0.021

Center Worked Prebake Technology

Year	kg CF_4 per tonne	Participating Production (Tonnes)
1990	0.42	2,626,117
1998	0.24	1,379,218
1999	0.24	1,349,110
2000	0.21	1,139568

Point Feed Prebake Technology

Year	kg CF_4 per tonne	Participating Production (Tonnes)
1990	0.37	5,066,427
1998	0.13	10,242,354
1999	0.11	10,997,111
2000	0.11	11,362,665

Vertical Stud Soderberg Technology

Year	kg CF_4 per tonne	Participating Production (Tonnes)
1990	0.52	1,827,760
1998	0.37	2,250,236
1999	0.37	2,246,337
2000	0.36	2,231,019

Side Worked Prebake Technology

Year	kg CF_4 per tonne	Participating Production (Tonnes)
1990	1.37	1,446,781
1998	1.45	1,108,272
1999	1.37	1,056,762
2000	1.06	873,797

Horizontal Stud Soderberg Technology

Year	kg CF_4 per tonne	Participating Production (Tonnes)
1990	0.54	863,290
1998	0.57	388,395
1999	0.49	663,400
2000	0.51	472,017

Each of the calculated annual technology specific emission rates (kilograms of CF_4 per tonne of aluminium produced for example), based upon the individual plant response calculations, is a production weighted average.

Kilograms CF_4 per Tonne of Aluminium Produced

Technology Type	Year 1990	Year 2000
CWPB	0.42	0.21
PFPB	0.37	0.11
SWPB	1.37	1.06
VSS	0.52	0.36
HSS	0.54	0.51
All Technologies	0.54	0.22

Kilograms C_2F_6 per Tonne of Aluminium Produced

Technology Type	Year 1990	Year 2000
CWPB	0.054	0.027
PFPB	0.048	0.014
SWPB	0.137	0.106
VSS	0.023	0.016
HSS	0.054	0.051
All Technologies	0.057	0.021

Using the estimated emission rates calculated as described above and the reported production from the corresponding responses, the annual emissions (tonnes) was calculated for each response. The annual emissions of CF_4 were then plotted by technology type on a cumulative production and cumulative emissions basis. This plot is provided in Figure 1. As is shown in Figure 1, based upon the participating production (61% to 66% of world production), emissions of CF_4 have decreased by 2,900 tonnes (18.9 million tonnes CO_2 equivalents) or 46% over the 1990 to 2000 time period

Figure 1 - Rank Ordered Cumulative CF_4 Emissions vs Cumulative Aluminium Production by Production Facility

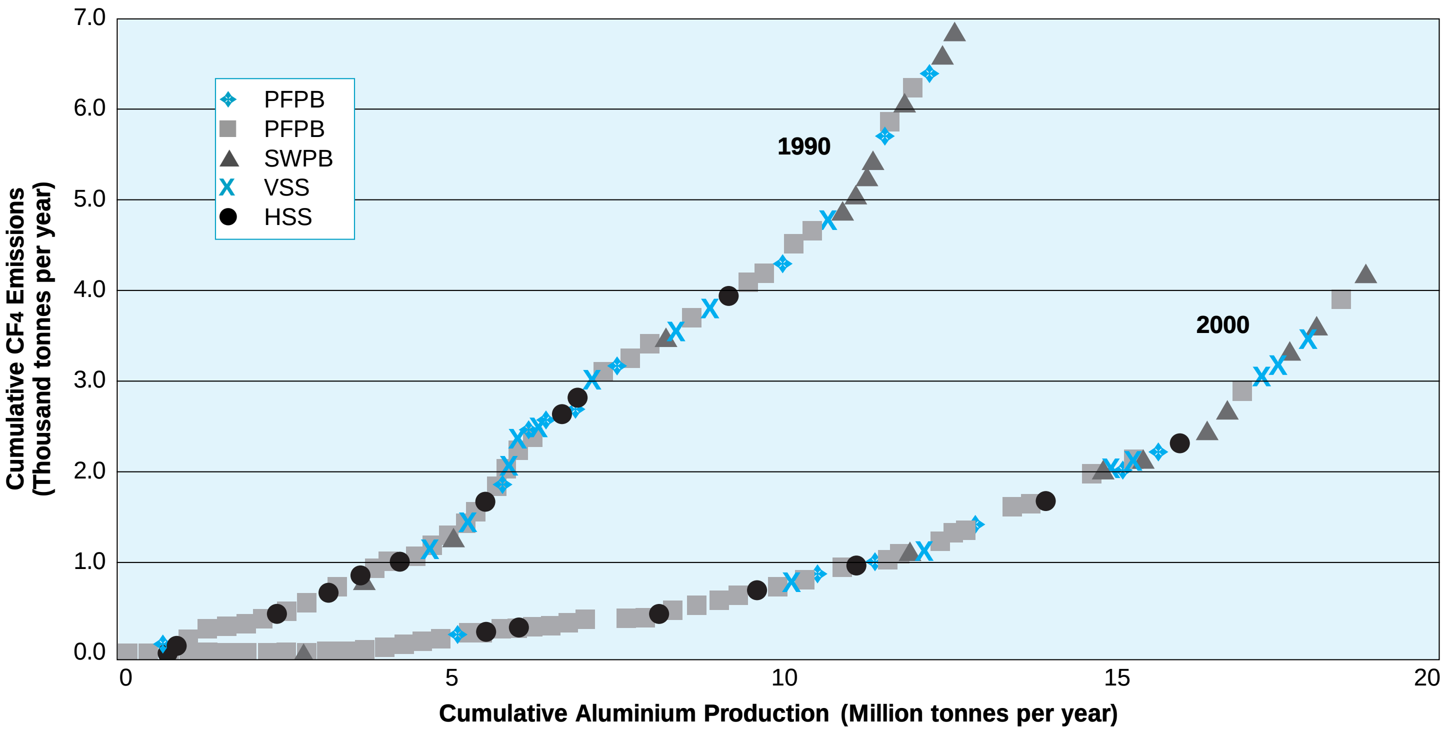
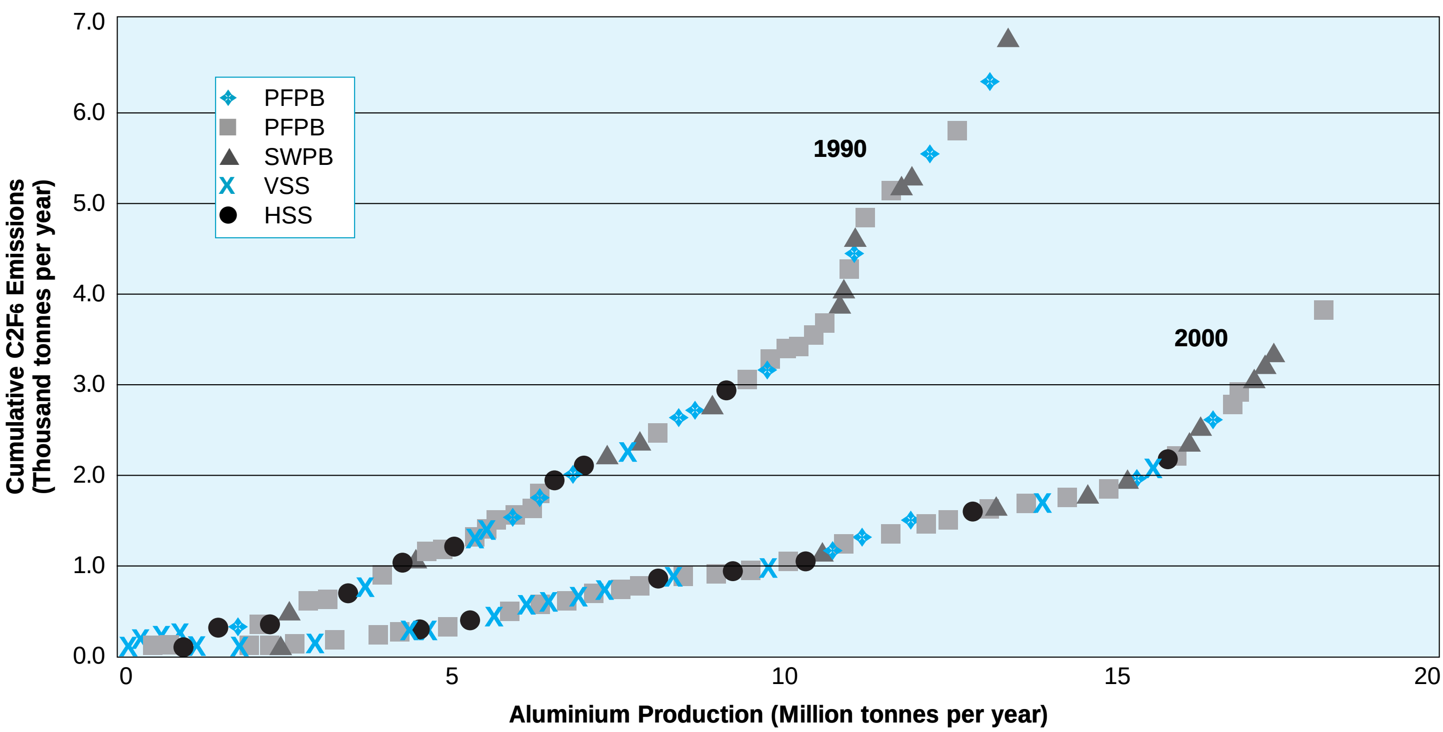


Figure 2 - Rank Ordered Cumulative C_2F_6 Emissions vs Cumulative Aluminium Production by Production Facility



while participating production has increased by just over 4,000,000 tonnes or 36% over the same period. A companion plot for C_2F_6 is provided in Figure 2. As is shown in Figure 2, emissions of C_2F_6 have decreased by 328 tonnes or 67% over the 1990 to 2000 time period with the increased production noted above.

A further breakdown of annual emissions of CF_4 and C_2F_6 by technology type is provided in tabular form below.

Annual Emissions From Participating Production CWPB Technology

Year	CF_4	C_2F_6
1990	1112 tonnes	143 tonnes
2000	243 tonnes	31 tonnes

Annual Emissions From Participating Production PFPB Technology

Year	CF_4	C_2F_6
1990	1887 tonnes	243 tonnes
2000	1260 tonnes	162 tonnes

Annual Emissions From Participating Production SWPB Technology

Year	CF_4	C_2F_6
1990	1987 tonnes	199 tonnes
2000	929 tonnes	93 tonnes

Annual Emissions From Participating Production VSS Technology

Year	CF_4	C_2F_6
1990	952 tonnes	42 tonnes
2000	797 tonnes	35 tonnes

Annual Emissions From Participating Production HSS Technology

Year	CF_4	C_2F_6
1990	466 tonnes	47 tonnes
2000	240 tonnes	24 tonnes

3.0 BENCHMARKING DATA FOR YEAR 2000

The data presented in this section allows individual producers to evaluate their year 2000 performance, the most recent year for which data is currently available, in comparison to the performance of other producers participating in the IAI anode effect survey. Each Member and Corresponding Company receives their confidential individual copy of the data graphs, which marks the position of their plant or plants on the curves. This allows producers to evaluate performance relative to overall respondents, and, to respondents operating within the same technology category. For purposes of this comparison five smelter technologies are evaluated, Center Work Prebake (CWPB), Point Fed Prebake (PFPB), Side Work Prebake (SWPB), Horizontal Stud Soderberg (HSS) and Vertical Stud Soderberg (VSS) cells. In 2000 a total of 115 facilities reported complete anode effect data from which emissions of CF_4 and C_2F_6 could be calculated. Of this total there were seven CWPB, sixty-six PFPB, ten SWPB, nine HSS and twenty-three VSS facilities identified. These 115 facilities accounted for 66 percent, or, 16.1 million tonnes of the estimated world total of 24.3 million tonnes of primary aluminium produced in 2000.

The data are presented in two formats to facilitate the evaluation of performance relative to others. First box and whiskers plots are shown for each of the technologies. These plots provide a overall view of how the data is distributed with upper and lower quartiles identified by the ends of the whiskers. The outline of the box identifies second and third quartiles and the median is marked by a line across the box. The mean is also indicated by a plotted point in the box. Outlier data points are plotted outside the whiskers. Next, individual facility performance is plotted in cumulative probability plots and in cumulative production diagrams. In the cumulative probability plot the parameter being evaluated is plotted on the horizontal axis versus the cumulative probability for the data point on the vertical axis. The vertical axis value for each point is interpreted as the total probability for the data point and all points below it. For example, if the vertical axis value is 0.75, then 25 percent of all the data exceeds the selected value, and, 75 percent of the reporting facilities are at or below the selected value.

Parameters shown for benchmarking include anode effect frequency, anode effect duration, anode effect minutes per cell day, anode effect overvoltage, specific emissions of CF_4 and C_2F_6 and total carbon dioxide equivalent emissions.

Figure 3 - Center Work Prebake Technology Anode Effect Performance - Box and Whiskers Diagram

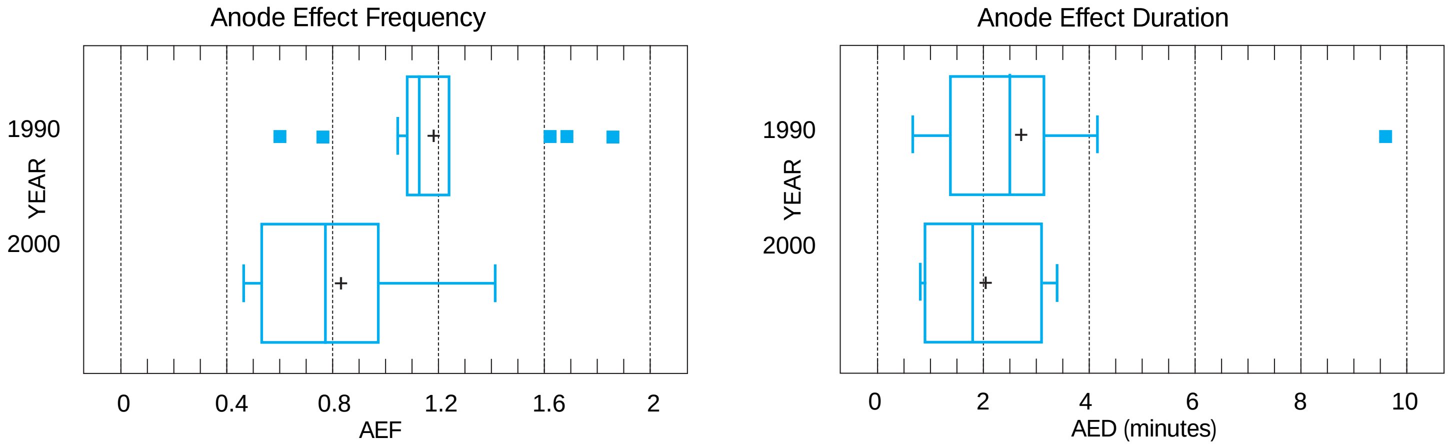


Figure 4 - Point Fed Prebake Technology Anode Effect Performance - Box and Whiskers Diagram

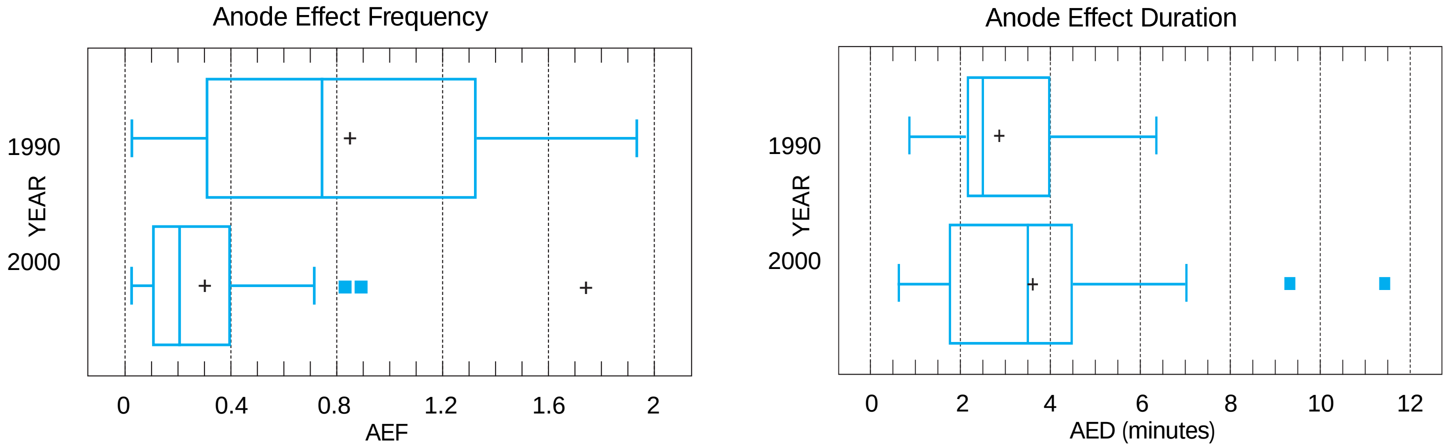


Figure 5 - Side Work Prebake Technology Anode Effect Performance - Box and Whiskers Diagram

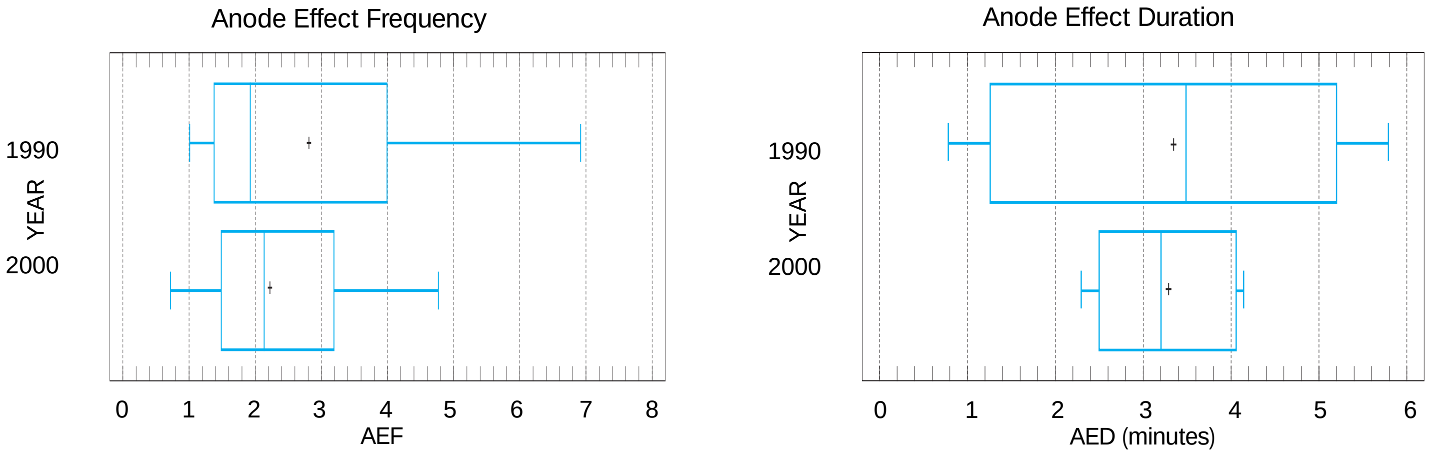


Figure 6 - Horizontal Stud Soderberg Technology Anode Effect Performance - Box and Whiskers Diagram

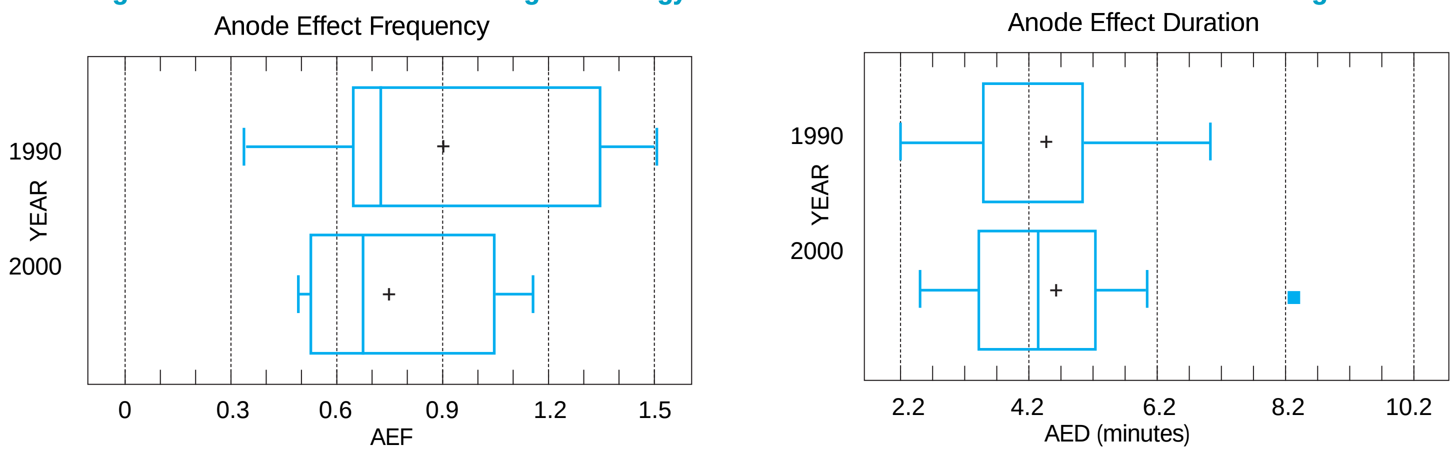
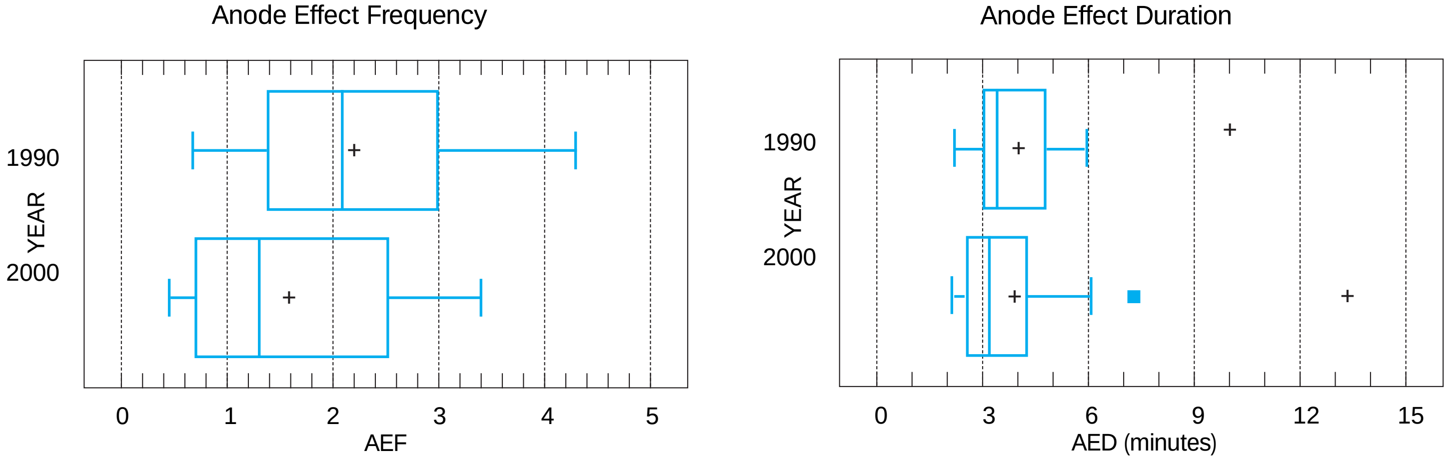


Figure 7 - Vertical Stud Soderberg Technology Anode Effect Performance - Box and Whiskers Diagram



Anode effect frequency and anode effect average duration performances are compared among facilities of the same operating technology in Figures 3 through 7. The most notable changes are in anode effect frequency performance where data distributions have been shifted toward lower anode effect frequency in all technology categories. The PFPB category shows the most pronounced shift to lower values. This has been the technology category that has experienced the most growth in production over the decade from 1990 to 2000. Changes in anode effect duration for all categories are generally not as great as for anode effect frequency over the same period. The median performance for anode effect duration for PFPB technology actually shows some increase. This increase might be expected because, as anode effect frequency reductions are achieved by more effective computer control algorithms, the remaining anode effects would contain a higher percentage of the longer, manually killed anode effects. Still the sharp reduction in frequency of anode effects in this category outweighs the modest deterioration in anode effect duration to give an overall decrease in anode effect minutes per cell day. PFC emissions are directly proportional to anode effect minutes per cell day. Figure 5 shows some deterioration in median anode effect frequency performance for SWPB cells from 1990 to 2000; however, the overall spread in performance has been much reduced over the period. Very good reductions in data distributions for both anode effect frequency and anode effect duration have been made for both Horizontal Stud and Vertical Stud Soderberg cells from 1990 to 2000.

Figures 8 compares the anode effect frequency performance of each individual reporting facility with others in the same smelter technology. The figure illustrates the difference in ability to control anode effects inherent in the different technologies. The highest degree of control and thus the lowest anode effect frequency distribution is in the more modern PFPB facilities. Anode effect frequency performance is similar for the CWPB cells and HSS cells. The best performing VSS operators have comparable anode effect frequency performance to the CWPB and HSS operators; however, performance diverges significantly for the highest two-thirds of the data distribution. Finally, the SWPB operators consistently show the poorest anode effect frequency performance throughout the entire distribution of data.

Figure 8 - Comparison of 2000 Anode Effect Frequency Performance of Individual Facilities by Technology Category

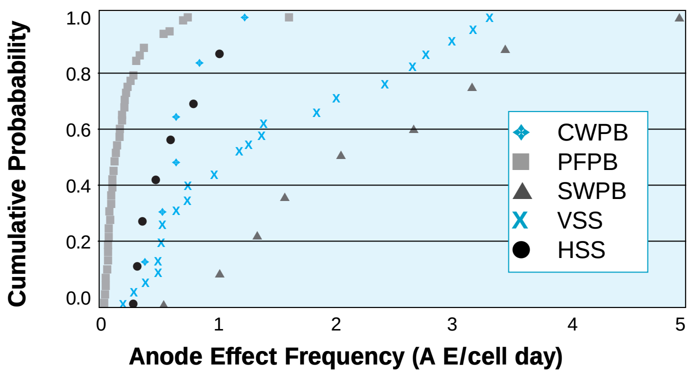


Figure 9 shows benchmark data for anode effect minutes per cell day, which is the product of anode effect frequency and average anode effect duration. This parameter has been found to be the best predictor of PFC emissions for all types of cells with the exception of those operating with Pechiney technology and Pechiney computer control systems. PFPB and CWPB cells show the best performance for anode effect minutes per cell day. Performance for SWPB, HSS and VSS cells overlap in Figure 9.

Figure 9 - Comparison of 2000 Performance for Anode Effect Minutes Per Cell Day

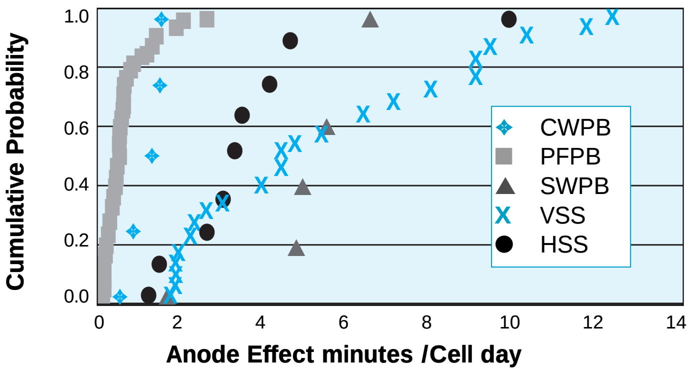
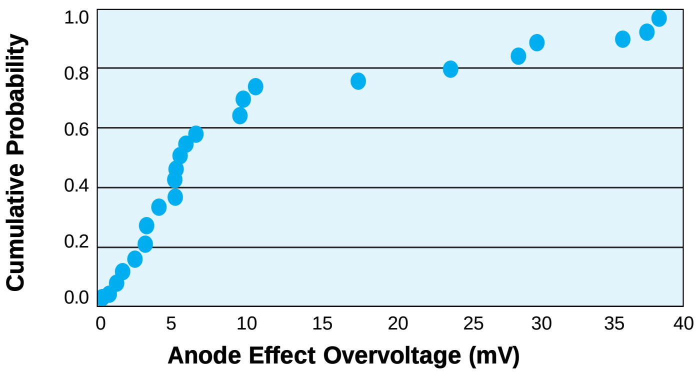


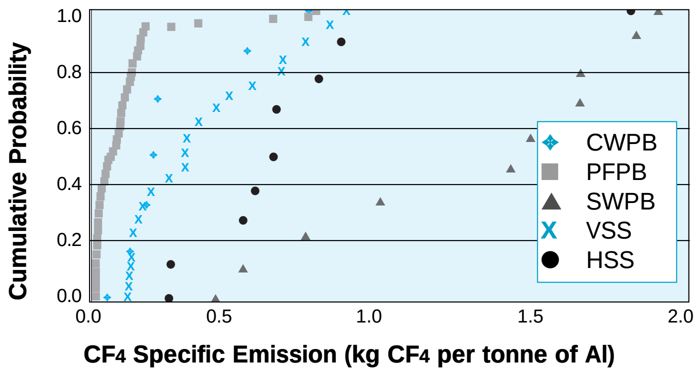
Figure 10 - Anode Effect Performance for PFPB Facilities Reporting Overvoltage Data



Anode Effect Overvoltage (AEO) is the parameter that is directly proportional to PFC emissions for those facilities operating with Pechiney Technology. No specific survey information was requested on whether operators were using Pechiney technology; however it is most likely that operators reporting AEO data within the PFPB smelter technology category are using Pechiney technology with Pechiney anode effect monitoring and squelching technology. For this reason benchmark data is shown in Figure 10 for AEO data reported by PFPB operators. The data in Figure 10 show a sharp break at about 10 mV with about 70 percent of operators below that value and the remaining 30 percent reporting poorer performance ranging from 10 mV to 37 mV. In addition to higher PFC emissions resulting from the higher AEO values, those operators also consume more electrical power. At the highest reported AEO values operators are wasting about 0.5 percent additional power as a result of anode effects.

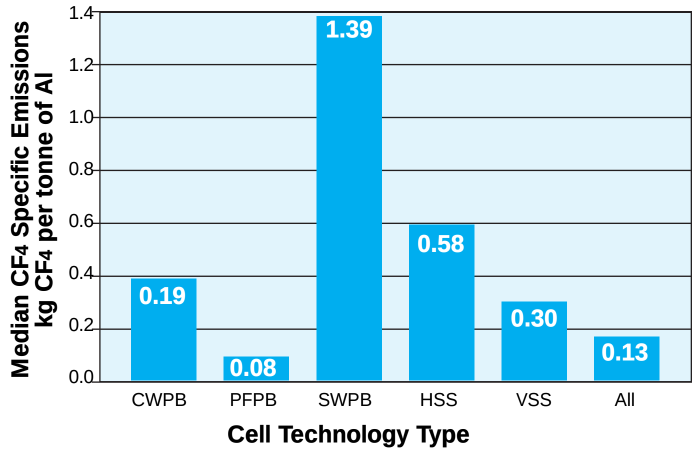
Figure 11 compares the year 2000 performance for specific CF_4 emissions by technology. The specific emissions data were calculated using IPCC Tier 2 method, which uses technology average emissions factors for anode effect minutes per cell day, or, a value of 1.9 for the anode effect overvoltage coefficient. The PFPB cells show the best specific emissions performance followed by the CWPB and VSS technology groups. The poorest specific emissions performance is shown in the SWPB and HSS cell groupings. This poor performance is the result of the relatively high anode effect minutes per cell day and the higher slope factors for these two categories of cells. The slope factor is multiplied by the anode effect minutes per cell day to calculate specific emissions. The slope factor for SWPB and HSS cells is 0.29 and 0.18, respectively, while the slope factor for PFPB, CWPB and VSS cells is 0.14, 0.14 and 0.068.

Figure 11 - Comparison of CF_4 Specific Emissions by Facility for Year 2000



The median specific CF_4 emissions value for each of the technology categories is shown in Figure 12.

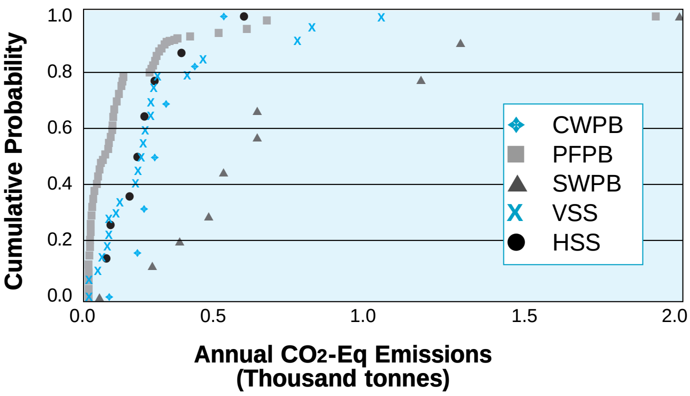
Figure 12 - Comparison of Median CF_4 Specific Emissions by Facility and Technology Type for Year 2000



While CF_4 specific emission values calculated for each facility ranged from 0.007 to 1.8 kg CF_4 per tonne of primary aluminium produced, the overall median calculated value was 0.13. This means, of the total of 115 facilities reporting data from which specific CF_4 emissions could be calculated, there were an equal number of facilities for which calculated specific emissions values were less than 0.13 as there were for those facilities where calculated values were higher than 0.13.

Figure 13 compares the combined emissions of CF_4 and C_2F_6, plotted as tonnes of CO_2 equivalent by multiplying total annual tonnes of each PFC emitted by the facility by the global warming factor for each gas, 6500 for CF_4 and 9200 for C_2F_6. The CO_2 equivalent value is most often used in scientific literature for inventorying and comparing the climate impact of emissions of different gases.

Figure 13 - Comparison of Total Annual PFC Emissions for Year 2000 as CO_2-Equivalent by Facility and Technology Type



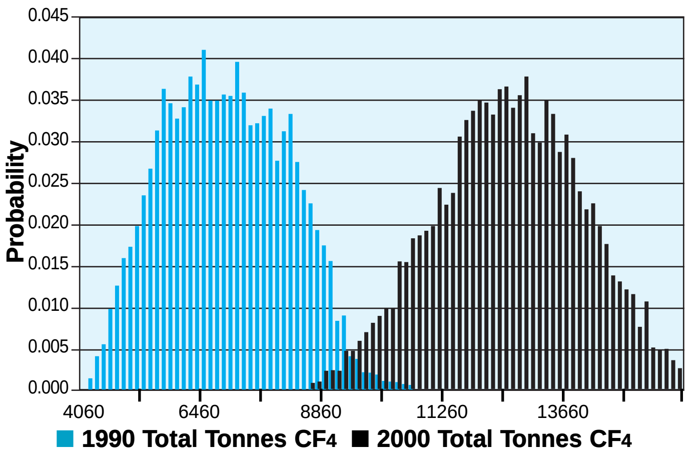
The calculated CO_2 equivalent results for each facility ranged from 7 tonnes to 1973 tonnes with an overall median result for all facilities of 132 tonne-equivalents of carbon dioxide.

4.0 GLOBAL EMISSIONS OVERVIEW

As was shown earlier in the report, some 34% to 39% of world production did not participate in the 1990 and 2000 IAI anode effect surveys. In order to estimate total world emissions of CF_4 and C_2F_6, an assessment of the emissions contribution of this non-participating production is needed. To assess the contribution of this non-participating production on total world emissions, a "Monte Carlo" simulation was performed using Crystal Ball® software. The simulation used specific emissions data calculated by the IPCC Tier 2 method from facilities reporting anode effect data as a sample to calculate a statistical distribution of emission performance for each technology type for 1990 and 2000. The calculated distributions were then applied to the non-participating production for 1990 and 2000. In order to make a meaningful assessment, it was necessary to obtain facility production figures through non-IAI sources. These sources included published data such as the Bureaus of Mines from some countries and CRU, as well as by direct contact with some facilities.

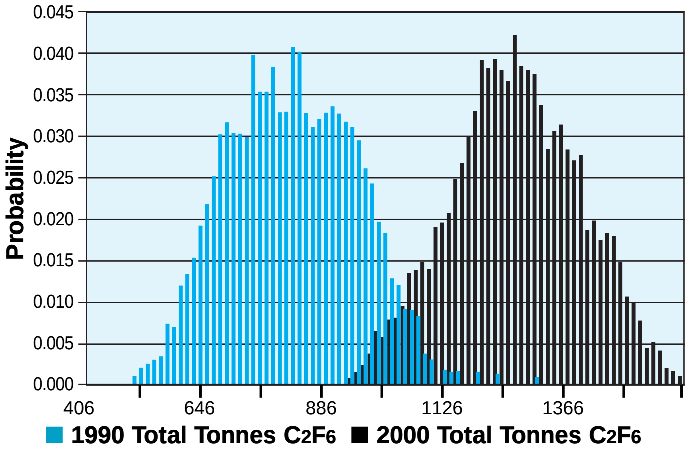
The results of one of the Monte Carlo simulations for CF_4 are shown in Figure 14 in a plot overlaying the Monte Carlo simulation output from the year 1990 and the year 2000. In this simulation, non-participating production is assumed to have an anode effect related performance (frequency and duration or over voltage) distribution identical to that of the participating production for the two respective years compared. As can be seen from the plot, the estimated annual world emissions of CF_4 from primary aluminium production have been reduced from a mean of 12,546 tonnes in 1990 to a mean level of 6,711 tonnes, a reduction of 5,835 tonnes (46%) over that period. Also the standard deviation of the distributions decreased from 1,299 to 1,090 indicating an increase in the certainty of the estimate over the same period.

Figure 14 - Reduction in Total CF_4 Emissions from 1990 to 2000



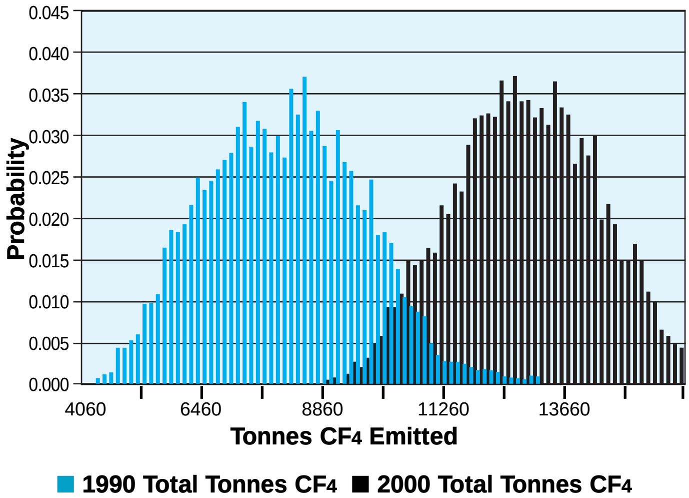
In Figure 15, a companion overlay plot for C_2F_6 is provided. As can be seen from the plot, the estimated annual world emissions of C_2F_6 from primary aluminium production have been reduced from a mean value of 1,232 tonnes to a mean level of 786 tonnes, a reduction of 446 tonnes (36%) between 1990 and 2000.

Figure 15 - Reduction in Total C_2F_6 Emissions from 1990 to 2000



A second simulation was performed in order to evaluate a "worst case" assumption. For this worst case assumption, the non-participating production is assumed to not have improved its anode effect related performance since 1990. As is shown in Figure 16, using the worst case assumption for non-participating production as described above, the estimated annual world emissions of CF_4 from primary aluminium production have been reduced by 4,973 tonnes (40%) between 1990 and 2000. In this worst case scenario the uncertainty as measured by the standard deviation in the estimate of annual emissions of CF_4 is about the same between 1990 and 2000.

Figure 16 - Worst Case Illustration of Reduction of CF_4 Emissions from 1990 to 2000



Similar results are obtained by using a similar worst case approach for C_2F_6 reductions. The estimated annual world emissions of C_2F_6 from primary aluminium production have been reduced by 319 tonnes (26%) between 1990 and 2000.

The results of the Monte Carlo simulations described above are also provided in the table below.

Global Emission Estimates of CF_4 and C_2F_6 from Primary Aluminium Production

Monte Carlo Simulation with Year 2000 Anode Effect Related Performance Distributions for Year 2000 Non-Participating Production

Year	CF_4 (mean tonnes)	Uncertainty (standard deviation)	C_2F_6 (mean tonnes)	Uncertainty (standard deviation)
1990	12,546	1,299	1,232	123
2000	6,711	1,090	786	113

Global Emission Estimates of CF_4 and C_2F_6 from Primary Aluminium Production

Monte Carlo Simulation with Year 1990 Anode Effect Related Performance Distributions for Year 2000 Non-Participating Production

Year	CF_4 (mean tonnes)	Uncertainty (standard deviation)	C_2F_6 (mean tonnes)	Uncertainty (standard deviation)
1990	12,549	1,309	1,230	123
2000	7,576	1,348	911	150

5.0 CONCLUSIONS AND FUTURE OPPORTUNITIES

Reducing PFC emissions offers both an environmental benefit and at the same time it has a positive economic benefit. The data reported here shows that the worldwide aluminium industry has made good progress in reducing PFC emissions over the period 1990 to 2000. Producers that reported anode effect data to the IAI accounted for 63 percent of global primary aluminum production in 2000. They have succeeded in reducing total PFC emissions (reported as carbon dioxide equivalents) to just 54 percent of the 1990 PFC emissions total. The total aluminium production over the same time period increased by 4.8 million tonnes, a 24 percent increase.

International attention is increasingly being focused on greenhouse gas emissions reductions as many countries are now developing strategies to meet national reduction targets under the Kyoto Protocol. The reductions already achieved by aluminium producers, as well as projected future reductions, have already been incorporated into some countries' non carbon dioxide greenhouse gas reduction strategies. Past and future emissions reductions by aluminium producers may result in economic value realized through mechanisms provided for under the Kyoto Protocol. These mechanisms include emissions trading, joint implementation projects among producers operating in Protocol Annex 1 countries as well as projects carried out between parties in Annex 1 countries and non-Annex 1 countries by means of the Clean Development Mechanism.

While significant progress has been made in PFC reduction in the past, further reductions remain a top IAI priority. Anode effects that could be easily eliminated have been eliminated. Further reductions require a carefully formulated plan for process improvement with current facilities, or, evaluating the costs and benefits from capital investments in a plant upgrade. The IAI data show that for each broad reduction technology category there remains a wide range of anode effect performance. This observation suggests there may be scope for considerable further improvement remaining through the implementation of best practices. Calculation shows that the IAI all technology average specific CF_4 emissions could be reduced from the 0.22 kg CF_4/tonne aluminium reported for 2000 to 0.15 kg CF_4/tonne aluminium, a further 46 percent improvement in 2000 performance, if those facilities that are operating at specific emission levels higher than the median could improve their performance to the median performance. This level of improvement would eliminate 1086 tonnes of annual CF_4 emissions and 112 tonnes of annual C_2F_6 emissions globally, an additional 8 million tonnes of carbon dioxide equivalents. This might be accomplished through the implementation of good practices. Beyond the implementation of good practices, investments in upgrading facilities can lead to further improvements. Installation of point feeders for Soderberg cells can substantially reduce anode effect frequency and at the same time improve current efficiency. Also, development continues toward demonstration on a commercial scale of inert anode technology retrofitted into current design cells. Success in this effort would in the long term offer the possibility of complete elimination of both the PFC emissions and the carbon dioxide emissions associated with the electrolysis of alumina with carbon anodes.

Other opportunities exist to improve the quality of the greenhouse gas inventory from the global aluminium industry. Anode effect data was reported for sixty-six percent of global primary aluminium production in the 2000 IAI survey. Continuing contacts are being made with representatives from companies that do not currently participate in the survey to improve the coverage and thus the completeness of the inventory data. Another opportunity exists to improve the quality of the survey data analysis by calculating PFC emissions by IPCC Tier 3 method wherever possible. A number of production locations have made facility specific measurements according to good measurement practices and could adopt the more accurate Tier 3 calculation of emissions. Also, a Protocol for Good PFC Measurement Practices has been developed in cooperation with the US Environment Protection Agency. The Protocol should be adopted for future PFC measurements to improve the consistency and quality of Tier 3 coefficients. The IAI makes available expert advice on implementation of PFC measurements to those producers interested in making measurements. Finally, the measurements that have been made to date show that the current IPCC Tier 2 coefficients, developed in 1999, when there was little measurement data available, should be updated to improve the accuracy of the calculated PFC emissions. The IAI is working with the IPCC and the international agencies to have these improvements adopted as internationally accepted IPCC Good Practices.