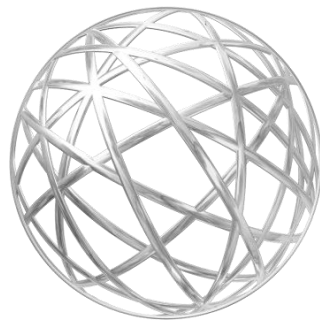


Results of the 2018 Anode Effect Survey

Report on the Aluminium Industry's Global
Perfluorocarbon Gases Emissions

July 2019



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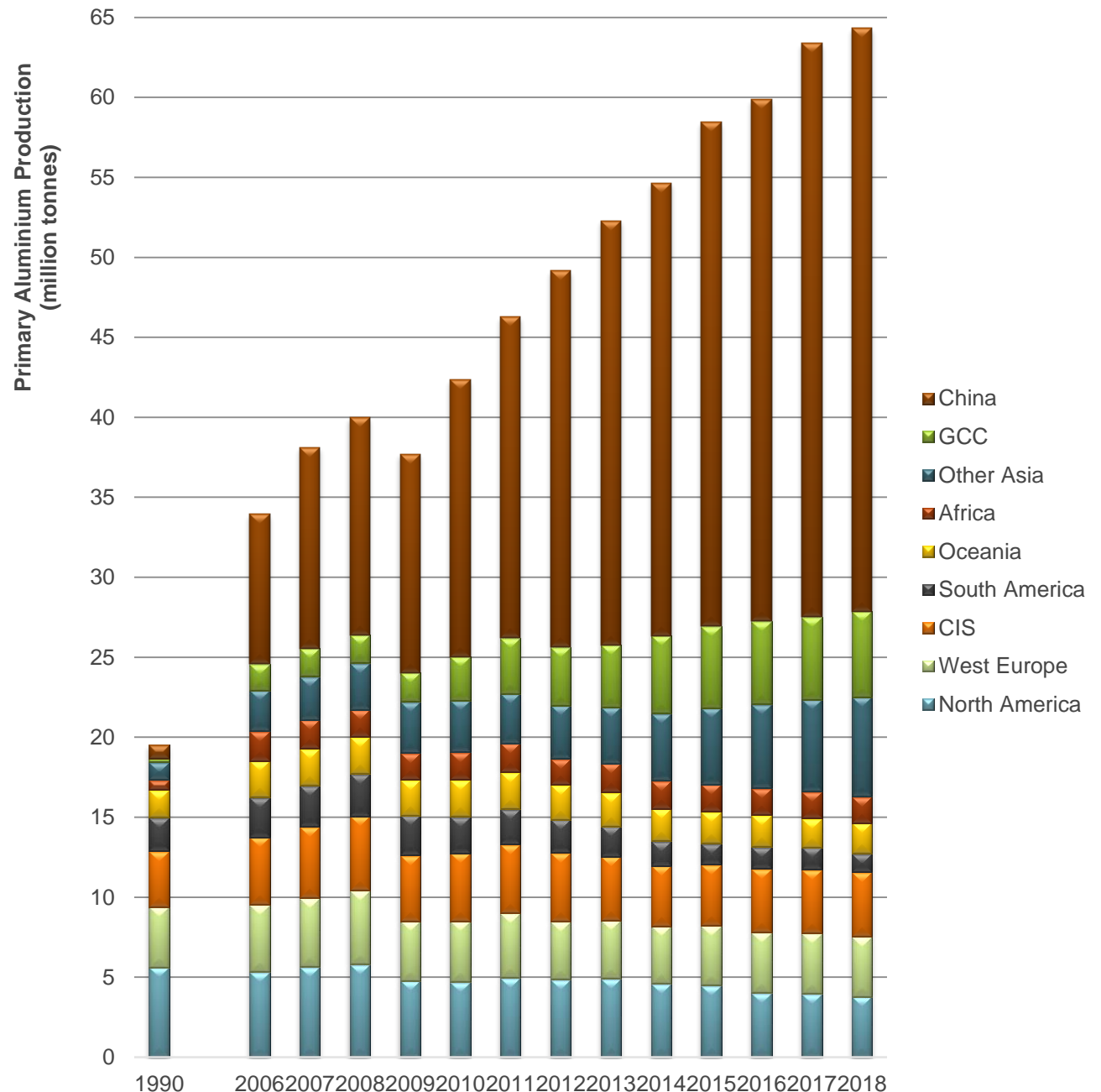
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INDUSTRY SUMMARY

Industry Trend

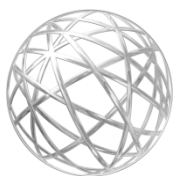
- Growth in primary aluminium production continues to be driven by countries in Asia, particularly China;
- 2018 global primary aluminium production is over 64 million tonnes, and China has contributed about 57%;
- Among all technologies, PFPB kept increasing and the rest were decreasing.



2018 ANODE EFFECT SURVEY

Survey Methodology

- The IAI Anode Effect Survey requests all aluminium smelting facilities to report data by potline (where possible), via IAI member companies, direct correspondence with non-member producers and regional industry associations. The reporting form and guidelines (*PFC001*) can be found from the IAI website (http://www.world-aluminium.org/media/filer_public/2018/07/31/pfc001_version2018.xls).
- Data calculation follows 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Volume 3, Chapter 4, Section 4.4 --- Primary Aluminium Production, (http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf)
- Carbon dioxide equivalent (CO₂e) emissions for survey participants are calculated by multiplying the total tonnes of each PFC component gas by the Global Warming Potential (GWP) values reported in the IPCC 4th Assessment Report (i.e. 7,390 for CF₄ and 12,200 for C₂F₆).



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2018 Anode Effect Survey participation by technology

TECHNOLOGY	2018 primary aluminium production (1,000 tonnes)	2018 production represented in survey (1,000 tonnes)	2018 participation rate by production	
CWPB	843	431	51%	
PFPB (Rest of World)	23,560	17,711	75 %	34%
PFPB (China)	36,485	0	0 %	
SWPB	401	401	100 %	
VSS	2,973	2,973	100 %	
HSS	73	73	100 %	
All Technologies (excluding China)	27,851	21,590	78 %	
All Technologies (Including China)	64,336	27,955	43 %	

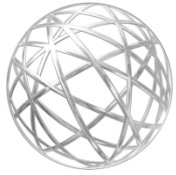
Note: any inconsistencies due to rounding

Perfluorocarbon emission results from facility data reporting to the 2018 Anode Effect Survey

Technology	IPCC Tier	No. of reporting entities	Reported production (kt Al)	Total CF ₄ emissions (Gg CF ₄)	Total C ₂ F ₆ emissions (Gg C ₂ F ₆)	Median CF ₄ intensity (kg CF ₄ /t Al)	Median C ₂ F ₆ intensity (kg C ₂ F ₆ /t Al)	Mean C ₂ F ₆ : CF ₄ weight ratio	IPCC 4 th GWP		
									Total PFC emissions (kt CO ₂ e)	Median PFC intensity (t CO ₂ e/t Al)	Mean PFC intensity (t CO ₂ e/t Al)
CWPB	2	2	431	0.009	0.001	0.020	0.002	0.12	83	0.18	0.19
	3	0									
PFPB	2 Slope	51	6,574	0.142	0.016	0.018	0.002	0.10	2,834	0.15	0.16
	3 Slope	36	7,305	0.114	0.011						
	2 OV	11	2,203	0.051	0.005						
	3 OV	6	1,629	0.021	0.002						
SWPB	2	1	40	0.008	0.002	0.188	0.047	0.34	1,077	1.96	2.68
	3	2	361	0.086	0.030						
VSS	2	2	65	0.009	0.0005	0.078	0.004	0.06	1,700	0.64	0.57
	3	68	2,908	0.199	0.013						
HSS	2	0				0.069	0.005	0.070	40	0.57	0.55
	3	4	73	0.005	0.0003						
ALL	-	183	21,590	0.662	0.082	-	-	0.12	5,733	-	0.21

Note: any inconsistencies due to rounding

GLOBAL EMISSIONS ESTIMATIONS



Estimation of Emissions from Non-reporting Facilities

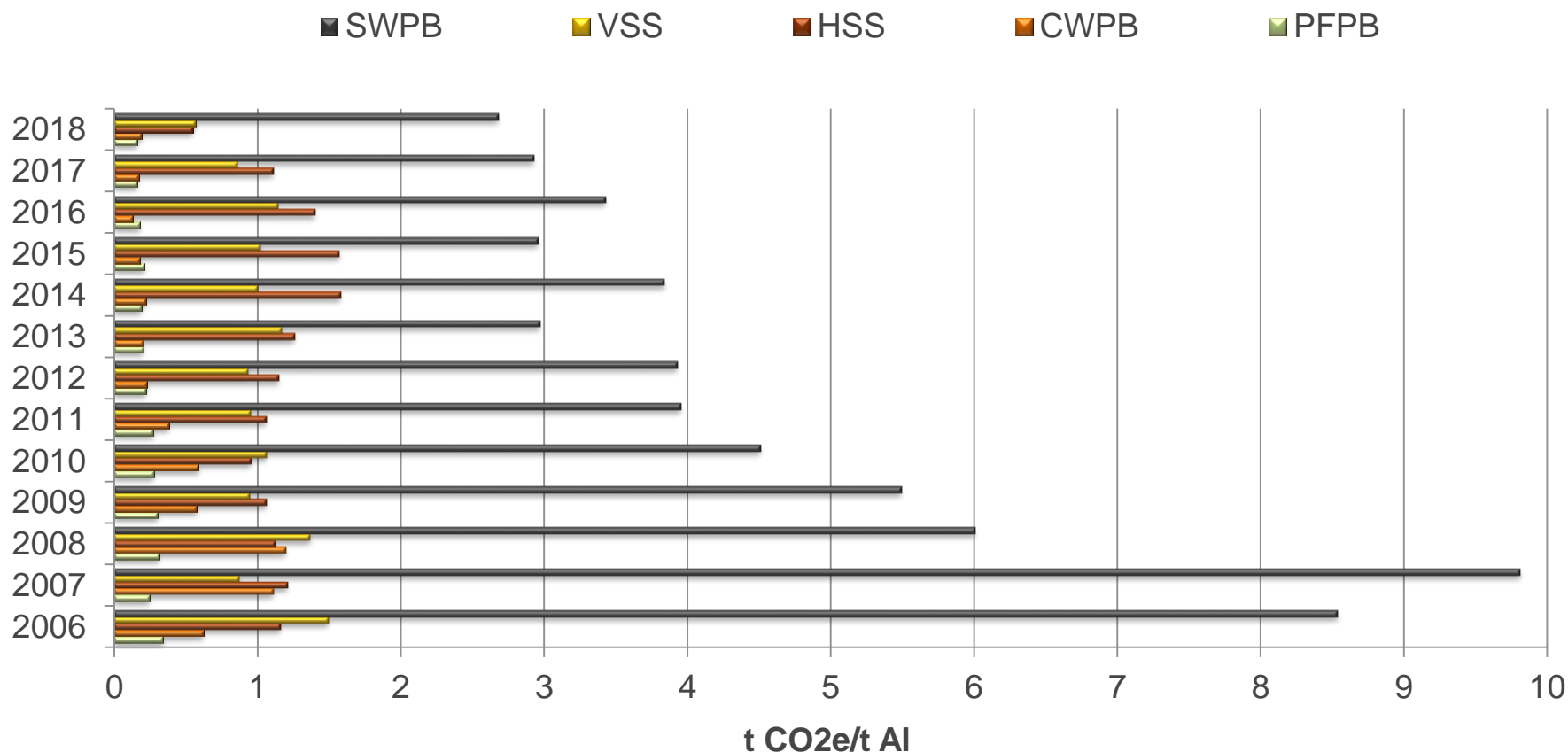
China

- Latest measurement (2008-2013) of PFC emissions at 27 PFPB facilities in China is adopted
- Median emission factor = 0.80 t CO₂e /t Al
- CF₄ median = 0.100 kg/t Al;
- C₂F₆:CF₄ weight fraction = 0.046

Rest of World

- Median PFC emissions performance per technology from the survey result is applied to non-reporting production by technology

Median PFC emission rates (as CO₂e) of reporting entities, per technology, 2006-2018



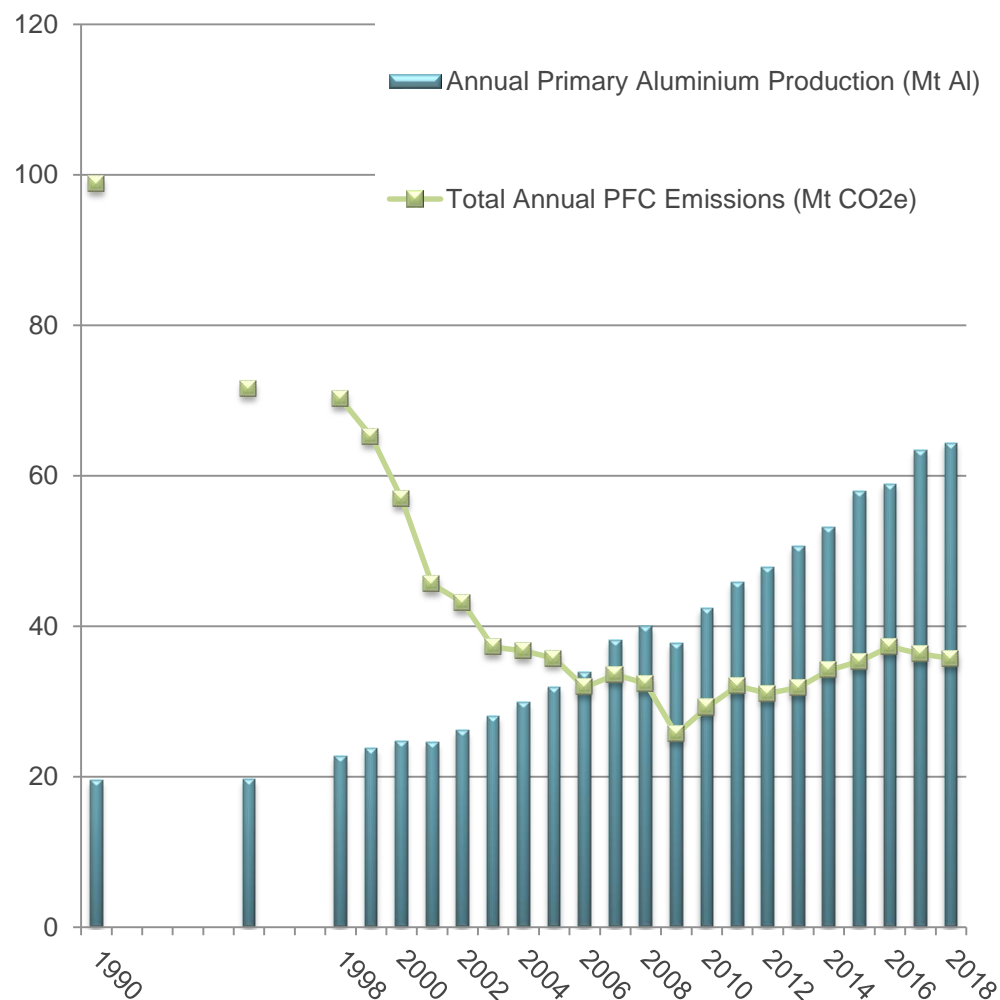
Total global 2018 PFC emissions

	Total PFC emissions (1,000 t CO ₂ e)	Total aluminium production (1,000 tonnes)	PFC emission factor (t CO ₂ e/t Al)
			IPCC 4 th GWP
Reported	5,733	21,590	0.27
Calculated from non-reporters	29,972	42,746	0.70
TOTAL GLOBAL	35,706	64,336	0.55

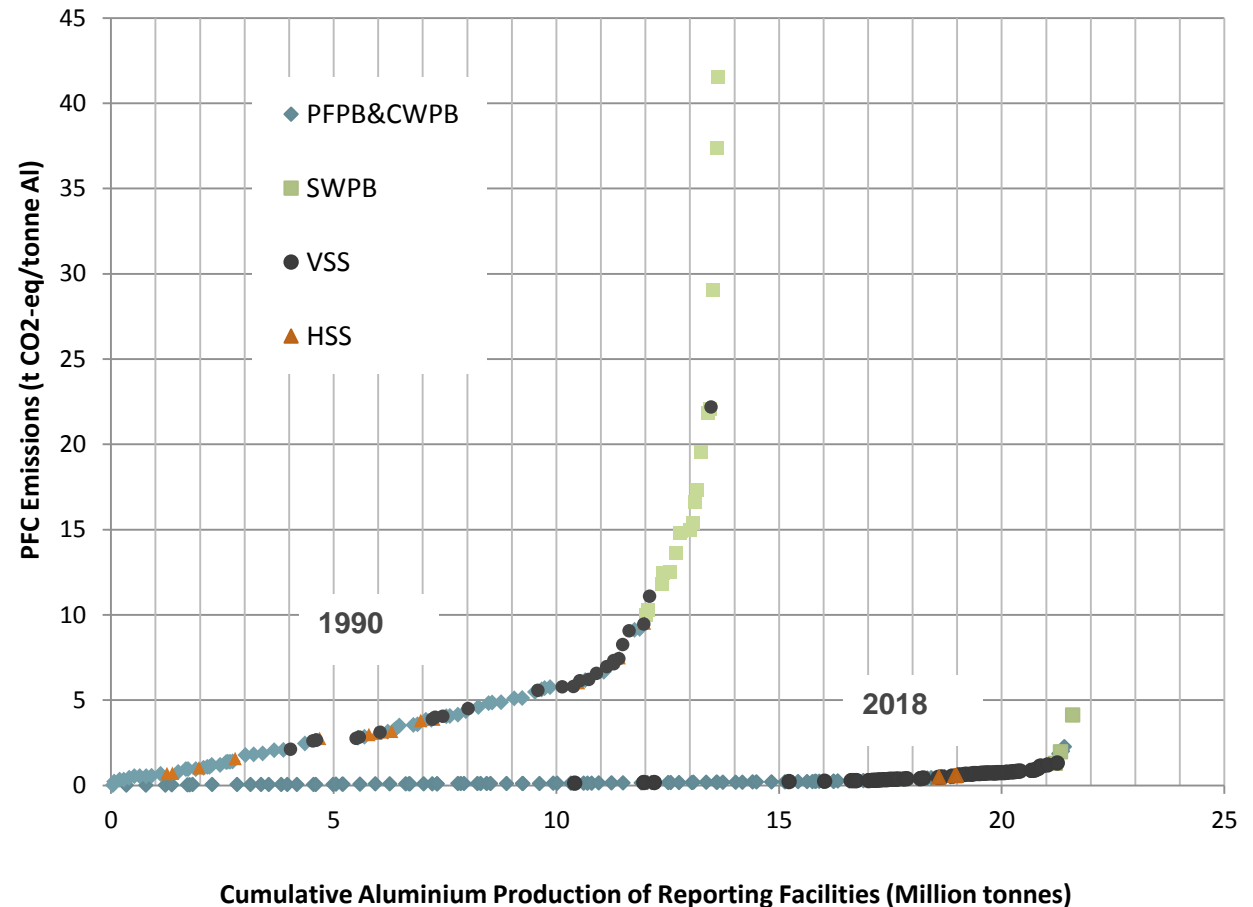
CONCLUSION

With PFC emissions per tonne cut by nearly 90% since 1990 and primary aluminium production having grown by over 200% over the same period, absolute emissions of PFCs by the aluminium industry have been reduced from approximate 100 million tonnes of CO₂e in 1990 to 36 million tonnes in 2018, a fall of nearly 65%.

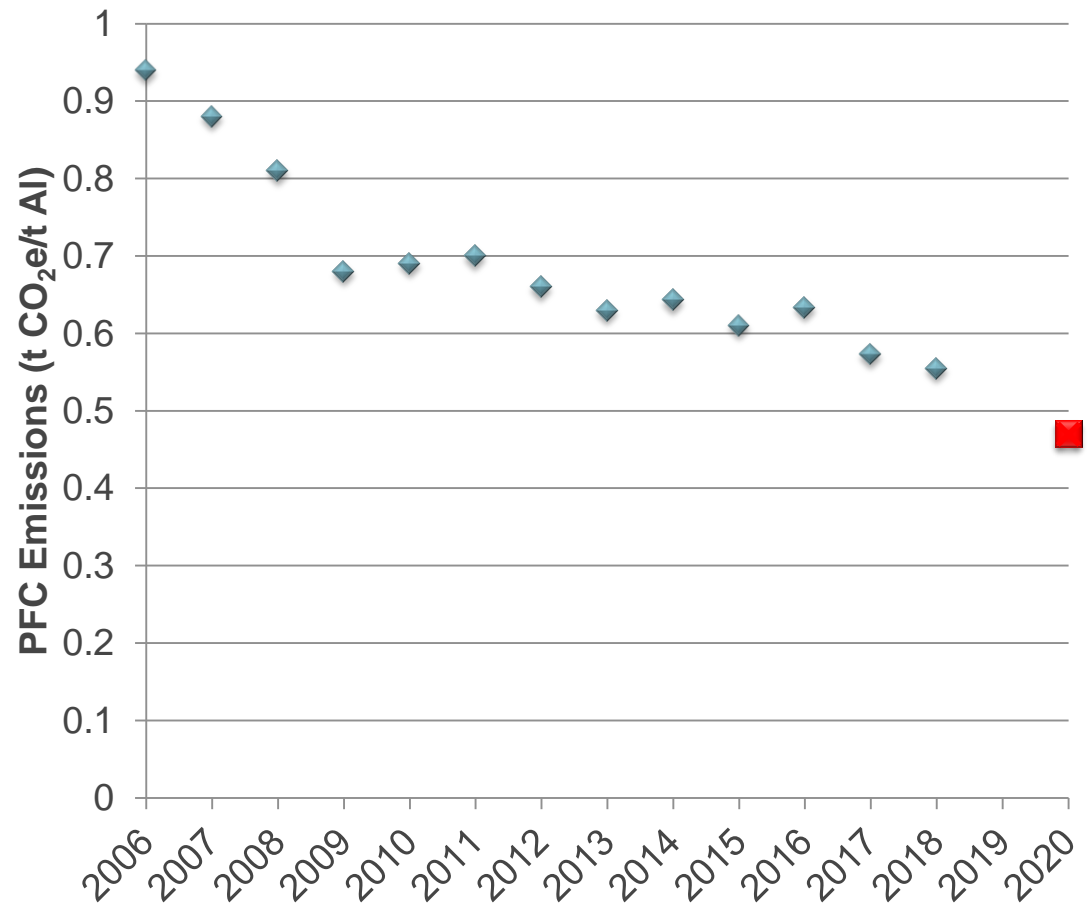
An increase in total emission estimates since 2009, however, reflects the growth in Chinese PFPB production. This has a high uncertainty given the low number of emission measurements (27 facilities) on which a Chinese average is based.



Taking the 1990 reporting cohort and plotting it against 2018 data shows improvement both from existing facilities over this time but also, importantly, the positive contribution of new (predominantly PFPB) capacity added since 1990.



- Global PFC emissions (as CO₂e) per tonne of production have been reduced by nearly 40% since 2006, by nearly 90% since 1990
- The global PFC emission intensity remains stable since 2009 due to China, where emission intensity is based on an assumed average, majority of PFC emission is from this area, in correspondence to its significant aluminium production.
- Emissions from both HSS and VSS have reduced by over 40%, which have driven down 2018 global PFC emission intensity.



INTERNATIONAL ALUMINIUM INSTITUTE

3rd floor, 2 Duke Street

London SW1Y 6BN

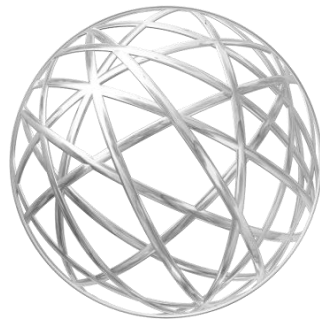
United Kingdom

Tel: + 44 (0) 20 7389 3828

Email: wu@world-aluminium.org

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