HFC Emissions Report for Ghana

Prepared under contract to UNDP for CCAC

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PROJECT OBJECTIVE

TO DEVELOP AN EMISSIONS MODEL FOR HFCs IN GHANA BASED ON INFORMATION AND MATERIALS GENERATED IN AN EARLIER COUNTRY REVIEW OF HFC CONSUMPTION.

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OUTLINE OF THE BASIC METHODOLOGY

The CCAC sponsored HFC Survey on the historic consumption of HFCs in Ghana and the predictions in growth in demand to 2020 has been used as the basis for the assessment of likely emission profiles. Annual demand within Ghana can be viewed as being consumed in either one of two ways:

1. Servicing demand to replace refrigerants and fire protection agents emitted during the year

or

2. Demand created by the installation of new products or equipment within the year

In practice, the amount of new product manufacture in Ghana is limited with most new products imported from elsewhere in either a charged or non-charged form. This has been reflected in the fact that year-on-year assessments of consumption have been more variable than in countries where there is a more established manufacturing base.

Nevertheless, for the purposes of this work, it has been assumed that the historic and projected consumption values for each HCFC and HFC (and blends thereof), as presented in the HFC Survey and its Supplement, are reliable. This sets a clear value on the sum of (1) + (2). Hence, the identification of leakage rates in each sub-sector will have an immediate bearing on the projected growth of the installed base, since diversion of consumption into servicing will result in lower allocations to new equipment and vice versa.

ANALYSIS OF CONSUMPTION AND DERIVATION OF EMISSIONS

The model to assess emissions of HFCs from various sources was developed by firstly generating an analysis of consumption patterns for each agent (whether an individual substance or a blend) by sub-sector of use. In the case of Ghana, this was derived from a series of publications as follows:

- HCFC Phase-out Management Plan for Ghana – March 2010

- Verification of HCFC Consumption and other HPMP Commitments (2010-2014) – July 2014
- Market penetration of Hydrofluorocarbon (HFC) Refrigerants in Ghana – March 2015
- Market penetration of Hydrofluorocarbon (HFC) Refrigerants in Ghana (Supplement) – April 2016

By combining the information from these four publications it proved possible to put together a time series for consumption of both HCFCs and HFCs. There were a few particularly notable points about the Ghanaian situation:

1. With only flexible foam manufacture in the country prior to the CFC phase-out, the implementation of the Montreal Protocol meant that the predominant use of HCFCs and, more latterly HFCs, is in the refrigeration and air conditioning (RAC) sector. This explains the focus of all the listed reports on the RAC sector.

2. Until 2012, used refrigerators could be imported into Ghana from Europe and elsewhere for re-use, leading to a varied and relatively uncontrolled combination of refrigerants within the domestic refrigeration sector. This changed in 2012 because of a ban on such imports, which was required to limit energy consumption in the country.

3. Ghana is unusual in that R-406A (a blend of HCFC-22 and HCFC-142b) has been a significant component of the mix of refrigerants used until significant reductions occurred around 2013. As of 2009 it represented 39% of Ghana's refrigerant imports. As of 2014, R-406A was estimated to represent just over 10% of the country's overall refrigerant bank.

The categories of refrigerant use across the RAC sector were once again slightly different than for other countries leading to the need to develop the following reallocation for consistency:

		HPMP: Data Collection & Surveys - Table 3.5				*HFC Supplement Table 5.3*
Refrigeration	Domestic					Domestic Refrigeration
	Commercial	Light commercial Refrigeration/AC - 50%	34.73%	35.42%		Commercial Refrigeration
		Cold Stores	0.70%			
	Industrial/Supermarkets	Industrial Refrigeration/AC	1.34%	1.34%		Industrial Refrigeration
	Transport	Road Transport Refrigeration/AC	0.64%	0.96%		
		Marine Refrigeration/AC	0.32%			
Air Conditioning	Stationary A/C	Chillers	0.73%	62.28%		Stationary A/C
		Residential Air Conditioning	25.81%			
		Light commercial Refrigeration/AC - 50%	34.73%			
		Commercial Air Conditioning	1.02%			
	Mobile Air Conditioning	Mobile Air Conditioning Manufacturing				MACs
	Other A/C					

Table 1 – Allocation of RAC sub-sectors to standardized format

Picking up on the specific use of R-406A in Ghana, the following table illustrates the areas of use:

Kg						Consumption of Gas by Sector - R406A									
		%	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Total Consumption			120,000	916,400	181,500	220,200	208,600	89,500	85,025	80,774	76,735	72,898	69,253	65,791	62,501
Growth Rate				*664%*	*-80%*	*21%*	*-5%*	*-57%*	*-5%*	*-5%*	*-5%*	*-5%*	*-5%*	*-5%*	*-5%*
Refrigeration	Domestic	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	Commercial	35%	42,504	324,589	64,287	77,995	73,886	31,701	30,116	28,610	27,180	25,821	24,530	23,303	22,138
	Industrial/Supermarkets	1%	1,608	12,280	2,432	2,951	2,795	1,199	1,139	1,082	1,028	977	928	882	838
	Transport	1%	1,152	8,797	1,742	2,114	2,003	859	816	775	737	700	665	632	600
Air Conditioning	Stationary A/C	62%	74,736	570,734	113,038	137,141	129,916	55,741	52,954	50,306	47,791	45,401	43,131	40,974	38,926
	Mobile Air Conditioning	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	Other A/C	0%	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2 – Predominant use of R-406A in the Commercial Refrigeration and Stationary A/C sectors

As noted in an earlier section of this Report, annual imports of refrigerants have been fairly erratic, leading to substantial fluctuations which are difficult to interpret year-on-year. In view of the relatively emissive nature of the RAC sector overall, these trends are also reflected in the annual emissions estimates in the graphs that follow, although it is doubtful whether these fluctuations are real, since the installed equipment base will not have varied in that manner. It is likely that the amounts listed in the various reports as consumption are effectively "imports minus exports" as defined under the Montreal Protocol and do not take account of variables such as changes in stock levels.

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In a second step dealing with emissions, the consumption by agent (substance or blend) as set out by example in Table 2 was then transposed to an analysis by sub-sector, which then assembled the different agents used and the emission factors related to each of those sub-sectors. In some instances, where there was evidence of a potential reduction in emission rates over time, this was factored into the modelling of emissions, as shown in Table 3 below.

Sub-Sector	*Annual Emission Rate*	*Growth in Installed Base (2008-2020)*
Refrigeration – Domestic	1%	363%
Refrigeration – Commercial	25% reducing to 19%	43%
Refrigeration – Industrial	20%	148%
Refrigeration – Transport	40%	-6%
Stationary A/C	10%	67%
Mobile A/C	25%	270%

Table 3 – Adopted IPCC Annual Emission Rates and resulting Growth in Installed Bases

The growth in the installed base of HFC-134a refrigerant in domestic refrigerators arises from the fact that the penetration of domestic refrigerator ownership within Ghana in 2008 was only around 20.1% and is expected to increase substantially in the period to 2020 amongst the 5.5-6 million households.

INSTALLED BASES BY SUB SECTOR AND RESULTING EMISSIONS

Since it is not only emissions from the current year's consumption that need to be considered, focus was also placed on the determination of actual banks of agents in 2008. In this respect, the analysis was helped by information on the installed banks of refrigerant. However, this was not always linked to the number of equipment units, making the assessment of average charges difficult. Average charges depend heavily on the mix of equipment covered in each category and this was not always clear from the categories used (e.g. from Table 3.5. of the 2010 HPMP Report). There are hence discrepancies on average charges used when compared with data from the 2005 IPCC/TEAP Special Report on Ozone and Climate (SROC):

Sub-Sector	*2008 Installed Base (Units)*	*Average Charge (kg)*
Refrigeration – Domestic	1,135,290	0.1
Refrigeration – Commercial	605,200	1
Refrigeration – Industrial	522	30
Refrigeration – Transport	946	10
Stationary A/C	1,251,086	1.45
Mobile A/C	150,000	0.5

Table 4 – Installed Base assumptions and average agent charges by sub-sector

Using this information in conjunction with the annual consumption data, it is possible to derive the trends in bank development over the period already shown in Table 3). Emissions assessments are also determined as shown in Table 5:

	Kg					Consumption of Gas by Sector - Refrigeration Commercial									
		%	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
	Total Consumption		147,502	497,685	290,141	260,011	241,736	210,175	175,814	181,793	178,136	173,560	166,773	162,079	157,745
				237%	*-42%*	*-10%*	*-7%*	*-13%*	*-16%*	*3%*	*-2%*	*-3%*	*-4%*	*-3%*	*-3%*
By Gas	HCFC-22	57%	93,721	159,000	208,234	159,992	105,587	130,735	124,198	117,989	112,089	106,485	101,160	96,102	91,297
	HCFC-141b	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-134a	8%	3,943	4,928	6,161	7,701	16,932	18,541	10,200	16,948	21,087	26,242	28,351	29,507	30,834
	R404A	6%	6,617	8,271	10,338	12,923	39,631	24,697	11,200	14,646	13,880	10,913	8,232	7,467	7,275
	R406A	28%	42,504	324,589	64,287	77,995	73,886	31,701	30,116	28,610	27,180	25,821	24,530	23,303	22,138
	R407C	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	R410A	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	R507A	1%	717	896	1,120	1,400	5,700	4,500	100	3,600	3,900	4,100	4,500	5,700	6,200
	R507C	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-125	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-227ea	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-152a	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-365mfc	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	Estimated Bank		605,200	601,402	951,743	1,013,465	1,035,312	1,038,926	1,015,342	967,781	941,501	921,922	906,488	891,964	880,109
	Cons as % Bank		24.37%	82.75%	30.49%	25.66%	23.35%	20.23%	17.32%	18.78%	18.92%	18.83%	18.40%	18.17%	17.92%
	Emissions Est.	25%	25%	25%	24%	24%	23%	23%	22%	22%	21%	21%	20%	20%	19%
	Addn to Bank		-3,798	350,341	61,722	21,847	3,615	-23,584	-47,561	-26,280	-19,579	-15,434	-14,524	-11,854	-9,476
		GWP													
Emissions	HCFC-22	1810	108,813	105,967	164,275	171,284	171,254	168,116	160,648	149,643	142,194	135,922	130,387	125,090	120,263
(kg)	HCFC-141b	730	0	0	0	0	0	0	0	0	0	0	0	0	0
	HCFC-142b	2310	17,382	16,927	26,241	27,361	27,356	26,855	25,662	23,904	22,714	21,712	20,828	19,982	19,211
	HFC-125	3500	5,252	5,115	7,929	8,268	8,266	8,115	7,754	7,223	6,863	6,561	6,294	6,038	5,805
	HFC-134a	1430	12,155	11,838	18,351	19,134	19,131	18,780	17,946	16,717	15,884	15,184	14,565	13,974	13,435
	HFC-143a	4470	6,002	5,845	9,061	9,448	9,446	9,273	8,861	8,254	7,843	7,497	7,192	6,900	6,633
	HFC-152a	124	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-227ea	3140	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-365mfc	782	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-32	675	0	0	0	0	0	0	0	0	0	0	0	0	0
All	$ktCO_2$-eq		299.70	291.86	452.45	471.76	471.67	463.03	442.46	412.15	391.64	374.36	359.12	344.53	331.23

Table 5 – Emissions derivation by gas for Commercial Refrigeration Sector in Ghana

MODELLED EMISSIONS

Using the information derived from the analysis set out above, Figures 1 & 2 show the HFC emissions projected by gas and by sector for Ghana. It is interesting to note that the two graphs are relatively flat, indicating that the growth of the equipment base in Ghana is expected to be more modest than in some other developing countries (e.g. Bangladesh). The growth can therefore be somewhat offset by the anticipated improvement in leakage rates in the commercial refrigeration sector. In comparing the HFC emissions with the on-going HCFC emissions (see appendix), it is also interesting to note that HCFC sources are expected to emit more than HFC sources through to 2019. This reflects the substantial HCFC-22 and R-406A used in the period prior to 2013.

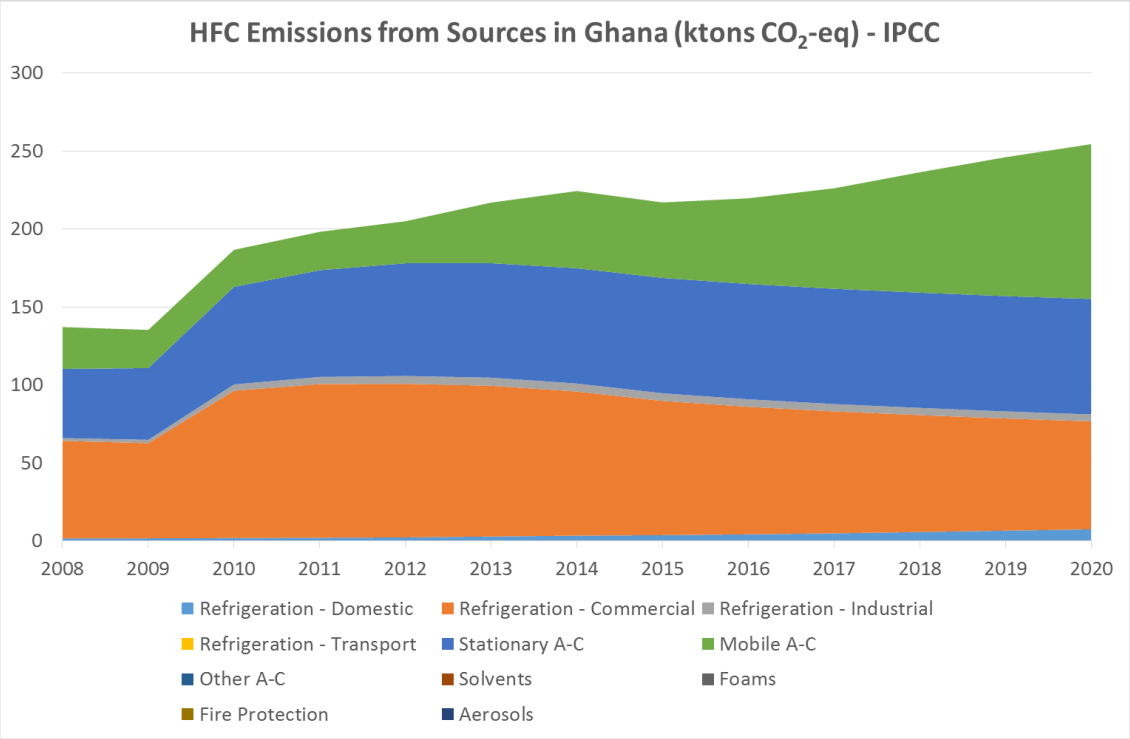

Figure 1 – Growth in HFC Emissions in Ghana from the RAC sector

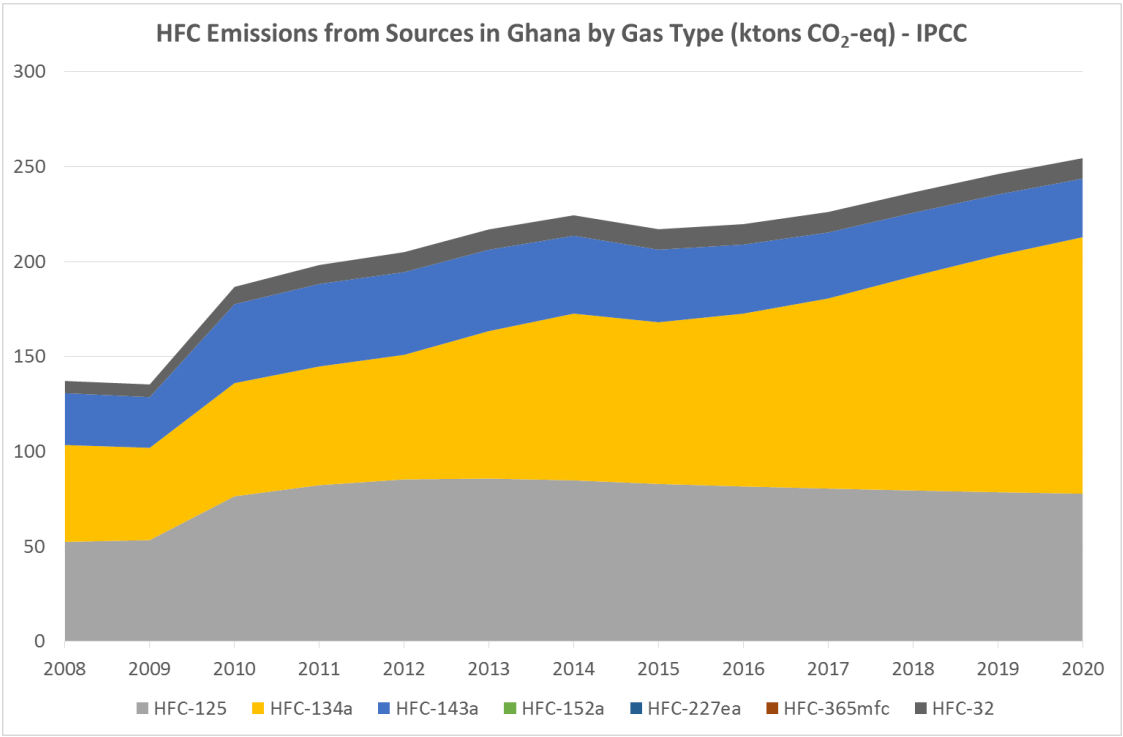

Figure 2 – Growth in HFC Emissions in Ghana by gas from the RAC sector

LIMITATIONS OF ANALYSIS

The emissions forecasts for this assessment have not been extended beyond 2020 in the absence of annual consumption projections beyond that date. Since a proportion of future annual emissions will always be dependent on the consumption in the same year, it seemed inappropriate to assign beyond the constraints of the respective HFC Surveys and related sources.

HCFC emissions have been omitted from this Report in line with the sponsor's scope of assessing HFC emissions only. However, since HCFC's are being replaced, there should be a commensurate reduction in HCFC emissions over time. Accordingly, these are aggregated into the analysis within the graphs included in Annex 1.

CONCLUSIONS

The assessment of annual trends in HFC emissions for Ghana has proved possible based on the availability of the CCAC HFC Survey (March 2015) and its Supplement (April 2016) in combination with earlier HCFC reports. The approach adopted has assumed that the annual consumption figures reported by HFC Survey and the installed based reported in the 2011 HCFC Report are reliable, although there is some concern that annual fluctuations might have reflected varying 'in country' stock levels.

Although there was good information on installed banks of refrigerant, it proved quite difficult to link these to the installed equipment base because of the lack of information on average charge sizes. The situation was exacerbated by the range of equipment types included within the RAC categories of the 2010 HPMP Report (Table 3.5). Nevertheless, the overall findings of this analysis are believed to be relatively robust.

Paul Ashford – Anthesis-Caleb, July 2016

Annex 1 – Graphs inclusive of HCFC emissions

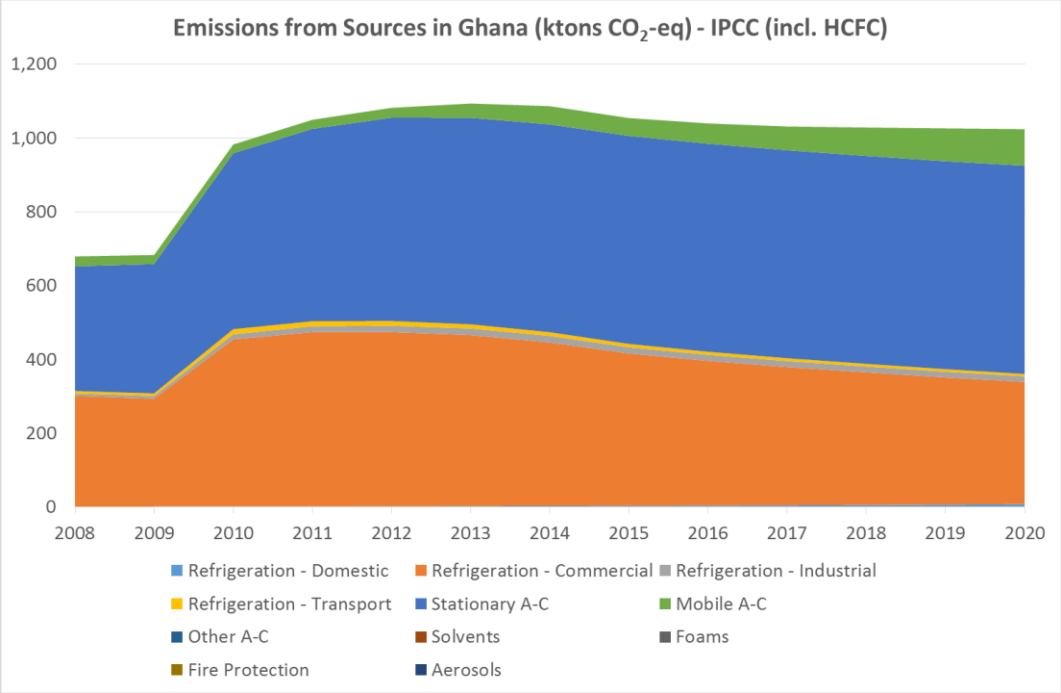

Figure A1 – Emissions from Sources in Ghana based on IPCC Emission Rates (incl. HCFCs)

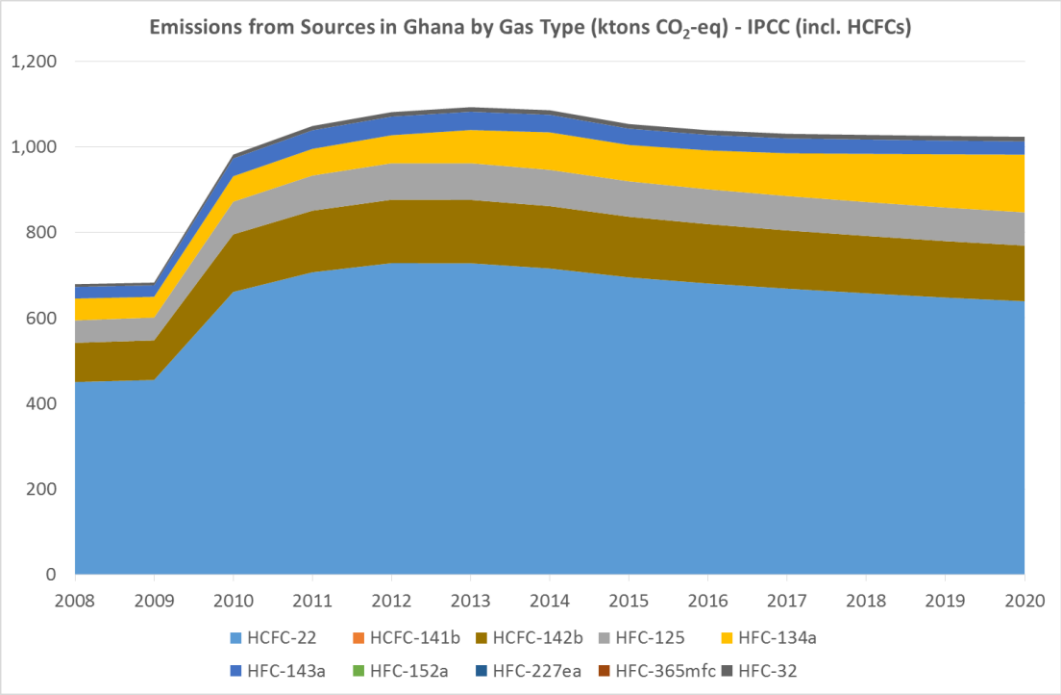

Figure A2 – Emissions by Gas Type in Ghana based on IPCC Emission Rates (incl. HCFCs)