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HFC Emissions Report for Nigeria

Prepared under contract to UNDP for CCAC

PROJECT OBJECTIVE

TO DEVELOP AN EMISSIONS MODEL FOR HFCs IN NIGERIA 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 Inventory Report on the historic consumption of HFCs in Nigeria and the predictions in growth in demand to 2017 have been used as the basis for the assessment of likely emission profiles for the country. Annual demand within Nigeria 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

All demand for sectors such as foam will fall into the 'new product' category, since no servicing of foam products takes place once installed. However, the split between (1) and (2) for refrigerants and fire protection agents will depend on the balance between annual leakage rates by sector and the growth in the overall installed base of relevant equipment.

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 Report and the Nigerian HPMP, 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 in Nigeria 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 Nigeria, this was derived from two primary publications as follows:

- UNDP's Work Programme for 2014 (detailing Nigeria's Stage 2 HPMP) – May 14
- Inventory of Hydrofluorocarbons (HFCs) in Nigeria – March 2015 (revised October 2015)

Having access to the 2014 UNDP Work Programme was important in that it provided additional information on the refrigeration and air conditioning (RAC) sub-sectors prevalent in Nigeria. Although there was some limited qualitative information on those sub-sectors served by HFC blends in the HFC Inventory Report, there was little clarity on the following:

1. Quantitative assessment of refrigerant use at the sub-sector level
2. Extent of consumption for new equipment manufacture versus servicing.
3. Specificity about the range of HFC blends used in Nigeria (collectively referred to in the Inventory as 'HFC Mixtures')
4. The size of HCFC/HFC banks contained in installed equipment in Nigeria

The 2014 UNDP Work Programme, drawing as it does on the Nigerian HPMP, provided particular information on (1) and (2), as well as giving some further guidance on (3). What became obvious from the 2014 Work Programme was:

- The structure of the RAC sector in Nigeria is relatively simple with limited ranges of refrigerants available for the sub-sectors in question. The two main non-HCFC refrigerants in use are HFC-134a and R-410A, with some additional use of R-407C.

- There is some activity in the manufacture of RAC equipment in Nigeria with commercial refrigeration and stationary air conditioning equipment being the primary outputs.

- There is a significantly developed foam sector in Nigeria with PU Spray Foam being one of the significant consumers of HCFC-141b. Although alternatives are yet to be finalized, they are assumed to be non-HFC (methyl formate, methylal, CO_2 and HFOs all being considered). The annual emission rate for the foam sector was increased from 4% to 8% to reflect this Spray Foam activity

The absence of good information on the breadth of use of specific HFC mixtures in the various RAC sub-sectors meant that a proxy was necessary for Nigeria. Given the geographic proximity of Ghana to Nigeria and the similarities in both climate and economic leverage, it was decided to use the sub-sectoral split for Ghana as the basis for the sub-sectoral split in Nigeria, where no better information was forthcoming. This should be a matter for further study and analysis as information on the Nigerian situation becomes more readily available.

The outcome of this approach is seen for the use of HFC-134a in the RAC sector in Nigeria:

	Kg						Consumption of Gas by Sector - HFC134a									
			%	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
	Total Consumption			590	48,530	683,400	589,470	789,870	671,030	118,470	428,350	338,400	267,330	211,191	166,841	131,804
	Growth Rate				*8125%*	*1308%*	*-14%*	*34%*	*-15%*	*-82%*	*262%*	*-21%*	*-21%*	*-21%*	*-21%*	*-21%*
Sector	Refrigeration	Domestic	36%	213	17,539	246,987	213,040	285,466	242,516	42,816	154,809	122,301	96,615	76,326	60,298	47,635
		Commercial	16%	92	7,580	106,749	92,076	123,379	104,816	18,505	66,909	52,859	41,758	32,988	26,061	20,588
		Industrial/Supermarkets	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
		Transport	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	Air Conditioning	Stationary A/C	0%	1	74	1,047	903	1,210	1,028	181	656	518	409	323	255	202
		Mobile Air Conditioning	48%	284	23,336	328,618	283,451	379,815	322,670	56,967	205,975	162,722	128,548	101,553	80,227	63,379
		Other A/C	0%	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2 – Distribution of HFC-134a use in Nigeria based in patterns of use in Ghana

It is also noted that projections of future consumption were only made in the HFC Inventory Report through to 2017. For consistency with the analyses from other countries, these were extrapolated at the same rate of growth to 2020, as seen for HFC-134a in Table 2. The only exception to this was the case of HFC mixtures (notably R-401A and R407C) where the rate of growth between 2016 and 2017 was 59%. In this case, the growth rates were curtailed for each successive year to 40%, 20% and 10% respectively.

The HFC Inventory Report itself addresses some of the fluctuations in annual consumption seen for both HFC-134a and HFC mixtures and speculates on some of the regulatory and economic drivers (i.e. price) that might have led to stockpiling in certain years. Indeed, that Report provides a revised consumption time series for HFC-134a which is also adopted for this work. Even then, there are still some significant fluctuations to accommodate, especially in the time series for HFC mixtures.

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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%	144%
Refrigeration – Commercial	25% reducing to 19%	7%
Refrigeration – Industrial	20%	-11%
Refrigeration – Transport	40%	-6%
Stationary A/C	10%	187%
Mobile A/C	25%	27%
Foam	8%	23%

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

INSTALLED BASES BY SUB SECTOR AND RESULTING EMISSIONS

The absence of information on installed bases in Nigeria was partially compensated for by information from the 2014 UNDP Work Programme on the split between the new manufacture and servicing sectors. From knowledge of the servicing demand and annual emissions rates it was possible to derive the likely size of the installed base at 2008. In some cases (e.g. domestic refrigeration), it was also possible to use other sources, such as a published 'Survey of the Nigerian Middle Class' (2011) to gain complementary source information on matters such as refrigeration ownership. In the case of Nigeria, this was seen as pretty high (82%) amongst those middle classes. However, this group was seen to only represent about 23% of the total Nigerian population of 177 million. When considering future market growth in Nigeria, much depends on the likely future social mobility of the remaining 77% of the population, but this is seen as limited in the period to 2020, which explains the relatively low growths in installed bases shown in Table 3

In addition to the growth in installed bases, emissions assessments are also determined for each sector of use as shown in Table 4 for domestic refrigerators:

	Kg					Consumption of Gas by Sector - Refrigeration Domestic									
		%	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
	Total Consumption		213	17,539	246,987	213,040	285,466	242,516	42,816	154,809	122,301	96,615	76,326	60,298	47,635
				8125%	*1308%*	*-14%*	*34%*	*-15%*	*-82%*	*262%*	*-21%*	*-21%*	*-21%*	*-21%*	*-21%*
By Gas	HCFC-22	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	HCFC-141b	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-134a	100%	213	17,539	246,987	213,040	285,466	242,516	42,816	154,809	122,301	96,615	76,326	60,298	47,635
	R404A	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	R406A	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	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	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	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		945,243	936,004	944,183	1,181,728	1,382,951	1,654,587	1,880,557	1,904,568	2,040,332	2,142,229	2,217,422	2,271,574	2,309,156
	Cons as % Bank		0.02%	1.87%	26.16%	18.03%	20.64%	14.66%	2.28%	8.13%	5.99%	4.51%	3.44%	2.65%	2.06%
	Emissions Est.		1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%
	Addn to Bank		-9,239	8,179	237,545	201,222	271,637	225,970	24,011	135,764	101,897	75,193	54,152	37,582	24,544
		GWP													
Emissions	HCFC-22	1810	0	0	0	0	0	0	0	0	0	0	0	0	0
(kg)	HCFC-141b	730	0	0	0	0	0	0	0	0	0	0	0	0	0
	HCFC-142b	2310	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-125	3500	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-134a	1430	9,452	9,360	9,442	11,817	13,830	16,546	18,806	19,046	20,403	21,422	22,174	22,716	23,092
	HFC-143a	4470	0	0	0	0	0	0	0	0	0	0	0	0	0
	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		13.52	13.38	13.50	16.90	19.78	23.66	26.89	27.24	29.18	30.63	31.71	32.48	33.02

Table 4 – Emissions derivation by gas for Domestic Refrigeration Sector in Nigeria

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 Nigeria. As with Ghana, the growth rates in emissions are relatively modest, reflecting the enduring challenges in Africa for inward investment.

The emissions forecasts have used the 2006 IPCC Reporting Guidelines as sources for the emissions factors applied, with the exception of the foam sector where a composite figure has been used – suitably adjusted for the prevalence of PU Spray Foam in Nigeria. The other contributing factor to foam emissions that has not been considered in this assessment is the import of pre-blended polyols into the country. Although these are understood to be significant in volume, they will primarily be used in closed cell foam applications which will be relatively slow emitters. As a result, the impact on overall emission levels through to 2020 is expected to be limited.

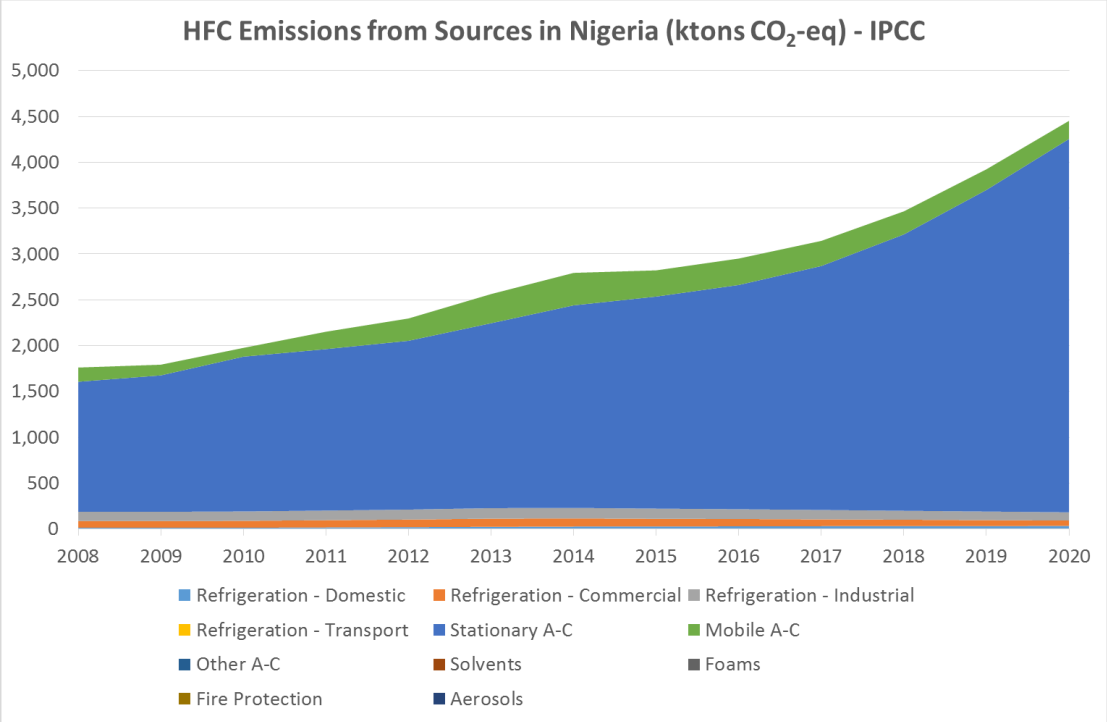

Figure 1 – Growth in HFC Emissions in Nigeria from a range of sectors

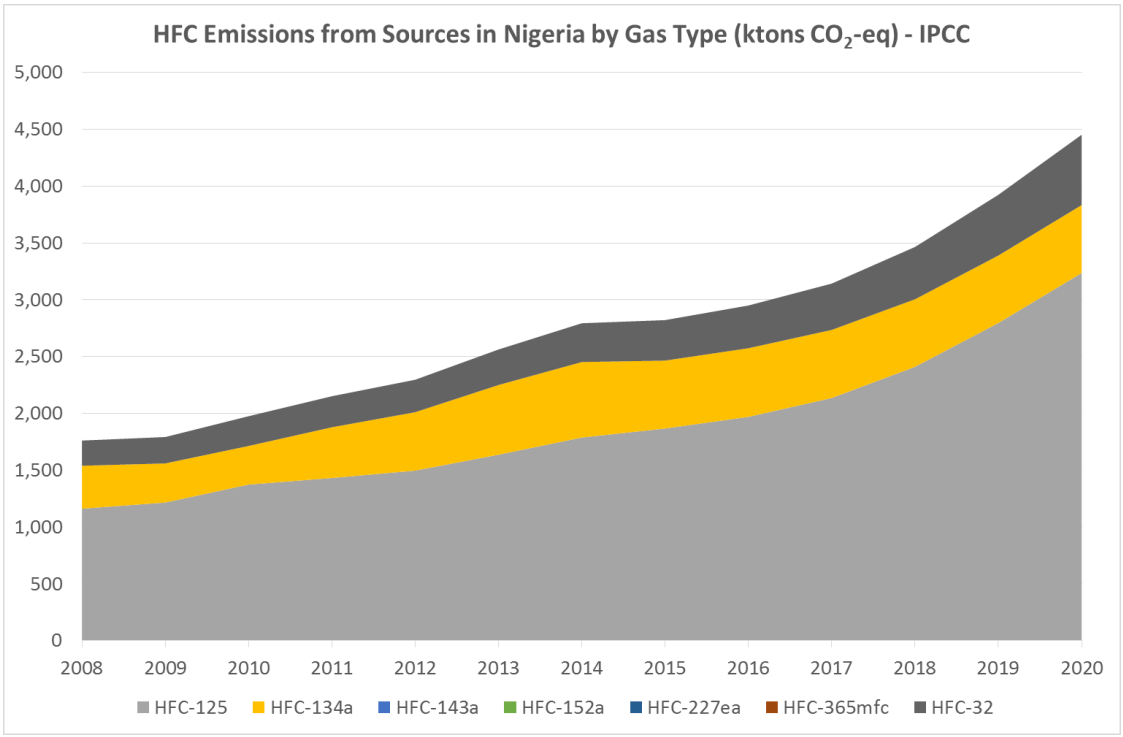

Figure 2 – Growth in HFC Emissions in Nigeria by gas

LIMITATIONS OF ANALYSIS

The emissions forecasts for this assessment have been projected to 2020 for consistency with other country-level assessments despite the absence of annual consumption projections for the period beyond 2017. The data gap has been filled by extrapolating from growth rates in the 2016-2017 period where those growth rates are seen to be reliable. In other cases (e.g. for HFC blends), expert judgement is applied to the extrapolation process.

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 Nigeria has proved possible, but more challenging than most other countries owing to the lack of availability of quantitative information on the use patterns of refrigerants at the RAC sub-sector level. Nevertheless, based on the availability of the HFC Inventory Study (2015) and the 2014 UNDP Work Programme, it has been possible to develop an appropriate model for emissions forecasting purposes. The approach adopted has assumed that the annual consumption figures reported in both documents are reliable, although there is some concern that annual fluctuations might have reflected varying 'in country' stock levels.

The outcome of this work is that annual emissions of HFCs in Nigeria have been foreseen to grow from 1.76 MtonCO_2-eq. in 2008 to 4.45 MtonCO_2-eq. in 2020.

Paul Ashford – Anthesis-Caleb, July 2016

Annex 1 – Graphs inclusive of HCFC emissions

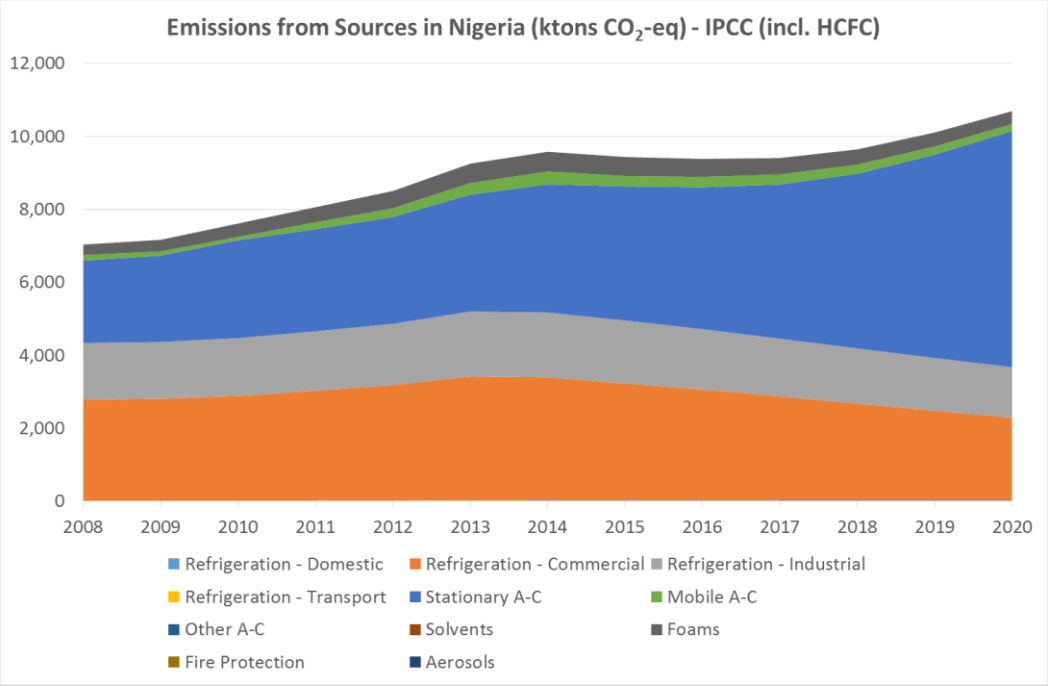

Figure A1 – Emissions from Sources in Nigeria based on IPCC Emission Rates (incl. HCFCs)

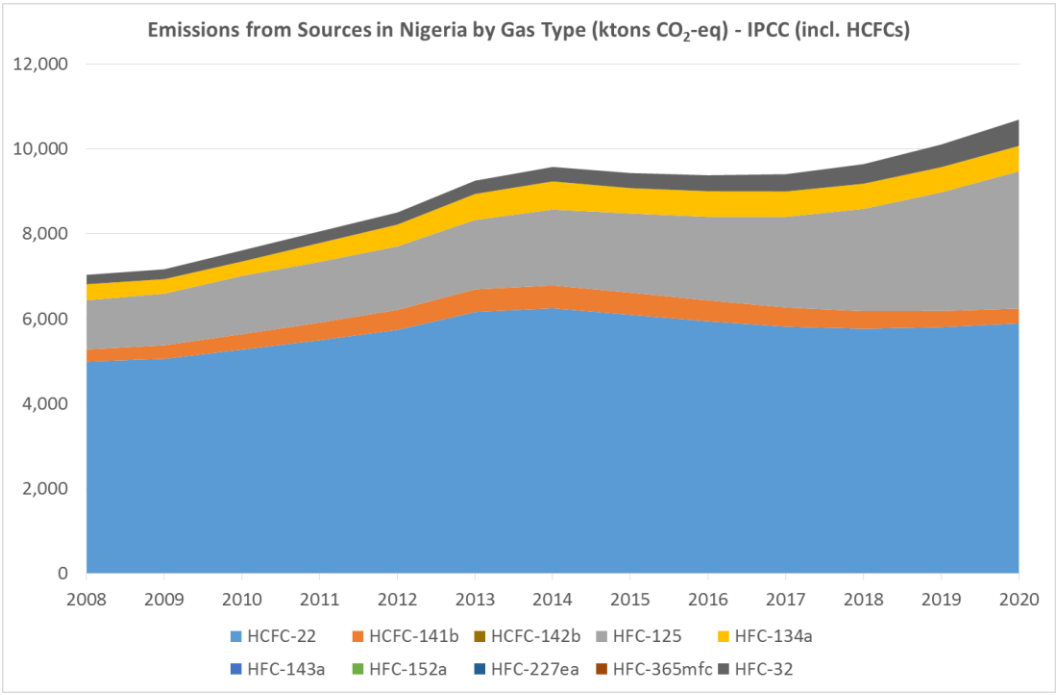

Figure A2 – Emissions by Gas Type in Nigeria based on IPCC Emission Rates (incl. HCFCs)