HFC Emissions Report for Bangladesh

Prepared under contract to UNDP for CCAC

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PROJECT OBJECTIVE

TO DEVELOP AN EMISSIONS MODEL FOR HFCs IN BANGLADESH 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 Bangladesh 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 Bangladesh 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 Survey, 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 Bangladesh, this was assisted not only by the HFC Survey itself (notably Tables 3.4 and 3.5), but also from the HCFC Survey published back in 2011. The only area of information missing was the allocation of use of HCFC-22 in servicing by sub-sector. Since the annual demand for HCFC-22 servicing across the RAC sector was broadly equivalent to the demand for consumption in new equipment

in 2010, the servicing use patterns were assumed to follow those for new equipment. Projections through to 2020 were based on the comment in the HFC Survey Report that overall consumption of HFCs in Bangladesh was expected to rise by 100 tes/year.
Since the sub-sector allocations in Tables 3.4 and 3.5 did not align with each other or with those typically used in other countries, the following interpolation was used for the cross-reading of and subsequent aggregation of data.

		Table 3.5	*Table 3.4*
Refrigeration	Domestic	Domestic Refrigeration Manufacturing	Domestic Refrigeration
	Commercial		Commercial Refrigerator
			Cold Storage
	Industrial/Supermarkets	Commercial/Industrial Refrigeration Manufacturing	Supermarket/Shops (50%)
	Transport	Transport Refrigeration Manufacturing	Sea-going vessels
			Reefer/Container etc.
Air Conditioning	Stationary A/C	Industrial Air Conditioning (incl. chillers)	Domestic Air Conditioner
		Residential Air Conditioner Manufacturing	ATM Booths
		Commercial/Industrial Chiller Manufacturing	Mobile Phone Towers
			Supermarket/Shops (50%)
	Mobile Air Conditioning	Mobile Air Conditioning Manufacturing	Mobile Air Conditioner
	Other A/C		Industrial Air Conditioner
			Other Servicing
Solvents			
Foams			
Aerosols		Pharmaceutical Applications (MDIs)	
Fire Protection		Fire Extinguisher Manufacturing	Fire Extinguisher
Other Uses			

With HFC-134a being by far the largest element of consumption, the following table illustrates the consumption trends.

Kg						Consumption of Gas by Sector - HFC134a									
		%	***2008***	***2009***	***2010***	***2011***	***2012***	***2013***	***2014***	***2015***	***2016***	***2017***	***2018***	***2019***	***2020***
Total Consumption			162,611	203,264	254,080	317,600	373,803	479,550	572,229	664,908	757,588	850,267	942,946	1,035,625	1,128,304
Growth Rate				*25%*	*25%*	*25%*	*18%*	*28%*	*19%*	*16%*	*14%*	*12%*	*11%*	*10%*	*9%*
Refrigeration	Domestic	54%	87,045	108,806	136,007	170,009	200,094	256,700	306,311	355,921	405,532	455,142	504,753	554,363	603,974
	Commercial	2%	4,035	5,044	6,305	7,881	9,276	11,900	14,200	16,500	18,799	21,099	23,399	25,699	27,999
	Industrial/Supermarkets	1%	2,119	2,649	3,311	4,139	4,872	6,250	7,458	8,666	9,874	11,082	12,289	13,497	14,705
	Transport	3%	5,680	7,100	8,875	11,093	13,056	16,750	19,987	23,224	26,461	29,699	32,936	36,173	39,410
Air Conditioning	Stationary A/C	2%	3,055	3,819	4,774	5,967	7,023	9,010	10,751	12,493	14,234	15,975	17,716	19,458	21,199
	Mobile Air Conditioning	15%	23,702	29,628	37,035	46,294	54,486	69,900	83,409	96,918	110,427	123,936	137,445	150,954	164,464
	Other A/C	1%	2,235	2,793	3,492	4,364	5,137	6,590	7,864	9,137	10,411	11,684	12,958	14,232	15,505
Solvents		0%	0	0	0	0	0	0	0	0	0	0	0	0	0
Foams		0%	0	0	0	0	0	0	0	0	0	0	0	0	0
Aerosols		21%	34,740	43,425	54,281	67,851	79,858	102,450	122,250	142,050	161,849	181,649	201,449	221,249	241,048
Fire Protection		0%	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Uses		0%	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 1 – Consumption trends by sub-sector for HFC-134a (2008-2020)

Since consumption data was only available from 2011 to 2013 for HFCs, the prior years from 2008 were assumed to show a 25%/year growth rate for the period 2008 to 2011. In the case of Bangladesh, it is also interesting to note that a significant part of the HFC-134a demand was for metered dose inhalers (MDIs) which are manufactured 'in country', but will be bound for export in a number of instances. This is a factor which is taken up further when considering emissions arising from the reported consumption.

In the case of Bangladesh, there is a significant manufacturer of domestic refrigerators where the blowing agent of choice up until 2012 was HCFC-141b. As part of the HCFC Phase-out Management Plan (HPMP) for Bangladesh this has now been transitioned to cyclopentane, leading to the demand pattern shown in Table 2 below:

Kg						Consumption of Gas by Sector - HCFC-141b									
		%	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
Total Consumption			120,000	190,000	196,000	98,000	0	0	0	0	0	0	0	0	0
Growth Rate				*58%*	*3%*	*-50%*	*-50%*								
Refrigeration	Domestic	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	Commercial	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	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%	0	0	0	0	0	0	0	0	0	0	0	0	0
	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
Solvents		0%	0	0	0	0	0	0	0	0	0	0	0	0	0
Foams		100%	120,000	190,000	196,000	98,000	0	0	0	0	0	0	0	0	0
Aerosols		0%	0	0	0	0	0	0	0	0	0	0	0	0	0
Fire Protection		0%	0	0	0	0	0	0	0	0	0	0	0	0	0
Other Uses		0%	0	0	0	0	0	0	0	0	0	0	0	0	0

Table 2 – Consumption trends by sub-sector for HCFC-141b (2008-2020)

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In a second step dealing with emissions, the consumption by agent (substance or blend) as set out by example in Tables 1 and 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%	1,973%
Refrigeration – Commercial	25% reducing to 19%	276%
Refrigeration – Industrial	20%	55%
Refrigeration – Transport	40%	284%
Stationary A/C	10%	192%
Mobile A/C	25%	222%
Other A/C	10%	244%
Solvent	50% reducing to 26%	N/A
Foams	4%	80%
Aerosols (MDIs)	100%	594%
Fire Protection	5%	124%

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

The substantial growth in the installed base of HFC-134a refrigerant in domestic refrigerators arises from the fact that the penetration of domestic refrigerator ownership within Bangladesh in 2008 was only around 8.6% and is expected to increase substantially in the period to 2020, especially as a result of 'in country' manufacture.

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. To do this it is necessary to understand the size of that installed base of equipment and the related average charge of agent. In this respect, it was particularly helpful to find that the 2011 HCFC Report for Bangladesh provided some appropriate estimates of equipment charges. This was the coupled with information on average charges from the 2005 IPCC/TEAP Special Report on Ozone and Climate (SROC) to provide the following information for each subsector:

Sub-Sector	*2008 Installed Base (Units)*	*Average Charge (kg)*
Refrigeration – Domestic	1,720,000	0.1
Refrigeration – Commercial	4,500	7.5
Refrigeration – Industrial	25	2,400
Refrigeration – Transport	1,100	25
Stationary A/C	1,200,000	1.5
Mobile A/C	300,000	0.5
Other A/C	5,000	5
Solvent	N/A	N/A
Foams	1,720,000	0.2
Fire Protection	3,000	6

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 (see Table 3). Emissions assessments are also determined as shown in Table 5:

		%	*2008*	*2009*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*2020*
	Total Consumption		11,001	11,709	12,921	14,551	16,455	19,413	22,052	24,703	27,365	30,037	32,718	35,410	38,110
By Gas	HCFC-22	19%	6,145	5,639	5,334	5,067	4,814	4,573	4,344	4,127	3,921	3,725	3,538	3,361	3,193
	HCFC-141b	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-134a	65%	4,035	5,044	6,305	7,881	9,276	11,900	14,200	16,500	18,799	21,099	23,399	25,699	27,999
	R404A	9%	439	549	687	858	1,182	1,780	2,124	2,468	2,812	3,156	3,500	3,844	4,188
	R407C	0%	0	0	0	0	0	0	0	0	0	0	0	0	0
	R410A	6%	381	477	596	745	1,184	1,160	1,384	1,608	1,833	2,057	2,281	2,505	2,729
	R507A	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		33,750	36,314	39,126	42,657	47,184	52,786	60,322	69,104	78,949	89,735	101,376	113,819	127,034
	Cons as % Bank		32.60%	32.24%	33.02%	34.11%	34.87%	36.78%	36.56%	35.75%	34.66%	33.47%	32.27%	31.11%	30.00%
	Emissions Est.	25%	25%	25%	24%	24%	23%	23%	22%	22%	21%	21%	20%	20%	19%
	Addn to Bank		2,564	2,812	3,531	4,527	5,603	7,536	8,781	9,846	10,785	11,641	12,443	13,215	13,973
		GWP													
Emissions	HCFC-22	1810	1,645	1,734	1,830	1,954	2,115	2,315	2,587	2,896	3,232	3,586	3,952	4,326	4,704
(kg)	HCFC-141b	730	0	0	0	0	0	0	0	0	0	0	0	0	0
	HFC-125	3500	615	649	684	731	791	866	967	1,083	1,209	1,341	1,478	1,618	1,759
	HFC-134a	1430	5,500	5,800	6,121	6,534	7,074	7,742	8,651	9,685	10,807	11,991	13,217	14,468	15,734
	HFC-143a	4470	408	431	454	485	525	575	642	719	802	890	981	1,074	1,168
	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	270	284	300	320	347	379	424	475	530	588	648	709	771
All	$ktCO_2$-eq		15.00	15.82	16.70	17.82	19.29	21.12	23.60	26.42	29.48	32.71	36.05	39.46	42.91

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

MODELLED EMISSIONS

Using the information derived from the analysis set out above, Figures 1 & 2 show the emissions projected by gas and by sector based on the worst-case assumption that all aerosols (MDIs) produced in Bangladesh are used 'in country':

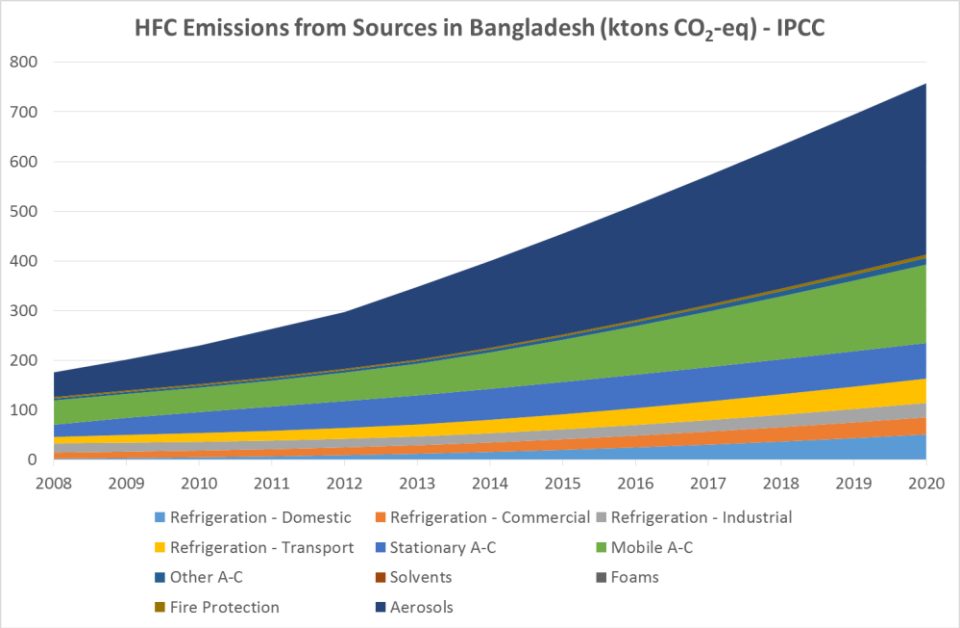

Figure 1 – Growth in HFC Emissions in Bangladesh by sector based on all MDI use 'in country'

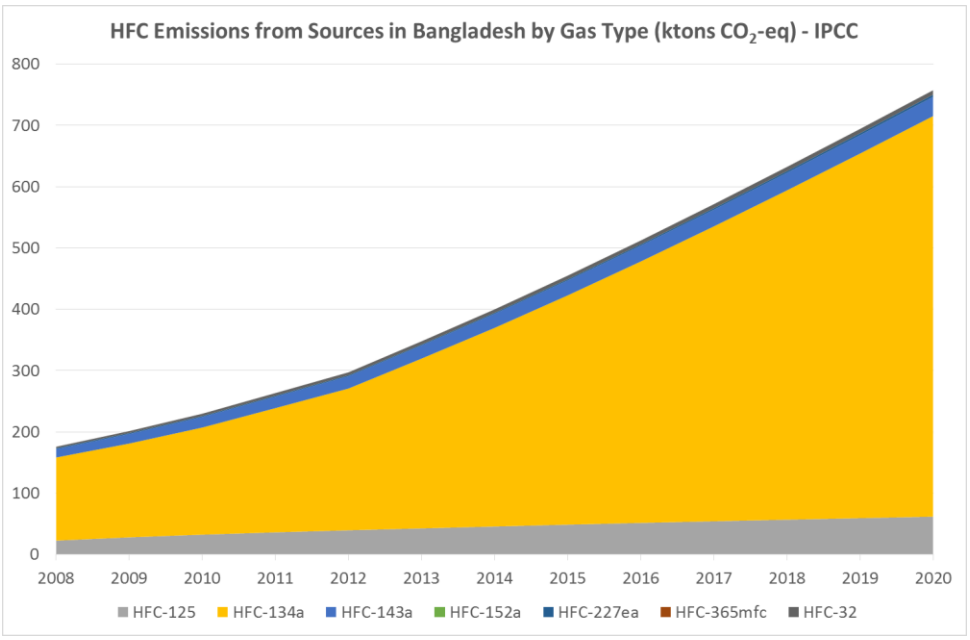

Figure 2 – Growth in HFC Emissions in Bangladesh by gas based on all MDI use 'in country'

On the more likely assumption that most Metered Dose Inhalers will be exported for use outside of Bangladesh, the following graphs assume that only 20% of MDIs are used 'in-country'.

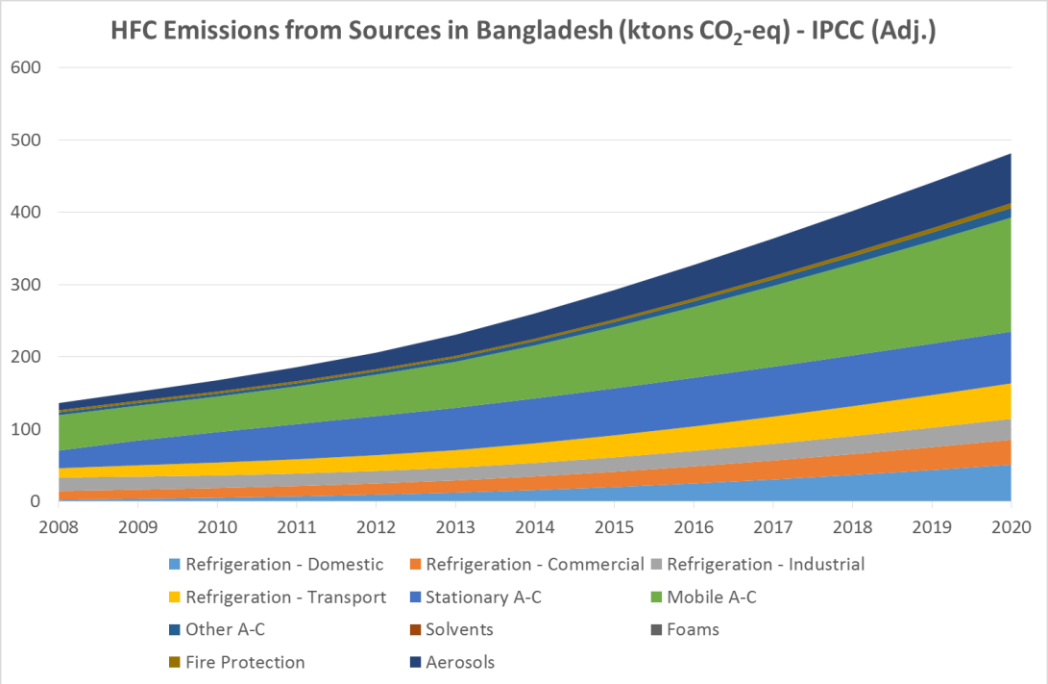

Figure 3 – Growth in HFC Emissions in Bangladesh by sector based on 20% MDI use 'in country'

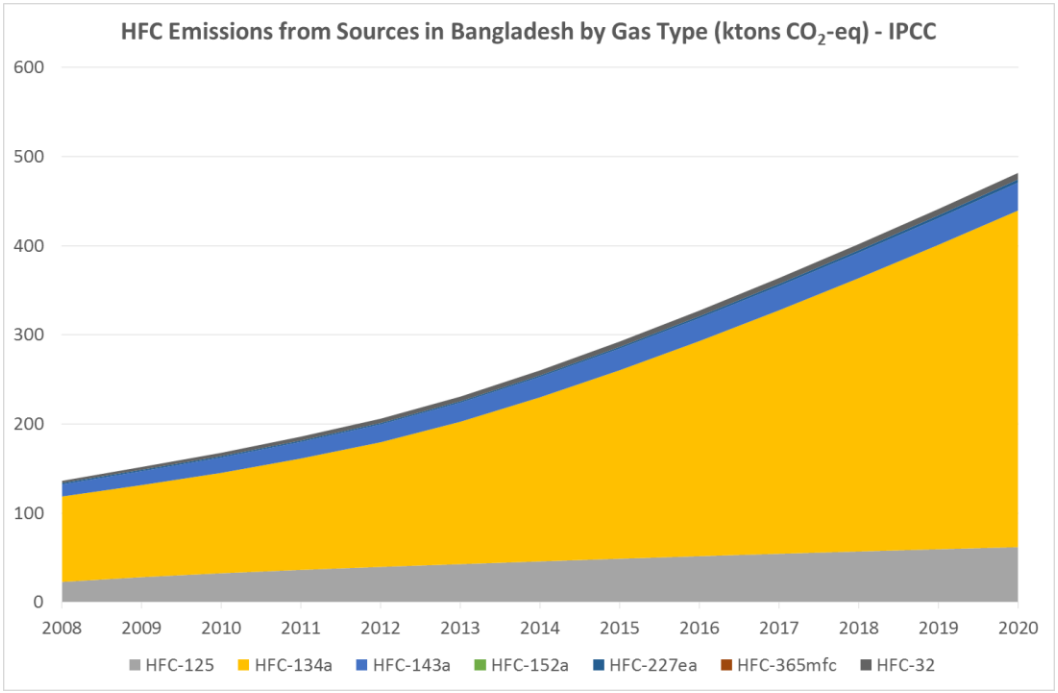

Figure 4 – Growth in HFC Emissions in Bangladesh by gas based on 20% MDI use 'in country'

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 Survey.

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 has for Bangladesh has proved possible based on the availability of the CCAC HFC Survey and the earlier analysis on installed products/equipment reported within 2011 HCFC Report. 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.

A major source of uncertainty in the projected emissions arises from the fate of MDIs manufactured in Bangladesh. It is expected that a large proportion (est. 80%) are manufactured for r-export and this scenario has been included within this assessment.

Further information on installed bases would be helpful in determining more accurately the split between servicing requirements and original product/equipment manufacture, especially as it relates to HCFC-22, but 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

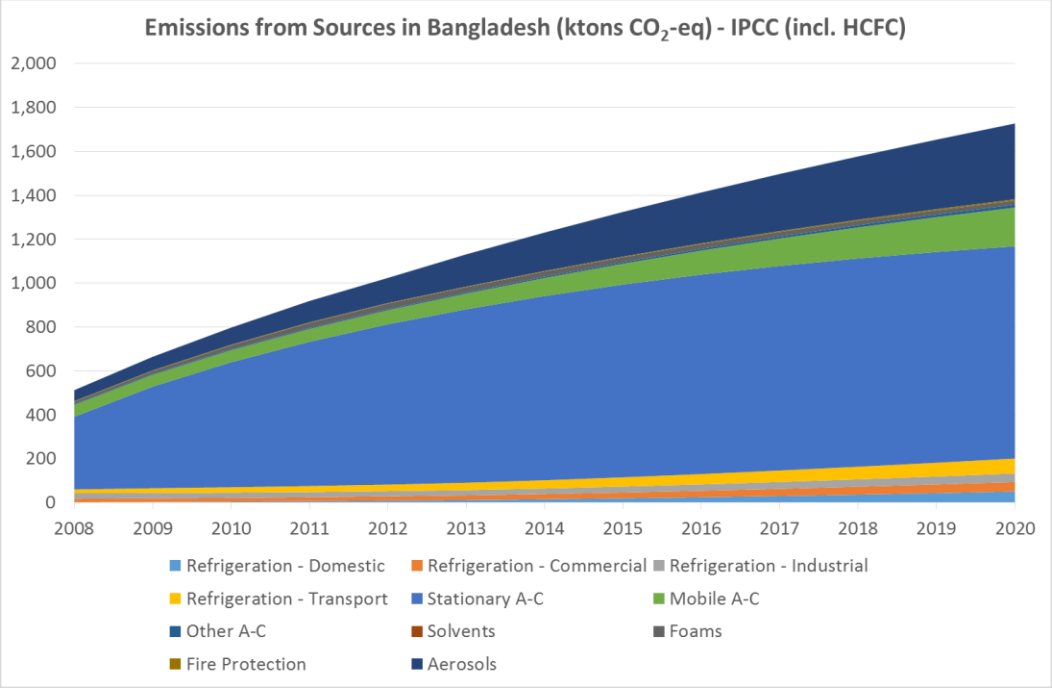

Figure A1 – Emissions from Sources in Bangladesh based on IPCC Emission Rates (incl. HCFCs)

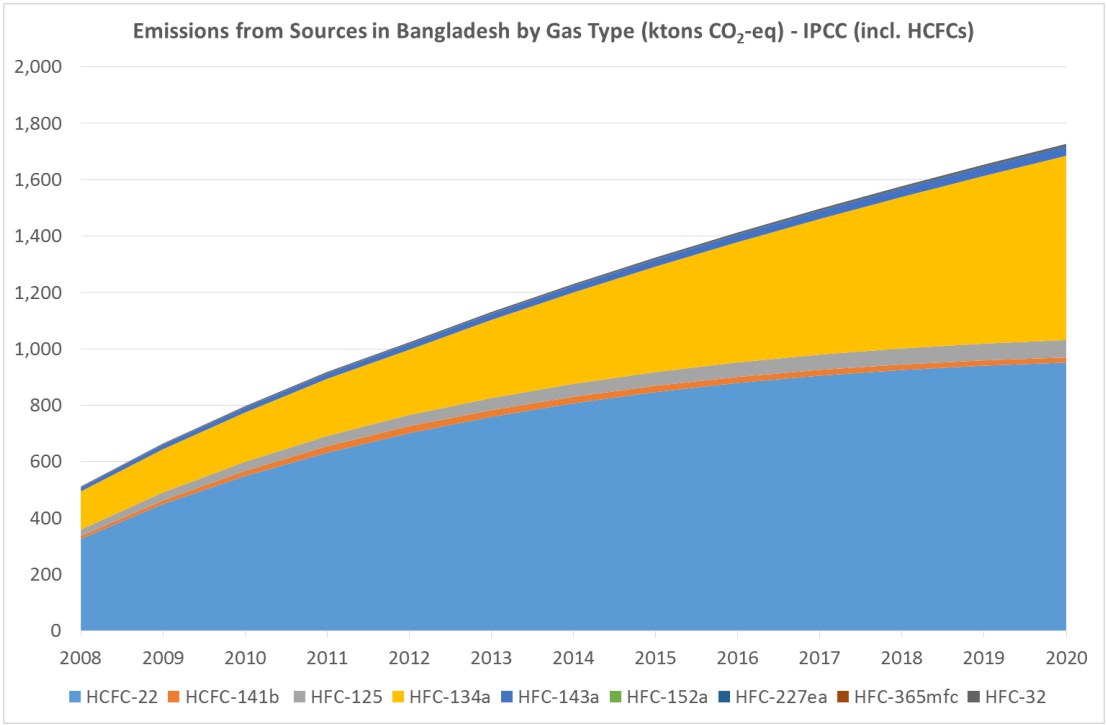

Figure A2 – Emissions by Gas Type in Bangladesh based on IPCC Emission Rates (incl. HCFCs)