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PRIORITIZATION OF HCFC PHASE-OUT TECHNOLOGIES TO MINIMIZE OTHER IMPACTS ON THE ENVIRONMENT (DECISION 57/33 AND PARAGRAPH 147 OF THE REPORT OF THE 58TH MEETING OF THE EXECUTIVE COMMITTEE)

Addendum

This addendum is being issued to:

- **Add** Annex I, containing examples for the use of the MLF climate impact indicator, to document UNEP/OzL.Pro/ExCom/59/51.

Annex I

EXAMPLES FOR THE USE OF THE MLF CLIMATE IMPACT INDICATOR

Introductory remarks

1. As requested in decision 57/53, this annex to document UNEP/OzL.Pro/ExCom/59/51 includes four examples for the use of the indicator model.

2. The examples show the input and output data of the model. The input data consist of data that has been requested with previous investment projects and investment activities in phase-out plans and umbrella projects as well, such as name of the company, HCFC to be replaced, number of units produced, amount of HCFC used, etc. The only new information is the share of exports.

3. The output consists of two sets of information:

(a) One is a list of alternatives in sequence of ascending climate impact, with the additional information of the relative difference as compared to the HCFC to be replaced. This list would allow in a decision-making process to use the technology highest on the list which is still applicable to the problem. The Secretariat decided to display all technologies, even if potentially impractical, to avoid defining arbitrarily which technologies are applicable and which not; and

(b) The second set of information relates to results of the calculation for a number of alternatives which can be selected during data input. For these alternatives, an increased amount of data is provided for each alternative substance considered.

4. Both the refrigeration as well as the foam model rely on data available in the background and related to the country choice. This data refers to the frequency of different temperatures in the country during a year, and the CO2 emitted due to generation of electricity.

5. Both models calculate the climate impact of the amount of goods manufactured in one year for the whole lifetime of the goods. Typically, it is assumed that the substance is not recovered at the end-of-life; these assumptions can be updated as recent developments continue in regard to the disposal of ODS.

6. Both models foresee the possibility to improve the product manufactured, with the intention to lower its climate impact. Examples are not provided here, but would lead to a significant reduction in the indirect climate impact calculated. The related parts of the input tables are presently shaded.

7. The technologies chosen as “Alternative refrigerant” or “Alternative foam blowing agent” were randomly chosen and are not for the expression of any preference, but for the purpose of explaining the model and its results. Company names and assumptions are also fictitious.

REFRIGERATION MODEL - EXAMPLE 1

Input			
	Generic		
	Country	[-]	**Nigeria**
	Company data (name, location)	[-]	**Model C Inc., Abijian**
	Select system type	[list]	Commercial cooling - factory assembly
	General refrigeration information		
	HCFC to be replaced	[-]	HCFC-22
	Amount of refrigerant per unit	[kg]	0.8
	No. of units	[-]	9,000
	Refrigeration capacity	[kW]	4
	Selection of alternative with minimum environmental impact		
	Share of exports (all countries)	[%]	10
	Calculation of the climate impact		
	Alternative refrigerant (more than one possible)	[list]	HFC-407C, HFC-134a
	If technical upgrade is desired:		
	Present energy efficiency classification	[list]	
	Increase in heat exchanger size/values	[%]	
	Increase in compressor quality	[list - %]	

NOTE

All data displayed is specific to the case investigated and is not generic information about the performance of one alternative; performance can differ significantly depending on the case.

Output	*Note: The output is calculated as the climate impact of the refrigerant systems in their life time as compared to HCFC-22, on the basis of the amount produced within one year. Additional/different outputs are possible*		
	Country		**Nigeria**
	Identification of the alternative technology with minimum climate impact		
	List of alternatives for identification of the one with minimum climate impact	[Sorted list, best = top (% deviation from HCFC)]	HC-600a (-6%) HC-290 (-2%) HFC-134a (-1%) **HCFC-22** HFC-407C (3%) HFC-410A (6%) HFC-404A (10%)
	Calculation of the climate impact of the conversion		
	Alternative refrigerant 1		**HFC-407C**
	*Total direct impact (post conversion – baseline)**	*[t CO2 equiv]*	*-94*
	*Indirect impact (country)***	*[t CO2 equiv]*	*18,116*
	*Indirect impact (outside country)***	*[t CO2 equiv]*	*1,068*
	Total indirect impact	*[t CO2 equiv]*	*19,184*
	Total impact	**[t CO2 equiv]**	**19,090**
	Alternative refrigerant 2		**HFC-134a**
	*Total direct impact (post conversion – baseline)**	*[t CO2 equiv]*	*-3,557*
	*Total indirect impact (country)***	*[t CO2 equiv]*	*-4,192*
	*Total indirect impact (outside country)***	*[t CO2 equiv]*	*-153*
	*Total indirect impact***	*[t CO2 equiv]*	*-4,345*
	Total impact	**[t CO2 equiv]**	**-7,902**

*Direct impact: Different impact between alternative technology and HCFC technology for the substance-related emissions.

**Indirect impact: Difference in impact between alternative technology and HCFC technology for the energy-consumption-related emissions of CO2 when generating electricity.

REFRIGERATION MODEL - EXAMPLE 2

Input			
	Generic		
	Country	[-]	**Egypt**
	Company data (name, location)	[-]	**Model D Inc., Port Ghalib**
	Select system type	[list]	Air Conditioning - factory assembly
	General refrigeration information		
	HCFC to be replaced	[-]	HCFC-22
	Amount of refrigerant per unit	[kg]	2
	No. of units	[-]	80,000
	Refrigeration capacity	[kW]	10
	Selection of alternative with minimum environmental impact		
	Share of exports (all countries)	[%]	40
	Calculation of the climate impact		
	Alternative refrigerant (more than one possible)	[list]	HFC-410A, HC-290
	If technical upgrade is desired:		
	Present energy efficiency classification	[list]	
	Increase in heat exchanger size/values	[%]	
	Increase in compressor quality	[list - %]	

NOTE

All data displayed is specific to the case investigated and is not generic information about the performance of one alternative; performance can differ significantly depending on the case.

Output	*Note: The output is calculated as the climate impact of the refrigerant systems in their life time as compared to HCFC-22, on the basis of the amount produced within one year. Additional/different outputs are possible*		
	Country		**Egypt**
	Identification of the alternative technology with minimum climate impact		
	List of alternatives for identification of the one with minimum climate impact	[Sorted list, best = top (% deviation from HCFC)]	HC-600a (-6%) HC-290 (-2%) HFC-134a (-1%) HFC-407C (0%) **HCFC-22** HFC-410A (12%) HFC-404A (75%)
	Calculation of the climate impact of the conversion		
	Alternative refrigerant 1		**HFC-410A**
	*Total direct impact (post conversion – baseline)**	*[t CO2 equiv]*	*60,320*
	*Indirect impact (country)***	*[t CO2 equiv]*	*8,683*
	*Indirect impact (outside country)***	*[t CO2 equiv]*	*54,569*
	Total indirect impact	*[t CO2 equiv]*	*63,252*
	Total impact	**[t CO2 equiv]**	**123,572**
	Alternative refrigerant 2		**HC-290**
	*Total direct impact (post conversion – baseline)**	*[t CO2 equiv]*	*-372,320*
	*Total indirect impact (country)***	*[t CO2 equiv]*	*1,072*
	*Total indirect impact (outside country)***	*[t CO2 equiv]*	*2,288*
	*Total indirect impact***	*[t CO2 equiv]*	*3,360*
	Total impact	**[t CO2 equiv]**	**-368,960**

*Direct impact: Different impact between alternative technology and HCFC technology for the substance-related emissions.

**Indirect impact: Difference in impact between alternative technology and HCFC technology for the energy-consumption-related emissions of CO2 when generating electricity.

Results of the calculation – Refrigeration model

8. The first example chosen relates to commercial refrigeration, and a fictitious company in Nigeria. It would be a small operation with around 30 units manufactured per day, this could be chest coolers for soft drinks, for example. A second, also fictitious company in Egypt produces 300,000 air conditioners per year.

9. The model calculates the energy consumption of refrigeration cycles in some detail. It starts with determining certain characteristics, such as heat exchanger and compressor size at the design point for the HCFC used, selected by the country. For alternatives, heat exchangers remain constant, compressors are dimensioned depending on the alternative technology needed and the design point, and a calculation is made providing the energy consumption; with the kWh/CO2 conversion factor specific to the country's electricity, consumption is converted into CO2 consumption. For the export share in the calculation of the impact of the conversion, a global average weather pattern and kWh/CO2 conversion factor is used. The results, multiplied with the amount of units remaining in the country or being exported, provide the indirect climate impact.

10. The climate impact of the different solutions does not vary dramatically. HC-600a is an unlikely candidate for this application out for purely technical reasons, and so is HFC-404A. The intention of the model is that a manufacturer would probably first look at HC-290 (propane) as an alternative. After taking into account a number of issues – availability of components, for example, and safety standards for the equipment that might be easier or more difficult to meet – the manufacturer and implementing agency might choose this refrigerant, or move to the next refrigerant in line, etc. The actual process of selecting an alternative will not likely follow this ideal. However, the Executive Committee could provide incentives to follow this list closely, for example by imposing increasingly strict documentation needs depending on where on the list a selected solution is positioned.

11. While the list above provided quantitative data on the basis of a comparison with HCFC data, the climate impact is calculated on the basis of an increment as compared to the status quo. In the example provided, HFC-407C has a higher energy consumption than HFC-134a. The difference is relatively small, but since the result shows only the increment to HCFC-22, the difference seems very significant. But a look at the "List of alternatives for identification of the one with minimum climate impact" above shows that HFC-134a and HFC-407C are both in a +/-3 per cent bandwidth around the present technology, i.e. HCFC-22. A 3 per cent bandwidth is just slightly above the level of insignificance.

12. The case of an air conditioning manufacturer in Egypt has a more surprising result. The list shows very significant differences between the different alternatives. The reason is the particular weather pattern in Egypt, a country with a largely Mediterranean climate, where the annual running time of the air-conditioning equipment is moderate. Consequently, the energy consumption has a minor effect on the overall climate impact, and the direct effect of the refrigerant becomes the determining factor; this is somewhat reduced in the calculation of the climate impact by taking into account the export share, which leads to more hours per year at higher temperatures.

FOAM MODEL - EXAMPLE 1

Input			
	Generic		
	Country	[-]	**Pakistan**
	Company data (name, location)	[-]	**Model A Inc., Islamabad**
	Select System Type	[list]	General insulation
	General foam information		
	HCFC to be replaced	[-]	HCFC-141b
	Type of product	[-]	Thermoware
	Amount of foam per unit	[m3]	0.0235
	No. of units	[-]	1,000,000
	Selection of alternative with minimum environmental impact		
	Share of exports (all countries)	[%]	0
	Calculation of the climate impact		
	Alternative blowing agent (more than one possible)	[list]	CO2, HFC-245fa red
	If technical upgrade is desired:		
	Change in density	[kg/w3]	
	In insulated space	[deg C]	
	Present insulation thickness	[mm]	
	New insulation thickness	[mm]	

NOTE
All data displayed is specific to the case investigated and is not generic information about the performance of one alternative; performance can differ significantly depending on the case.

Output			
	Country		**Pakistan**
	Identification of the alternative technology with minimum climate impact		
	List of alternatives for identification of the one with minimum climate impact	[Sorted list % deviation from baseline]	CO2 (-100%) Pentane (-99%) HFC-245fa red (-19%) **HCFC-141b**
	Calculation of the climate impact of the conversion		
	Alternative blowing agent 1		CO2
	*Total direct impact (post conversion – baseline)**	*[kg CO2 equiv]*	*-4,534*
	*Indirect impact (country)***	*[kg CO2 equiv]*	*n.a.*
	*Indirect impact (outside country)***	*[kg CO2 equiv]*	*n.a.*
	*Total indirect impact***	*[kg CO2 equiv]*	*n.a.*
	Total impact	**[kg CO2 equiv]**	**-4,534**
	Alternative blowing agent 2		HFC-245
	*Total direct impact (post conversion – baseline)**	*[kg CO2 equiv]*	*-858*
	*Total indirect impact (country)***	*[kg CO2 equiv]*	*n.a.*
	*Total indirect impact (outside country)***	*[kg CO2 equiv]*	*n.a.*
	*Total indirect impact***	*[kg CO2 equiv]*	*n.a.*
	Total impact	**[kg CO2 equiv]**	**-858**

*Direct impact: Different impact between alternative technology and HCFC technology for the substance-related emissions.

**Indirect impact: Difference in impact between alternative technology and HCFC technology for the energy-consumption-related emissions of CO2 when generating electricity.

FOAM MODEL - EXAMPLE 2

Input			
	Generic		
	Country	[-]	**Chile**
	Company data (name, location)	[-]	**Model B Inc., Santiago**
	Select System Type	[list]	Refrigerators
	General foam information		
	HCFC to be replaced	[-]	HCFC-141b
	Type of product	[-]	Refrigerator
	Amount of foam per unit	[m3]	0.133
	No. of units	[-]	300,000
	Selection of alternative with minimum environmental impact		
	Share of exports (all countries)	[%]	0
	Calculation of the climate impact		
	Alternative blowing agent (more than one possible)	[list]	HFC-245fa red, CO2
	If technical upgrade is desired:		
	Change in density	[kg/w3]	
	In insulated space	[deg C]	
	Present insulation thickness	[mm]	
	New insulation thickness	[mm]	

NOTE
All data displayed is specific to the case investigated and is not generic information about the performance of one alternative; performance can differ significantly depending on the case.

Output			
	Country		**Chile**
	Identification of the alternative technology with minimum climate impact		
	List of alternatives for identification of the one with minimum climate impact	[Sorted list % deviation from baseline]	Pentane (-52%) HFC-245fa red (-12%) CO2 (-35%) **HCFC-141b**
	Calculation of the climate impact of the conversion		
	Alternative blowing agent 1		**HFC-245fa**
	*Total direct impact (post conversion – baseline)**	*[kg CO2 equiv]*	*-9,620*
	*Indirect impact (country)***	*[kg CO2 equiv]*	*-1,426*
	*Indirect impact (outside country)***	*[kg CO2 equiv]*	*0*
	*Total indirect impact***	*[kg CO2 equiv]*	*-1,426*
	Total impact	**[kg CO2 equiv]**	**-11,046**
	Alternative blowing agent 2		**CO2**
	*Total direct impact (post conversion – baseline)**	*[kg CO2 equiv]*	*-50,837*
	*Total indirect impact (country)***	*[kg CO2 equiv]*	*17,099*
	*Total indirect impact (outside country)***	*[kg CO2 equiv]*	*0*
	*Total indirect impact***	*[kg CO2 equiv]*	*17,099*
	Total impact	**[kg CO2 equiv]**	**-33,738**

*Direct impact: Different impact between alternative technology and HCFC technology for the substance-related emissions.

**Indirect impact: Difference in impact between alternative technology and HCFC technology for the energy-consumption-related emissions of CO2 when generating electricity.

Results of the calculation – Foam model

13. The first example chosen relates to general insulation, and a fictitious company in Pakistan. It produces one million units of thermoware, in this case camping cooling boxes. A second company produces 300,000 refrigerators in Chile, with a HCFC-141b blown foam insulation.

14. The foam model has a very similar layout as the refrigeration model. Essentially the same type of data is required as input values. The calculation of climate impact differentiates a number of cases, but most importantly in some cases it takes into account energy–related emissions, and in others it does not. While polyurethane foam is often used for insulation purposes, it is not always clear how the foam is employed, and whether it is meaningful to calculate the effect on energy consumption. A case in point is the thermoware in the first example. While the foam is used for insulation purposes, there will be no effect on energy consumption if the cooler is slightly better or worse in its insulation value. In other cases, the effect will lead to a change in energy consumption, but the amount of possible parameters – energy source, other efficiencies, will make it essentially impossible to determine a value for the energy consumption in a theoretical model like this one.

15. In the example of the thermoware, the climate impact is solely a GWP-based calculation, taking into account how much of the different blowing agents are in the equipment and multiplying this value with the GWP of the alternative chosen; the result is compared to the values for HCFCs. In case of the refrigerators, the foam model uses the refrigeration model to calculate an energy consumption for different foam blowing agents, leading to an energy component of the climate impact.

16. Comparing the two alternative foam blowing agents for the calculation of the climate impact for the refrigerator factory in Chile, it becomes evident that for the case of Chile, with a comparatively moderate climate and a low CO2 emission per kWh of electricity generated, the energy consumption has a comparatively small climate impact; thus the foam blowing agent becomes the dominating part of the climate impact, and CO2 as a foam blowing agent even with a poor energy efficiency of the appliance, still leads to the more environmentally-friendly product.

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