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执行蒙特利尔议定书
多边基金执行委员会
第六十六次会议
2012 年 4 月 16 日至 20 日，蒙特利尔

关于多边基金气候影响指标的报告

（第 59/45、第 62/62、第 63/62、第 64/51 和第 65/48 号决定）

导言

1. 本文件根据第 59/45、第 62/62、第 63/62、第 64/51 和第 65/48 号决定编制，最新情况反映了第六十三次会议期间的讨论以及嗣后的决定。鉴于第六十三、第六十四和第六十五次会议作出决定，继续进行讨论以使执行委员会能一步审议这一问题，秘书处没有进一步扩展 UNEP/OzL.Pro/ExCom/63/58 号文件。

2. 执行委员会第五十九次会议通过了第 59/45 号决定。该决定的（g）分段请秘书处向第六十二次会议提交一份关于执行同一决定的（c）和（d）分段所取得的经验的报告。（c）分段请秘书处"说明自第六十次会议后，将多边基金气候影响指标适用于一系列项目呈件的情况，这将通告各机构和各国技术选择的气候影响"，并请秘书处"收集更多关于应用多边基金气候影响指标的数据，供执行委员会审查"。此外，同一决定的（d）分段还请秘书处完成多边基金气候影响指标的制订。

3. 执行委员会第六十二次会议简要讨论了多边基金气候影响指标的问题，并通过了第 62/62 号决定，将对关于实施多边基金气候影响指标所取得经验的报告的审议推迟至第六十三次会议。

4. 第六十三次会议的讨论涉及：

(a) 执行委员会有必要澄清多边基金气候影响指标的确切目标和目的，因为这将确定该模式今后发展的方向，并会对所希望的复杂程度产生直接的影响；

(b) 作为下一步提出的非正式会议的建议，组织召开这一会议将让执行委员会成员能够讨论模式本身，同时也讨论同秘书处、执行机构和专家一道组成一模式问题专家小组的可能性；

(c) 参与 2010 年底举行的网络讨论的机构很有限，导致必须鼓励各执行机构参与讨论，包括多边基金的网络讨论；以及

(d) 为维修行业制订一项气候影响指标并利用这一指标评估氟氯烃淘汰管理计划对于气候的影响（仅侧重于维修行业）的可能性。在这方面，有成员建议秘书处应同执行委员会成员、各执行机构以及必要时同专家密切协商制订一种方法，然后再视执行委员会的决定开始实际指标的工作。

5. 根据上述讨论，执行委员会通过了第 63/62 号决定，注意到 UNEP/OzL.Pro/ExCom/63/58 号文件所述关于执行多边基金气候影响指标所取得的经验的报告，并决定在第六十四次会议上继续讨论多边基金气候影响指标。

6. 第六十四次会议期间，普遍的共识是，虽然就多边基金气候影响指标做了实质性的工作，但仍需要进行深入的讨论以便弄清多边基金气候影响指标的确切目的、目标和最终用户。另一个好处是酌情借鉴各执行机构和其他专家的意见和经验。执行委员会几位成员表示，他们觉得在本次会议期间将多边基金气候影响指标用于正在审查的氟氯烃淘汰管理计划的提案，对于如何选择替代技术来说是有益的。但有成员指出，多边基金气候影响指标受到某些限制，例如，无法顾及设备升级和在行业分析中的用途的影响等因素。此外，

执行委员会还有必要澄清多边基金气候影响指标应该有何种具体的目的和目标，以便决定模式今后的发展方向。执行委员会将在第六十五次会议期间继续讨论第 64/51 号决定。

7. 执行委员会第六十五次会议期间的普遍共识是，需要进一步讨论澄清气候影响指标的确切目的。为此，最好是征求各执行机构的意见和经验。执行委员会注意到关于执行气候影响指标所积累的经验，并决定根据闭会期间的讨论，在第六十六次会议上继续讨论气候影响指标。为便利执行委员会与该机构间的讨论，秘书处设立了关于气候影响指标的论坛，各代表团和执行机构都可登录（http://multilateralfund.org/discussion/MCII-65-48/default.aspx）。印发本文件时，论坛包括了一名成员和两个执行机构的评论；论坛将至少在第六十六次会议之前和期间保持可登录状态。

背景

8. 在 UNEP/OzL.Pro/ExCom/55/47 号文件中，秘书处提出了“考虑淘汰氟氯烃供资问题相关成本的修订分析”；本文件还包括关于环境问题的部分内容，以及说明在含有氟氯烃的产品的生命周期中评估气候相关排放量的功能单元法提案的附件。根据第 55/43 号决定，执行委员会请秘书处进一步分析，是否本文件中所列的这种方法将为优先使用氟氯烃淘汰技术提供令人满意和透明的基础，以最大限度地减少对环境产生的其他影响，其中包括对气候的影响，正如缔约方第十九次会议第 XIX/6 号决定最初设想的那样。

9. 在 UNEP/OzL.Pro/ExCom/57/59 号文件中，秘书处提交了一份关于进一步分析指标工作的情况报告。这些指标被确认为优先使用氟氯烃淘汰技术的令人满意和透明的基础，以最大限度地减少对气候的影响。执行委员会注意到这份情况报告，请秘书处编制一份列举应用实例的报告，以促进进一步审查该方法，并决定讨论将与正在制定的指标相关奖励措施类型所涉的更多问题和其他相关问题（第 57/33 号决定）。

10. UNEP/OzL.Pro/ExCom/59/51 号文件向执行委员会通报了与“优先使用氟氯烃淘汰技术以最大限度地降低其对环境的影响”相关的问题。在本文件中，秘书处临时确定了该指标的范围，以便适用于转化生产能力、替代或结束这种能力。这种模式经历了很多次简化、提炼和分化过程，并且为提高结果的透明度和可用性进行了尝试。作为这些努力的一部分，“多边基金气候影响指标”这一术语替代了“功能单元法”中的术语。

自第五十九次会议后多边基金气候影响指标的制定情况

11. 自执行委员会第五十九次会议后，进一步制定和拓宽了多边基金气候影响指标的概念。该指标旨在为项目对气候产生的影响提供一个数值，很像“淘汰消耗臭氧层物质”设立的显示该项目对臭氧层影响值的指标。多边基金气候影响指标的另一个目标是用一种在行业和国家之间提供公平和可比较的结果的方式来规范对气候影响的计算。同时，秘书处正在关注仅应用在项目制定期间收集的数据的编制工作。

12. 与向第五十九次会议提交的报告相比，秘书处通过纳入溶剂和维修行业延伸了范围，同时坚持原则，只对与由多边基金供资的活动直接相关的气候影响的变化负责。涉及制冷、空调设备、泡沫塑料、溶剂、加工剂和制冷维修行业的相关技术说明见附件二。

<u>应用示范</u>

13. 在筹备第五十九次会议的过程中，设计了数据输入和数据提交的格式，并且该格式被载入 UNEP/OzL.Pro/ExCom/59/51/Add.1 号文件。但是，当时甚至迄今，大部分相关计算是手工完成的，时间成本过高，而且计算出错的可能性大。直到筹备执行委员会第六十二次会议的最后阶段，计算制冷行业多边基金气候影响指标的模式才大体实现自动化，得以用新制定的模式进行相关计算。相关信息见附件三。

14. 对于泡沫塑料行业，自第五十九次会议后，根据转化前后使用同吨位发泡剂的假设，手工进行了简化计算。尽管这并未考虑能效问题，但仍是个合理的近似值。还使用了在该产品的使用期限内排放发泡剂总量的设想。

<u>现状</u>

15. 在这一时间点上，已计划将制冷行业的气候影响指标完全在微软的 Excel 表格上使用，并且目前正在检查该指标的准确性。也正在确定将泡沫塑料行业以及溶剂和加工剂行业的多边基金气候影响指标用于 Excel。维修行业的多边基金气候影响指标已经概念化了。秘书处有待开展的剩余工作涉及数据输入的定义和质量，以提交大型氟氯烃淘汰管理计划。

16. 制冷和空调设备的多边基金气候影响指标的第一个版本被设计为一种 Excel 工具，并自第六十二次会议后载入秘书处的网页。随着概念性工作和程序设计方面取得的进展，将出现后续版本。各机构和执行委员会成员将随时能从秘书处网页上下载最新版本。根据可比较的和公正的评估，并在保持追踪多边基金氟氯烃淘汰活动对气候的影响时，该工具将在理解拟议活动的气候影响方面为秘书处和执行委员会提供支持。

17. 在完成编制 Excel 模式时，将需要多边基金气候影响指标的专家进行更广泛的审查，以将该工具用作将相同计算纳入多年期协定数据库的蓝图。在编撰氟氯烃淘汰管理计划多年期协定表格的概念时，充分考虑了进行更广泛审查的重要性。这最后一个步骤将显著减少数据输入的需要，并将允许进行更密切的监测和对该数据进行不断分析。鉴于在筹备即将召开的执行委员会会议过程中对秘书处的时间要求是未知的，而且存在大量有待审查的氟氯烃淘汰管理计划，所以无法在目前的时间点上明确指出完成 Excel 模式和多年期协定表格的时间框架。

18. 制定多边基金气候影响指标的最初设想是提供将进行以下活动的工具：

(a) 当考虑哪种氟氯烃替代物将用作不同用途时，在各国选择技术以制定氟氯烃淘汰管理计划过程中为它们提供支助；

(b) 允许执行委员会考虑是否采用奖励措施，以使用无害气候物质替代氟氯烃，并允许执行委员会鼓励开发新的替代资金来源，以支持气候相关活动，如能效活动；

(c) 使秘书处和执行委员会有可能客观测量并比较呈件中提交的技术选择的气候影响；以及

(d) 使执行委员会监测并负责由多边基金支助的项目的气候影响。

19. 执行委员会第五十五次会议上第一次提出该问题。在自那次会议起的两年时间内框架条件发生了变更。根据这项变更，自以下活动后开始使用多边基金气候影响指标：

(a) 执行委员会在第六十次会议的第 60/44 号决定决定商定了数目众多的奖励措施，用更多无害气候替代物质替代氟氯烃，且独立于多边基金气候影响指标。尽管该决定第（五）、（八）和（九）分段通过对增量经营成本供资，减少了间接激励使用高全球升温潜能值的物质，但第（四）和（七）段包括使用低全球升温潜能值技术的明确奖励措施。

(b) 对建立一项设施的讨论尚未结束。该设施将允许提供除符合多边基金项目资格外的额外资金。而且不能确定这些讨论何时和如何才能结束。

(c) 在广泛的基础上和短时间内为开展能源效率活动调动来自全球环境基金等资源的资金存在困难。这一点为人所知，并且限制了为与减少气候相关排放量有关的活动提供奖励措施制的前景。而这些奖励措施将为有资格获得多边基金供资的活动补充一项额外的气候变化内容。

(d) 多边基金以前的淘汰项目发生的模式转变重点关注独立活动或剩余消费量。开展了大型和具体活动后，该模式转变发展了自身对资源的动力和需求。由于执行委员会会议间的时间限制，不可能分配足够的时间给多边基金气候影响指标有关的问题，也不可能过早地以原本期望的速度取得进展。

20. 过去 24 个月越来越清楚地显示，由中央指导技术选择过程的设想可能不符合第 5 条国家的决策现实。从迄今收到的项目呈件来看，似乎明确的是，尽管并非所有问题（诸如内容的可用性）已完全澄清，但一些国家选择了现有的先进的无害气候替代物，而其他国家不愿意要求它们的工业使用非主流的技术，因为这在很多情况下将导致选择使用对气候影响大的替代物。多边基金气候影响指标不可能对这些决定造成重大影响，因为这些决定似乎基于更为基本的考虑，即在选择一种新技术时是否将考虑气候变化的问题，以及如何评估相关的经济风险和机遇。多边基金气候影响指标能决定的对气候变化产生影响的程度似乎只能起到次要作用。这种状况被以下事实进一步放大，即在有资格获得多边基金支助的范围内，直接或间接地考虑到一些气候变化问题，且执行委员会提供了一些关于项目优先问题的明确信息，但与除符合多边基金支助资格的活动外的活动有关的供资很少兑现。此外，对发展中国家缓解活动的未来供资仍然具有高度的不确定性。

<u>结论</u>

21. 最初设想是制定气候影响指标，以用四种不同方式支持各国、各机构和秘书处的工作，即：

(a) 对选择替代物进行决策；

(b) 可能根据多边基金提供奖励措施，同时还允许根据可量化的气候影响寻求可替代的资金来源；

(c) 理解提交至执行委员会的项目提案的气候影响；以及

(d) 不断监测多边基金的工作对气候产生的影响。

22. 基于上文第 19 段所述的原因，此时制定多边基金气候影响指标的主要目的可能是后两者，即通知执行委员会对氟氯烃各种替代物供资和监测多边基金的工作对气候产生的影响的结果。在第二阶段的筹备过程中，多边基金气候影响指标将帮助提供所有最初设想的支助，特别是早在决策过程中帮助各国评估不同的技术选择。各国和各机构在氟氯烃淘汰管理计划第一阶段中所得到的经验将便于适用多边基金气候影响指标。

23. 数据要求将与评估资格和增量必备的要求一致，包括数据收集的相关格式。将筹备和制定计算消防行业的气候影响的概念。一旦全面编制并应用了 Excel 模式，将实施多边基金气候影响指标工具向多年期协定表格的转移。将多边基金气候影响指标工具纳入多年期协定表格将大幅简化各机构和秘书处对该工具的适用，因为只有计算了资格、消耗臭氧潜能值和多边基金气候影响指标，并提供了关于该国的汇总信息，才能输入数据。秘书处最迟将在第六十七次会议上通知执行委员会转移该模式的状态和在该过程中做出的努力。

建议

24. 谨建议执行委员会：

(a) 注意到关于实施多边基金气候影响指标所取得经验的报告；

(b) 请秘书处参照所收到评论，完成制定 UNEP/OzL.Pro/ExCom/66/52 号文件所列各不同行业的多边基金气候影响指标的工作；

(c) 请秘书处不晚于第六十九次会议向执行委员会通报在将多边基金气候影响指标用于项目呈件方面所取得的进展和积累的经验；

(d) 请秘书处将气候指标用于所提交的相关项目和次级项目，以便让各呈件所提技术备选办法的气候影响能够加以衡量；以及

(e) 请秘书处不晚于第六十八次会议向执行委员会提交一份编撰充实的多边基金气候影响指标，以便评估可否将其作为编制及评估项目呈件的充分协调的工具加以应用，以计算多边基金氟氯烃消费项目的气候影响。

Annex I

FEEDBACK FROM THE EXECUTIVE COMMITTEE ON THE MULTILATERAL FUND CLIMATE IMPACT INDICATOR (Document 62/56 and Add.1)

(extracted from the Secretariat's on-line discussion forum)

Comments from the Government of Australia

Document 62/56

1. Paragraph 11 mentions the notion of expert review – we would appreciate more information on what is planned for an expert review. Is this only in relation to the calculations?

Fund Secretariat's response:

The Fund Secretariat believes that it is important to achieve broad consensus that the calculations provided by the MCII are a suitable tool to provide an indication about the climate impact of activities funded by the Executive Committee. In order to achieve wide spread acceptance, the Secretariat believes it would be helpful to maximise transparency, and would like to suggest providing the opportunity for stakeholders and experts to contribute to the finalisation of the development of the MCII. It would appear meaningful, though, to differentiate between discussions regarding the fundamental characteristics of the MCII and the technical details influencing the calculations.

Related to the technical issues, the Secretariat believes that a dialogue based on concrete suggestions for changes would be the best way to enable communications and facilitate acceptance of the tool. The present considerations on the side of the Secretariat are related to collecting written responses; this might be undertaken by assembling the necessary information in a package suitable for review, and asking members of the Executive Committee to provide either comments themselves, and/or to provide the Secretariat with addresses of appropriate experts to which the Secretariat could forward this package. The Secretariat would then have to collate the replies and address the different issues.

While the expert review would probably be broader than only looking at the calculations, it would still concentrate mainly on them. It could cover the following issues:

- Remarks related to the definition of the MCII
- Concept of the calculations
- Scope of the MCII in terms of alternatives
- Algorithm
- Underlying data
- Uncertainties

It does not seem that it would be useful to open the discussion any wider, since questions related to purpose, general definitions, applicability, and consequences appear to be non-technical issues that will need to be discussed by the Executive Committee.

2. Paragraph 14 implies perhaps that the MCII tool is not required as Article 5 countries are making technology selections independent of MCII information and the HCFC guidelines have defined the terms under which funding above the cost-effectiveness thresholds would be provided to further climate co-benefits. However, one of the key roles of the MCII is to better inform the ExCom of the climate implications of technology decisions, and if it does that well, this information will be useful as projects

and HPMPs are agreed in the next year. It will also be useful to determine the extent to which the funding guidelines are achieving their goals of encouraging the use of climate friendly alternatives. Finally, information on the potential climate benefits of various technology alternatives, whether or not the cost of alternatives may be within the parameters set by the HCFC guidelines, could assist efforts to mobilize additional financing for individual projects

Fund Secretariat's response:

The observation in the above paragraph is shared by the Secretariat, and a similar conclusion, i.e. the need to specify and monitor the climate impact, had been included in the previous paragraph 16 of document UNEP/OzL.Pro/ExCom/62/56. It is also possible that the MCII could be utilised to assess whether other funding mechanisms might have an interest in co-funding. Given the lead time for development of this or any other indicator, it is beneficial that the work has already started, and it might indeed prove to be of assistance to mobilize additional financing in the future. The Secretariat believes there might be a role for the MCII to assess financing possibilities during the preparation of stage II of an HPMP.

Document 62/56/Add.1

3. We generally agree with the proposition in paragraph 6(a) (i.e. that the CO_2 emissions related to energy consumption calculated under the MCII should essentially assume that there would be no technology upgrade beyond what would be necessary to allow the conversion to take place); however, in some cases, it would also be useful for the model to indicate what the climate impact would be if some technology upgrade were to be undertaken during the conversion process, with a view to using this information to help mobilize co-financing. Would it be feasible, for example, for the MCII to generate two results in a proposed project, one indicating the climate impact without technology upgrades, and another indicating the climate impact with a clearly-defined upgrade?

Fund Secretariat's response:

The comment is consistent with an approach the Secretariat has already largely prepared. Typically, the energy consumption of air conditioning equipment is being improved by four measures: bigger heat exchangers, a better compressor, a variable speed drive, and a better fine-tuning of the characteristics of the components towards each other. The effects of the first three measures can relatively easily be modelled, and their impact assessed. However, a higher level of uncertainty applies for these calculations as compared to the calculations replacing one fluid by another, since the latter use the assumption that the component characteristics remain constant, and just the fluid is changing. This calculation is relatively insensitive to the current quality of the equipment and its component, as the same quality is assumed for both calculations. However, if the quality is being improved, either the software needs to make assumptions regarding a certain quality level (this is currently the case), or information regarding the current quality level would need to be collected in a standardized way. The difference between the two approaches is that the results are more indicative and less precise using assumptions within the software, while the effort for data collection and risks of data manipulation towards specific results is bigger in the second. The Secretariat intends to provide the possibility to calculate technology upgrades based on the "standard quality level" approach.

4. Are there some limitations to the assumption made that "the entire foam blowing agent is emitted"? (para 8) It has been argued that when foam is disposed in landfills, emissions of the blowing agent may be insignificant even over large time horizons.

Fund Secretariat's response:

There are two issues addressed within this question. One relates to the knowledge on how operation and, in this case, disposal affects the release of the gases, and how prevalent the different ways of operation and disposal are in developing countries. The second issue is how the MCII should be defined.

- Essentially, the MCII can easily take into account different amount of emissions in the calculation, if two principles are taken into account: Actual situation in Article 5 countries, and as few information requirements as possible. Consequently, the question to ask would be how much of the foam produced in Article 5 countries is actually disposed of in landfills that are managed in a way which limits emissions.

- This has to be seen in conjunction with a second question: The definition of the MCII itself is an approximation of the total emission over the lifetime of the goods manufactured in one year (including emissions during manufacturing and disposal), i.e. aggregated emissions over many years for the amount of equipment produced in one year. Other definitions of the climate impact, e.g. the approach taken under the UNFCCC, look at the impact on the basis of annual emissions, in cases aggregated over e.g. 7 or 10 years, but they aggregate also the effect of the production of multiple years. For the MCII, even a slow release leads still eventually to a complete release; this is meaningful since in e.g. a steady use scenario, if the emissions take 50 years to complete, the annual emission from the bank of foam after 50 years (consisting of 50 years of foam production) is equal to the annual use of the substance. Consequently, assuming that for the MCII the current lifetime definition would prevail, consideration would have to be given on whether the emission from a landfill actually ceases after some years with an amount of HCFC remaining trapped sustainably within the landfill, or whether e.g. bacteria are transforming a share of the HCFC in the foam into something else. If such effects are widespread in Article 5 countries, the calculations can be easily adapted.

5. Could you clarify in which cases the energy efficiency factor in foam conversion projects is taken into account within the MCII and how it is considered? From paragraph 9, it appears that changes in energy consumption and related CO_2 emissions caused by a change in the blowing agent is taken into account only in the case of insulation foam used in confined refrigerated spaces - is this correct? If so, could the results of the MCII be misleading in other foam sector projects since it does not take energy considerations into account? Is it assumed that in most cases, changes in energy consumption may not be that significant to warrant more detailed analysis?

Fund Secretariat's response:

The climate impact noted in the Secretariat's review documents for foam projects so far does not take into account any energy related effects. It consists simply of the difference in climate impact, based on the calculated GWP of the blowing agent and amount used, between the blowing agent used for a quantity of HCFC blown foam and the alternative blowing agent used for the same quantity of foam.

The Fund Secretariat has tried to come up with concepts on how to address the energy conservation aspect of foams. The biggest obstacle turned out to be the fact that information about the actual use of the foam is largely unavailable, and use information is essential to understand what effect the foam has on energy conservation; the use information is e.g. the insulation thickness and quality, the temperature difference, and the effect on greenhouse gas emission that a difference in energy consumption would have, depending on the type of primary energy used to make up for any energy transfer through insulation. Finally, the information has to be linked either to an ideally very small sub-set of choices to be taken by the user of the MCII, and/or a number of meaningful assumptions in the background of the programme.

In some cases, there is simply no impact on energy when converting from one foam blowing technology to another. For example many if not all uses of integral skin foam have other purposes than insulation, and consequently the insulation characteristics of the different technologies are irrelevant.

Those applications where the quality of insulation matters fall into two groups: Applications where the thickness of insulation can be changed to accommodate for the change in insulation quality, and those applications where the thickness of insulation is a given. The latter are typically insulation for domestic refrigerators and for refrigerated transport. The Secretariat is presently not aware of other insulation applications where a typically small increase in wall thickness would pose major technical problems, and shortfalls in insulation quality could not be compensated by increased thickness. Specific points are:

- The proposed, but not yet realised calculation would, in those cases where the insulation thickness can be changed, just calculate the necessary change in thickness and, consequently, in volume of the foam to achieve the same insulation quality; the increase in volume would lead to a proportional change in blowing agent use, and the related impact of the blowing agent would be used to calculate the value for the MCII. The change in insulation thickness and the associated change in blowing agent use will therefore calculate the impact of efforts to offset the change in insulation quality through a change of wall thickness

- For domestic refrigerators and refrigerated transport, an energy consumption calculation will be carried out, and the difference between the energy consumption before and after conversion will be used for the calculation of the value for the MCII.

6. Paragraph 11 suggests that climate impacts resulting from political agreements that lead to the phase-out of HCFCs in the servicing sector should not be taken into account because they are not linked to funded activities but to a commitment of the country to phase out HCFCs. However, as was the case for CFCs, the commitments made by countries to eliminate HCFCs in the servicing sector without further assistance from the MLF is a direct result of HPMPs approved by the MLF. There is, therefore, a case to be made that the climate impact resulting from the entire phase-out of HCFCs in the servicing sector is linked to the work of the MLF and should, in theory, be accounted for. In practice though, we think it would be very difficult to predict this climate impact since it is not possible to predict what alternative technologies, and quantities, will ultimately be selected in the various end-user sub-sectors.

<u>Fund Secretariat's response</u>:

It is absolutely correct that the borders of what is taken into account for the MCII need to be very carefully assessed; the Secretariat can make suggestions in this regard, but the Executive Committee will have to decide on a meaningful definition.

The main concern of the Secretariat with a wider definition is that it makes it substantially more difficult to achieve consistency within the MCII calculations. Generally the stricter and more confined the rules, the easier to achieve consistency. As examples, we would like to provide two considerations regarding this particular point:

- Countries will achieve reductions in consumption by importing non-HCFC air conditioners from manufacturers who received support from the Multilateral Fund; these imports will subsequently lead to a reduced HCFC service demand. Should these reductions in the service sector be account for as positive impact, one has to find a mechanism to remove those emissions which have already been accounted for at the time of factory conversion. Lifetime emissions accounted for at the factory level conversion because the technical decision for a replacement at the time of conversion determines the climate emissions of the equipment during its lifetime and, consequently, the MCII should be associated with the time when the choice is being made.

- The relation between consumption reduction and Montreal Protocol is existing, but is not the sole explanation for reductions in consumption; economic circumstances, for example accession to a Union with stricter environmental legislation or additional national activities in combating climate change, are other reasons why the use of ODS might be reduced.

From the above it becomes also clear that with a broader definition, the credibility of the results might be reduced, for example through issues of double counting. This might be detrimental for the overall objective of the MCII.

The Secretariat agrees that calculations for the service sector are likely to have a higher uncertainty associated with it than calculations in the manufacturing sectors. There might be possibilities to focus on the savings related to better practices (refrigerant re-use and recycling, good practices, …) but whether this is efficient comparing the balance of efforts to information received is something the Secretariat does not venture to decide.

7. It would also be very challenging to measure, or even roughly estimate, the climate impact of R&R and good refrigeration practices (paragraph 12 a and b) . Evaluations of the RMPs and TPMPs have not been able to quantify the CFCs directly eliminated through these activities. When such quantification has been made (in PCRs or other sources), there appears to be very significant differences among countries, which could be due to factors not easily controllable through projects, such as the price of ODS, levels of awareness and commitment of stakeholders in the servicing sector (association of technicians etc..), political drivers, markets factors etc…

In the case of activities to replace equipment in the servicing sector, we agree that the climate impact may be assessed (paragraph 12 c). However, we see two possible problems. One is how to avoid the problem of double-counting mentioned in paragraph 12 c (ii) - i.e. how could it be known in advance whether the new equipment brought in will or will not be manufactured by enterprises assisted through the MLF? Secondly, the fact that the Secretariat believes that it would not be possible to take energy efficiency into account seems to be a major drawback. The Secretariat notes that the energy consumption between the system before conversion and afterwards is relatively small. However, applications of the MCII in Annex III suggest that variations in energy-related CO_2 emissions between different technologies are in fact significant. In the case of the application of the MCII to the ICR sector plan in China (annex III), it appears that for the conversion of equipment to HFC-410a, the change in indirect climate impact (i.e. change in CO_2 emissions related to energy consumption) is actually larger than the change in direct climate impact. Therefore, if the energy consumption factor in equipment replacement servicing sector projects is ignored, would the MCII still provide a meaningful indication of the climate benefit of such activities?

Fund Secretariat's response:

We agree with the comments made by Australia regarding the degree of uncertainty associated with any attempt to identify a climate impact for the service sector. It would be a very general approximation. It is relatively common in such methodologies to, in case of doubts, reduce claims of climate impact to the level where the impact is almost certain to occur. As a simplified example, an analysis might inform that on average a recycling machine recycles 500kg per year, but that 95 per cent of recycling machines recycle more than 100[1] kg per year. If one uses the 100 kg as a basis, the calculation of the climate impact might under-represent the result in the field, but carries a high certainty that the impact is at least as big as the value calculated.

Energy efficiency for retrofitted systems is very problematic to calculate. The following effects would in addition to refrigerant-inherent characteristics influence energy efficiency differences between a system prior to and post conversion: The degree of refrigerant-specific design and safety margins of the system pre conversion for HCFC-22, whether any optimisation is carried out during the conversion, and whether the opportunity is used for a general systems overhaul. These effects will often lead to a lower energy efficiency, sometimes to a better one. In addition, the available data from literature regarding retrofitted machines in the field is not always suitable to derive general statements from, since there are shortcomings in terms of coverage of different systems, measurement accuracy and ability to compare results prior and post conversion due to different operating conditions. It is not possible to make sufficiently accurate forecasts without a substantially higher amount of data available regarding the installation; and the results would depend very much on the quality of the data provided. Given the small impact of single converted refrigeration installations on the overall climate impact, the results from such an approach appear unlikely to justify the efforts to be undertaken.

8. In relation to the other sectors wherein the MCII could be applied, it seems that the HCFC solvent sector and fire fighting sector are relatively very small. There may not be much added value to extending the MCII to these sectors. Perhaps, this could be considered at a later stage. The Secretariat also mentions application of the MCII to the process agent sector. To date, the ExCom has not been made aware of any consumption of HCFCs for process agent uses in Article 5 countries. Is there some information available which suggests that this may be a significant or even small HCFC-consuming sector?

Fund Secretariat's response:

There is no concrete information available suggesting the use of HCFC as process agents.

9. With respect to the application of the MCII for the China sector plans, could you clarify:

(a) why the 2 foam sector plans were excluded from the analysis?

(b) how the 4 categories of "system type" in the ICR Sector Plan spreadsheet (3 called "AC factory assembly" and one "commercial frozen assembly") relate to the sub-sector identified in the plan, which are: compressor, unitary A/C, multi-connected AC/heat pump, industrial and commercial chiller/heat pump, small-sized water chiller/heat pump, heat pump water heater, 'condensing units, freezers & cold storage'.

[1] These numbers are selected arbitrarily for illustration purposes only

Fund Secretariat's response:

Related to (a), the assessment of both foam sector plans included paragraphs on the climate, both in the documentation for the 62nd and the 63rd Meetings; however, the information was included in the documentation of the projects (documents UNEP/OzL.Pro/ExCom/62/26/Add.1 and UNEP/OzL.Pro/ExCom/63/26). For the XPS foam sub-sector, document 63/26 provides the information in paragraph 99, for the PUR foam sub-sector, the information is contained in paragraph 84 and table 12 of the same document.

Related to (b), the concept of the MCII is to allow a choice between different systems in refrigeration and air conditioning according to 6 different types. These types have each their own underlying assumptions regarding operating conditions (temperatures, …), design characteristics (quality of compressor, …) and leakage rates. The types to be selected are Commercial refrigeration cooling, Commercial refrigeration freezing and Air conditioning, all three differentiated between on-site assembly and factory assembled, leading to in total 6 types.

Compressors and condensing units are not systems but counted as components, consequently they are not represented. Unitary A/C, multi-connected AC/heat pump, industrial and commercial chiller/heat pump, small-sized water chiller/heat pump are covered under Air Conditioning. Within Air Conditioning, the categories Unitary A/C, Multi-connected AC/heat pump are on-site assembled, the remaining categories mentioned in the ICR sector plan for China are factory assembled. Heat pump water heaters fall under air conditioning/factory assembled, freezers under commercial freezing, factory assembled, cold storage under commercial cooling, on-site assembled. The Secretariat recognises that a simpler selection or a guide to help selecting the right system type might be useful.

Comments from the Government of Argentina

10. In calculating the refrigerant's emissions for direct impact, does the model assume that all the charge will be lost during life time?

Fund Secretariat's response:

The model is based on lifetime emissions, i.e. including disposal emissions. At this time, disposal activities in Article 5 countries predominantly do not recover the ODS from equipment or foam. While the model has the possibility of using different settings for disposal at end-of-life (EOL), at the moment the parameters are set for emission of all ODS contained in the equipment into the atmosphere. However, for refrigeration/air conditioning applications with high leakage rates (e.g. on-site assembled commercial refrigeration), the leakage rates are so high that the equipment has only 40% of remaining refrigerant content before it reaches the EOL. In that case, the equipment is assumed to be recharged up to 100 per cent of the refrigerant charge, and the amount of this recharge is added to the overall refrigerant use over the lifetime. Consequently, at this time the refrigerant emissions over the lifetime are always at least 100 per cent of the initial charge, in several cases higher. This also shows that the model is as such capable of calculating the effect of different rates of EOL recovery, if desired.

11. In the case of R-410a, we have noticed a 5% increase of emissions that is depicted, however, the total climate impact of appliances working with this refrigerant should be lower because of its higher efficiency and the lower amount of refrigerant contained in comparison to HCFC-22.

Fund Secretariat's response:

It is correct that the impact calculated by the MCII for HFC-410A is in many cases higher than that for HCFC-22. This is on the one hand caused by a higher GWP, but also by a higher energy consumption, based on the definitions used for the MCII. Independently, your observation of the "lower energy consumption" also holds some truth. The reason is that when converting from HCFC-22 to HFC-410A, a number of optimisations are carried out, among them often a change in compressor technology and an increase in the surface of the heat exchangers, not to mention a general re-design with often improved fine-tuning of the component's characteristics. In other words, HFC-410A systems have very often a higher degree of sophistication, which, if used for HCFC-22 as well, would also substantially improve the energy efficiency of the HCFC-22 system. Consequently, it is difficult to find a standard on how to achieve a fair comparison for an air conditioner model before and after conversion.

The standard chosen was actually to assume the same component quality. At present, this is calculated by using a constant isentropic efficiency for the compressor and a constant value for the product of heat exchanger surface and heat transfer coefficient for the heat exchanger[2].

12. Also, data suggest that the calculations have not taken into account improvements in the design of the equipments with R410a, only a change in the compressor, but no other improvements such as a change in the heath exchangers.

13. For instance, in our (Argentina's) case, the kits offered to our manufacturers are more energy efficient for Argentina's average temperatures, so, the manufacturing sector has adopted them in order to comply with the new energy efficiency laws in our country.

Fund Secretariat's response:

The Secretariat believes this question raises two issues, namely the general definition of the MCII and the additional features it should offer.

In paragraph 11 above, we already referred to the problem of comparing different levels of sophistication in a fair way. The MCII has defined the conversion in a somewhat simple way, as if the manufacturer would undertake, for him, the most cost effective conversion. This standard for comparison has the following advantages:

- It is relatively easily defined;
- It is fair in the sense that similar levels of sophistication are compared;
- It is fully consistent with Guidelines of the Executive Committee on eligible cost.

However, it might be misleading if, as it might be in this case, a government wants to document the actual choice taken including advances in sophistication of the equipment, as it appears to be the case here. For these cases, it is expected that a number of system parameters in the model – heat exchanger surface area, compressor isentropic efficiency, and possibly the replacement of a fixed speed drive by a variable speed one – can be upgraded from the original conversion; this will lead to a substantial reduction in energy consumption. However, it is actually indicated in the question from Argentina that a number of products which used ODS had an energy efficiency below the regulatory benchmarks. The conversion was not only meant to convert away from HCFCs, but was superimposed by a move to more energy efficient products. With the options currently available, the MCII would separate the two steps and calculate only one of them, the

[2] The model calculates assuming the vastly predominant air-to-refrigerant heat exchangers; for liquid-to-refrigerant heat exchangers, the accuracy would be somewhat lower using the model explained

conversion away from ODS; an upgrade in components and, therefore, of energy efficiency can be introduced in addition to the conversion. If the Executive Committee desires to do so, the MCII could, for example, be adapted to calculate the contribution of refrigerant change and component / energy efficiency upgrade separately visible in the results.

The Secretariat would like to use this opportunity to point out that a common understanding on what is to be compared using the MCII is absolutely fundamental in coming to a possibly different set of assumptions for comparisons.

14. That said, we think that this indicator gives a climate impact that can only be considered as a generic one, and has not taken into account the efficiency of the alternative. The performance of the appliances may have big variations according to the design.

15. As said before, the additional impact caused by the higher GWP of the R410A can be compensated by the lower charge needed, the improvement in the equipments' design and the higher efficiency of the refrigerant.

Fund Secretariat's response:

It is correct that the indicator can only indicate and not provide exact results; this should actually not be its purpose. More precisely, for exact climate assessment once the exact specifics of the equipment before and post conversion are known, the MCII is probably not the ideal instrument for comparison. Life-cycle climate assessment might be a suitable tool for those cases where the information is largely known.

However, these cases will form an exception rather than the rule. The case of Argentina is particular and not typical since in Argentina the manufacturers know the energy efficiency of their equipment to be built in the future, actually they can even select it. This is due to the fact that the manufacturers have the possibility to choose the most suitable from several pre-fabricated kits with specified performance characteristics that can be assessed by the manufacturers even before they have even assembled one unit. In the number of conversions under the Multilateral Fund, this is predominantly not the case; the manufacturers often have little insight and in many cases also no particular interest in the energy consumption of future equipment; in a fair number of cases, not even the current energy efficiency is known. The Secretariat would therefore like to seek caution when drawing conclusions from this particular question, since the case presented here by Argentina is not generally applicable.

The MCII allows a forecast on a very small set of entry data, and aims to provide a fair comparison of alternatives within the limits given. It cannot compete with measured data, which is the basis for performance characteristics for pre-fabricated kits, and is not intended to take into account increases in sophistication, not the least because technical upgrade is specifically not eligible under the Multilateral Fund. It is critical to limit the expectations towards the MCII to a task which can be fulfilled on the basis of the effort that typically national ozone units and bilateral and implementing agencies can be asked to undertake.

The Secretariat would like to advise that, at present, there are little indications in literature that the refrigerant has an inherently higher efficiency; that the efficiency is actually lower and therefore components need upgrading is also frequently claimed by implementing agencies of the Multilateral Fund. However, there are strong indications, that new models using HFC-410A often have a similar or higher energy efficiency than the models with HCFC-22 which they replace. These two facts are not at all mutually exclusive.

16. Regarding the last column "impact indicator", we think that the language could be modified in order to better emphasize the impacts, for instance, of you consider an 11% decrease in emissions as "significant", then a 50% decrease could be considered as "highly significant", and a 3% decrease as a "moderate" one.

Fund Secretariat's response:

In the present selection there is a range defined as "climate neutral", which represents the assumed error band left and right of the figure "zero". The borders for other deviations were selected based on the apparent frequency of the different results. While this delivers an acceptable relative rating, it is definitely not perfect, and other margins determined with other approaches are definitely possible. We are happy to take the suggestions from Argentina and/or others on board.

17. As a general comment, we would like to add that the development methodology for this index has been a little bit difficult to follow since it implies a very technical approach that can be followed only by experts.

Fund Secretariat's response:

We agree that the model distributed needs further improvement to make it easier to use. The main point at this time was to provide the possibility for members of the Executive Committee to gain an understanding of how it would work, and provide feedback to give the final developments more direction where needed. In using the MCII for several submissions, a number of possible improvements have already been identified.

The Secretariat has also faced the difficulty of, on the one hand ensuring that the approach is transparent, and on the other that it is simple to understand. Unfortunately the two are not far from being mutually exclusive. The Secretariat has therefore tried to move a lot of the purely technical information into annexes. As explained above, we also strive at further simplifications for the users, in particular regarding the classification of their equipment. We also understand that the results can benefit from further simplification and are considering how to achieve that – classification of results as mentioned in above paragraph 16 might be one of the actions which can be taken.

The concept of the MCII tool is, in the end, that the user would need to make some very simple entries, trust the calculations within the tool, and receive a relatively straight-forward feedback, with the possibility to look deeper into the underlying data if desired. To achieve this objective, a few more steps might be necessary.

Annex II

MULTILATERAL FUND CLIMATE IMPACT INDICATOR TECHNICAL DESCRIPTIONS OF DIFFERENT CONSUMPTION SECTORS

1. Decision XIX/6 of the Meeting of the Parties requested the impact of energy consumption on the climate to be taken into account. The Secretariat focussed its work on achieving progress with the MCII for the refrigeration and air-conditioning manufacturing sectors first, since it is assumed that in these two sectors the effects of energy consumption on the climate are more prevalent than in other sectors.

MCII for refrigeration and air-conditioning manufacture conversion activities

2. The MCII has been developed to allow an indication of the effect on the climate of future conversion projects to be funded by the Multilateral Fund. The MCII is therefore a tool operating on the basis of data available during the preparation and/or review of Multilateral Fund project submissions. Consequently, data related to the characteristics of products using the current technology is often only sketchily documented, information about the conversion and the characteristics of the converted project are not available at all. On this basis, the MCII is meant to help indicating the climate impact of the activities. It is not meant to replace any possibly desired subsequent analysis undertaken on the basis of more detailed data, and maybe detailed performance information of specific models for baseline and alternative, such as a life cycle climate performance (LCCP) or a life cycle analysis (LCA).

3. The MCII for refrigeration and air-conditioning activities takes into account:

(a) the emissions of refrigerant during manufacturing, operation and at the end of life, called the direct emissions; as well as

(b) the energy consumption of products using HCFC and their alternatives as refrigerants, called the indirect emissions.

4. In a first step the model used calculates the emission of one refrigeration or air-conditioning unit over its lifetime as a sum of direct and indirect effects, and multiplies the result with the amount of units produced in one year. This interim result represents the climate impact of the annual production for a given technology. For a qualitative comparison of different alternatives, the ratio between the baseline (HCFC) and the alternative is used (percentage values). For aggregated, sector-or country-wide figures, the difference between the two is being used (absolute values in tonnes of CO_2 equiv.). Negative values for the MCII denote a reduction in the climate impact as compared to the baseline, positive values an increase,

5. The direct emissions of HCFCs and alternatives take into account a large number of factors related to the lifetime of each unit manufactured, and aims to use general assumptions to quantify them. This quantification is carried out for the lifetime of the equipment and relates to:

(a) The HCFC charge, being an input value, and the potentially different charge of the alternatives[1];

[1] Charge differences are generalized assuming same inner volume of the components, and using the ratio of the liquid densities of the different refrigerants in reference to the baseline (e.g. HCFC-22). The liquid density is assumed as the mean of the values for 42°C and, depending on the application, for -32°C, -4°C and 0°C.

(b) A 2 per cent emission at the time of manufacturing for systems assembled and charged in a factory;

(c) Typical annual emissions for an average unit, depending on the type of refrigeration or air-conditioning equipment and on assembly in a factory or on site, as shown in Table 1;

(d) An average lifetime for each unit depending on the various types of refrigeration and air-conditioning equipment as well as on assembly in a factory or on site, as shown in Table 1;

(e) Recovery at the end of life, currently, in line with practices typical for Article 5 countries assumed to be zero, as shown in Table 1; and

(f) The climate impact of the substance, calculated on the basis of the substances Greenhouse Warming Potential (GWP) for a 100-year time horizon.

Table 1: Values used as assumptions for annual emissions and lifetime

Type of application	**AC, factory assembly**	**AC, on site assembly**	**Commercial Cooling, factory assembly**	**Commercial Cooling, on site assembly**	**Commercial Frozen, factory assembly**	**Commercial Frozen, on site assembly**
Baseline refrigerant	R22	R22	R22	R22	R22	R22
Product lifespan	10	10	10	14	10	14
Leakage at manufacturing	2%	0%	2%	0%	2%	0%
Annual leakage	2%	5%	2%	25%	2%	25%
Recharge level	55%	55%	55%	55%	55%	55%
Recovery fraction	0%	0%	0%	0%	0%	0%

6. The carbon dioxide emissions related to energy consumption of refrigeration equipment depends on the size, quality of the components, quality of design, application and the operating conditions (chiefly the ambient temperature), and, finally, the CO_2 emission related to the production of electricity. In order to take the different factors into account, a number of assumptions were made and procedures were developed:

(a) It is assumed that the principle quality of components and quality of the design remain constant; reflecting the content of decision 61/44 of the Executive Committee, asking the Secretariat to "maintain the established practice when evaluating component upgrades in HCFC conversion projects for the refrigeration and air-conditioning sectors, such that after conversion the defining characteristics of the components would remain largely unchanged or, when no similar component was available, would only be improved to the extent necessary to allow the conversion to take place […]"[2];

[2] For heat exchangers decision 61/44 was reflected assuming constant product of heat exchange surface and heat transfer coefficient, based on the values calculated for an HCFC baseline system at the design temperature of the system. For compressors, decision 61/44 of the Executive Committee was reflected by using a constant isentropic efficiency while adapting the swept volume to the compressor to provide the specified capacity at the design temperature of the system. The design temperature of the system is either 32°C or 40°C, the selection of which depends on the country of production and, for export, a generalised figure of 32°C.

(b) The parameters entered as input values are also assumed to remain constant; in particular the capacity of the system, the application and whether a unit is factory assembled or assembled in the field, as well as the country and the share of export;

(c) The load of the system is estimated depending on the design load = capacity of the unit, and an estimated deviation for different temperatures. A more detailed description can be found in Annex III;

(d) The energy efficiency varies, depending on the refrigerant used, for different outdoor temperatures; two refrigerants having the same energy efficiency at one outdoor temperature and otherwise identical operating conditions will show a difference in energy consumption at other conditions. In order to reflect this important effect, the Secretariat has attempted to collect the frequency of occurrence of temperatures for each Article 5 country in steps of 2 deg C. The energy efficiency is accordingly calculated for these outdoor temperatures and multiplied with the occurrence and the number of hours per year. In case of countries with several climate zones, the occurrence has been calculated by weighting the different climate zones according to the population living in them, as a proxy to the number of refrigeration systems used[3];

(e) The emission of carbon dioxide are published for a number of Article 5 countries and have been estimated for the remainder according to information found in literature; however, for most countries with refrigeration manufacturing capacity, i.e. larger Article 5 countries, information has been published[4].

7. Major challenges encountered by the Secretariat were related to the lack of precedent as to how countries and implementing and bilateral agencies would address the issue of data collection for refrigeration and air-conditioning equipment, due to a significant amount of submissions for projects covering more than one enterprise coming forward only to the 61st and 62nd Meetings of the Executive Committee. The formats used by the agencies to collect data lead to the need for significant changes in data management as compared to the original concept. It is assumed that these challenges faced by the Secretariat can be largely reduced in the next round of submissions by providing sufficiently detailed yet still practical data formats for submission.

MCII for foam manufacture conversion activities

8. For products manufactured in the foam sector, the direct effect caused by the foam blowing agent used over the lifetime of the product is relatively easily determined for the current use of HCFCs, since the entire foam blowing agent is emitted[5]. For post conversion emission, the case is more complex, since the amount of foam blowing agent used to produce a pre-defined quantity of foam will change; in addition, in some cases this quantity is defined based on mass of foam, in others on the volume of the foam. Additional variations are possible by using more than one blowing agent, e.g. in case of the common practice of adding water to HFC-245fa. Finally, in the case of insulation foams, the thickness of the insulation foam might be changed to accommodate changes in the insulation properties of the foam; a different foam thickness would be equivalent to a higher volume of foam, leading to a respective increase in foam blowing agent used.

[3] For example, Algeria shows both Mediterranean climate as well as hot and arid climate. However, the population is predominantly concentrated at the more temperate coast; consequently the coastal conditions have a higher relative weight than the conditions in the centre of the country.

[4] The Secretariat is still in the process of assessing the quality of the related data and improving it, where necessary.

[5] While the indicator is being set-up in a way which allows accounting for collection and destruction of the substance at the end of life of the product, at this time there is little indication to assume that in Article 5 or non-Article 5 countries a significant portion of foam blowing agent will be collected from products containing such foam.

9. Based on these considerations, a concept was developed on how to incorporate energy efficiency in the calculation of the MCII. After consultation with experts, the current concept is to distinguish between several different scenarios:

(a) Use of polyurethane foam for applications which require constant insulation effect. The related calculation model is meant to use some basic information and standardized properties of polyurethane foam to determine the change in wall thickness necessary to provide the same insulation effect when changing the foam blowing agent from an HCFC to an alternative technology from a pre-defined list. The change in wall thickness, in combination with the different amount of blowing agent per volume of foam needed and the change in density, will allow a calculation of the amount of alternative foam blowing agent needed. Typical applications would be all types of insulation with a defined insulation effect: e.g. based on regulatory requirements;

(b) Applications requiring the same volume of polyurethane foam, calculating the different amounts of blowing agent for the various technologies needed to produce a given volume of foam. This would be for example applicable to integral skin foam products for automotive use;

(c) Insulation foam used in confined refrigerated spaces, where the wall thickness cannot be changed to accommodate different insulation properties and where the insulated space is refrigerated. This option can be used for the insulation of refrigerators, commercial refrigeration equipment etc. where an increase in insulation thickness is often not possible due to space constraints[6];

(d) Use of extruded polystyrene foam for applications which require constant insulation effect. The calculations are performed similar those in the case indicated in sub-paragraph (a) above for the manufacture of polyurethane foam. This is a likely occurrence in the building industry;

(e) Use of extruded polystyrene foam in confined spaces, for applications where the wall thickness cannot be changed. The calculations are carried out similar to those in sub-paragraph (c) above manufacture of polyurethane foam.

MCII for conversion activities in other manufacturing sectors

10. In preparation for the 62nd Meeting, the Secretariat has also received projects and activities in the solvent and fire fighting sectors. The concept of the MCII can be extended to those sectors by assuming a certain release pattern. For solvent as well as for process agent uses, an assumption of a complete release in a short period of time after consumption is certainly meaningful. For the fire fighting sector, a more differentiated approach is necessary, since large quantities of fire fighting agents are simply stored and typically not released or released only after many decades of storage in fire fighting systems. The Secretariat has not yet developed a methodology for the MCII for the fire fighting sector.

[6] The cycle calculation model and country-specific data from the refrigeration model is meant to be used to calculate a change in energy consumption and related emissions of CO_2 related to electricity generation, which is added to the climate impact of the blowing agents. The reason for the calculation of energy related emissions only in cases where the energy use is refrigeration, and not for heating is that the difference is in energy used for heating, from sun powered over electricity, gas, oil, and coal as well as heat pumps is so diverse that no meaningful assumptions can be made for the emissions of carbon dioxide related to the additional heating needs of e.g. a building caused by a change in the insulation properties used.

MCII for the servicing sector

11. The Secretariat has attempted to extend the concept of the MCII to the servicing sector by addressing specific activities that are undertaken as part of the funded service sector activities in HPMPs. The basis for a methodology considered for submissions is that only those emission reductions are taken into account which are directly and quantifiably linked to activities funded by the Multilateral Fund, and that double counting with manufacturing sector activities is avoided. Consequently, changes in the climate impact caused by political agreements, for example the phase-out of HCFCs, are not covered since they are not linked to funded activities but to a commitment of the country to phase-out HCFCs. Accordingly, activities such as awareness and customs training will not contribute positively to the climate impact, since they are supporting compliance with a political agreement and are not directly causing reductions in climate relevant emissions. The remaining activities have in common that they are meant to reduce the consumption of HCFCs through reducing inefficient use of refrigerant. However, should the demand for HCFCs in the country be larger than the supply, any HCFC saved by reducing inefficient use of refrigerant would be used to satisfy the demand. The likely reasons why the supply would be smaller than the demand are import restrictions caused by the need to comply with the reduction schedule of the Montreal Protocol. If the activity leads to a better distribution of refrigerant away from inefficient use towards servicing more existing refrigeration systems, this would help the country to remain in compliance with the provisions of the Montreal Protocol. It would, however, not reduce the absolute amount of HCFC refrigerant used. Consequently, it would be difficult to assign under these circumstances a reduction in climate-relevant emissions directly related to the activity. However, the effect of this provision is likely to be very small, since according to reported data most countries consume less than their compliance target.

12. The attempt to calculate the value for the MCII for the servicing sector focuses on three types of activities in the servicing sector:

(a) Activities related to recovery can reduce the amount of refrigerant used by recovering, possibly recycling and reclaiming refrigerant during service and end-of-life of the equipment. For recovery, recovery and recycling and reclamation equipment, the existing experience of the Multilateral Fund allows for some broad assumptions regarding the amount of substance recovered, recycled, or reclaimed per year. The amount of refrigerant recovered, recycled or reclaimed will reduce the amount of new HCFCs to be used, and will consequently have a climate impact for those cases where otherwise new HCFC could have been used. The available data will allow this climate impact to be quantified depending on the number of machines to be used. A problem yet unresolved is how to determine a maximum meaningful number of machines for a given country in order to take into account the law of diminishing returns for increasing effort to recover refrigerant from existing systems.

(b) Servicing practices can be improved to some extent through training and provision of better tools for servicing. It is possible to assume that training of a refrigeration technician (as compared to no training) has some impact in terms of a reduction in refrigerant consumption. However small the effect might be for each technician, the relatively large training programmes supported by the Multilateral Fund are likely to show a noticeable positive effect in reduction of use of refrigerant during the service of refrigeration and air-conditioning equipment. Since every kilogramme of reduced consumption is reducing the impact on the climate accordingly, a figure for the climate impact of these measures can be calculated for those cases where otherwise new HCFCs could have been used.

(c) Activities related to replace HCFC-22 in existing refrigeration systems:

(i) The precondition of a positive impact on the climate for any replacement of HCFC-22 in existing systems is the recovery of the remaining refrigerant and its destruction or, for those countries with HCFC consumption below the compliance requirements, possibly its recycling. In all other cases, the impact of a replacement on the climate is most probably negative;

(ii) The replacement of existing HCFC-22 systems in refrigeration or air-conditioning with new systems using an alternative technology might lead to an impact on the climate. In order to avoid double-counting, such replacements would only be accounted for under the MCII for systems which would not be covered by a manufacturing sector phase-out project under the Multilateral Fund, i.e. the impact would only be calculated for custom-made systems, typically assembled, installed and charged at the owners location; an example would be a supermarket system. The implementing agency would have to provide the number of systems to be replaced, their approximate refrigeration capacity[7], whether the system is assembled and charged locally, and the alternative technology. The impact indicator would use this data to estimate the charge of HCFC-22 per refrigeration system, and extend this information to all systems covered by this specific activity. Based on an average remaining charge of HCFC-22 in the system at the time of replacement, and the design charge for the replacement, the difference in climate impact between the two can be determined. In those cases, the energy efficiency is not taken into account since the specific conditions of systems assembled on site do not allow the meaningful use of the relatively small differentiation in energy consumption between the system before conversion and afterwards.

(iii) After some consideration, the Secretariat has decided not to propose retrofit of existing systems in the activities which lead to a climate impact. The reason is that for existing systems, the typical retrofit technology would be the refrigerant with the closest match in thermodynamic and thermophysical properties, i.e. HFC-407C. Other than certain efforts related to exchanging the refrigeration oil and possibly replacing some controls, chiefly the expansion valve, the retrofit would be very simple to undertake. The difference in GWP between HCFC-22 and HFC-407C is fairly small (2.0 per cent) with HFC-407C having the lower GWP, further amplified by the density difference leading to a difference in climate impact based on the amount of fluid within the system of 5.43 per cent. However, the energy consumption in an existing system is more likely to increase than decrease with a conversion to HFC-407C. In combination, the climate impact is likely to be marginal, and should be assumed zero. While in terms of refrigeration characteristics HC-290 (propane) could be used in a similar way as HFC-407C, the flammability of HC-290 should in the vast majority of cases prevent HC-290 from being used for retrofits. Should a large retrofit programme be submitted to address this particular issue in an attempt to overcome the barrier for using HC-290 safely in systems designed for non-flammable refrigerants, the related calculations could be established based on principles explained above.

[7] The refrigeration capacity would be used to calculate the likely charge of these systems, since at the time of project submission such an approach might be the most accurate one.

13. The Secretariat is presently in the conceptual phase and wanted to present the above considerations regarding the service sector to the Executive Committee and the bilateral and implementing agencies; the Secretariat welcomes any feedback on these considerations. Some modelling calculations done by the Secretariat have shown that even using conservative assumptions and despite the limitations spelled out above, the effect that the activities in the servicing sector have on the climate might in some cases be significant.

Annex III

BACKGROUND INFORMATION REGARDING THE CALCULATION OF THE MCII (REFRIGERATION PART)

Introduction

1. The refrigeration model described in this document is part of the Multilateral Fund Climate Indicator (MCII) developed by the Multilateral Fund Secretariat; this model has been developed by Re/gent, a Research & Development centre in The Netherlands specialised in refrigeration, air conditioning and heat pumps. It has been integrated into a Microsoft Excel shell for data entry and, in particular, data management by Mr. Anton Driesse from Canada. The model can at this time be used to assess the environmental impact of HCFC-22 and its alternatives under different climatic conditions. It is still in a state of development, and therefore details described in this annex might be subsequently changed and documented accordingly. This annex concentrates mainly on the description of the model used for the calculation of the refrigeration cycle.

2. This version of the model is entirely developed as a spreadsheet tool, which is able to calculate refrigeration and AC system performances under a variety of ambient conditions and compare the results with an HCFC¬22 base case. This comparison does include both energy consumption as well as the related CO_2 emissions for which regional data is included in the model.

3. The spreadsheet model is structured as follows:

(a) A main sheet which contains the user input data (such as refrigeration system to be studied, country of application, etc.). Also the main output data is shown here, such as annual energy consumption and CO_2 emission for all the HCFC-22 alternatives included. The results are shown in tabular format;

(b) A transfer sheet into the actual refrigeration model, which is contained in a separate Excel file. This second Excel file contains also the other refrigeration-relevant information, such as

(i) A detail sheet which contains some of the main results calculated. It shows the system performance at the design point as well as a diagram of system efficiencies and compressor run time over the various ambient temperatures;

(ii) A set of cycle x sheets containing the refrigeration cycle calculations[1], based on ideal loop calculations extended with isentropic efficiencies of the compression process. The cycle calculations are automatically be performed for all relevant ambient temperatures (using a bin approach with temperature intervals);

(iii) A settings sheet which contains predefined data for the refrigeration/AC systems which can be assessed; and

(iv) A work area sheet where some background calculations, intermediate results etc. are placed.

[1] With “x” representing the name of the refrigerant.

(v) The spreadsheet model further contains some code modules (using VBA programming language), which is used for the necessary user interfacing.

(c) The spreadsheet model does require refrigerant property data. The data included in the model has been derived from the refrigeration property software (Refprop 6) from the National Institute for Standards and Technology in Boulder, United States of America. The Refprop data is included in the model by using tabular data and using interpolation methods to find intermediate data points. This avoids that a real property model needs to be installed along with the spreadsheet model, in order to be able to distribute the spreadsheet model without issues related to intellectual property.

Model description

4. Within the cycle model the refrigeration system is calculated using various refrigerants and for various ambient conditions. The ambient conditions are taken from the country specific occurrence of temperatures, which is for the purpose of the calculation converted to 20 different ambient temperatures where for each temperature the number of hours is known.

5. In a first step, a calculation of the base system is performed using HCFC-22 in the design condition. This generates some system data which is then used to calculate the cycle in the various ambient conditions in the off-design point calculations. For each of the operating temperatures this results in a system cooling capacity and the energy consumption. By multiplying the consumption with the number of hours in each temperature interval, it is possible to establish the total annual energy consumption of the system.

6. There are some special cases in the cycle calculations:

(a) If the compressor run time exceeds 100 per cent in general the system will not maintain the product temperature any more (e.g. the cooling unit will start to increase in temperature). In the model this is not compensated for, i.e. it is assumed that the compressor runs 100 per cent of the time, and the product or room is actually increasing in temperature. However, this is only the case at temperatures very significantly higher than the design temperature, and has not been reached in the simulations carried out;

(b) At very low ambient temperatures the condensation temperature may drop below the evaporation temperature (e.g. for the cooling application). This is prevented in the programme by setting a minimum temperature differential between condenser and evaporator and assuming for all temperatures below 10^{o}C constant conditions similar to 10^{o}C outdoor temperature. This is the simulation equivalent of the reality of a condenser fan control or a condensation pressure regulator; and

(c) The model has been extensively tested and rewritten to improve both running times and convergence of the result.

Design calculation

7. After the selection of the type of refrigeration or air-conditioning system, and the country with its climate data in the background, it is necessary to specify the required thermal load for which the system was designed (the amount of heat the cooling system must extract at design condition). This is equal to the capacity to be provided by the user. By the selection of the refrigeration and air-conditioning system and the country, a large number of parameters are preset; those are partially referred to already in Annex I

of this document. With these parameters being set the following calculation structure is applied for the base refrigerant HCFC-22:

(a) First the main refrigerant loop parameters are calculated, condensation and evaporation temperatures and outlet conditions of the evaporator as well as the condenser;

(b) From the system cooling capacity, an evaporator analysis is carried out leading to the evaporator conductance used for further calculations at off-design conditions;

(c) The refrigerant mass flow is determined;

(d) From the compression process the exit conditions at the compressor, which are equal to the inlet conditions of the condenser are derived; and

(e) Finally a condenser analysis can be made leading to the condenser conductance and the condenser air flow rate.

8. After the analysis of the HCFC-22 system at design condition, the evaporator and condenser sizes (conductance or UA values) are known as well as the air flows through evaporator and condenser. In addition also the compressor size needed for HCFC-22 to match the thermal load supplied is calculated. The evaporator and condenser information (UA and flow rate) is then applied to calculate the operation of the selected system with all alternative refrigerants. For each of these refrigerants a compressor size is selected which matches the thermal load at the design condition. After these preliminary calculations the off-design point calculations can start.

Main circuit parameters

9. It is possible to derive the evaporation temperature from the air inlet temperature to the evaporator and the temperature differential given by the user. From the refrigerant properties the evaporation pressure can be calculated. As the evaporator superheat is defined by the system selection, it is possible to calculate the evaporator exit enthalpy using the appropriate refrigerant relations.

10. For the condenser side, the condensation temperature can be derived from the air temperature entering the condenser and the temperature differential given by the user. Also here the condensation pressure is derived from refrigerant properties. The condenser exit temperature can be found by subtracting the sub-cooling supplied by the system selection from the condensation temperature. Using the appropriate refrigerant relations it is possible to calculate the condenser exit enthalpy.

11. Assuming isenthalpic expansion in the throttling device in the circuit, the evaporator inlet enthalpy can be set equal to the condenser exit enthalpy.

Evaporator calculation at design

12. The cooling capacity of the system can be calculated from the thermal load given and the compressor run time:

$$Q_r = \frac{Q_L}{R_p}$$

13. For the evaporator air side, the temperature differential is specified during system selection. As the cooling capacity is known, it is possible to calculate the air mass flow (and hence also the air volumetric flow):

$$\dot{m}_{e,air} = \frac{Q_r}{c_{p,air}(T_{e,air,in} T_{e,air,out})}$$

14. As all temperatures are defined it is further possible to calculate the logarithmic mean temperature difference for the evaporator. It is then simply possible to calculate the evaporator conductance by:

$$(UA)_e = \frac{Q_r}{LMTD_e}$$

This implies that the evaporator heat transfer characteristics at design conditions are fixed and can be used later for other temperature conditions.

Refrigerant mass flow at design

15. The refrigerant mass flow can be calculated from:

$$m_r = \frac{Q_r}{h_{e.out} - h_{e.in}}$$

Compression process at design

16. The compressor exit conditions can be calculated using the isentropic efficiency and the inlet conditions. These are typically taken equal to the exit conditions of the evaporator. This allows calculating in the next step the compressor exit enthalpy as follows:

$$h_{comp,out} = \frac{h_{isentropic} + h_{comp,in}(\eta_i - 1)}{\eta_i}$$

17. From the compressor volumetric relations it is possible to derive the compressor displacement volume.

Condenser calculation at design

18. For the warm side (the condenser) it is now possible to perform the heat transfer calculations. First it is assumed that the air entering the condenser coil is at ambient temperature (so the design ambient temperature). As the condensation temperature is known and the temperature efficiency is supplied by the user, it is possible to calculate the air exit temperature:

$$T_{c,air,out} = \eta_c(T_c - T_{c,air,in})$$

Knowing all temperatures also the logarithmic temperature difference can be calculated.

19. The condenser reject heat can be calculated as the refrigerant mass flow has already been established and the refrigerant state points at inlet and exit of the condenser are already known from the previous analysis:

$$Q_c = \dot{m}_r \left(h_{c,in} - h_{c,out}\right)$$

Knowing the condenser heat flow, it is possible to calculate the condenser conductance:

$$(UA_c) = \frac{Q_c}{LMTD_c}$$

It is further possible to resolve the condenser air mass flow from:

$$\dot{m}_{c,air} = \frac{Q_c}{c_{\ p,air}\left(T_{c,air,out} - T_{c,air,in}\right)}$$

<u>Compressor</u>

20. The compressor mass flow can be calculated as follows:

$$\dot{m} = \rho_{comp,in}\eta_v\phi_v$$

With the compressor volumetric efficiency defined as follows (using the clearance volume ratio CL):

$$\eta_v = 1 - CL\ \left\|\left[\left(\frac{p_c}{p_e}\right)^{1/k} - 1\right]\right\|$$

and the compressor displacement is typically found as the product of the compressor swept volume and the operating frequency. In the model the compressor displacement is used rather than swept volume in order to make systems independent on operating frequency as this is generally linked to the main supply frequency.

The compressor outlet conditions can typically be found using the isentropic efficiency given by the selection of the system:

$$\eta_i = \frac{h_{isentropic} - h_{comp,in}}{h_{comp,out} - h_{comp,in}}$$

if the inlet enthalpy to the compressor is known. The isentropic enthalpy is typically found using the appropriate refrigerant property relations.

Condenser

21. Basically three heat transfer relations are relevant for the condenser, for the air side, refrigerant side and the heat transfer between air and refrigerant, respectively:

$$Q = \dot{m}_{c,air} c_{p,air} \left(T_{c,air,out} - T_{c,air,in} \right)$$
$$Q = \dot{m}_r \left(h_{c,in} - h_{c,out} \right)$$
$$Q = (UA)_c \, LMTD_c$$

which must result in the same heat transfer in a stationary situation.

In this relation the logarithmic mean temperature difference is defined as:

$$LMTD_c = \frac{T_{c,air,in} - T_{c,air,out}}{\text{In}\left(\frac{T_c - T_{c,air,in}}{T_c - T_{c,air,out}} \right)}$$

To evaluate the heat transfer for a coil type of heat exchanger, it is possible to use the classical number of transfer units approach. This requires first the definition of the heat exchanger temperature efficiency:

$$\eta_c = \frac{T_c - T_{c,air,out}}{T_c - T_{c.air.in}}$$

It is possible to express the number of transfer units as the ratio of the conductance and the flow capacity:

$$NTU_c = \frac{(UA)_c}{\dot{m}_{c,air} \; c_{\rho,air}}$$

Assuming a cross flow heat exchanger, it is now possible to relate the number of transfer units and the heat exchanger efficiency with

$$\eta_c = 1 - e^{-NTU}$$

In total this is a set of seven equations, with the following 11 variables:

$$Q, \dot{m}_{c,air}, T_{c,air,in}, T_{c,air,out}, \dot{m}_r, h_{c,in}, h_{c,out}, (UA)_c, T_c, NTU_c, \eta_c$$

In general it requires therefore that four variables needs to be specified in order to solve the remaining parameters. Typically the mass flow of air is a given parameter as well as the air inlet temperature. If also the UA-value of the condenser coil is supplied and the refrigerant inlet enthalpy is supplied the remaining parameters can be calculated.

Note that the above only holds for the single fluid refrigerants. For the mixed refrigerants using a temperature glide, an extended model for the heat transfer effectiveness is integrated.

Evaporator

22. Basically three heat transfer relations are relevant for the evaporator, for the air side, refrigerant side and the heat transfer between air and refrigerant, respectively:

$$Q = \dot{m}_{e,air} c_{p,air} \left(T_{e,air,in} - T_{e,air,out}\right)$$
$$Q = \dot{m}_r \left(h_{e,out} - h_{e,in}\right)$$
$$Q = (UA)_e \, LMTD_e$$

which must result in the same heat transfer in a stationary situation.

In this relation the logarithmic mean temperature difference is defined as:

$$LMTD_e = \frac{T_{e,air,out} - T_{e,air,in}}{\text{In}\left(\frac{T_{e,air,in} - T_e}{T_{e,air,out} - T_e}\right)}$$

To evaluate the heat transfer for a coil type of heat exchanger, it is possible to use the classical number of transfer units approach. This requires first the definition of the heat exchanger temperature efficiency:

$$\eta_e = \frac{T_{e,air,out} - T_e}{T_{e,air,out} - T_e}$$

It is possible to express the number of transfer units as the ratio of the conductance and the flow capacity:

$$NTU_e = \frac{(UA)_e}{\dot{m}_{e,air} \; c_{\rho,air}}$$

Assuming a cross flow heat exchanger, it is now possible to relate the number of transfer units and the heat exchanger efficiency with

$$\eta_e = 1 - e^{-NTUe}$$

In total this is a set of seven equations, with the following 11 variables:

$$Q_r, \dot{m}_{e,air}, T_{e,air,in}, T_{e,air,out}, \dot{m}_r, h_{e,in}, h_{e,out}, (UA)_e, T_e, NTU_e, \eta_e$$

In general it requires therefore that four variables needs to be specified in order to solve the remaining parameters. Typically the mass flow of air is a given parameter as well as the air inlet temperature. If also the UA-value of the evaporator coil is supplied and the refrigerant inlet enthalpy is supplied the remaining parameters can be calculated.

Note that the above only holds for the single fluid refrigerants. For the mixed refrigerants using a glide, an extended model for the heat transfer effectiveness is integrated.

Off-design point calculation

23. Once the system has been selected and the calculation of the refrigeration system in the design point has been completed, it is possible to calculate the refrigeration cycle at other conditions. From the design point the air flow and thermal conductance (UA) of both the evaporator and condenser have been derived and are assumed to be the same in other operating conditions. Other parameters, such as superheat, sub-cooling and isentropic compressor efficiency are all supposed to remain constant when the operating conditions of the system changes.

24. With this given set of data an iterative calculation of the system is needed. This is due to the fact that only the air entrance temperatures are given for both the condenser and evaporator, but the condensation temperature and evaporation temperature are unknown. In fact the set of relations described under the compressor, condenser and evaporator topics are all applied and calculated. This requires first some assumptions for certain parameters, here the evaporation and condensation temperature are applied. Once assumed, it is possible to derive an error in the set of equation, which is used for revising the assumed evaporator and condenser temperature, this until convergence is achieved. In the cycle sheets, the off-design calculations are performed for different external ambient conditions, which generally impact the condenser performance.

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