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多边基金执行委员会
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关于氟氯烃淘汰供资方面有关费用因素的订正分析
（第 53/37(i)和 54/40 号决定）

执行摘要

氟氯烃和氟氯烃供资问题概述

1. 截至 2008 年 4 月，多边基金已核准的 项目和活动若得以全面执行，预计将淘汰大约 250,000 ODP 吨的消耗臭氧层物质消费量。与此同时，相比之下第 5 条国家 25,765 ODP 吨的氟氯烃的消费量看似适度，但这一 ODP 消费量转换为公吨后约为 363,400 公吨，似乎使待处理的氟氯烃淘汰高于基金迄今为止所实现的淘汰。

2. 目前，HCFC-141b、HCFC-142b 和 HCFC-22 三种化学品占第 5 条国家所有氟氯烃消费总量的 99%以上。这些氟氯烃主要用于制造泡沫塑料产品和制冷设备以及用于制冷维修次级行业。剩余的氟氯烃消费量被用于气雾剂、灭火器和溶剂行业中的专门用途。虽然还没有足够的数据可以查明准确数字，但确定的是，约 90 个国家只在制冷维修和空调设备中使用 HCFC 22，此外，约有 50 个第 5 条国家的企业在生产制造中使用氟氯烃。因此，在遵守 2013 年冻结目标和 2015 年削减目标方面，制冷维修行业将发挥重要作用，特别是那 90 个或更多的没有使用氟氯烃的制造企业的国家。鉴于基金迄今所取得的经验，那些只在维修行业使用氟氯烃的国家将有可能通过氟氯烃淘汰管理计划和诸如技师培训、回收和再循环及转产奖励方案等相关活动实现淘汰。而那些在制造行业使用氟氯烃的国家将必须通过行业或国家投资构成部分加强氟氯烃淘汰管理计划活动。

淘汰氟氯烃的现有政策

3. 根据第 53/37(i)号决定，现已查明泡沫塑料和制冷行业淘汰氟氯烃的可靠替代技术，并对相应的费用指示性范围进行了估算。特别是，估算了制造企业向替代技术转产的增支资本费用和与新替代技术有关的增支经营费用。有观点认为，在这一阶段，现有的费用范围没有为建议项目转产模版或确定特定类型转产供资阈值提供基础，而是展示了与转产有关的资本费用和经营费用的相关数额，以便更好地为执行委员会当前的讨论提供信息。在此基础上，基金秘书处认为，有充分的依据按照第 54/39 (d)号决定[1]编制、审查、审议和核准初期的独立氟氯烃转产项目。但是，关于行业或国家氟氯烃淘汰计划，秘书处不确定其是否有能力就这些计划的适当费用问题向执行委员会提供明智的建议，而是认为，或许有必要首先根据从对少数独立氟氯烃转产项目和将由第 5 条国家编制的氟氯烃淘汰管理计划[2]的审查中获取的经验制订氟氯烃淘汰项目费用框架。

4. 如上所述，多边基金项目的供资取决于对符合供资条件的增支资本费用和增支经营

[1] 关于选择在氟氯烃化合物淘汰管理计划完成之前执行投资项目的国家：（一）各项目的核准应实现淘汰氟氯烃化合物淘汰管理计划所定消费量的氟氯烃，并且在 2010 年以后不再核准此类项目，除非它们是氟氯烃化合物淘汰管理计划的一部分；和（二）如果采用各别项目的方法，第一个项目提交的资料应说明示范项目如何与氟氯烃化合物淘汰管理计划相关，以及何时提交氟氯烃化合物淘汰管理计划。

[2] 对 115 个以上第 5 条国家氟氯烃化合物淘汰管理计划编制的供资已提交执行委员会第五十五次会议审议。

费用的评估。增支资本费用由实现转产所必须的设备费用决定。相对的，增支经营费用在概念上是已支付的使用如各类氟氯化碳的费用和使用取而代之的氢氟碳化物的费用之间的差额，支付的持续时间由执行委员会决定。各行业时间长短有所不同，在零到四年之间。在有些情况下，如气雾剂行业，替代物质的成本要低于其所替代的化学品，较低的增支经营费用导致可用于支付转产资本费用的供资减少，使转产更加困难。至于氟氯烃，目前在第 5 条国家新技术商业化的当前阶段，关于准确量化构成氟氯烃淘汰项目中增支经营费用的费用参数还有很高的不确定性。但是，如果现行的对消耗臭氧层物质供资的政策和标准保持不变，则氟氯烃淘汰项目中增支经营费用，视选定的替代物质，将占据项目总费用的大部分，类似的氟氯化碳淘汰项目也是如此。以现金形式支付的增支经营费用对企业而言是一种奖励，以便在氟氯化碳淘汰过程中尽早进行转产。但是，考虑到如 HFC-245fa 等费用较高的替代物质，以及如碳氢化合物等费用较低的零全球变暖潜势[3]替代物质，似乎目前的增支经营费用机制将导致对企业的不正当奖励，促使其申请转向定价更高而全球变暖潜势也更高的替代物质，其结果显然不会符合缔约方大会第 XIX/6 号决定的精神或条款。因此，执行委员会深入审议这一问题的时机已经成熟，可酌情提交一些初期独立项目以及评估增支经营费用所需的相关资料，以便使委员会能够依据更准确的数据来审议该问题。

5. 在确定是否符合替代在多边基金援助下安装的使用氟氯烃的设备（第二次转产）的供资条件过程中，不可能提交使用此类设备的企业关于氟氯烃淘汰的独立项目。执行委员会将在 2009 年初第五十七次会议上就有关第二次转产和安装截止日期的问题做出决议，以便为替代氟氯烃的设备供资。这对于是否考虑让独立转产项目避免严重拖延而继续进行至关重要。

<u>泡沫塑料行业技术和费用</u>

6. 如上所述，约 50 个第 5 条国家在制造业中使用氟氯烃。因此，最大的应用领域是在泡沫塑料生产中使用 HCFC-141b。幸运的是，在泡沫塑料行业中有很多种替代物质可用于替代氟氯烃的使用。在该行业中，水溶性化学品和碳氢化合物发泡剂已经通过了验证，在第 5 条国家被广泛用作各类氟氯化碳的非氟氯烃替代物质，并且还将被用作 HCFC-141b 的替代物质。与碳氢化合物有关的安全规定给规模很小的企业提出了许多经营难题；但是，气雾剂行业的碳氢化合物技术已克服了类似的难题。此外，现在还有更新的基于氢氟碳化物的技术，并且在非第 5 条国家中被经常使用。但是，从商业角度讲，这些技术还没有被引入第 5 条国家。与氟氯烃相比，取而代之的氢氟碳化物备选办法的全球变暖潜势更高。另一种备选办法是甲酸甲酯技术，它的全球变暖潜势较低，并且能够以较低的费用满足第 5 条国家企业在自结皮泡沫塑料生产和硬质泡沫塑料次级行业某些用途的需要。但是，对某些用途而言，甲酸甲酯仍不能被看作是一项成熟技术。上述替代物质是第 5 条国家可用于应对 2013 年和 2015 年控制目标的所有技术选择。

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[3] 全球变暖潜势是衡量指定质量的温室气体预计对全球变暖造成多大影响的标准。它是一种相对等级，是将所涉气体与同质量二氧化碳的等级相比得出的，而后者的全球变暖潜势被定义为 1。

7. 本文件初步估算了泡沫塑料企业氟氯烃使用转产的增支资本费用和增支经营费用。泡沫塑料行业增支资本费用的数额将主要取决于技术的选择。从积极的方面来看，增支资本费用对于那些安装了新设备以实现从 CFC-11 向 HCFC-141b 转产的企业而言是适度的，不论是依靠其自身资源还是借助多边积极的资源。类似地，水溶性技术总体上能够应用于使用氟氯烃的处理设备。这些企业为实现氟氯烃转产所需的相关费用主要包括培训方面的技术援助和新化学配方的试验。有观点认为，有必要使相关费用的供资水平高于由各类氟氯化碳向氟氯烃转换时的供资额。使用氟氯烃的企业向碳氢化合物技术转产的相关费用与新的处理及安全设备的提供有关，而且设备的费用大约等同于为淘汰氟氯化碳所用碳氢化合物技术提供的设备的费用。但是，如同氟氯化碳淘汰，小企业可能对基于碳氢化合物的技术的吸收能力有限。

8. 尽管用于泡沫塑料行业转产的增支资本费用看似适度，但替代化学品的高昂费用将导致巨大的增支经营费用，特别是对使用氢氟碳化物的溶剂。如果在类似的过渡时期支付了泡沫塑料行业由各类氟氯化碳转产所花费的增支经营费用，则这些费用将在今后使用氢氟碳化物技术的项目的供资总额中占据主要地位，即用于经营费用的成本将远远高于使企业实现转产从而能够使用氢氟碳化物所需要的资本费用。关于碳氢化合物技术，虽然在对实际项目进行审查和评价之前无法完全量化增支经营费用的准确数额，但预计目前规则和政策的适用将产生一些结余。不过，一个第 5 条国家提供的信息指出，在有些生产环境下，向碳氢化合物转产可能与某些经营费用有关。

9. 虽然上述讨论强调更多地从具体项目角度出发，但在泡沫塑料行业氟氯化碳淘汰方面所取得的经验表明，化学品供应商和系统厂商[4]在使生产泡沫塑料所使用的化学系统[5]满足地方市场需求以及各项条件（气候及其他）方面发挥着重要作用。这些为众多泡沫塑料制造商所熟知的中间商能够配制泡沫塑料系统，以使其满足最终用户的特殊需求。因此，有观点认为，继续供资并执行旨在实现第 5 条国家泡沫塑料化学系统最优化和有效性以最大限度降低生产成本的项目将有助于氢氟碳化物和低全球变暖潜势技术（如碳氢化合物、甲酸甲酯）在第 5 条国家的商业化和深入推广。这些项目将直接支持系统厂商的工作，以促进向泡沫塑料生产企业提供新的、非氟氯烃化学系统。

<u>制冷剂行业技术和费用</u>

10. 在制冷行业使用的氟氯烃主要是 HCFC 22。在制冷行业，关于用于生产制造的 HCFC-22 的替代物的情况与泡沫塑料行业有些相似之处。第 5 条国家已经具有氢氟碳化物和碳氢化合物的替代物。虽然大体而言，各种技术都已在多边基金项目中得到应用，但在具体用途和次级行业之间却有明显差别。

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[4] 系统厂商是从事大量泡沫塑料系统预混合业务以向泡沫塑料制造商配给和销售的化学公司。预混合避免了在内部预混站和大量采购系统混合中各种化学成分方面的必要投资。

[5] 泡沫塑料化学系统是专门配制和混合和的化学成分的混合，以便满足特殊的泡沫塑料加工条件和产品质量要求。

11. 在此背景下，第 5 条国家采用低全球变暖潜势技术的可能性，特别是在制冷和空调次级行业，是一个至关重要的问题。谨建议执行委员会考虑是否要求在该行业开展一些示范项目。此举旨在演示和评估关于向低全球变暖潜势技术转产的具体步骤和费用。

12. 目前制冷行业可使用的氢氟碳化物，与其将要替代的氟氯烃相比，大部分都带有更高的直接全球变暖潜势。另一方面，低全球变暖潜势物质的使用，特别是碳氢化合物，还涉及到安全问题。安全问题可以很容易地解决，但结果是产生与泡沫塑料行业相类似的增支资本费用，并且增加了在维修行业确保安全的难度。氢氟碳化物和碳氢化合物技术是第 5 条国家有可能用于应对 2013 年和 2015 年控制目标的所有技术选择。之后，不易燃、毒性低的低全球变暖潜势制冷剂是否、何时以及将在何种用途中使用仍不清楚。本文件初步估算了制冷制造行业使用氟氯烃的企业转产所需的增支资本费用和增支经营费用。

13. 关于制冷维修次级行业，注意到有关许多第 5 条国家氟氯烃使用情况的资料有限，对于为满足 2013 年和 2015 年控制措施的淘汰费用的初步估算依据的是多边基金为实现制冷行业氟氯化碳淘汰而给予供资的各项活动的经验。

14. 可能近乎所有的第 5 条国家的维修行业都使用了 HCFC-22，而且许多第 5 条国家将只在维修行业有氟氯烃消费量。在淘汰氟氯化碳时，许多国家至少有一些生产是使用氟氯化碳的，这一部分消费量是可以解决的，从而促进该国履行其淘汰义务。与氟氯化碳淘汰的情况相比，就氟氯烃而言，大部分第 5 条国家或许没有这样的备选办法。由多边基金指导的氟氯化碳淘汰主要是依靠通过许可证和配额制度实施的供应限制，与此同时，通过为良好做法方面的培训供资以及提供工具和设备，使维修行业能够应对氟氯化碳供应的减少。氟氯烃淘汰面临的新的挑战是供应方管理必须淘汰计划非常初期的时候就开始，并且在一个更长的时间框架内持续进行。

15. 秘书处在审查维修行业时注意到，当前和今后用于维修的 HCFC-22 的需求量与消费国使用 HCFC-22 的空调设备的安装规模成正比。通过使用 HCFC-22 的制冷设备的进口，安装设备的数量持续增加。因此，为加快实现第 5 条国家制冷维修行业今后的消费量削减，并为空调制造商从使用氟氯烃转产提供更有力的奖励，将考虑引入关于 HCFC-22 设备进口的早期国家控制时间表的可能性。这将影响对多边基金 HCFC-22 空调生产设施转产的要求。

环境问题

16. 根据第 XIX/6 号决定，秘书处审查了关于执行委员会将如何优先考虑符合成本效益的项目和氟氯烃淘汰方案的备选办法，它们最大限度地降低对环境的其他影响，特别是对气候，包括全球变暖潜势和能源使用。首先，秘书处研究了三种基本方法以评估寿命周期，即仅以全球变暖潜势为基础的办法、以寿命期气候性能为基础的办法和以“功能单元”做法为基础的办法。

17. 在其初步审查中，秘书处没有考虑到仅以全球变暖潜势为基础的办法将全面涉及第

XIX/6 号决定规定的任务，因为它无法按照决定的要求解释“能源使用”。制订正式的寿命期气候性能需要大量数据，并且还要输入很多变量，而在申请供资时，这些数据对企业或国家来说可能有一些是未知的。全球变暖潜势和寿命期气候性能方法代表了两个极端，而秘书处已评估了能够克服两种方法弊端的折衷的备选办法。这促成了对“功能单元”[6]方法的初步评价，这一方法提供了简化的、对数据量要求较低的方法所具有的强力，同时确保考虑到第 XIX/6 号决定列出的重要标准。此方法得出的最初结果将是有关寿命周期气候影响的比较评估，并且考虑到替代品的全球变暖潜势、经营中所使用物质的数量和消费的能源，以及寿命周期的排放功能。

18. 此方法需要在各个行业进一步发展和评估，以确保这一基本方法能够得到广泛适用。考虑到这一点，秘书处正在就执行委员会是否建议秘书处继续深入发展这一方法，以便在下一次执行委员会会议上提交更详细报告征询其意见。

<u>共同供资</u>

19. 多边基金迄今所积累的经验，特别是在冷风机行业，表明编制、核准并执行由不同实体共同供资的项目需要花费大量时间。考虑到有时间限制的《蒙特利尔议定书》削减承诺，各国很难承担因共同供资的不确定前景而使其项目受到拖延的风险。因此，如果其他供资实体在提供支持方面拖沓迟缓的现象继续下去，将呼吁讨论利用其他机构为多边基金活动提供支持的可能性问题。为减少这种阻碍，秘书处可能会接触其他机构，以便了解是否可以制订清楚的方法和更加简化的机制，从而使其他机构能够全额支付多边基金臭氧供资，以实现其他的气候效益。关于本文件提出的某些问题，一旦执行委员会内部讨论取得进展，即可与其他机构展开交流，特别是有关截止日期、第二次转产和如何最大限度降低其他环境影响。

20. 在任何情况下，都是根据第 XIX/6 号决定第 11(b)段，通过编制氟氯烃淘汰管理计划，鼓励各国、双边和执行机构探索可能的财政奖励和利用其他资源的机会，以实现环境效益最大化。因此，下一次会议将审议共同供资的目标和此类项目的初步框架，而这些将会适用于那些能够促进与可能的共同供资实体合作的氟氯烃项目。重要的一点是在初步框架内纳入关于通过基金支持产生额外效益并且在现在或今后将具有一定价值－如符合碳融资供资条件－的项目的指导方针。

[6] “功能单元”方法强调物质在一个行业的典型使用，被称为“要素”，以便描述与整个寿命周期中的“要素”有关的影响。其目的并非为每种用途计算准确的气候影响，而是描述这些影响，使其能够用于技术比较。

一、导言

1. 本份初步讨论文件系根据执行委员会的第 53/37(i)号决定提出，内载关于氟氯烃淘汰供资的若干费用问题的分析。

一. 1 执行委员会的任务

2. 在 2007 年 11 月的第五十三次会议上，执行委员会审议了基金秘书处编制的关于评估和确定氟氯烃消费和生产淘汰活动中符合资格的增支费用的备选办法的文件。[7]

3. 除其他外，执行委员会最后要求"秘书处与了解发展程度不同的第 5 条国家和非第 5 条国家的经验的技术专家协商后，在 2008 年 3 月 25 日之前编制完成初步讨论文件，就资助氟氯烃淘汰的所有相关费用问题作出分析，同时顾及执行委员会成员在第(l)段所提呈件中表示的意见，并包括：

(a) 关于费用基准/限额以及氟氯烃替代技术的适用性的资料；以及

(b) 根据缔约方第十九次会议通过的第 XIX/6 号决定第 11(b)段审议替代技术、财务奖励措施和共同筹资的机会，这些都与确保氟氯烃的淘汰能够带来好处有关"（第 53/37(i)号决定）。[8]

4. 秘书处介绍了根据第 53/37(i)号决定向执行委员会第五十四次会议提交的文件。在随后的讨论中，委员会提出了若干问题，除其他外包括，立即就氟氯烃淘汰展开行动的必要性，以及确保实现符合第 XIX/6 号决定第 11(b)段提出的效益；作为整个淘汰项目费用主要构成部分的增支经营费用的计算；针对新建制造企业的截至日期；以及第二次转产的供资资格。还提到必须尽量降低氟氯烃淘汰活动的环境影响，并考虑运用除消耗臭氧潜能值外的其他环境指标，考虑淘汰对低消费量国家的费用影响，确保氟氯烃淘汰尽可能地与氟氯化碳淘汰相结合。关于共同供资问题，各种观点不一而足，即寻求共同供资可能性或许应成为一种备选办法；有必要收集关于全球环境基金会（全环基金）以外的供资来源的信息，有人认为全环基金的时限太长；共同供资应带来额外贷款，并且供资的主要来源仍应是基金本身。

5. 执行委员会为审议关于氟氯烃淘汰管理计划编制的准则和关于氟氯烃淘汰筹资的相关费用因素而设立了一个联络小组，委员会在听取了该联络小组调解人的陈述后决定在其第五十五次会议上审议 UNEP/OzL.Pro/ExCom/54/54 号文件的订正本，其中将考虑截至 2008 年 4 月底各成员提交给基金秘书处的所有评论（第 54/40 号决定）。

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[7] UNEP/OzL.Pro/ExCom/53/60 号文件。

[8] 执行委员会成员国受邀在 2008 年 1 月 15 日前就氟氯烃化合物淘汰管理计划编制准则应考虑的因素、秘书处应考虑的费用因素、供资资格的截止日期以及第二阶段转产问题向秘书处提交其观点看法。

一.2 文件的范畴

6. 第 53/37(i)号决定规定，多边基金现有的政策和准则可适用于氟氯烃淘汰的供资问题，除非另有决定。因此，在分析中运用了以下基本原则：

(a) 本文件中关于扩展现有政策范围的任何假设都不妨碍执行委员会今后就供资准则问题进行的任何政策讨论；

(b) 对资格问题的分析，如是否资助第二次转产（即替代已在多边基金援助下安装的使用氟氯烃的设备）或资助特定截至日期后建立的制造能力的问题，未被视为本文件任务的一部分。根据第五十四次会议的决定（第 54/5 (iii)号决定），将考虑核准对氟氯烃淘汰项目编制的供资直至第五十六次会议，而在第五十八次会议前将不可能再提交后续项目。执行委员会希望为 2009 年初第五十七次会议前的设备安装确定截止日期，有关这一政策的决议将允许考虑出现轻微拖延的独立的淘汰项目；以及

(c) 本文件的编制不妨碍缔约方会议关于 2009－2011 年多边基金为执行《蒙特利尔议定书》补充基金的研究工作范围的第 XIX/10 号决定，也不妨碍该研究的筹备。

7. 本文件的主要内容有：

(a) 关于氟氯烃淘汰供资的政策概述，以及关于第 5 条国家氟氯烃使用情况的概览。辅助的材料还有附件一：蒙特利尔议定书缔约方和执行委员会所通过的关于氟氯烃淘汰问题的有关政策和决定，以及附件二：关于第 5 条国家氟氯烃消费情况的概览；

(b) 附件三载有关于泡沫塑料行业相关技术和费用问题的详细分析，它为泡沫塑料行业淘汰氟氯烃消费量的增支费用分析提供了支持。费用分析得益于多边基金在审查了 1,000 个淘汰用作发泡剂的各类氟氯化碳的投资项目后获得的经验。从秘书处的核准项目数据库[9]目录中选定项目代表范例供审查，以期确定各种 CFC-11 替代技术的性质、适应范围和主要特征，及其在从氟氯烃向最终技术转产中的适用性。还对照完成项目报告提供的信息审查了选定项目范例的增支资本费用和增支经营费用，因为其中有些费用也可适用于氟氯烃的淘汰。[10]审查了设备和化学品价格以确定项目核准时的价格和三至四年后完成项目报告提交时的价格是否存在巨大差额。从 1998 年末至 2006 年中期

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[9] 核准项目目录是秘书处关于得到多边基金资助的项目的主要数据库，提供执行委员会核准的所有项目的记录，在许多其他内容中包括核准的条件、转产技术、增支资本和经营费用、完成日期。

[10] 由执行机构提交的完成项目报告提供了所有核准项目的执行记录，包括关于核准增支资本费用实际支出的信息、项目转产前后使用的发泡剂的价格、实际使用的技术以及从技术使用中汲取的经验。

提交的完成项目报告中得到了价格和其他相关的项目信息。将化学品的价格与选定的多个臭氧机构在其有关国家方案执行情况的进度报告中提供的价格以及由替代发泡剂生产商提供的价格进行了比较。从分析中得到的信息被当作起点，以估算淘汰氟氯烃可能的增支费用。为提供必要的背景资料，包括目前在非第 5 条国家已经成熟的转产技术的价格，对已发布的资料进行了审查，并咨询了了解这些技术的专家。所获得的全部信息为估算指示性增支资本和经营费用范围提供了基础；

(c) 附件四载有对包括维修行业在内的制冷行业相关技术和费用问题的详细分析，它为制冷行业淘汰氟氯烃消费量的增支费用分析提供了支持。费用分析不会如泡沫塑料行业那样建立在既有经验基础上。虽然多边基金在制冷设备大规模生产方面有可以利用的经验，但使用氟氯烃的设备的生产所针对的是不同的市场部分，并且与以往的项目相比，在规模和生产数量上都有所不同。此外，在有可能成为 HCFC-22 替代物质的大部分非消耗臭氧层物质方面没有任何经验。由于现有的与项目费用有关的经验无法直接转化，因此秘书处利用了已经问世的氟氯烃研究中所含的信息，特别是关于中国的氟氯烃。项目评估方面的经验被转用到了新的行业，从多位专家和生产设备制造商那里收集了信息，并且运用确定示范公司的方法定义相关的转产费用。根据多边基金自 1991 年以来所取得的丰富经验就维修次级行业提出了不同的分析。对根据第 31/48 号决定核准的制冷剂管理计划以及根据第 45/54 号决定核准的最终淘汰管理计划进行了特别审议；

(d) 环境问题，特别是在多边基金内落实第 XIX/6 号决定的必要步骤，见附件五；

(e) 联合供资的奖励措施和机会；以及

(f) 建议。

8. 在编制本文件时考虑了所收到的执行委员会成员根据第 53/37(l)和 54/40 号决定提出的意见。关于第 54/40 号决定，已收到了来自中国、多米尼加共和国、德国和黎巴嫩政府以及开发计划署的评论。许多评论都与详细的增支费用问题有关。这些都与在适当的时候审议独立项目有关，特别是在秘书处的项目审查进程中。还有关于一些政策问题的评论，如氟氯烃转产项目增支经营费用的处理，对此问题的决议没有在本文件中专门提出。在编制本文件时已酌情考虑了其他评论。本文件附件六全文摘录了各种评论。

一. 3　　用于资助氟氯烃淘汰的政策

9.　　多边基金项目增支费用评价依据的是蒙特利尔议定书缔约方在其第二次会议上商定的一般性原则。[11] 根据在这些原则以及增支费用分类提示性清单，执行委员会拟订了关于不同行业应用中各类别增支费用的具体政策和准则。在泡沫塑料和制冷的主要行业中，这些政策已适用于各氟氯化碳淘汰项目。虽然各氟氯烃淘汰项目有相似点，但需要重新审议一些主要的不同之处，并对现有规则做出恰当的修正。

10.　　多边基金项目的供资取决于对符合条件的增支资本费用和增支经营费的评估。增支资本费用涉及以企业选定的替代技术取代消耗臭氧层物质所需的辅助设备、技术转让、培训、试运行和投产。增支经营费用反映的是向消耗臭氧层物质替代物质转产所需费用的变动，以及生产过程所使用的化学品－如推进剂、制冷剂或发泡剂－变更而产生的费用。影响增支经营费用数额的因素有原料价格的波动以及此类费用支付的期限。根据执行委员会的决定，多边基金项目增支经营费用支付期限在各行业中各不相同，从给予制造压缩机或汽车空调系统制造企业零年（无增支经营费用）到给予气雾剂和软质块状泡沫塑料制造企业四年不等（见附件一）。[12]

11.　　随着淘汰项目数量的增加，资本费用已是众所周知，并且一般都是随时间延长而减少。用于计算增支经营费用的输入数据通常具有不确定性，而这种不确定性常常使此类数据无法用于事前核查。然而，对主要行业许多项目的审查促成了主要标准的出台，从而使申请的增支经营能够与之对照。随后，汲取了这方面的经验，对行业和国家淘汰计划的费用也进行了审查。

12.　　目前，在第 5 条国家，新技术正处于商业化阶段，因此构成氟氯烃淘汰项目增支经营费用的费用参数的准确量化有很大不确定性。例如，新泡沫塑料配方中各类化学品的数量和比例，及其在第 5 条国家的价格和供应量，特别是氢氟碳化物。然而，如果现行的消耗臭氧层物质淘汰供资政策和标准保持不变，则较之于类似的氟氯化碳淘汰项目，泡沫塑料和制冷行业中氟氯烃淘汰项目的增支经营费用占项目总费用的份额较大。增支经营费用是实际提供的唯一现金支助，在氟氯化碳淘汰期间，是对各企业的一种奖励。然而，选择从经济角度讲可持续性最小，即增支经营费用最高的备选办法，得到的经济奖励却最大。本文件所做的分析试图说明这些费用部分对多边基金供资义务的影响。然而，在没有针对个别项目的费用评估经验的情况下，将很难就与生产能力转产有关的行业或国家淘汰管理计划的费用向执行委员会提供适当的技术指导。

13.　　执行委员会为资助拥有制造设施的低消费量国家 [13] 项目商定了特殊的供资备选办

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[11] 第 II/8 号决定附录 1（财务机制）。

[12] 本文件的附件一载有已选择氟氯烃技术淘汰第 5 条国家所使用氟氯化碳的行业增支经营费用的支付期限。

[13] 低消费量国家是指氟氯化碳基准消费量为 360 ODP 吨的国家。截至 2008 年 3 月，有 102 个第 5 条国家被归类为低消费量国家。

法，执行委员会的做法是为不适用成本效益阈值[14]的投资项目设立特别专用款。然而，为淘汰氟氯烃，已将第 5 条国家分为两类，即在制冷维修行业有氟氯烃消费量的国家以及在制造业和制冷维修行业都有氟氯烃消费量的国家。[15]关于中小型企业淘汰消耗臭氧层物质，准则规定了一项专用款，以便于非低消费量国家气雾剂和泡沫塑料行业大量小型企业的转产。执行委员会是否愿意在氟氯烃问题上继续类似的做法是执行委员会需要进一步审议的问题。

14. 由于氟氯烃[16]属于《蒙特利尔议定书》规定的受控物质，自 1993 年 11 月缔约方第五次会议、1994 年 3 月执行委员会第十二次会议以来，已做出了多项涉及这些消耗臭氧层物质淘汰的特别决定。对氟氯烃淘汰尤其重要的是执行委员会做出的要求各执行机构充分说明为何建议使用氟氯烃的技术转产的决定，包括对可能采用的非氟氯烃技术的分析。此外，必须指明，有关企业已同意承担随后向非氟氯烃技术转产所产生的费用。多年来执行机构根据执行委员会决定提供的关于替代技术的资料也为对本文件所考虑的预期技术的审查提供了信息。

15. 执行委员会第五十三次会议审议了淘汰氟氯烃供资政策框架，并决定多边基金现行政策和准则将适用于氟氯烃淘汰的资助，除非另有决定，特别是根据第 XIX/6 号决定做出的决定（第 53/37 号决定 d 段）。在确定是否符合第二次转产项目供资条件的过程中，不可能提交已得到多边基金对氟氯烃转产供资的企业的独立氟氯烃淘汰项目。然而，据估计目前泡沫塑料行业中至少有 65%的氟氯烃消费量与迄今未获得多边基金支助的企业有关，可以此为契机，在重新审议第二次转产相关政策之前编制并提交独立项目。

16. 随后，执行委员会第五十四次会议通过了一些准则，指导各国制订阶段性方法，以便通过制订实现全部淘汰氟氯烃的总体计划来执行其氟氯烃淘汰管理计划。各国应根据可利用的资源，运用这些准则，详细制订氟氯烃淘汰管理计划的第一阶段，涉及各国如何在 2013 年冻结目标和 2015 年 10%的削减目标，以及对相关费用因素的估算。因此，要求仅在维修制冷系统时使用氟氯烃的国家制订一项氟氯烃淘汰管理计划，其所开展的各项活动应与制冷剂管理计划和最终淘汰管理计划的要求类似，而拥有使用氟氯烃的制造企业的国家要在根据国家或行业注重绩效的计划制订各种活动。准则还允许选择在完成氟氯烃淘汰管理计划之前执行投资项目的国家采取此种做法，条件是各项目的核准应实现淘汰氟氯烃淘汰管理计划所定消费量的氟氯烃，这是累计削减的起点，并且在 2010 年以后不再核准此类项目，除非它们是氟氯烃淘汰管理计划的一部分。如果采用各别项目的方法，第一个项目提交的资料应说明示范项目如何与氟氯烃淘汰管理计划相关，以及何时提交氟氯烃淘汰

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14 执行委员会第十六次会议通过了适用于不同行业的成本效益阈值，作为确定投资项目优先次序的手段。成本效益值的计算是根据总的增支资本分业务费用与所淘汰以 ODP 公斤计算的消耗臭氧层物质总量的比。本文件附件一载有关于执行委员会通过的成本效益和阈值的补充资料。

15 执行委员会第五十四次会议商定的氟氯烃化合物淘汰管理计划拟定准则的依据为第 5 条国家的这一分类。

16 本文件附件一按年代顺序载有蒙特利尔缔约方和执行委员会通过的所有关于氟氯烃的决定。

管理计划（第 54/39 号决定）。[17]

17. 因此，本讨论文件是在上述文件附件一概述的与氟氯烃有关的政策和准则背景下编制。

一. 4 氟氯烃用途概览

18. 2006 年所有第 5 条国家的氟氯烃总消费量为 363,372 公吨，是 1995 年报告的氟氯化碳 178,144 公吨消费量的两倍多，这是所报告的各类氟氯化碳的最高消费量。然而，氟氯烃对臭氧层的整体消极影响（即共计 25,765 ODP 吨）低于各类氟氯化碳的影响（176,405 ODP 吨），原因是其消耗臭氧潜能值低。[18]

19. 2006 年第 5 条国家氟氯烃的消费情况表现为：

(a) HCFC-141b、HCFC-142b 和 HCFC-22[19] 的消费量占全部氟氯烃消费量的 99%以上；极少数国家报告有少量 HCF-123 和 HCFC-133 消费（0.6%）。

(b) 71 个国家的氟氯烃消费量低于 360 公吨。29 个其他国家 [20] 或者报告零消费量，或者没有报告任何消费；

(c) 40 个第 5 条国家 [21] 使用 HCFC-141b，其中 20 个国家的消费量低于 10 ODP 吨（91 公吨），而只有 19 个 [22] 第 5 条国家使用 HCFC-142b，其中 18 个国家的消费量低于 10 ODP 吨（154 公吨）；

(d) 在报告了 HCFC-22 消费量的 117 个第 5 条国家 [23] 中，70 个国家 [24] 的消费量低于 10 ODP 吨（182 公吨）；以及

(e) 氟氯烃主要是用于泡沫塑料产品的生产（氟氯烃消费总量的 32.5%），及用于制冷制造和维修次级行业（66.2%）。少量的亦用于气雾剂（0.2%）、灭火器（0.1%）和溶剂（1.0%）行业。[25]

20. 这些数据表明，少数国家氟氯烃的消费量较高，并且在第 5 条国家存在大量中小型

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[17] 本文件附件一载有第 54/39 号决定全文。

[18] 这些数据不包括大韩民国、新加坡和阿拉伯联合酋长国的消耗臭氧物质消费量（即尚未得到多边基金援助的第 5 条国家）。

[19] HCFC-141b 的 ODP 值是 0.11，HCFC-142b 的 ODP 值是 0.065，HCFC-22 的 ODP 值是 0.055。

[20] 29 个国家中有 27 个现被归类为低消费量国家。

[21] 不包括大韩民国、新加坡和阿拉伯联合酋长国消费的 1,028.7 ODP 吨（9,352 公吨）。

[22] 不包括大韩民国和新加坡消费的 126.7 ODP 吨（1,949 公吨）。

[23] 不包括大韩民国、新加坡和阿拉伯联合酋长国消费的 1,213.9 ODP 吨（22,071 公吨）。

[24] 另有 16 个第 5 条国家报告了 2005 年 HCFC-22 的消费量。

[25] 开发计划署针对 12 个选定的第 5 条国家进行的氟氯烃调查（UNEP/OzL.Pro/ExCom/51/Inf. 2）。

企业。根据对受到资助的单独的泡沫塑料项目的分析，在所有从氟氯化碳向使用氟氯烃的技术转产的泡沫塑料企业中，80%以上位于不到 12 个第 5 条国家里，这一情况便证明了上述结论。同样，据估计，第 5 条国家所有泡沫塑料企业中 70%以上每年的氟氯化碳消费量低于 40 ODP 吨。

21. 鉴于 99%的氟氯烃消费量用于泡沫塑料和制冷行业，本文件仅涉及这两个行业，以便汲取经验教训并尽早在国家一级实现氟氯烃消费量的削减。但在适当的时候，有必要就消费氟氯烃的其他行业制订一份类似的技术和费用结构谅解。

二、淘汰泡沫塑料行业氟氯烃消费的增支成本

22. 在多边基金的援助下，第 5 条国家淘汰了超过 89,370 ODP 吨用作泡沫塑料发泡剂的各类氟氯化碳。这其中包括在软质和硬质聚氨酯泡沫塑料中使用的 CFC-11 以及在挤塑聚乙烯和聚苯乙烯泡沫塑料板和塑料网中使用的 CFC-12。第 5 条国家选择了永久性技术以淘汰硬质泡沫塑料和自结皮泡沫塑料次级行业中使用的 CFC-11，包括水性体系，为那些能够安全地利用易燃物质操作发泡机器的企业选择了碳氢化合物（戊烷），以及选择氟氯烃作为过渡技术。用作发泡剂替代物质的氟氯烃约占全部被淘汰氟氯化碳的 40%。利用永久性转产技术[26]淘汰了其他泡沫塑料次级行业所使用的 CFC-11 和 CFC-12。

23. 在大多数非第 5 条国家，发展了使用各类氢氟碳化物（主要是 HFC-245fa、HFC-365mfc 及其混合物 HFC-365mfc/HFC227ea）、甲酸甲酯的泡沫发泡技术和其他较少使用的技术，以替代与第 5 条国家一样最初作为过渡性氟氯化碳淘汰技术的氟氯烃。由于没有需求，目前这些技术仅限于第 5 条国家，但也可在第 5 条国家利用这些技术淘汰作为发泡剂的氟氯烃。

二. 1 淘汰氟氯烃的费用范围

24. 同淘汰泡沫塑料用途中的各类氟氯化碳类似，由氟氯烃向使用非消耗臭氧层物质的技术转产所产生的增值资本费用取决于企业的现有基准设备、所生产泡沫塑料产品的类型和生产数量、所选择替代发泡剂以及企业的所在地，在许多情况下，企业所在地可能是决定是否选择使用易燃性物质的重要因素。

增支资本费用的范围

25. 根据第 53/37(i)号决定的要求，关于氟氯烃替代技术在泡沫塑料用途的费用基准/范围进行了两次类似的增支资本费用估算。一次估算根据的是对现有设备的改造，另一次估算根据的是取代现有而设备采用以下替代技术：水性体系、碳氢化合物（既有戊烷也有环

[26] 用于生产挤塑聚乙烯和聚苯乙烯泡沫塑料薄膜的 CFC-12 主要是被丁烷和液化石油气淘汰。软质块状聚氨酯泡沫塑料次级企业中的 CFC-11 被二氯甲烷和液化二氧化碳淘汰，而用于模塑聚氨酯泡沫塑料的 CFC-11 被水性体系淘汰。

戊烷）、HFC-245fa 以及甲酸甲酯。以下说明解释了进行两次类似估算的原因。

26. 由氟氯烃转换为氢氟碳化物、水性体系或甲酸甲酯技术：

(a) 根据现有政策，所有在多边基金协助下更新生产设备以便能够暂时使用氟氯烃发泡剂的硬质聚氨酯自结皮泡沫塑料企业，在替代现有设备方面都不应申请额外的资本费用，除非具备技术性理由并做出充分论证。[27] 可申请与技术转让、培训、试运行和投产相关的费用，以确保替代技术适合当地的条件；

(b) 上文(a)小段所述的相同条件将适用于那些在多边基金没有提供援助的情况下已变更或替代其使用氟氯化碳的设备，转而使用氟氯烃的企业，因为这些企业与得到多边基金援助的企业有着相同的基准。同样，相同的条件将适用于建立了带有高压分送器的新设施的企业。可申请技术转让、培训、试运行和投产方面的援助；以及

(c) 只有仍在用手搅拌设备加工 HCFC-141b 泡沫塑料以及 1995 年 7 月 25 日现有符合条件的截至日期之后可能安装、或者在多边基金参与期间不符合供资条件的低压分送器，才可能需要改造和替代现有基准设备以及技术转让、培训、试运行和投产的资本费用。但供资的模式将取决于执行委员会可能决定的关于供资资格的规则。因此，估算取代备选办法的费用基准，以应对这种可能性。

27. 与其他现有技术相比，生产硬质或自结皮聚氨酯硬质泡沫塑料企业向戊烷技术的转产将涉及大量资本费用。这些技术需要有适合使用碳氢化合物发泡剂、新型多元醇预混合器、碳氢化合物储存系统的高压分送器以及处理易燃物质的安全设备。还需要让当地工人适应碳氢化合物储存系统和车间的改变。某些情况下还需要搬迁工厂。然而，碳氢化合物技术和设备设计方面的最新发展将使得中型泡沫塑料生产企业在应用该技术时产生更大的成本效益（附件三附录 2）。

28. 下文表二.1 是各种泡沫塑料应用的增支资本费用范围的概览。费用计算所参考的企业只有一台基准泡沫塑料分送器和辅助设备，生产硬质泡沫塑料时的氟氯烃消费量为 5、25 或 75 公吨（或 0.6、2.8 或 8.3 ODP 吨），或生产自结皮泡沫时的氟氯烃为 10 或 30 公吨（或 1.1 或 3.3 ODP 吨）。这些消费量代表着典型的小型、中型和大型的作业。这一范围内的最低费用依据的是对所有必要设备项目进行改造，而最高费用依据的是以新设备替换老设备的费用，并且是绝对数额。由于预计要使泡沫塑料配方产生最好效果需要开展更多活动并提供更多化学品，因此试运行的费用有可能高于向 HCFC-141b 过渡时的情况，作为增支资本费用组成部分的技术转让、培训和试运行的费用便估计得高于由氟氯化碳向氟

[27] 作为资助多边基金项目的一项要求，转用氟氯烃技术的企业必须与其政府一道做出在多边基金不再给予援助的情况下淘汰剩余的 ODP 的承诺。多边基金几乎所有关于使用 HCFC-141b 的理由都确认，最后的转变不需要对设备进行新的投资。

氯烃的过渡。

29.　通过计算显示，除了向碳氢化合物技术的转换外，在所有情况下，转产费用大大低于替换备选办法的费用。关于碳氢化合物技术的转换，有观点认为，转产的费用和替换现有分送器的费用之间差别最小。HFC-365mfc 和甲酸甲酯的增支资本费用类似于 HFC-245fa 的增支资本费用，但取得储存罐可能例外。

表二.1：泡沫塑料应用中的增支资本费用范围概览（美元）

泡沫塑料应用	HFC-245fa/HFC-365mfc/甲酸甲酯		水性体系		戊烷	
	低	高	低	高	低	高
仪表和家用以及商业制冷						
转产	30,000	60,000			375,000	710,000
替换	100,000	195,000			385,000	780,000
管中管和注塑机（*）						
转产	30,000	60,000	25,000	55,000	375,000	710,000
替换	100,000	195,000	95,000	180,000	385,000	780,000
喷涂泡沫塑料(**)						
转产	15,000	55,000	15,000	55,000		
替换	50,000	110,000	60,000	110,000		
不再继续的隔热用（垫箱用）泡沫塑料(***)						
转产	15,000	55,000	15,000	40,000		
替换	85,000	140,000	65,000	95,000		
自结皮泡沫塑料						
转产	40,000	70,000	75,000	125,000	265,000	405,000

(*) 水性体系在管中管方面的应用很有限，戊烷在注塑机方面的应用也很有限。

(**) 戊烷的易燃性令其现场应用无法让人接受。

(***) 垫箱操作使戊烷用途十分危险。

增支经营费用范围

30.　由氟氯烃向非消耗臭氧层物质技术转产的增支经营费用数额主要取决于新配方的性质以及这些配方所使用化学品的相对价格。有时，与泡沫密度增加相关的费用，以及水发自结皮泡沫中使用的模内涂覆化学品，都可能增加经营费用的数量。对于碳氢化合物技术来说，由于安装其他新设备而造成的辅助保养和能源使用费，以及由于使用易燃物质造成的附加保险费，也会增加增支经营费用。

31.　泡沫塑料配方中发泡剂、多元醇和异氰酸酯（或二苯基甲烷二异氰酸酯[28]）等主要

[28] MDI：二苯基甲烷二异氰酸酯。

化学品成分的比例和价格，是决定增支经营费用数额的主要因素。这些成分的价格在第 5 条国家里差别很大，下文表二.2 进一步显示了这些差别。根据淘汰各类氟氯化碳的经验，这种情况可能会导致某一企业增支经营费用大幅增加，但根据某些或全部成分的价格以及转产前后的差别，这种情况会使同一类型的另一企业生产同样数量的泡沫塑料仍有结余。用泡沫塑料系统的相对价格（氟氯烃和替代发泡剂）替代各企业使用预混和系统情况下的个别化学品的价格有助于缩小化学品价格方面的一些差距。

表二.2：　泡沫塑料配方所使用化学品的时价

化学品	价格：美元/公斤	
	低	高
HCFC-141b	2.50	3.80
二苯基甲烷二异氰酸酯	3.00	3.50
戊烷	1.90	2.50
环戊烷	2.10	3.30
HFC-245fa	10.40	12.00
甲酸甲酯	2.20	3.20

32.　　泡沫塑料密度增加是由于添加了额外泡沫塑料材料成分，而这又造成了费用的增加。泡沫塑料密度增加对增支经营费用有重大影响，某些情况下会使增支经营总费用增加 50% 甚至更多。[29] 利用泡沫塑料密度增加程度计算增支经营费用，是基于由 CFC-11 向 HCFC-141b 的转换，有必要重新对其进行检查以了解 HCFC-141b 淘汰的情况。但现有的资料似乎显示，泡沫塑料密度的增加在由氟氯烃转向氢氟碳化物和甲酸甲酯替代品方面不会是一个问题。

33.　　计算了以下替代技术的增支经营费用的范围：水基性体系、碳氢化合物（戊烷和环戊烷）、HFC-245fa 和甲酸甲酯。这一计算主要依据的是：泡沫塑料配方 [30] 中主要化学品成分的函数比例及其价格，[31] 以及影响已知增支经营费用数额的相关因素。为确保连续性和准确性，根据核准项目对计算进行了核对。

[29] 与不同泡沫塑料用途相关的泡沫塑料密度增加的程度已经执行委员会第三十一次会议核准（第 31/44 号决定），以便今后再次审议这一问题并在必要时做出修订。

[30] 这一比例的依据为，氟氯烃、替代化学品以及可获得的任何已知减缓因素（例如，潜在最优化产生的因素）分子量之间的函数关系。

[31] HCFC-141b、戊烷和二苯基甲烷二异氰酸酯的价格是基于 2000 至 2006 年项目完成情况报告的价格范围与 2008 年 3 月某些第 5 条国家通过双边和执行机构提供的最新价格的比较，以及根据第 54/40 号决定，收到的评论所提供的信息。HFC-245fa 和甲酸甲酯价格基于制造商所提供价格。全球散装货箱（罐箱）加工表报告显示 HFC-245fa 的价格较低，而估计小包装价格稍高，相差在 15%。

表二.3：泡沫塑料用途淘汰每公吨 HCFC-141b 的
年度增支经营费用范围概览（美元/公斤）[32]

发泡剂	硬质泡沫塑料		自结皮泡沫塑料	
	低	高	低	高
HFC-245fa	2.20	5.30	0.40	1.14
甲酸甲酯	（1.40）	（2.20）	（1.00）	（1.66）
水性体系	1.45	2.00	7.40	12.48
戊烷	（1.25）	（2.20）	（1.84）	（2.84）
环戊烷	（1.15）	（1.80）	（0.76）	（1.41）

34. 为显示企业一级增支经营费用的范围，对两年内 HCFC-141b 的消费量为 5 公吨（0.6 ODP 吨）、25 公吨（2.8 ODP 吨）和 75 公吨（8.3 ODP 吨）的硬质泡沫塑料企业运用了上表所示平均增支费用，两年是硬质泡沫塑料行业经营费用的现时计算期。下文的表二.4 列出了带来的指示性增支经营费用：

表二.4： 企业一级两年内计算的增支经营总费用（美元）

技术	企业消费量（吨）					
	5.0 公吨（0.6 ODP）		25.0 公吨（2.8 ODP）		75.0 公吨（8.3 ODP）	
	低	高	低	高	低	高
HFC-245fa (50%)	19,140	23,490	95,700	117,450	287,100	352,350
HFC-245fa (75%)	45,240	46,110	226,200	230,550	678,600	691,650
水性体系	12,615	17,400	63,075	87,000	189,225	261,000
甲酸甲酯	(12,180)	(19,140)	(60,900)	(95,700)	(182,700)	(287,100)
戊烷	(10,875)	(19,140)	(54,375)	(95,700)	(163,125)	(287,100)
环戊烷	(10,005)	(15,660)	(50,025)	(78,300)	(150,075)	(234,900)

35. 分析增支经营费用时，提出了以下看法：

(a) 泡沫塑料配方中用水取代某些数量的 HFC-245fa，可大大降低增支经营费用。但这取决于如何在节省成本和泡沫塑料制造商所要求的泡沫塑料隔热性能之间做出权衡；

(b) 甲酸甲酯的使用导致自结皮和硬质泡沫塑料企业增支经营的结余，原因是价格相对较低和使用量较少；[33]

(c) 过去，转用戊烷技术的硬质泡沫塑料用途（从 CFC-11 过渡）造成了巨额的

[32] 因 HCFC-22 通常较 HCFC-141b 便宜，淘汰 HCFC-22 的相关增支经营费用可能较表中估计数高。

[33] 价格在戊烷的同一范围内，一份 HCFC-141b 被 0.5 份的甲酸甲脂取代。

增支经营费用，尽管发泡剂的价格较低和将由其所取代的大约一半的 HCFC-141b 的使用率较低。原因是泡沫塑料密度的增加，还需要额外的保养、保险和能源费用。然而，在考虑到泡沫塑料密度增加 10%，以及根据多边基金项目中该行业增支经营费用的计算办法得出的额外保养、保险和能源费用后，从 HCFC-141b 向使用戊烷技术的硬质泡沫塑料用途转产仍会带来经营结余；以及，

(d) HFC-245fa 和水性体系、特别是为提高泡沫塑料质量满足市场要求使用模内涂覆的自结皮泡沫塑料中的 HFC-245fa 和水性体系，造成的增支经营费用最多。

36. 根据该行业现行的增支经营费用计算政策的延续，增支经营费用将是淘汰氟氯烃整体费用中的一部分，应重点解决与其计算相关的问题（即期限、化学品价格和加强结构、泡沫塑料的密度以及其他因素）。在淘汰氟氯烃的过程中，配方的性质，特别是氢氟碳化物和甲酸甲酯，将在决定企业的增支经营费用的适当水平方面发挥重要作用。因此，项目编制的处理方式可能要有所不同，并在初期就应让系统的供应者尽早参与。

二.2 对器皿和非器皿泡沫塑料用途的特殊考虑

37. 根据多边基金的做法，传统上为淘汰作发泡剂用途的 CFC-11 的供资是在泡沫塑料行业下进行，这是针对其成本效益阈值为 7.83 美元/公斤的制造硬质聚氨酯泡沫塑料（即所说的非器皿泡沫塑料）的企业来说的。但对于制造家用和商业制冷设备的企业（即所说的器皿泡沫塑料）来说，供资是在制冷行业内处理，家用制冷的次级行业成本效益阈值为 13.76 美元/公斤，商业制冷为 15.21 美元/公斤。家用和商用制冷次行业的成本效益为企业一级泡沫塑料和制冷生产过程中增支成本费用和增支经营费用的总值。

38. 家用和商业制冷行业内的许多多边基金项目已将泡沫塑料隔热转向 HCFC-141b 技术，而制冷剂部分转向了非氟氯烃替代品。因此，将需要在泡沫塑料行业下处理目前由 HCFC-141b 转向采用非消耗臭氧层物质替代品的下一阶段，因为没有制冷部分。

二.3 第 5 条国家转向使用 HCFC-142b

39. 1990 年代初以来，HCFC-142b 和 HCFC-22 在非第 5 条国家被广泛用作氟氯化碳发泡剂的替代品，特别是在挤塑聚苯乙烯泡沫塑料保温板以及建筑行业。这些大多数国家已淘汰这种氟氯烃。[34]

40. 目前，多边基金淘汰 HCFC-142b/HCFC-22 的现有经验十分有限，而且只是在挤塑

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[34] 所选择主要技术是：HFC-134a、HFC-152a、二氧化碳（或二氧化碳/酒精）以及异丁烷。但加拿大和美国的淘汰较困难，原因是具体产品的要求，特别是家居行业。因此，预期这两个国家 2010 年后还会继续使用 HCFC-142b 和 HCFC-22。

聚苯乙烯泡沫塑料薄膜和塑料网方面有此类经验。但在过去的几年里，中国隔热材料市场的大力发展和少数其他第 5 条国家较小规模的发展正在推动挤塑聚苯乙烯企业迅速引入使用氟氯烃的技术。[35] 需要对相关第 5 条国家的泡沫塑料次级部门作进一步的研究，以澄清有关的技术和费用问题。

二. 4　系统厂商积极参与氟氯烃的淘汰

41.　在自结皮硬质泡沫塑料企业生产中，大多数企业依赖与商业上与发泡剂预先混合的化学品以及由所谓的系统厂商提供的其他重要成分（预混多元醇）。在氟氯化碳淘汰的第一阶段，系统厂商在 HCFC-141b 向第 5 条国家的市场渗透方面发挥重要的作用。[36] 为生产适合的非氟氯化碳预混多元醇的和为其客户（即下游泡沫塑料企业）提供技术转让和培训的少数系统厂商核准了资金。

42.　由于目前可用的氢氟碳化物有限，以及某些区域在使用 HFC-245fa 等较新技术时可能遇到的处理和加工问题，第 5 条国家由氟氯烃转向非消耗臭氧层物质技术可能是一种挑战。为了缓解这一问题，需要鼓励或支持第 5 条国家的系统厂商在项目编制之前，探索制订或完善适合当地市场的配方的可能性，以及可能的话适合氟氯烃消费量较低因而无法建立系统厂商的邻国的配方。

43.　通过与当地系统厂商和泡沫塑料业合作解决的其他重要领域有：

(a)　降低依靠昂贵发泡剂（即 HFC-245fa 或 HCF-356mfc）的泡沫塑料配方的费用，为需要大量成本的用途提供一种有竞争力的隔热产品（例如使用与碳氢化合物的混合物或与发泡时同时使用水）；

(b)　研发并引进使用碳氢化合物的预混多元醇，从而可以让第 5 条国家尽快摆脱氟氯烃；以及

(c)　向选择使用氢氟碳化物技术的企业提供培训和技术援助，确保这些企业从事生产活动的方式给全球环境带来的风险最小，例如在泡沫塑料生产期间限制氢氟碳化物的排放。

44.　与有关系统内的企业相关的示范项目，有可能是促进优化系统和向当地工业引进淘汰技术的办法之一。

<u>确认氟氯烃替代品泡沫塑料系统的系统厂商项目</u>

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[35] 2001 年评估（硬质泡沫塑料和软质塑料泡沫技术选择委员会 2006 年评估报告）以来，仅这一行业每年就有 20,000 公吨的新消费量。

[36] 包括 4 个国家的 290 家侧重于当地土著系统厂商的中小型企业的 11 个集体项目获得核准，费用总额为 720 万美元。系统厂商参与的直接影响是淘汰超过 1,300 ODP 吨的 CFC-11。

45. 在第 5 条国家及时提供经确认是可应用的具有成本效益且无害环境的淘汰技术被认为是成功开展由多边基金资助的氟氯烃淘汰方案所必不可少的。因此，本方案的目的在于使选定的第 5 条国家的系统厂商确认可以被用于氟氯烃淘汰项目的新技术或经重大修改的技术。重要的是使调查时间与编制首份氟氯烃淘汰管理计划的时间相符，以便调查项目可以直接得到确认工作的指导。因此，该方案应立即开始，并包括：非消耗臭氧层物质/低全球变暖潜势的新技术以及传统的非消耗臭氧层物质/低全球变暖潜势技术的低成本备选办法。

46. 提议只核准向参与方案的下游企业预付增支资本费用，因为增支资本费用将是调查的一部分，并在方案执行期间或之后予以支付。每一系统厂商的项目的费用估计为：不易燃发泡剂在 145,000 和 210,000 美元之间，易燃发泡剂在 200,000 和 320,000 美元之间。下游企业转换为不易燃发泡剂的增支资本费用范围估计在 13,000 和 20,000 美元之间，转换为易燃发泡剂的增支资本费用范围估计在 79,000 和 165,000 美元之间。增支资本费用的细目载于本文件附件三的附录二。

三、淘汰制冷行业氟氯烃消费的增支费用

47. 目前，HCFC-22 是第 5 条国家制冷和空调行业使用的最主要物质。2006 年，123 个第 5 条国家报告称，制冷和空调行业制造新设备（主要是空调机和少量商用冰箱）和维修现有设备消费了 12,375 ODP 吨（225,000 公吨）的 HCFC-22。[11]制冷行业还有一些其他氟氯烃，特别是冷风机使用的 HCFC-123，以及作为无须改造设备的 CFC-12 替代制冷剂的 HCFC-124 和 HCFC-142b。由于第 5 条国家似乎没有这些制冷剂产品方面的专门制造能力，同时由于与 HCFC-22 相比所使用的数量很小，本文件未对这些氟氯烃作进一步的研究。

三. 1 行业和次级行业

48. 在空调方面，60 多年来 HCFC-22 一直是最主要的制冷剂，是小型、中型和大型空调系统首选的制冷剂，大型空调系统不包括中央冷风机。似乎几乎全世界的小型家居空调系统的制造能力都集中在少数第 5 条国家（不到 15 个）。为编制本文件，秘书处确定了以下各次级行业：室内和分体式空调，其中包括家居产品；中型管道和整体式商用空调，例如大型商业建筑屋顶使用的空气－空气式系统；以及用于工业空调和若干加工降温用途的功能在 500 千瓦以下的 HCFC-22 冷风机。空调行业内主要的是拥有集中制造能力的大型工业。

49. 商用制冷是产品范围和种类分布最为广泛的次级行业，因为商业企业所使用的和未明确说明属于另外的次级行业的所有制冷设备均归属这一类别。产品大多数、但并非全部用于制冷和冰冻货物的零售、展览和销售。其他用途包括水冷却机及肉类和乳制品的储藏

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[11] 据估计，在生产聚苯乙烯泡沫塑料方面，与 HCFC-142b 一道作为发泡剂使用的 HCFC-22 的额外消费量为 300 ODP 吨（5,500 公吨）。

室。由于用途广泛和需要满足各种具体需要，导致工业界很少有大型、但却有很多中小型生产定制程度高的产品的企业。在这方面，商用制冷行业和维修行业的某些部分的区分变得模糊了。商用制冷系统有可能是由各高消费量国家制造的，某种程度上也可能是在许多低消费量国家制造的。该行业使用 HCFC-22 主要是受 CFC-12 淘汰的驱使，其次是由于维修承包商和小型公司拥有进行空调维修的的 HCFC-22 基础设施。这些公司通过在维修空调系统以及在商用制冷设备安装、灌充和维修时使用相同的制冷剂，使其操作大为简化。

三. 2　　替代品

50.　　不同的行业都拥有一些替代的制冷剂。从技术上说，制冷中的降温有很多可能性。本文件侧重的是那些目前已拥有一定发展水平和应用领域的物质，在中期内它们有可能成为第 5 条国家取代 HCFC-22 的替代品，即，这些替代品有可能与多边基金 2013 年冻结或 2015 年消费量削减步骤相关项目有关。这些替代品主要是氢氟碳化物制冷剂、碳氢化合物和氨。关于替代技术的详细说明载于附件四。

51.　　氢氟碳化物是一般特性类似于氟氯化碳和氟氯烃的制冷剂；从淘汰 CFC-12 引入 HFC-134a 的过程中，人们了解了这些技术的一些重要方面。非第 5 条国家最广泛使用的 HCFC-22 替代品较 HCFC-22 都具有更高的全球变暖潜势。实际上这些替代品大部分是在 12 多年前更换氟氯化碳期间被采用的。只有 HFC-134a 的全球变暖潜势低于 HCFC-22，目前正被用于某些特别是较小功能的用途。对第 5 条国家来说，看来这些用途涵盖了有可能符合供资条件的很大一部分设备。HFC-134a 迄今未被用于替代 HCFC-22，因此，没有费用方面的数据。研究了用若干氢氟碳化物取代具体用途中的 HCFC-22，非第 5 条国家和第 5 条国家都成功而广泛地予以使用。有些氢氟碳化物，特别是 HFC-410A 所拥有的特性，由于作用压力的要求高，需要对设备的设计、部件的制造和维修设备做很大的改动。对于现有的一些氢氟碳化物和碳氢化合物的混合物来说，很多情况下可以让 HCFC-22 设备转向使用无消耗臭氧层物质的替代品而无须对设备进行改造。

52.　　碳氢化合物和氨是全球变暖潜势低的制冷剂，多年来一直在使用。它们都面临安全方面的挑战。虽然人们很了解处理这些制冷剂的必要技术，但上述特点导致改装过程中的增支资本费用较高，同时对相关设备的使用带来限制。主要问题有：

(a)　碳氢化合物，特别是异丁烷、丙烷和丙烷，同 HCFC-22 一样都是极好的制冷剂。其易燃性需要在制造和维修的过程中进行安全处理，也限制了对每一设备灌充碳氢化合物的数量，可对生产设施的所在地（比如，必须在居民区以外）和大系统所安装设备（比如，通风要求、远离公众）做出了限制规定。碳氢化合物已成功地用于制冷器中，已成为得到成分肯定和广泛使用的技术，同时也成功地用于小型空调和小型商用制冷剂中；以及

(b)　氨技术过去用于大型的制冷车间，特别是与食品加工和化学工业相关的制冷车间，也用于大型的冷风机。安装和维修氨制冷设备所需专门技术有别于氟氯化碳/氟氯烃/氢氟碳化物技术。氨现用于一些第 5 条国家，主要是因为历

史的原因，但在以往没有使用过的国家难以推行。与大型的碳氢化合物系统类似，氨通常在安装的地点方面受到限制。

53. 现有能源效益资料显示，大多数有关用途都有氢氟碳化物和全球变暖潜势低的制冷剂，它们都能形成 HCFC-22 设备所提供的同样或更好的能源效益。在某些情况下，这种情况可能需要重新设计压缩机或使用优化的压缩机，两种情况都会导致费用有所增加，因此，在不久的将来，只能在逐案的基础上才可实施。

54. 很可能在氟氯烃淘汰的初期，上述替代品成为所有的可能选择。据报道，进行了关于汽车空调行业不易燃、低毒性的全球变暖潜势低的制冷剂方面发展的研究，但目前还不清楚是否能够以及何时能够商业化。更重要的是，利用次级行业的制冷剂对 HCFC-22 是否适用还不清楚，因为这对替换带来了特别的挑战。过去 20 年一直在研发能够将二氧化碳用作替代制冷剂，目前已用于示范性试运行。其主要的适用是在小型商业系统，而在大型中央超市系统则被用于制冷。在小型系统中，二氧化碳要求与其他制冷剂根本不同的设计和部件。同时，由于其在特殊适用中的高压，具有与其他制冷剂根本不同的维修特点。此外，与 HCFC-22 相比，其能效由于较高的室外温度而被大大削弱。目前尚不清楚的是，是否能够以及在何种情况下能够开发出适当的技术来打破现有的利基市场。对于大型低温系统而言，所使用的技术只是对通常所使用的技术进行了稍许的改动 ，但是在第 5 条国家可以被用来替代 HCFC-22 的应用可能非常少。

三. 3 维修行业的具体挑战

55. 空调系统在全世界范围内被用来舒适制冷。在一些国家，空调可能仅被用于像宾馆和医院这样的地方，其他地方包括办公室，可能也包括住所。HCFC-22 有可能被用于几乎所有的空调系统，从特别小型的空调至 500 千瓦的系统。鉴于这些系统都需要维修，HCFC-22 有可能被用于每一个第 5 条国家的维修行业。

56. 尽管很多空调装置不需要很多修理，但其数量很多而且越来越多，将带来对于维修的很大整体需求。商用制冷广泛使用 HCFC-22 也进一步增加了维修需求。CFC-12 的淘汰让人们了解了维修行业的一般结构。在淘汰氟氯化碳的努力中，这一行业的活动被分为一组，特别是作为制冷剂管理计划和最终淘汰管理计划的一部分，与立法和执行许可证和配额制度相关的活动分在一组。

57. 由于泡沫塑料和制冷剂行业中以氟氯烃为基础的制造以及使用氟氯烃的溶剂仅限于少数国家，大量第 5 条国家的氟氯烃的消费量很可能全部是在维修行业。这一行业包括商用制冷设备的安装和灌充次级行业。对于氟氯化碳的淘汰而言，大多数国家里至少某些制造（例如软泡沫塑料）是使用氟氯化碳技术，问题解决后可借以支持有关国家履行其团体义务。就氟氯烃而言，与上述情况正相反，很多第 5 条国家可能就没有这种备选办法。在氟氯化碳的淘汰期间，很明显的是，无法在逐个企业的基础上解决和监测维修行业，这主要是由于所涉企业数目之少、其规模之小以及其通常为非正式组织。因此，多边基金的氟氯化碳淘汰一直主要依靠通过许可证和配额制度对供应实行限制，与此同时，确保维修行

业能够通过良好做法的培训和提供工具和设备，应付日益减少的氟氯化碳供应。与此同时，多边基金对维修行业的支助让各国政府能够相信，供应方面的条例不会给制冷设备的维修带来大的问题。迄今，这种做法的结果一般地说是好的。氟氯烃淘汰面临的新的挑战是供应方管理必须淘汰计划非常初期的时候就开始，并且在一个更长的时间框架内持续进行。

58. 维修行业对 HCFC-22 的需求与第 5 条国家空调设备进口 HCFC-22 有关，因为这些国家因此在修行业创造了对 HCFC-22 的需求。为了便利维修行业今后消费的减少，看来应该在国家一级考虑是否可以在初期就限制 HCFC-22 设备、特别是空调机的进口。这样做将对提出资助改造特别是 HCFC-22 空调机制造设备的时机产生影响。需要在一开始就改造这些设备，使之能够为其他第 5 条国家供应无氟氯烃的空调。

59. 为使低消费量国家能够就进口管制做出决定，对这些国家的维修行业应给与足够的支持，以便尽量减少氟氯烃消费，确保适当处理替代品。因此，或许应该考虑在 2010 年甚至更早便资助主要消费量在维修行业的国家的维修次级行业和相关行业（安装、灌充和最终用户）的氟氯烃淘汰活动，以便为遵守 2015 年 10％削减步骤提供便利。

三. 4 费用因素

60. 为了了解与制冷制造行业氟氯烃淘汰有关的可能费用，征询了拥有第 5 条国家经验的专家以掌握对各行业和次级行业的结构的意见。作为下一步，已做出努力为每一次级行业确定一两个典型的使用氟氯烃的企业。借助淘汰氟氯化碳的经验以及专家的服务、价格表和其他现有数据，已经能够对各种替代品的增支资本费用和增支经营费用的范围做出估计。这一做法是建筑在对替代或更新仍在使用寿命期间的现有设备的假设之上的，这也是氟氯化碳淘汰项目期间的做法。由于几个次级行业没有确定增支经营费用的支付期限的准则，所有增支经营费用的期限都标准地定为一年，以便于迅速估算增支经营费用长短期限的影响。附件四载有不同次级行业的替代技术、这些次级行业的说明以及由增支费用的计算条件和结果得出的计算指示性费用范围。

61. 使用“典型”企业确定制造企业增支资本费用的方式限制了估算每一企业增支资本费用的不确定性，这是因为，资本费用项目仅在不同规模的作业之间呈现差异。但由于一直不知道某一行业内企业的数目和确切的产品范围，在可见的将来，仍无法用推算法来确定全部行业的改造费用。应该指出的是，就氟氯化碳的淘汰而言，资本费用，而且甚至是与增支经营费用有关项目（压缩机、油、制冷剂）的费用，都会随着时间的推移而减少，并显示不同市场间的重大差别。

62. 制冷剂制造行业不同模式企业的费用计算导致出现表三.1 所示结果。经营费用将按年度分列。如果执行委员会做出例如 4 年期限的决定，表中所示增支经营费用的值将相应增加。对增支经营费用所做计算显示，增支经营费在增支费用中所占比例常常大于通常氟氯化碳淘汰项目所占比例。应该指出的是，由于这些经营费用是多边基金下唯一现金形式的支助，因而为企业早日转换其生产提供了重要的奖励。在另一方面，当前的增支经营费用方式为选择经济上最无法持续的技术提供了激励，比如每台设备费用增加最多的备选办

法。这种情况下，在执行期间遇到问题，或后来出现的问题或重新转用的风险特别高。

表三.1：制冷制造行业有选择的项目表格的增支资本费用和增支经营费用预测[12]

行业/次级行业和设备类型	年度生产（装置/年）	增支资本费用（美元）		增支经营费用（美元）	增支资本费用（美元）		增支经营费用（美元）	增支资本费用（美元）		增支经营费用（美元）
		最高	最低	年度	最高	最低	年度	最高	最低	年度
空调		**R410A**			**R407C**			**R290**		
室内和分体式空调	250,000	275,000	950,000	2,660,000	190,000	250,000	4,250,000	545,000	670,000	4,512,000
商用管道和整体式空调**	1,000	245,000	145,000	36,600	120,000	80,000	28,500	n/a	n/a	n/a
	100									
冷风机	200	300,000	85,000	Tbd	n/a	n/a	n/a	n/a	n/a	n/a
商用制冷		**R404A**			**R134a**			**R290**		
单独项目：商用冰柜	10,000	66,000	66,000	140,000	66,000	66,000	110,000	320,000,	320,000	230,000
单独项目：自动售货机	10,000							500,000	800,000	150,000
冷凝装置	5,000	55,000	60,000	390,000	55,000	60,000	310,000			

63. 秘书处还尝试对维修行业的增支费用进行了初步的估计。维修行业干预措施的确切性质和数量仍有待讨论，*除其他外*，包括制冷剂管理计划和最终淘汰管理计划经验的基础之上。似乎最终淘汰管理计划的主要组成部分将继续发挥重要的作用，即立法和执行支助、技术人员设备和教育的更新以及执行监督。估计的费用假定，必须为审查消耗臭氧层物质的法律和根据 2006 年氟氯烃消费量估计的供资水平的培训方案提供额外的资金。2015 年以前的费用估计在消费最低国家的 110,000 美元和消费最高国家的 13,940,000 美元之间。这一估计的详细内容载于附件四。

四、环境问题

四.1 对环境问题进行优先排序的决定

64. 第 XIX/6 号决定呼吁各缔约方“促进选择能将环境影响降低到最低点和照顾到各项健康、安全和经济因素的氟氯烃的替代品。”该决定还向执行委员会指出，在为选择资助项目和方案制定标准时，应“重点考虑成本有效的侧重于可以使环境影响最小化的替代物的项目和方案，包括对气候的影响，同时考虑到全球变暖潜势、能源利用和其他相关因素。”

65. 对“重点考虑”这一术语有不同的诠释，包括对时间、绝对技术选择或资金的提供方面重点考虑。时间上的重点考虑可被视作是一个‘前提’，假设有利于气候的技术早已存在。但是，如果在消耗臭氧层物质淘汰的背景之下满足第 XIX/6 号决定中“最不重要”要求的措施与其他可用备选办法相比不是特别有利于气候（或者甚至出现不利于气候的结果）的话，可能会出现问题。

66. 当存在能够支付的不影响气候或对气候有利的技术时，执行委员会可能最好不要采

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[12] 该表按照现有可用的数据提供了增支资本费用。应指出的是，不仅有可能存在增支费用的变化，而且不同的技术受这种变化的受影响程度也不一样。因此，不同技术之间的费用比率也会出现相应的变化。

用可能导致对气候不利的技术，不要向多边基金提供任何的资助。在多边基金历史上出现过这样的先例。然而，采用这种办法必须向企业或国家提供充足的得到资助的技术供选择。在编制这一文件时，秘书处认为需要就在此时做出这种优先排序是否适当的问题得到执行委员会的指导。

67. 在这一分析当中，没有对第 XIX/6 号决定中提到的“其他环境影响”作更进一步的考虑。原则上，这些可包括诸如导致形成少量臭氧的挥发性有机化合物的排放。然而，由于这些通常是地方因素，这些影响因素将在这一水平进行考虑，并成为有益技术选择的组成部分。

68. 由于本文件是在考虑一系列费用因素的背景之下编制的，所报告的工作主要关于执行委员会的供资办法如何被用来鼓励采纳能带来最大气候效益的技术。第 XIX/6 号决定自身指出，必须考虑“全球变暖潜势、能源利用和其他相关因素”。在评估这些指标时，秘书处一直致力于制定一个足以作为供资评估的办法，同时确保足够敏感来做出有意义的气候比较。其他资料可以在附件五中找到。出现了三大基本的方法：

(a) 通过了纯粹基于全球变暖潜势的方法；

(b) 通过了基于寿命周期气候性的方法；以及

(c) 针对寿命周期通过了“功能单元”的方法。

69. 在其初次审查中，秘书处没有认为纯粹基于全球变暖潜势的方法能够解决第 XIX/6 号决定的授权，因为它不能够解释该决定中所要求的“能源利用”。此外，如果这一方法要体现一种公正的技术比较，它必须解释在寿命周期控制做法和恢复选择中的差异。按照定义，这将使其进入对寿命周期组成部分的评估。

70. 如所有的寿命周期评估进程一样，寿命周期气候性的制定对数据十分敏感，需要了解大量的变量，这些变量在申请经费时并不全部为企业或国家所知。即使这些数据当时可用，秘书处进行相互参照并证实这些假设为适当时也可能是不切实际的。因此，寿命周期气候性的方法被认为不适合作为经费评估的基础。

71. 全球变暖潜势和寿命周期气候性方法体现了两个极端，因此，秘书处一直在研究可以克服每一种办法弊端的中间办法。这一研究的结果是对“功能单元”方法的评估，它提供了更为简便，对数据不是那么敏感的方法，同时确保考虑到第 XIX/6 号决定中所列的几项主要标准（全球变暖潜势、能源利用和其他相关因素）。应当强调的是，迄今为止，评估仅限于一个行业，需要进一步制定方法，以确保方法适用于第 XIX/6 号决定中所设定的一系列项目和方案。但是，秘书处认为，应在这一阶段确定基本的方法，并根据这一方法做出供资办法，以便尽早收到执行委员会关于拟议方法的反馈。

72. “功能单元”方法侧重于某一行业物质的典型利用，称为“要素”，以便确定整个寿命周期内对有关这一“要素”的影响的特征。例如，泡沫塑料对能效的贡献可以通过典

型建筑物在各部分之间维持 10^0C 温差（温度梯度）中的能效值来确定。这一典型的应用被用于行业中所有活动的“代表”。其目的并不是计算每一应用的精确气候影响，而是确定这些影响的特点，以便使其能够被用于比较各种技术。在实践中，主要的结果将是对寿命周期气候影响的比较评估，同时考虑到该替代物的气候变化潜势、灌充规模、操作中的能源利用，以及通过寿命周期进行的排放。替代技术可以以淘汰消耗臭氧层物质最有效并可导致类似于氟氯烃技术最初的气候影响的技术为基准进行评估。

73. 这一方法需要在一系列广泛的行业进行发展与评估，以保证基本的方法可以得到更为广泛的应用。因此，秘书处寻求经执行委员会订正的在当前道路上继续其工作的授权，以向第五十七次会议上提交更为具体的提案。

五、奖励措施和共同供资的机会

74. 在编制这一文件时，秘书长被要求对财政奖励措施和共同供资的机会加以考虑，而根据议定书缔约方第 XIX/6 号决定第 11(b)段，财政奖励措施和共同供资可能与确保氟氯烃的淘汰带来好处有关。与此同时，执行委员会第五十四次会议决定在其第 54/39 号决定中通过关于编制氟氯烃淘汰管理计划的准则。这些准则鼓励各国和机构探索可能的财政奖励措施和共同供资的机会，以寻求其他的资源来使氟氯烃淘汰管理计划的环境益处最大化。共同供资可以在个别的项目或国家计划进行，分别或一起进行。第 54/39 号决定规定了寻求与个别项目或方案相关的共同供资的要求。

75. 就本文件而言，环境益处的问题被认为是指气候变化和减少温室气体排放。多边基金下的淘汰项目在减少温室气体排放量方面各有不同。削减 HCFC-22 的生产将导致 HFC-23 联合产量的减少，后者是一种潜在的温室气体。氟氯烃生产量和消费量的减少将使这些具有很高全球变暖潜势物质的排放量的减少。同样应用中的替换也会有排放，而其中的一些排放物也可能是温室气体。最后，氟氯烃被用作制冷剂，在某种程度上用塑料泡沫发泡剂，与能源消费紧密相关，反过来也与碳排放有关。

76. 由多边基金执行的淘汰计划在吸引共同供资方面至少需要一个本文件第五部分所提到的气候相关的指标。这应为评估多边基金执行的项目对其他供资机制目标的贡献提供一个好的起点。

77. 有一些供资机制可能适合于为多边基金项目提供联合供资。其中，有来自受益者的资金、基于传统供资模式的机制、来自政府或工业的国家能源效率项目，以及基于市场的机制。这些是当前最可能的共同供资来源。

78. 传统的筹资模式包括与多边基金结构类似的基金，比如若干捐助者根据控制实体规定的额度向受援者提供经费。全球环境基金会就属于这一类型，另外还有其他的国际、区域和个别捐助国层面的气候或环境相关的基金。目前，这一类的基金正在迅速增长，不管是金额还是机制的数目都是如此。这些基金的标准和获得模式可能与多边基金的目标相符。

79. 在一些国家，经营节能基金的是政府或者供电者。通常情况下，可以认为此种基金与多边基金项目相符，但是这种基金在第 5 条国家似乎并不常见。

80. 基于市场的机制发放碳信贷或碳排放权利，旨在抵消其他地方某些严格定义项目实现的排放削减所产生的碳排放。此种活动所产生的收入取决于销售时此种权利或信贷的市场价格。这些机制在实际的排放削减基础之上进行运作，并要求环境附加因素，即该项目必须做到在其他地方不可能实现的排放削减。将环境益处最大化的活动可以被理解为是附加的活动。

81. 在有关多边基金及其执行机构下的个别项目或方案的共同供资方面已有经验。几乎所有的多边基金项目都是作为对第 5 条国家受益企业和机构的赠款获得核准，少数项目需要联合供资，如冷风机的情况一样。赠款数额的确定，依据的是对符合资格的增支费用所作的分析。与项目有关的其他不符合资格的增支费用或非增支费用，很多情况下由受益企业支付。有的情况下是通过支付增支经营费用所提供的现金支助。

82. 由企业支付的非增支费用的实例有：与超出基准水平的车间改造、能力提高或技术更新有关的建筑费用。[13]此外，在制冷维修行业，作为制冷剂管理计划、最终淘汰管理计划和国家淘汰计划的一部分，制订了各项奖励方案，特别是对最终用户行业，在这方面，向受益最终用户提供了部分资金，使其将使用消耗臭氧层物质的制冷系统改造为使用替代制冷剂。这些都是可被视为多边基金项目的受益者联合供资的实例。[14]

83. 执行委员会第四十五次会议决定设立的中央冷风机替换用途专用款获得核准，替换冷风机用途专用款的设立是建筑在这样的谅解之上，即：用使用替代技术的冷风机替换老的使用氟氯化碳的冷风机会带来多重的好处。并只有落实了联合供资后才发放资金。[15]执行委员会第四十六次和第四十七次会议上核准了冷风机项目。一些项目取决于较多数目的受惠捐款，实际上是创建了一个类似于上文提到的奖励方案的执行基金。其他项目正在寻求使用其他的供资机制，诸如全球环境基金会，其他环境基金或来自与能源保护有关的电力公司的基金。项目核准大约 18 个月起，全球环境基金（全环基金）或其他环境基金提供的较多数目的资金便开始到位，但还没有完全确立。国际金融机制的资金和电力公司的资金尽管做出了很大努力，但迄今仍然没有到位。

84. 这些项目有可能将那些在多边基金现有准则下不合格的活动纳入在内，其中部分经费将来自于收到的共同供资的一部分。这可能，比方说，可以成为空调行业所用技术的更新，以实现更高的能效。同样的，还会施加一些限制，比如在设备来源、采用特别的技术

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[13] 秘书处没有对这些非增支费用进行评估和记录，因此，除了通过编制这种可能被包括在项目文件中定量资料之外，不可能提供数量方面的资料。

[14] 根据其他供资机制，这些费用被视为“对应供资”或“联合供资”。

[15] 为对本专用款下冷风机项目开展审查，秘书处在 ExCom/46/37、ExCom/47/20 和 ExCom/47/21 号文件中承担对关于本文件授权也可用的共同供资的重要方面和相关经验进行分析。

等等方面。有必要根据各缔约方提供的总体授权对在何种情况下共同供资才足以开展满足这些要求所需的其他努力工作进行仔细评估。

85. 在同意氟氯烃准则的同时，执行委员会已经要求获得关于可适用的国家或区域供资机制的资料。因此，确立了为个别项目和计划提供共同供资的前提条件。

86. 对项目所取得的进展进行的评估表明，应该在 2009 至 2013 年之间编制和执行氟氯烃淘汰项目，以便实现 2013 年和 2015 年的氟氯烃履约目标。执行冷风机项目中有很大一部分联合供资的成分，这一经验表明，如果淘汰项目取决于区域或多边来源的共同供资，那么有可能在氟氯烃淘汰项目中出现重大的拖延，为实现 2013 年和 2015 年履约目标提出了潜在的巨大挑战。考虑到《蒙特利尔议定书》中基于时间的削减承诺，各国为了不确定的共同供资而冒着项目被拖延的风险是比较困难的。因此，如果其他的供资实体的支助速度仍然十分缓慢的话，那么利用其他机构来支持多边基金的活动的可能性将遭到质疑。

87. 共同供资也可以在全球范围进行评估，即不仅仅限于个别项目或方案的共同供资。为此目的，基于市场的机制和气候或环境基金都可以被利用。类似的全球方法可能具有一些优点，诸如将程序进行简化并集中努力来利用共同供资。为减少由于探索共同供资可能性而导致的项目拖延问题，基金秘书处将有可能与其他机构联系，以探讨是否可以制定其他的方法和更为简化的机制，使其他机构能够成为多边基金臭氧供资的重点，以实现其他的气候效益。一旦与执行委员会就本文件所提出的某些问题所进行的讨论取得进展，就可以与其他机构开始进行交流。特别是有关截止日期、第二次转产以及如何使其他对环境的影响最小化的问题。

88. 此种活动可能由以下活动组成：

(a) 确定合适与协调一致的区域或多边供资机制；

(b) 对相关的业务需求进行评估，诸如对监测的必要性、对追加活动或限制的要求；

(c) 为项目评估、执行、监督与评价的合作与必要的调整制定可能的业务概念。

89. 上述几点构成了一个初步的清单，将要求秘书处和各执行机构在执行委员会的一贯指导和监督下进行密切的合作。因此，谨建议执行委员会考虑是否应进一步探索共同供资的可能性。

六、建议

90. 谨建议执行委员会:

(a) 注意到对氟氯烃淘汰供资所涉相关费用情况提供分析的讨论文件，

(b) 注意到在第 5 条国家采用的至今为止可用的氟氯烃替代物质十分有限，必须在第 5 条国家对其进行证实并使尽可能其以最有效的方式适应当地的条件，以及，相应地，在更换设备和原材料的费用方面差异很大：

（一） 请秘书处继续收集关于在气雾剂、灭火器和溶剂中淘汰氟氯烃的技术资料，以审查提交的这些行业的任何项目，并视情况将其提交至执行委员会供其单独的审议；以及

（二） 考虑将秘书处欲采取的任何关于计算增支经营费用或氟氯烃转产项目中节余的政策的决定推迟至秘书处 2010 年的第一次会议上进行，以及确立成本效益的阈限值，以便从该会议之前的氟氯烃淘汰项目审查中所取得的经验中获益；

(c) 同意载于 UNEP/OzL.Pro/ExCom/55/47 号文件的技术资料足以在个案的基础上对泡沫塑料、制冷剂和空调行业淘汰氟氯烃的一些独立项目（每个地区 4 个）进行编制、审查和提交，以证明替代技术的可适用性，促进对关于增支资本费用和经营费用或节余以及其他有关技术适用的精确数据的收集，如下文第(d)和(e)段所示；

(d) 作为紧急事项，邀请各双边和各执行机构编制并提交有限数量的具有具体时限的项目提案，这些项目提案涉及有关的系统厂商和/或化学品供应商在以下基础之上开发、优化和证实与非氟氯烃发泡剂使用的化学系统：

（一） 作为项目组成部分，根据发展与证实的进程，合作的系统厂商将向一些选定的下游泡沫企业提供技术转让和培训，以完成这些企业的氟氯烃淘汰；

（二） 各机构将收集并汇报精确的项目费用数据和其他有关技术适用的数据；

（三） 为编制和执行氟氯烃淘汰管理计划，以及任何独立的项目，这些特别项目将在不超过 18 个月的时期内完成，同时将向执行委员会提交关于上述第（一）和（二）段所列的两个执行阶段中每一个阶段的进度报告；

（四） 鼓励双边和执行机构以及有关的合作系统厂商解决与编制和分发含有碳氢发泡剂的组合聚醚有关的技术问题；

(e) 考虑邀请双边和执行机构提交数量有限的制冷剂和空调次级行业的氟氯烃项目转用低全球变暖潜势技术的示范项目，以确定所有需要采取的步骤，并对其相关费用进行评估；

(f) 继续审议其关于第二阶段转产的政策和确定使用氟氯烃的制造设备安装截止

日期，因为安装之后转换此种设备的增支费用将不符合供资的资格，以便在向第五十六次会议提交独立项目之前完成对其的审议；

(g) 考虑 UNEP/OzL.Pro/ExCom/55/47 号文件所列的方法中是否有某种方法可以为氟氯烃淘汰技术进行优先排序提供一个满意的基础，以便将第 XIX/6 号决定最初所设想的气候影响减小至最低程度，以及是否希望秘书处继续其评价，以便在以后的执行委员会会议上提出更为详细的报告；

(h) 考虑秘书处联系其他机构的可能性，以期找到合适而一致的可以作为共同供资来源的区域或多边供资机制，以全额支付多边基金臭氧供资，从而实现其他的气候效益，并向下一次会议作进一步的报告；

(i) 考虑是否希望在下一次会议上审查将重点放在多边基金对设备更换的支助上，因为目前此种设备已经到达其有用寿命的末期，从而避免在 2013 年和 2015 年的履约目标一旦实现之后昂贵和全面运转的基础设施的过早退役和报废。

ANNEX I

POLICIES FOR FUNDING HCFC PHASE-OUT

1. The evaluation of the incremental costs of all Multilateral Fund project has been based on the general principles agreed by the Parties to the Montreal Protocol at their 2nd Meeting[1], namely:

(a) The most cost-effective and efficient option should be chosen, taking into account the national industrial strategy of the recipient Party. It should be considered carefully to what extent the infrastructure at present used for production of the controlled substances could be put to alternative uses, thus resulting in decreased capital abandonment, and how to avoid deindustrialization and loss of export revenues;

(b) Consideration of project proposals for funding should involve the careful scrutiny of cost items listed in an effort to ensure that there is no double-counting;

(c) Savings or benefits that will be gained at both the strategic and project levels during the transition process should be taken into account on a case-by-case basis, according to criteria decided by the Parties and as elaborated in the guidelines of the Executive Committee; and

(d) The funding of incremental costs is intended as an incentive for early adoption of ozone protecting technologies. In this respect the Executive Committee shall agree which time scales for payment of incremental costs are appropriate in each sector.

I.1 Categories of incremental costs

2. On the basis of these principles, the Executive Committee has developed specific policies and guidelines of categories of incremental costs in different industrial applications. The two main categories of incremental costs are capital costs and operating costs:

(a) Capital costs are typically related to the additional equipment that would be needed to replace ODSs with the alternative technology selected by the enterprise, technology transfer, technical assistance, training, trials and commissioning. They also include safety equipment and modifications to the enterprise when the technology selected is based on flammable substances. The size of the capital costs depends on the installed production capacity of the enterprise, the equipment available before the conversion, the alternative technology selected, and the location of the enterprise. Throughout the years, as the number of investment projects increased, the actual prices of major pieces of equipment required for the conversion were well established and used in the majority of the projects.

[1] Appendix 1 of decision II/8 (Financial Mechanism).

(b) Incremental operating costs reflect changes in costs attributable to the conversion to CFC alternatives and arising from changes in starting materials and chemicals used in the production process such as additives, propellants and blowing agents. Fluctuations in raw material prices leading to changes in incremental operating costs occur frequently[2], and vary widely at the local and regional levels[3]. Typically enterprises respond to these changes by passing the increases to their customers in an orderly manner and as market conditions allow;

(c) The level of incremental operating costs is associated with their duration. According to decisions adopted by the Executive Committee, the duration for the application of incremental operating costs varies among sectors and sub-sectors[4], as follows:

(i) No operating costs for compressors;

(ii) For domestic refrigeration, ten per cent of incremental cost to be paid up-front, or six months of incremental operating costs calculated at current prices and paid up-front, or incremental operating costs for a duration of one year adjusted according to prevailing costs at the time of disbursement, when the modified plant was operating, which ever is greater;

(iii) Two years for commercial refrigerator, rigid and integral skin foam manufacturing plants; and

(iv) Four years for aerosol and flexible slabstock manufacturing plants.

I.2 Cost-effectiveness thresholds

3. In order to prioritize the approvals of investment projects, at its 16th Meeting in March 1995, the Executive Committee established cost-effectiveness threshold[5] values for different sectors and sub-sectors, as shown in Table I.1 below. The values were established on the basis of project proposals that were fully prepared and submitted by implementing agencies, as well as proposals that were partially developed where costs and amounts of ODS to be phased out were roughly estimated.

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[2] For example, the price of HCFC-141b dropped from US $5.45/kg in 1993 to US $3.40/kg in 1998, a reduction that is typical of pricing trends once a product is introduced, production is optimised, economies of scale increase and competition becomes established in the marketplace. Enterprises that received funding in 1993 when the price of HCFC-141b was at US $5.45/kg were overcompensated for the incremental operating costs that they actually incurred (UNEP/OzL.Pro/ExCom/36/34).

[3] According to the progress report on the implementation of the 2007 country programme submitted to the Fund Secretariat by Article 5 countries the 2006 price of HCFC-22 ranged from less than US $1.00 to US $30.00 per kilogram.

[4] These are the sectors where HCFC technologies were chosen for phasing-out the use of CFCs in Article 5 countries.

[5] The cost-effectiveness value is calculated as the ratio between the sum of the total incremental capital and operating costs and the total amount of ODS to be phased in kilograms ODP.

Table I.1. Sectoral cost-effectiveness threshold values established by the Executive Committee

Sector	Subsector	CE (US$/kg ODP)
Aerosol	Hydrocarbon	4.40
Foam	General	9.53
	Flexible polyurethane	6.23
	Integral skin	16.86
	Polystyrene/polyethylene	8.22
	Rigid polyurethane	7.83
Halon	General	1.48
Refrigeration	Domestic	13.76
	Commercial	15.21
Solvent	CFC-113	19.73
	TCA	38.50

4. While adopting the threshold values, the Executive Committee recognized that the conversion from CFCs to hydrocarbon technology of domestic refrigerators manufacturing enterprises would require additional funding for the provision of safety equipment and agreed that when calculating the cost of domestic refrigeration projects the safety related costs be discounted in a way that ensures parity with other options[6]. Since the adoption of cost-effectiveness thresholds, the cost-effectiveness of projects have been assessed against the threshold value, with projects above this threshold receiving lower funding priority or partial funding.

5. The Committee also recognized the special situation of low-volume consuming (LVC) countries and decided to reserve US $6,630,000 for allocation to projects from these countries in addition to any funds received as a result of approval of projects from LVC countries that qualified under the cost effectiveness threshold values.

I.3 Small and medium-sized enterprises (SMEs)

6. Special consideration has been given by the Executive Committee to the phase-out of ODSs by small and medium-sized enterprises SMEs since its 22nd Meeting in May 1997, when it constituted a contact group to address issues related to SMEs.

7. Subsequently, at its 25th Meeting, the Executive Committee allocated US $10 million from the resource allocation for 1999 for a funding window designed to facilitate pilot conversions of significant groups of small firms in the aerosol and foam sectors from non-LVC countries. The maximum allowable levels of consumption per enterprise were 25 ODP tonnes/year for flexible and extruded polyethylene/polystyrene foams and 10 ODP tonnes/year for flexible integral skin and rigid polyurethane foams. It was also decided that group projects should: be at a level of US $1 million or less; have an overall cost-effectiveness of no more than 150 per cent of the level of the current cost-effectiveness threshold values; use the most cost-

[6] The cost effectiveness threshold value for domestic refrigeration projects was adjusted at the 20th Meeting by discounting the numerator by 35 per cent which was sufficient to maintain parity between HCFC 141b/HFC 134a and cyclopentane/HFC 134a technology options in the domestic refrigeration sector (decision 20/45).

effective technologies reasonably available; and consider the possible use of centralized use of equipment and industrial rationalization. These projects should be submitted with a Government plan including policies and regulations designed to ensure that the specific level of agreed reduction to be achieved was sustained (decision 25/56).

I.4 Policies on HCFCs

8. As HCFCs are controlled substances under the Montreal Protocol, specific decisions addressing the phase-out of these ODSs have been taken by the Parties since their 5th Meeting in November 1993, and the Executive Committee since its 12th Meeting in March 1994. As reference, all relevant decisions adopted by the Parties to the Montreal Protocol and the Executive Committee regarding HCFCs are presented below in chronological order of adoption.

Fifth Meeting of the Parties (November 1993)

9. The Fifth Meeting of the Parties decided (decision V/8) that each Party is requested, as far as possible and as appropriate, to give consideration in selecting alternatives and substitutes, bearing in mind, *inter alia*, Article 2F, paragraph 7, of the Copenhagen Amendment regarding hydrochlorofluorocarbons, to:

(a) Environmental aspects;

(b) Human health and safety aspects;

(c) The technical feasibility, the commercial availability and performance;

(d) Economic aspects, including cost comparisons among different technology options taking into account:

(i) All interim steps leading to final ODS elimination;

(ii) Social costs;

(iii) Dislocation costs; and

(e) Country-specific circumstances and due local expertise.

Twelfth Meeting of the Executive Committee (March 1994)

10. The Twelfth Meeting of the Executive Committee adopted the following recommendations on the use of transitional substances as substitutes for ozone depleting substances:

(a) In view of the ongoing review requested of the Technology and Economic Assessment Panel by the Parties to the Montreal Protocol, the paper on The Use of Transitional Substances as Substitutes for Ozone Depleting Substances (UNEP/OzL.Pro/ExCom/12/34) may not be considered as a policy guideline but as a possible input to the work of the Open-ended Working Group of the Parties to the Montreal Protocol.

(b) Meanwhile, consideration of the use of HCFC in the Multilateral Fund projects should be sector-specific and approved for use only in areas where more environment-friendly and viable alternative technologies are not available.

Fifteenth Meeting of the Executive Committee (December 1994)

11. The Fifteenth Meeting of the Executive Committee stated that, whenever possible, HCFCs should not be used. It further requested that the applicability of HCFCs in commercial refrigeration projects should be examined by an expert group, possibly the OORG, which should prepare a report for submission to the Executive Committee.

12. The Executive Committee also requested Implementing Agencies to take the following issue into consideration when preparing projects for domestic refrigerator insulation foam conversion:

(a) As HCFCs were not controlled substances for Article 5 countries, incremental costs for conversion of HCFC-141b plants were not eligible for funding;

(b) Implementing Agencies should note a presumption against HCFCs when preparing projects; and

(c) Where HCFC projects were proposed, the choice of this technology should be fully justified and include an estimate of the potential future costs of second-stage conversion.

Nineteenth Meeting of the Executive Committee (May 1996)

13. The Executive Committee, noting the recommendation of the Sub-Committee (UNEP/OzL.Pro/ExCom/19/5, para. 12), decided (decision 19/2):

(a) To take note of decision VII/3 of the Seventh Meeting of the Parties to control HCFCs and to note further that projects involving conversion to HCFCs should be considered in the light of that decision, as well as other relevant factors;

(b) That in the future, in cases where conversion to HCFCs was recommended, the Implementing Agencies should be requested to provide a full explanation of the reasons why such conversion was recommended, together with supporting documentation that the criteria laid down by the Executive Committee for transitional substances had been met, and should make it clear that the enterprises concerned had agreed to bear the cost of subsequent conversion to non-HCFC substances; and

(c) To request the Secretariat to prepare for examination by the Executive Committee at its Twentieth Meeting a paper on:

(i) The historical background to HCFC conversion projects;

(ii) What information on alternatives to HCFCs had been provided by the Implementing Agencies to the applicant countries, and how that information had been received and acted upon; and

(iii) The justifications given for the choice of one technology over another.

Twentieth Meeting of the Executive Committee (October 1996)

14. The Twentieth Meeting of the Executive Committee, decided (decision 20/48 (b, c)):

(a) To request the Implementing Agencies to ensure that adequate information on all alternative technologies was provided to enterprises converting from CFCs;

(b) To reaffirm paragraph (b) of its decision 19/2 which stated that, in cases where conversion to HCFCs was recommended, the Implementing Agencies should be requested to provide a full explanation of the reasons why such conversion was recommended, together with supporting documentation that the criteria laid down by the Executive Committee for transitional substances had been met, and should make it clear that the enterprises concerned had agreed to bear the cost of subsequent conversion to non-HCFC substances.

Eighth Meeting of the Parties (November 1996)

15. The Eighth Meeting of the Parties decided (decision VIII/13):

(a) That UNEP distribute to the Parties of the Montreal Protocol a list containing the HCFCs applications which have been identified by the Technology and Economic Assessment Panel, after having taken into account the following:

(i) The heading should read "Possible Applications of HCFCs";

(ii) The list should include a chapeau stating that the list is intended to facilitate collection of data on HCFC consumption, and does not imply that HCFCs are needed for the listed applications;

(iii) The use as fire extinguishers should be added to the list;

(iv) The use as aerosols, as propellant, solvent or main component, should be included, following the same structure as for other applications;

(b) That the Technology and Economic Assessment Panel and its Technical Options Committee be requested to prepare, for the Ninth Meeting of the Parties, a list of available alternatives to each of the HCFC applications which are mentioned in the now available list.

Twenty-third Meeting of the Executive Committee (November 1997)

16. The Twenty-third Meeting of the Executive Committee decided (decision 23/2):

(a) To request the Fund Secretariat to produce a paper containing figures on an analysis of what projects were being submitted for funding using HCFC technologies, to see whether there existed any trend towards or away from HCFC use in specific sectors, particularly the foam sector;

(b) To request the Secretariat to incorporate the following elements in the project evaluation sheets and, in the case of (i) below, in the list of projects and activities presented to the Committee for approval:

(i) Information on the conversion technology to be used;

(ii) A comprehensive outline of the reasons for selection of the HCFC technology, if used; and, where possible,

(iii) An indication of how long an enterprise intended to use a transitional HCFC technology.

Twenty-sixth Meeting of the Executive Committee (November 1998)

17. The Twenty-sixth Meeting of the Executive Committee decided (decision 26/26):

(a) That the full information provided in the project document should be included in the project evaluation sheet;

(b) That where, upon review by the Fund Secretariat, a project proposal requesting HCFC technology was considered to provide inadequate information justifying the choice of that technology, the project should be submitted for individual consideration by the Sub-Committee on Project Review.

Twenty-seventh Meeting of the Executive Committee(March 1999)

18. The Executive Committee at its Twenty-seventh Meeting (decision 27/13) expressed its appreciation for the increased information/justification provided for the selection of HCFCs and noted that that was the level of information originally expected, and that at least that level was expected in the future; stressed to the Implementing Agencies that it considered this to be more than a paper exercise, and urged the Agencies to take seriously the obligations related to providing information on alternatives available; and decided, in recognition of Article 2F of the Montreal Protocol, to request that Implementing Agencies provide, for all future projects or groups of projects for HCFCs from any country, a letter from the Government concerned. In the letter, the country should:

(a) Verify that it had reviewed the specific situations involved with the project(s) as well as its HCFC commitments under Article 2F;

(b) State if it had nonetheless determined that, at the present time, the projects needed to use HCFCs for an interim period;

(c) State that it understood that no funding would be available for the future conversion from HCFCs for these companies.

Twenty-eighth Meeting of the Executive Committee (July 1999)

19. The Twenty-eighth Meeting of the Executive Committee decided (decision 28/28) that information on a possible study comparing costs of alternative technologies and the impact on their choice of support from the Multilateral Fund should be the subject of a separate agenda item for its Twenty-ninth Meeting, for consideration by the Executive Committee itself.

Eleventh Meeting of the Parties (December 1999)

20. The Eleventh Meeting of the Parties decided (decision XI/28) to request the Technology and Economic Assessment Panel to study and report by 30 April 2003 at the latest on the problems and options of Article 5 Parties in obtaining HCFCs in the light of the freeze on the production of HCFCs in non-Article 5 Parties in the year 2004. This report should analyze whether HCFCs are available to Article 5 Parties in sufficient quantity and quality and at affordable prices, taking into account the 15 per cent allowance to meet the basic domestic needs of the Article 5 Parties and the surplus quantities available from the consumption limit allowed to the non-Article 5 Parties. The Parties, at their Fifteenth Meeting in the year 2003, shall consider this report for the purpose of addressing problems, if any, brought out by the report of the Technology and Economic Assessment Panel.

Thirtieth Meeting of the Executive Committee (March 2000)

21. The Thirtieth Meeting of the Executive Committee decided (decision 30/1) to establish an open-ended contact group, with Sweden as convener, in order to consider the question of policy on HCFC use as an interim technology and that the outcome of the group's work would be discussed under "Other matters".

Thirty-fourth Meeting of the Executive Committee (July 2001)

22. The Thirty-fourth Meeting of the Executive Committee decided (decision 34/51) to request the Secretariat, in relation to all future projects which involved conversion to HCFC-141b, to include in the meeting documentation the letter from the Government concerned, explaining the reasons for the choice of the technology, as per Decisions 23/20 and 27/13.

Thirty-sixth Meeting of the Executive Committee (March 2002)

23. The Thirty-sixth Meeting of the Executive Committee decided (decision 36/56):

(a) To take note with appreciation of the paper submitted by France;

(b) To request the Multilateral Fund Secretariat to update document

UNEP/OzL.Pro/ExCom/36/34 with new costs for various options and to investigate the availability of non-ODS pre-blended polyol, and to submit the updated document and its findings for the consideration of the 39th Meeting;

(c) To request Implementing Agencies to amplify the relevant enterprise information pursuant to Decision 20/48 with data concerning import restrictions into non-Article 5 countries and the cost situation for alternatives, and to inform the enterprises that they should acknowledge having received that information. The corresponding documentation should accompany the project proposal;

(d) To request the Secretariat to send to the National Ozone Unit of the recipient country, a letter recalling that HCFC-141b projects would be excluded from funding in the future (no second conversion), with copies to the Ministries of the Environment and Foreign Affairs;

(e) That the annual Executive Committee report to the Meeting of the Parties should state by country the amount of HCFC-141b consumption phased in through projects using HCFC as replacements, a consumption which would - in application of Decision 27/13 - be excluded from funding at future stages.

Thirty-eighth Meeting of the Executive Committee (November 2002)

24. The Thirty-eighth Meeting of the Executive Committee decided (decision 38/38) for projects to phase-out CFCs by conversion to HCFC technologies, Governments had officially endorsed the choice of technology and it had been clearly explained to them that no further resources could be requested from the Multilateral Fund for funding any future replacement for the transitional HCFC technology that had been selected.

Fourteenth Meeting of the Parties (November 2002)

25. The Fourteenth Meeting of the Parties (decision XIV/10), noting that the Intergovernmental Panel on Climate Change and the Technology and Economic Assessment Panel are invited by the Convention on Climate Change to develop a balanced scientific, technical and policy-relevant special report as outlined in their responses to a request by the Subsidiary Body for Scientific and Technological Advice of the Convention on Climate Change (UNFCCC/SBSTA/2002/MISC.23), decided to request the Technology and Economic Assessment Panel to work with the Intergovernmental Panel on Climate Change in preparing the report mentioned above and to address all areas in one single integrated report to be finalized by early 2005. The report should be completed in time to be submitted to the Open-ended Working Group for consideration in so far as it relates to actions to address ozone depletion and the Subsidiary Body for Scientific and Technological Advice of the Convention on Climate Change simultaneously.

Fifteenth Meeting of the Parties (November 2003)

26. The Fifteenth Meeting of the Parties decided:

(a) That the Parties to the Beijing Amendment will determine their obligations to ban the import and export of controlled substances in group I of Annex C (hydrochlorofluorocarbons) with respect to States and regional economic organizations that are not parties to the Beijing Amendment by January 1 2004 in accordance with the following:

(i) The term "State not party to this Protocol" in Article 4, paragraph 9 does not apply to those States operating under Article 5, paragraph 1, of the Protocol until January 1, 2016 when, in accordance with the Copenhagen and Beijing Amendments, hydrochlorofluorocarbon production and consumption control measures will be in effect for States that operate under Article 5, paragraph 1, of the Protocol;

(ii) The term "State not party to this Protocol" includes all other States and regional economic integration organizations that have not agreed to be bound by the Copenhagen and Beijing Amendments;

(iii) Recognizing, however, the practical difficulties imposed by the timing associated with the adoption of the foregoing interpretation of the term "State not party to this Protocol," paragraph 1 (b) shall apply unless such a State has by 31 March 2004:

(i) notified the Secretariat that it intends to ratify, accede or accept the Beijing Amendment as soon as possible;
(ii) certified that it is in full compliance with Articles 2, 2A to 2G and Article 4 of the Protocol, as amended by the Copenhagen Amendment;
(iii) submitted data on (i) and (ii) above to the Secretariat, to be updated on 31 March 2005, in which case that State shall fall outside the definition of "State not party to this Protocol" until the conclusion of the Seventeenth Meeting of the Parties;

(b) That the Secretariat shall transmit data received under paragraph 1 (c) above to the Implementation Committee and the Parties;

(c) That the Parties shall consider the implementation and operation of the foregoing decision at the Sixteenth Meeting of the Parties, in particular taking into account any comments on the data submitted by States by 31 March 2004 under paragraph 1 (c) above that the Implementation Committee may make.

Forty-second Meeting of the Executive Committee (April 2004)

27. The Forty-second Meeting of the Executive Committee decided (decision 42/7):

(a) To request the Government of Germany to take into account the views expressed on the eligibility of funding HCFC phase-out management studies by the Multilateral Fund at the 42nd Meeting of the Executive Committee, in the informal group meeting and, in addition, further submissions of additional ideas and opinions sent by e-mail to GTZ-Proklima, as the German bilateral Implementing Agency, provided that they were received 10 weeks prior to the 43rd Meeting of the Executive Committee; and

(b) Also to request the Government of Germany to circulate to the Executive Committee, through the United Kingdom delegation, a policy paper on the issues of the responsibility of the Multilateral Fund and potential eligibility requirements for such a study and to reformulate the project proposal for submission and consideration at the 43rd Meeting of the Executive Committee on that basis.

Forty-third Meeting of the Executive Committee (July 2004)

28. The Forty-third Meeting of the Executive Committee decided (decision 43/19):

(a) To note that:

(i) The May 2003 Technology and Economic Assessment Panel’s HCFC Task Force Report predicted a dramatic increase in HCFC consumption in China in the foreseeable future;

(ii) The intent of the proposed project was also to allow utilization of its results for all Article 5 countries; and

(iii) Established Executive Committee policies did not support conversion of capacity installed after July 1995 nor a second conversion and the study was therefore not aiming at preparing or initiating any conversion projects;

(b) To approve the project “Development of a suitable strategy for the long-term management of HCFCs, in particular HCFC-22, in China”, addressed in documents UNEP/Ozl.Pro/ExCom/43/21 and UNEP/OzL.Pro/ExCom/43/51, at the level of funding of US $300,300 plus support costs for the Government of Germany of US $39,039 on an exceptional basis on the condition that, as one of the outcomes, a study would look into the effects of management of HCFCs in China and in other Article 5 countries; and

(c) To further note that:

(i) A schedule for the study, indicating a project duration of 21 months, had been submitted to the Fund Secretariat. Both the Government of Germany and the Government of China would strive to adhere to that schedule;

(ii) The Government of China intended to use relevant outcomes of the study as a basis for subsequent national action by the Government and expected that such action would take place within three years after finalization of the study; and

(iii) Interested Executive Committee members and Implementing Agencies would be invited to participate in an informal advisory group, which might discuss survey methodologies, the evaluation of information gathered, and policies.

<u>Nineteenth Meeting of the Parties (September 2007)</u>

29. The Nineteenth Meeting of the Parties agree (decision XIX/6) to accelerate the phase out of production and consumption of hydrochlorofluorocarbons (HCFCs), by way of an adjustment in accordance with paragraph 9 of Article 2 of the Montreal Protocol and as contained in annex III to the report of the Nineteenth Meeting of the Parties, on the basis of the following:

(a) For Parties operating under paragraph 1 of Article 5 of the Protocol (Article 5 Parties), to choose as the baseline the average of the 2009 and 2010 levels of, respectively, consumption and production; and

(b) To freeze, at that baseline level, consumption and production in 2013;

(i) For Parties operating under Article 2 of the Protocol (Article 2 Parties) to have completed the accelerated phase out of production and consumption in 2020, on the basis of the following reduction steps:

(ii) By 2010 of 75 per cent;

(iii) By 2015 of 90 per cent;

(iv) While allowing 0.5 per cent for servicing the period 2020–2030;

(c) For Article 5 Parties to have completed the accelerated phase out of production and consumption in 2030, on the basis of the following reduction steps:

(i) By 2015 of 10 per cent;

(ii) By 2020 of 35 per cent;

(iii) By 2025 of 67.5 per cent;

(iv) While allowing for servicing an annual average of 2.5per cent during the period 2030–2040;

(d) To agree that the funding available through the Multilateral Fund for the Implementation of the Montreal Protocol in the upcoming replenishments shall be stable and sufficient to meet all agreed incremental costs to enable Article 5 Parties to comply with the accelerated phase out schedule both for production and consumption sectors as set out above, and based on that understanding, to also direct the Executive Committee of the Multilateral Fund to make the necessary changes to the eligibility criteria related to the post-1995 facilities and second conversions;

(e) To direct the Executive Committee, in providing technical and financial assistance, to pay particular attention to Article 5 Parties with low volume and very low volume consumption of HCFCs;

(f) To direct the Executive Committee to assist Parties in preparing their phase-out management plans for an accelerated HCFC phase-out;

(g) To direct the Executive Committee, as a matter of priority, to assist Article 5 Parties in conducting surveys to improve reliability in establishing their baseline data on HCFCs;

(h) To encourage Parties to promote the selection of alternatives to HCFCs that minimize environmental impacts, in particular impacts on climate, as well as meeting other health, safety and economic considerations;

(i) To request Parties to report regularly on their implementation of paragraph 7 of Article 2F of the Protocol;

(j) To agree that the Executive Committee, when developing and applying funding criteria for projects and programmes, and taking into account paragraph 6, give priority to cost-effective projects and programmes which focus on, inter alia:

(i) Phasing-out first those HCFCs with higher ozone-depleting potential, taking into account national circumstances;

(ii) Substitutes and alternatives that minimize other impacts on the environment, including on the climate, taking into account global-warming potential, energy use and other relevant factors;

(iii) Small and medium size enterprises;

(k) To agree to address the possibilities or need for essential use exemptions, no later than 2015 where this relates to Article 2 Parties, and no later than 2020 where this relates to Article 5 Parties;

(l) To agree to review in 2015 the need for the 0.5 per cent for servicing provided for in paragraph 3, and to review in 2025 the need for the annual average of 2.5 per cent for servicing provided for in paragraph 4 (d);

(m) In order to satisfy basic domestic needs, to agree to allow for up to 10% of baseline levels until 2020, and, for the period after that, to consider no later than 2015 further reductions of production for basic domestic needs;

(n) In accelerating the HCFC phase out, to agree that Parties are to take every practicable step consistent with Multilateral Fund programmes, to ensure that the best available and environmentally-safe substitutes and related technologies are transferred from Article 2 Parties to Article 5 Parties under fair and most favourable conditions.

30. The Nineteenth Meeting of the Parties also decided (decision XIX/8):

(a) To request the Technology and Economic Assessment Panel to conduct a scoping study addressing the prospects for the promotion and acceptance of alternatives to HCFCs in the refrigeration and air-conditioning sectors in Article 5 Parties, with specific reference to specific climatic conditions and unique operating conditions, such as those as in mines that are not open pit mines, in some Article 5 Parties;

(b) To request the Technology and Economic Assessment Panel to provide a summary of the outcome of the study referred to in the preceding paragraph in its 2008 progress report with a view to identifying areas requiring more detailed study of the alternatives available and their applicability.

<u>Fifty-third Meeting of the Executive Committee (November 2007)</u>

31. The Fifty-third Meeting of the Executive Committee decided (decision 53/37):

(a) That ratification of or accession to the Copenhagen Amendment was the prerequisite for an Article 5 Party to access Multilateral Fund funding for phasing out the consumption of HCFCs;

(b) That ratification of or accession to the Beijing Amendment was the prerequisite for an Article 5 Party to access Multilateral Fund funding for phasing out the production of HCFCs;

(c) That, in the case of a non-signatory country, the Executive Committee might consider providing funding for conducting an HCFC survey and the preparation of an accelerated HCFC phase-out management plan, with the commitment of the government to ratify or accede to the necessary Amendment and on the understanding that no further funding would be available until the Ozone Secretariat had confirmed that the government had ratified or acceded to that Amendment, through the deposit of its instrument in the Office of the United Nations Headquarters in New York;

(d) That the existing policies and guidelines of the Multilateral Fund for funding the phase-out of ODS other than HCFCs would be applicable to the funding of HCFC phase-out unless otherwise decided by the Executive Committee in light of, in particular, decision XIX/6 of the Nineteenth Meeting of the Parties;

(e) That institutions and capacities in Article 5 countries developed through Multilateral Fund assistance for the phase-out of ODS other than HCFCs should be used to economize the phase-out of HCFCs, as appropriate;

(f) That stable and sufficient assistance from the Multilateral Fund would be provided to guarantee the sustainability of such institutions and capacities when deemed necessary for the phase-out of HCFCs;

(g) That the production sector sub-group would be reconvened at the 55th Meeting to consider issues pertaining to the phase-out of HCFC production, taking into account decision XIX/6 of the Nineteenth Meeting of the Parties and the following issues, as well as further elaboration and analysis of those issues to be prepared by the Secretariat in consultation with technical experts:

(i) The continued applicability of the current approach to funding HCFC production phase-out being based on the assumption of plant closures;

(ii) The timing of funding HCFC production phase-out in view of the long duration between the HCFC freeze in 2013 and the final phase-out in 2030, taking into consideration that production and consumption phase-out could take place simultaneously;

(iii) The eligibility of the CFC/HCFC-22 swing plants in view of the commitment in the CFC production phase-out agreement not to seek funding again from the Multilateral Fund for closing down HCFC facilities that use the existing CFC infrastructure;

(iv) The cut-off date for funding eligibility of HCFC production phase-out;

(v) Other measures that could facilitate management of HCFC production phase-out; and

(vi) Other issues related to the HCFC production sector, taking in account subparagraph (g)(ii) above.

(h) That the Secretariat would work with the implementing agencies to examine the existing guidelines for country programmes and sector plans (decision taken at the 3rd Meeting of the Executive Committee and decision 38/65), and propose draft guidelines to the 54th Meeting for the preparation of HCFC phase-out management plans incorporating HCFC surveys, taking into consideration comments and views relating to such guidelines expressed by Executive Committee members at the 53rd Meeting and the submissions to the 54th Meeting referred to in paragraph (l) below, and that the Executive Committee would do its utmost to approve the guidelines at its 54th Meeting;

(i) That the Secretariat, in consultation with technical experts with knowledge of experiences in Article 5 countries with different levels of development and non-Article 5 countries, would prepare by 25 March 2008 a preliminary discussion document providing analysis on all relevant cost considerations surrounding the financing of HCFC phase-out, taking into account the views expressed by Executive Committee Members in the submissions referred to in paragraph (l) below, and including:

(i) Information on the cost benchmarks/ranges and applicability of HCFC substitute technologies; and

(ii) Consideration of substitute technologies, financial incentives and opportunities for co-financing which could be relevant for ensuring that the HCFC phase-out resulted in benefits in accordance with paragraph 11(b) of decision XIX/6 of the Nineteenth Meeting of the Parties;

(j) That the current classifications of low-volume-consuming (LVC) countries and small and medium-sized enterprises (SMEs) should be maintained until the cost-effectiveness thresholds of HCFC phase-out had been developed and the potential impact of those thresholds on LVC countries and SMEs had become better known. It would then be possible to review those classifications including a classification for very low-volume consuming countries, and current policies and funding arrangements targeting those countries and enterprises;

(k) To note that the following cut-off dates for funding HCFC phase-out had been proposed:

(i) 2000 (Cap of HCFC production/consumption in one major country);

(ii) 2003 (Clean Development Mechanism);

(iii) 2005 (proposal for accelerated phase-out of HCFCs);

(iv) 2007 (Nineteenth Meeting of the Parties);

(v) 2010 (end of the baseline for HCFCs);

(vi) Availability of substitutes;

(l) As a matter of priority, and taking into account paragraphs 5 and 8 of decision XIX/6 of the Nineteenth Meeting of the Parties, to invite Executive Committee Members to submit their views on the following issues to the Secretariat, by 15 January 2008, with the understanding that the Secretariat would make the submissions available to the 54th Meeting:

(i) Elements the Secretariat should consider in the draft guidelines for the preparation of national HCFC phase-out management plans;

(ii) Cost considerations to be taken into account by the Secretariat in preparing the discussion document referred to in paragraph (i) above;

(iii) Cut-off date for funding eligibility; and

(iv) Second-stage conversions;

(m) To approve 2008 expenditure of up to US $150,000 to cover the costs of consultations with technical experts and other stakeholders required for the preparation of the documents referred to in the present decision.

Fifty-fourth Meeting of the Executive Committee (April 2008)

32. The fifty-fourth Executive Committee decided to adopt the following guidelines (decision 54/39):

(a) Countries should adopt a staged approach to the implementation of an HCFC phase-out management plan (HPMP), within the framework of their over-arching-strategy;

(b) As soon as possible and depending on the availability of resources, countries should employ the guidelines herein to develop, in detail, stage one of the HPMPs, which would address how countries would meet the freeze in 2013 and the 10 per cent reduction in 2015, with an estimate of related cost considerations and applying cost guidelines as they were developed;

(c) The elaboration of stage one of the HPMP and subsequent stages should be developed as follows:

(i) For countries with consumption in the servicing sector only:

a) To be consistent with existing guidelines for the preparation of RMPs/RMP updates pursuant to decisions 31/48 and 35/57; and, if applicable, with the preparation of TPMPs pursuant to decision 45/54;

b) To contain commitments to achieve the 2013 and 2015 HCFC control measures and include a performance-based system for HPMPs based on the completion of activities in the HPMP to enable the annual release of funding for the HPMP;

(ii) For countries with manufacturing sectors using HCFCs, HPMPs should contain a national performance-based phase-out plan (NPP) with one or several substance or sector-based phase-out plans (SPP) consistent with decision 38/65 addressing consumption reduction levels sufficient to achieve the 2013 and 2015 HCFC control measures and provide starting points for aggregate reductions, together with annual reduction targets;

(d) For countries that chose to implement investment projects in advance of completion of the HPMP:

(i) The approval of each project should result in a phase-out of HCFCs to count against the consumption identified in the HPMP and no such projects could be approved after 2010 unless they were part of the HPMP;

(ii) If the individual project approach was used, the submission of the first project should provide an indication of how the demonstration projects related to the HPMP and an indication of when the HPMP would be submitted;

(e) Consideration should be given to providing funding for assistance to include HCFC control measures in legislation, regulations and licensing systems as part of the funding of HPMP preparation as necessary and confirmation of the implementation of the same should be required as a prerequisite for funding implementation of the HPMP;

(f) In cases where there were multiple implementing agencies in one country, a lead agency should be designated to coordinate the overall development of stage one of the HPMP;

(g) HPMPs should contain cost information at the time of their submission based on and addressing:

(i) The most current HCFC cost guidelines at the time of submission;

(ii) Alternative cost scenarios based on different potential cut-off dates for new capacity if a specific cut-off date had not yet been decided, for funding eligibility of manufacturing facilities as specified in decision 53/37(k), as well as the current policy for a 25 July 1995 cut-off date;

(iii) Alternative cost scenarios for the operational and capital costs for second conversions;

(iv) The incremental costs of regulating import and supply to the market of HCFC dependent equipment once proven alternatives were commercially available in the country and describing the benefits to the servicing sector of associated reduced demand;

(v) Cost and benefit information based on the full range of alternatives considered, and associated ODP and other impacts on the environment including on the climate, taking into account global-warming potential, energy use and other relevant factors;

(h) Countries and agencies were encouraged to explore potential financial incentives and opportunities for additional resources to maximize the environmental benefits from HPMPs pursuant to paragraph 11(b) of decision XIX/6 of the Nineteenth Meeting of the Parties;

(i) HPMPs should address:

(i) The use of institutional arrangements mentioned in decision 53/37(e) and (f);

(ii) The roles and responsibilities of associations of refrigeration technicians and other industry associations and how they could contribute to HCFC phase-out; and

(j) HPMPs should, as a minimum, fulfil the data and information requirements, as applicable, listed in the indicative outline for the development of HPMPs, as set out in Annex XIX to the present report.

ANNEX II

OVERVIEW OF HCFCS USES

1. HCFCs have been used as early as 1936 when HCFC-22 was commercialized as a refrigerant. Production and consumption levels of HCFCs were substantially increased as a result of new applications particularly in the air conditioning sector as well as the Montreal Protocol, since several countries selected these substances as interim replacements of CFCs and other controlled substances.

2. As a consequence, global production of HCFCs reached 37,749 ODP tonnes (549,941 metric tonnes) in 2000 while the global consumption reached 38,219 ODP tonnes (546,996 metric tonnes) in the same year of which Article 5 countries accounted for 23 per cent. Since then, HCFC production and consumption levels have been reduced worldwide as a result of their phase-out in non-Article 5 countries.

3. However, against the global reduction trend, a substantial growth in HCFC production and consumption occurred in Article 5 countries[1] resulting in this group of countries accounting for nearly 80 per cent of the global production and over 75 per cent of the global consumption, as shown in Table II.1 below:

Table II.1 Levels of production and consumption of HCFCs (*)

	2000	2001	2002	2003	2004	2005	2006
HCFC production							
In ODP tonnes:							
Non-Article 5 countries	29,981	26,176	25,271	17,095	14,180	11,863	7,075
Article 5 countries	7,768	8,460	10,482	13,629	17,589	20,543	27,003
Total ODP tonnes production	37,749	34,635	35,753	30,724	31,769	32,406	34,078
In metric tonnes:							
Non-Article 5 countries	420,785	359,889	335,577	254,287	221,251	205,779	118,044
Article 5 countries	129,156	140,358	165,778	211,580	276,476	326,518	413,659
Total metric tonnes production	549,941	500,247	501,355	465,867	497,727	532,297	531,703
HCFC consumption							
In ODP tonnes:							
Non-Article 5 countries	25,219	23,360	22,333	14,865	10,975	10,278	7,120
Article 5 countries	13,000	12,435	13,403	15,826	19,783	21,536	28,040
Total ODP tonnes consumption	38,219	35,795	35,736	30,691	30,758	31,814	35,160
In metric tonnes:							
Non-Article 5 countries	347,741	321,823	291,318	225,013	185,019	182,326	122,107
Article 5 countries	199,255	191,854	201,023	230,354	287,407	329,104	396,099
Total metric tonnes consumption	546,996	513,677	492,341	455,367	472,426	511,430	518,206

(*) Data reported under Article 7 of the Montreal Protocol

[1] This category includes data from the Republic of Korea, Singapore and United Arab Emirates, representing countries that have so far not received assistance from the Multilateral Fund.

II.1 HCFCs consumption in Article 5 countries

4. Based on an analysis of HCFC data reported by Article 5 countries under Article 7 of the Montreal Protocol , it was noted that:

(a) HCFC-141b, HCFC-142b and HCFC-22 accounted for more than 99 per cent of the total amounts of HCFCs that were produced or consumed in 2006;

(b) Consumption of HCFC-22 represented 48.5 per cent of the total consumption of HCFCs in 2006, while consumption of HCFC-141b and HCFC-142b represented 43.5 and 7.2 per cent respectively of the total HCFC consumption;

(c) Seventy one countries reported a total HCFC consumption below 360 ODP tonnes in 2006 while 29 other countries either report zero consumption or not reported consumption (27 of these countries are currently classified as LVC countries);

(d) HCFC-142b increased significantly from 106.5 ODP tonnes (1,639 metric tonnes) in 2000 to 2,029.9 ODP tonnes (31,229 metric tonnes) in 2006. Consumption of HCFC-141b increased by 19 per cent while consumption of HCFC-22 increased by 8 per cent over the same period;

(e) In 2006, the total production and consumption of HCFCs by Republic of Korea, Singapore and United Arab Emirates amounted to 146.5 ODP tonnes (6,764 metric tonnes) and 1,016.2 ODP tonnes (33,372 metric tonnes) respectively. These three Article 5 countries have not received any assistance from the Multilateral Fund for phasing out their production and consumption of ODSs;

(f) For the purpose of comparison, the total consumption of CFCs reported by all Article 5 countries under Article 7 excluding Republic of Korea, Singapore and United Arab Emirates, amounted to 178,144 metric tonnes in 1995, which represented the maximum amount ever reported. The total 2006 consumption of HCFCs in metric tonnes is more than two times the CFC consumption reported in 1995.

5. Consumption of HCFC-141b and HCFC-142b was reported only in 40 and 19 Article 5 countries[2] respectively in 2006. Twenty[3] of the 40 countries reported consumption of HCFC-141b consumption below 10 ODP tonnes (91 metric tonnes). Similarly, 16[4] of 19 countries reported consumption of HCFC-142b below 10 ODP tonnes (154 metric tonnes). Thus, virtually three countries accounted for the entire HCFC-142b consumption of Article 5 countries in 2006. These levels of HCFC consumption point to a large number of SMEs among Article 5 countries with respect to HCFCs.

[2] Excluding Republic of Korea, Singapore and United Arab Emirates.
[3] Excluding 1,028.7 ODP tonnes (9,352 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.
[4] Excluding 126.7 ODP tonnes (1,949 metric tonnes) consumed by Republic of Korea and Singapore.

6. Seventy[5] of the 114 Article 5 countries that reported consumption of HCFC-22[6] in 2006 had consumption below 10 ODP tonnes (182 metric tonnes). It appears that the consumption of HCFC-22 in these countries is mainly for servicing refrigeration systems.

7. The number of countries by level of consumption and type of HCFC is presented in Table II.2 below.

Table II.2 Number of countries by level of HCFC consumption in 2006 (ODP tonnes)

HCFC	<10	>10 and <50	>50 <100	>100 < 1,000	>1,000	Total
HCFC-141b**	22	8	6	3	1	40
HCFC-142b**	17		1		1	19
HCFC-22(*)	73	20	7	13	1	114

(*) An additional 16 countries had reported HCFC-22 consumption in 2005.

II.3 Sectoral distribution of HCFCs

8. The only information on the sectoral uses of HCFCs in Article 5 countries available at the Fund Secretariat was that contained in the preliminary surveys on HCFCs undertaken by the Government of Germany for China[7] and UNDP for 12 selected Article 5 countries[8]. Some of the results of these surveys were the following:

(a) Excluding HCFC feedstock consumption, about 4,950 ODP tonnes of HCFC-22 were used in China in 2004 as refrigerant and 550 ODP tonnes as foaming agent and in the aerosol sector. The largest share of HCFC-22 consumption in China is for room air-conditioners, with a total production of 67.6 million units in 2005. During the next ten years, the use of HCFC-22 is likely to increase to about 16,500 ODP tonnes for domestic consumption, unless constrained by policy and technology improvements;

(b) The room air-conditioner and the expanded polystyrene foam sub-sectors in China are expected to grow at an annual rate of 7 per cent and 9 per cent, respectively;

(c) According to the surveys conducted by UNDP, the two main industrial sectors where HCFCs are currently consumed in Article 5 countries are the foam sector (32.5 per cent of the total consumption) and the refrigeration sector (66.2 per cent). The remaining consumption is in the aerosol (0.2 per cent), fire extinguisher (0.1 per cent) and solvent (1.0 per cent) sectors; and

(d) The breakdown of HCFC use by manufacturing versus servicing sectors in countries covered by UNDP's surveys are country dependent as shown below:

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[5] Excluding 1,213.9 ODP tonnes (22,071 metric tonnes) consumed by Republic of Korea, Singapore and United Arab Emirates.
[6] An additional 16 countries Article 5 countries had reported HCFC-22 consumption in 2005. Republic of Korea, Singapore and United Arab Emirates are excluded from the analysis.
[7] UNEP/OzL.Pro/ExCom/51/Inf. 3.
[8] UNEP/OzL.Pro/ExCom/51/Inf. 2.

Country	Manufacturing (%)	Servicing (%)
Argentina	38.0	59.0
Brazil	45.0	52.0
Colombia	59.0	31.0
India	79.0	20.0
Indonesia	56.0	44.0
Iran	83.0	17.0
Lebanon	31.0	69.0
Mexico	64.0	35.0
Venezuela	21.0	77.0

II.4 HCFC technology in Multilateral Fund projects

9. Since the inception of the Multilateral Fund in 1991, the Executive Committee has approved 858 stand-alone investment projects in 47 Article 5 countries where HCFCs have been selected as the technology to replace CFC consumption, partially or totally[9]. Additionally, sectoral phase-out plans in the foam and refrigeration sectors and the conversion of CFC-12 compressors to HCFC-22-based systems have also been approved by the Executive Committee in a few Article 5 countries. The sectoral distribution of the stand-alone projects is presented in Table II.3 below:

Table II.3 Sectoral distribution of Multilateral Fund stand-alone projects with HCFC replacement technology

Sector	Projects	Countries
Foam	491	31
Refrigeration(*)	364	44
Solvent	3	2
Total	**858**	

(*) Compressor projects converted to HCFC-22 technology are not included.

10. Over 40,000 ODP tonnes of CFCs have been replaced by HCFC technologies, mainly HCFC-141b in foam applications including foam insulation in domestic refrigerator manufacturing enterprises, and HCFC-22 as a refrigerant and to a lesser extent as a foam blowing agent. The total amount of HCFC-141b and HCFC-22 consumption phased in through projects using HCFCs as a replacement of CFC-11 and CFC-12 amounts to over 3,700 ODP tonnes[10], as shown in Table II.4 below.

[9] Inventory of Approved Projects, including projects approved at the 53rd Meeting of the Executive Committee.

[10] This analysis has not included the amounts phased in from refrigeration manufacturing enterprises and a few foam enterprises covered under multi-year national phase-out plans since composite phase-out data for these plans are not yet available, although it is to be expected that the conversion technologies and their outcomes will be similar to those of the projects implemented as individual, umbrella projects or specific sector plans. It is also expected that these figures are relatively small.

Table II.4 Amounts of HCFC consumption phased-in through approved projects (ODP tonnes)

Country	CFC phased out in projects using HCFC technologies	HCFC phased in
Algeria	54.2	5.4
Argentina	817.4	79.0
Bahrain	15.3	1.5
Bolivia	11.0	1.1
Bosnia and Herzegovina	29.1	2.9
Brazil	4,830.8	476.1
Chile	236.5	20.2
China	14,078.4	1,168.4
Colombia	644.9	63.9
Costa Rica	33.1	3.3
Cuba	0.8	0.1
Dominican Republic	135.3	13.4
Egypt	484.4	37.4
El Salvador	18.3	1.8
Guatemala	45.4	4.5
India	4,463.8	432.6
Indonesia	2,839.7	281.4
Iran	1,045.5	103.6
Jordan	330.3	32.7
Kenya	22.8	2.3
Lebanon	81.0	8.0
Libya	61.5	6.1
Macedonia, FYR	75.1	7.4
Malaysia	1,226.5	118.5
Mauritius	4.2	0.4
Mexico	2,106.3	193.6
Morocco	118.0	11.7
Nicaragua	8.0	0.8
Nigeria	487.5	48.3
Pakistan	781.1	77.4
Panama	14.4	1.4
Paraguay	66.5	6.6
Peru	146.9	14.6
Philippines	518.9	51.4
Romania	192.0	19.0
Serbia	44.2	4.4
Sri Lanka	7.2	0.7
Sudan	4.4	0.4
Syria	628.4	62.3
Thailand	2,015.8	199.3
Tunisia	234.9	20.3
Turkey	372.2	36.9
Uruguay	98.1	9.7
Venezuela	699.1	69.3
Vietnam	44.4	4.4
Yemen	9.7	1.0
Zimbabwe	11.3	1.1
Total	**40,194.6**	**3,706.6**

ANNEX III

INCREMENTAL COSTS FOR PHASING OUT HCFC CONSUMPTION IN THE FOAM SECTOR

1. To date, over 89,370 ODP tonnes of CFCs used by Article 5 foam manufacturing enterprises have been phased out through Multilateral Fund individual and umbrella projects and sectoral phase-out plans, comprising 80,370 ODP tonnes of CFC-11 from the rigid polyurethane foam including domestic and commercial refrigeration, and integral skin foam sectors, and 9,000 ODP tonnes of CFC-12 from the extruded polystyrene and polyethylene foam sector. Out of this amount, some 34,000 ODP tonnes of CFC-11 were replaced by HCFC-141b, 760 ODP tonnes were replaced by HCFC-22[1] and about 280 ODP tonnes by HCFC-22/HCFC-142b[2], with a phase-in of some 3,380 ODP tonnes of HCFC-141b and 42 ODP tonnes of HCFC-22. The latest (2006) HCFC-141b consumption reported by Article 5 countries under Article 7 of the Montreal Protocol is about 12,200 ODP tonnes. The differences in the consumption levels may possibly be attributed to growth in the consumption of HCFC-141b resulting from industrial expansion in the foam sector already supported by the Multilateral Fund and installation of new capacity.

Size of Multilateral Fund projects

2. An analysis of 657 Multilateral Fund foam projects approved as individual projects for 38 Article 5 countries to phase out CFC-11 using HCFC-141b technology showed the following:

(a) About 50 per cent of the enterprises were small scale enterprises with CFC consumption below 20 ODP tonnes, 20 per cent were medium scale with CFC consumption ranging from 20 to 40 ODP tonnes, while 30 per cent had consumption above 40 ODP tonnes. Thus, nearly 70 per cent of all the enterprises were small and medium scale foam producers;

(b) Only 20 per cent of the enterprises had CFC consumption over 60 ODP tonnes and could have cost-effectively used hydrocarbon-based technology;

(c) Nearly 80 per cent of the foam enterprises converting to HCFC-141b technology were located in seven of the 38 Article 5 countries (i.e., Brazil, China, India, Indonesia, Malaysia, Mexico and Thailand). In these countries 80 per cent of the enterprises had consumption below 40 ODP tonnes per year.

3. An additional analysis of 454 Multilateral Fund projects approved for 48 Article 5 countries to phase-out CFC-11 using HCFC-141b technology and CFC-12 using alternative refrigerants in the domestic and commercial refrigeration sector, showed that:

(a) Over 75 per cent of the enterprises were small and medium scale producers with

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[1] HCFC-22 was used as a substitute for CFC-11 in rigid and integral skin foam projects only in the early stages of project funding in only one country under a special programme. Over 80 ODP tonnes of CFC-11 funded to be phased out using HCFC-22/HCFC-142b was phased out using HCFC-141b.
[2] These consumption data under the Multilateral Fund are based on baseline data reported in project proposals at the various times of their approval and do not factor in any growth in consumption.

annual CFC consumption below 40 ODP tonnes (over 60 per cent of the enterprises consumed less than 20 ODP tonnes);

(b) Nearly 14,300 ODP tonnes of CFCs used as blowing agent (i.e., over 63 per cent of the total consumption) were replaced by cyclopentane (63.5 per cent of the total) in only 119 enterprises (26 per cent). The other 335 enterprises (74 per cent) selected HCFC-141b technology;

(c) The selection of cyclopentane technology by 26 per cent of the enterprises was mainly related to the production capacity (size) of the enterprises and the products being manufactured.

4. Cyclopentane technology was selected by 26 refrigeration manufacturing enterprises with CFC-11 consumption below 20 ODP tonnes per year. The cyclopentane technology was feasible for these low volume CFC consuming enterprises since the projects were funded under the refrigeration manufacturing sub-sector where foam and refrigerant components were treated as one project, with cost-effectiveness thresholds of US $13.76/kg for domestic refrigeration and US $15.21/kg for commercial refrigeration. However, with a sub-sector cost-effectiveness threshold of US $7.83/kg, among rigid foam enterprises not manufacturing refrigeration equipment, only those with CFC consumption of over 40 ODP tonnes could select hydrocarbon-based technologies as a replacement of CFCs, .

5. From the above analysis and from a review of the baseline equipment described in Multilateral Fund project documents, the foam sector in many Article 5 countries comprises a large number of small scale units which are technically and chemically unsophisticated. Many of the enterprises usually manufacture within the same facility different combinations of foam products. For example, insulated panels for truck bodies could be produced in the same facility as block foam and moulded pipe sections, while at the same time doing spray foam at different sites using the same type of blowing agent. Some enterprises also manufacture both rigid foam and integral skin foam products in the same facility, using the same dispenser and hand mixing and the same type of blowing agent.

Selection of alternative technologies

6. Given the limited technical capabilities of many enterprises, the selection of alternative technology to CFC-11 has been driven by the need to have a technology which would not only resemble CFC-based technology (virtual drop-in) but would also be locally available to ensure readily available technical support from material suppliers (i.e., systems houses). Depending on the products being manufactured, the production volume and the baseline equipment, several alternative technologies were chosen by Article 5 countries. Specifically, methylene chloride and liquid carbon dioxide technologies were selected for polyurethane flexible slabstock foam; water/carbon dioxide technology for flexible moulded polyurethane; hydrocarbons (butane/LPG) for polystyrene and polyethylene foam and pentane/cyclopentane/isopentane for relatively large rigid and some integral skin foam operations.

7. For a large number of foam enterprises manufacturing rigid polyurethane and integral skin polyurethane foam enterprises, HCFC-141b met the needs of both small scale and medium scale enterprises. HCFC-141b-based systems were technically mature and commercially

available. They also provided relatively the most acceptable insulation value and energy efficiency, and the lowest investment and operating costs vis-à-vis other options. No major changes in the auxiliary equipment/tooling in the production programme, such as jig or mould redesign, were needed. According to information in approved project documents and enterprise commitment letters submitted with them, enterprises understood the transitional nature of HCFC-141b and expected the final replacement for it to have similar characteristics that would meet their production demands. Accordingly, the use of HCFCs as alternative blowing agent accounted for about 34 per cent of all CFCs phased out. Table III.1 below provides detailed breakdown of alternative blowing agents to CFC-11 used in approved Multilateral Fund rigid and integral skin polyurethane foam projects.

Table III.1. CFC replacement technologies in rigid and integral skin polyurethane foam projects

Replacement	ODP tonnes	% of subtotal
Rigid polyurethane foam		
50% reduced CFC	46.0	0.2%
HFC-134a	57.8	0.3%
HCFC-22	542.2	2.4%
Water/carbon dioxide	904.8	4.1%
Pentane/cyclopentane	4,036.2	18.2%
HCFC-141b	16,630.9	74.9%
Sub-total rigid polyurethane	**22,217.9**	**100.0%**
Rigid polyurethane (insulation refrigeration)		
Water/carbon dioxide	93.0	0.4%
50% reduced CFC	450.0	1.8%
HCFC-141b	9,255.7	36.6%
Pentane/cyclopentane	15,472.0	61.2%
Sub-total rigid (insulation ref.)	**25,270.7**	**100.0%**
Integral skin		
DOP (di-octyl-phtalate)	8.6	0.2%
Methylene chloride	8.8	0.2%
HCFC-22	60.0	1.5%
Pentane/cyclopentane	164.6	4.0%
Hexane	255.0	6.2%
HCFC-141b	837.6	20.4%
Water/carbon dioxide	2,766.6	67.5%
Sub-total integral skin	**4,101.2**	**100.0%**
Multiple-subsectors (*)		
HCFC-22	157	4.6%
Water/carbon dioxide	1,031	30.2%
HCFC-141b	2,231	65.2%
Sub-total multiple-subsectors	**3,419**	**100.0%**
Total	**55,008.8**	

(*) Enterprises producing a mix of several products either within or across foam sub-sectors, e.g., rigid polyurethane pipe sections, panels and flexible polyurethane moulded and integral skin foams.

Baseline equipment upgrades for conversion to HCFC-141b and other alternatives

8. Equipment baseline information provided in project documents showed invariably that existing equipment in many enterprises consisted of low pressure foam dispensers several of them home-made, with simple open top pre-mixers or mechanical drill and bucket for premixing foam chemical components and pouring into moulds and/or cavities by hand. Better equipped enterprises predominantly had low pressure foam dispensers with mechanical mixing heads while relatively small number had high pressure dispensers.

9. After extensive technical review and discussions among the Fund Secretariat, the implementing agencies, experts from the foam industry and representatives of equipment and chemical manufacturers, it was concluded that HCFC-141b-based foam would have poorer quality of insulation (e.g., increased thermal conductivity) than that produced with CFC-11, which was being replaced. It was also concluded that this problem could be mitigated by producing foam of fine cell structure which is achieved by impingement mixing of high pressure dispensers.

10. As a consequence, financial assistance was provided from the Multilateral Fund through approved projects to enterprises manufacturing rigid polyurethane foam for insulation applications as follows:

(a) Low pressure foam dispenser that existed in the baseline was replaced with a new high pressure dispenser of equivalent effective capacity. Where cost limitations precluded provision of high pressure foam dispenser, the existing low pressure unit was replaced with a low pressure dispenser with variable ratio and heating/coating facility;

(b) High pressure dispensers already existing in the baseline were retrofitted to enable them to accommodate the new formulations and mixing ratios, by changing the pump kits, the parts vulnerable to the solvent action of HCFC-141b and by recalibration;

(c) Where no dispenser existed in the baseline (i.e., manual operation), a high pressure dispenser meeting the product output requirements of the enterprise was provided with 50 per cent contribution from the enterprise towards the cost of the new machine. Where the enterprise could not afford the contribution required to be made for a high pressure machine, a low pressure machine was provided with a much lower agreed contribution from the enterprise (usually between 25 and 35 per cent depending on the size and capacity of the machine). It was understood by recipient enterprises that the equipment provided under such arrangement was sufficient for handling the next stage of phasing out the HCFC;

(d) Additional pieces of equipment were provided, mainly polyol pre-mixers, if they were used with the CFC-based foam production.

11. In the integral skin and flexible moulded foam sub-sector most enterprises had low pressure machines that had the capability to process CFC-based formulations while those that were inadequate were upgraded through retrofits. Since the insulation property of the foam is not

an issue in these applications, the replacement of the low pressure dispenser with a high pressure dispenser was not justified except when hydrocarbon-based technology was selected. Partial funding was provided for low pressure dispensers as described above for those enterprises that did not have a foam dispenser in the baseline (i.e., SMEs with hand-mixing operations). The weaknesses in the baseline dispensers, both low and high pressure, were addressed through several retrofits, including variable drive pump motors to control the ratio of the dispenser; heat exchangers for controlling material temperature; refrigeration unit (chiller) to properly control the reactivity of the water blown foams in a hot environment; barrier coat system to replicate the thick skin of the CFC-11 blown foams as closely as possible; power washer for product finishing operations; mould ovens for preheating of the moulds for the water-blown integral skin foam and for drying the barrier coat; and/or suitable moulds where baseline moulds are of glass fibre.

12. In one country, to cover polyurethane foam production for insulating products using HCFC-22 as a blowing agent in rigid polyurethane foam thermoware products, funding was provided to replace existing low-pressure with high-pressure foaming dispensing units as well as on-site pre-mixers since polyol blends with HCFC-22 were not available. For production of extruded polystyrene foam sheets using HCFC-22/HCFC-142b as a blowing agent, funding was provided for installation of a gas storage facility, replacement of the existing extruder with a new extruder and auxiliary equipment.

Items of IOC paid for CFC phase-out

13. The level of IOC of Multilateral Fund foam projects depend on several factors, including the nature of the new formulations that would produce foam of a similar quality as in the baseline, the relative prices of chemicals required for the manufacturing of foams; cost penalty resulting from increase in the density of the foam (applicable mainly to rigid insulation polyurethane foam); the cost of incremental maintenance, incremental insurance (estimated to be 5.5 per cent of net incremental cost of equipment) and incremental energy usage when selecting hydrocarbon-based technologies; and the cost of in-mould coating chemical in integral skin foam products.

14. Experience from approved foam projects shows that the IOC associated with foam density could be as high as 60 per cent of the total IOC of the project. Since the duration of IOC for rigid foam projects is two years, calculation of the component of IOC associated with increase in foam density is based on “initial density increase” for the first year and “mature density increase” for the second year. IOC of high density rigid insulation foams (above 45 kg/m^3), such as pipe-in-pipe foam (density: 70-80 kg/m^3) and spray foam for roofs (density: 48-50 kg/m^3) are not affected by foam density increase, all other applications are affected with increases in density ranging from 4-16 per cent for the first year and 3-13 per cent for the second year. Pentane and cyclopentane-based foam for boards and domestic refrigeration have the highest increase respectively of 16 and 13 per cent and 16 and 10 per cent in the first and second years.

15. The Secretariat and the implementing agencies have worked on and agreed the baseline densities and mature densities during conversion from CFC-11 to HCFC-141b technology. These mature densities could consequently become the baseline densities for the second stage conversion from HCFC-141b to non-ODS alternatives. However, information obtained on conversions using the new generation of alternative blowing agents, particularly HFC-245fa and

methyl formate indicate that increase in foam density after conversion might not be an issue as lower foam densities than that obtained with HCFC-141b could be achieved although 1 to 2 per cent increases in density could occur particularly with methyl formate which could be mitigated with time through formulation optimization. It may, therefore, be necessary to revisit the issue of changes in foam density in order to more accurately account for the required level of IOC.

Alternative blowing agents to HCFCs

16. The choice of substitute blowing agent and its associated conversion technology had to meet the following criteria which are equally applicable to conversion from HCFC-based technology:

(a) Proven and reasonably mature technology;

(b) Critical properties to be maintained in the end product;

(c) Cost effective conversion and local availability of substitute, at acceptable pricing;

(d) Support from the local systems suppliers; and

(e) Meeting established standards on environment and safety.

17. Information available from project documents and confirmed by project completion reports, the TEAP Foam Technical Options Committee and other sources point to the following technologies as potential alternatives to HCFCs in foam blowing.

<u>Technologies already in use in Article 5 countries</u>

Water-based (water/CO_2)

18. Water-based systems, where the blowing agent is carbon dioxide generated during the foaming process, became available in some Article 5 countries during the conversion from CFC-11 in rigid integral skin foams, rigid foams with relatively less critical insulation applications such as in-situ foams, surf boards, low density packaging foams, and thermoware and spray foam, initially with the use of HCFC-141b. Water-based systems, particularly for rigid foams, are up to 50 per cent more expensive than other CFC-free technologies since the technology is associated with reductions in insulation value and lower cell stability. The problem is addressed by adding more material (up to 50 per cent) to increase foam thickness, where feasible, with resulting increase in cost. Thus, the use of water-based technology in pour-in-place for insulation applications, while in principle feasible, would require an increase in thickness, which is not always practical or cost-effective.

19. Rigid integral skin foams have almost universally converted to all-water-based systems. In most of these applications, skin formation is triggered through densification (mould pressure) rather than condensation. Accordingly, subsequent coating may be required and densities can be increased. However, since densities in this application are already relatively high, this is not a major issue. This is not the case for flexible and semi-flexible integral skin foams. The related

cost penalty arising from significantly increased densities and the poor skin formation associated with water blown systems has made the use of pentane, hexane and HFCs attractive in non-Article 5 countries and has caused almost universal conversion to HCFC-141b in Article 5 countries. Under the Multilateral Fund also projects have been approved for 23 shoe sole (semi-flexible integral skin) manufacturers, mainly in Brazil, Indonesia, Mexico and Pakistan. About 60 per cent of the enterprises employed water/CO_2 technology while 40 per cent used hexane.

20. In one Article 5 country, with the assistance from the Multilateral Fund some enterprises converted their integral skin foam production to water-blown technology without increase in foam density to achieve a surface finish of the product using water-based cross-linked in-mould coating. This required inexpensive modifications to their manufacturing equipment. However, the IOC was still higher than that of using HCFC-141b due to the higher cost of the coating. Water-based systems have zero ODP. Water vapour is a major greenhouse gas; however, new emissions do not affect global warming because it is already at a saturation point in the atmosphere. CO_2 has a GWP of 1.

Hydrocarbons

21. Hydrocarbons as foam blowing agents have been proven commercially in both non-Article 5 and Article 5 countries. Pentanes, namely n-, iso-, and cyclopentane or their blends, have emerged as the most favoured blowing agents among the hydrocarbons, because the level of their use needed to achieve the same foam density is substantially lower than that for other blowing agents such as HCFC-141b. They constitute a permanent final technology, and their relatively low prices compared to other blowing agents make them economically attractive. However, in several projects approved under the Multilateral Fund claims for costs associated with increase in foam density or dimensional stability, incremental maintenance, incremental energy usage and incremental insurance have often resulted in substantial IOC.

22. Hydrocarbons have been the preferred conversion technology for large and organized foam producers, where the safety requirements could be complied with and investments could be economically justified. However, small-sized enterprises in non-Article 5 Parties have been unable to adopt hydrocarbon technologies to any significant extent due to the investment need in new equipment[3]. Most of these enterprises have selected HFC-based technologies despite the higher system costs. Where insulation requirements are less stringent, greater use of CO2 (water) has also occurred.

23. Recent developments in equipment and technological processes appear to have made it possible for the investment costs as well as safety concerns associated with the technology to be considerably reduced. These late developments would appear to make the conversion to hydrocarbon technology more affordable and feasible to enterprises with low to medium level of HCFC consumption. Furthermore, the role of systems houses in optimizing formulations for SMEs has been particularly important. Hydrocarbons have zero ODP and a relatively low GWP (maximum 25).

[3] TEAP Progress Report, May 2008.

Technologies with limited application/use in Article 5 countries

HFCs

24. HFCs have a higher insulating value than other foam blowing alternatives at operating temperatures for applications such as walk-in coolers and cold storage areas. They are mainly used where end product fire performance is an issue with insurers or where investment costs for hydrocarbon-based technology are prohibitive mainly for SMEs.

25. The three main HFCs currently used in foam applications are HFC-134a, HFC-245fa and HFC-365mfc (and its blend with HFC-227ea).

(a) HFC-245fa (marketed primarily by Honeywell as Enovate 3000) is currently available across most, if not all, non-Article 5 countries although only currently manufactured in the United States and, to a smaller extent, in Japan (Central Glass). It has been used to replace HCFCs in most rigid foam applications, including domestic refrigeration, spray foam, and metal faced sandwich panels. Feedback from users underlines the excellent flow properties of systems containing HFC-245fa, good solubility in polyol, possible foam density reductions and reduced panel waste due to ease of processing. In most cases it can be processed with the same spray foam and pour in place dispensers used for HCFC-141b. HFC-245fa is typically used as co-blowing agent with CO_2/water in order to gain from the thermal performance, while limiting the cost impact. However, HFC-245fa poses some technical challenges to formulators due to its low boiling point and its lower fire-resistance properties relative to HCFC-141b. It currently has limited commercial availability in Article 5 countries due to lack of demand. It has a high price, currently costing over US $10.00/kg for bulk containers. HFC-245fa has zero ODP value and a GWP of 1,020.

(b) HFC-365mfc and its blend HFC-365mfc/HFC227ea (marketed almost exclusively by Solvay Fluor as Solkane-365 and Solkane-365/227, respectively), is currently available in most, if not all, non-Article 5 countries with the exception of the Canada and the United States, where patents prevent its use in foams. HFC-365mfc-blown foams have a fine cell structure with good insulation properties and good compressive strength. These foams are good for insulation purposes, where a non flammable liquid foaming agent with low thermal conductivity is needed, but does have a lower blowing efficiency than some other alternatives. For several applications, HFC-365mfc is blended with HFC-227ea to overcome a minor flammability issue. It has also a high price ranging from US $4.50 to US $5.00/kg. HFC-365mfc has zero ODP and GWP of 610. HFC-227ea has a much higher GWP value (2,900), however, it is used in relatively small proportions;

(c) HFC-134a has been used widely in Multilateral Fund projects as a refrigerant in refrigeration projects. However its use as a foam blowing agent has been very minimal due to processing difficulties, the fact that its pre-blends cannot be made available, and high production costs owing to the need for on-site pre-mixer which would limit its application by SMEs. New formulations for replacing

HCFCs in the manufacture of extruded polystyrene boards in North America are almost certain to relay on HFC-134a as a large component of the final blowing agent[4]. HFC-134a has zero ODP and GWP of 1,300.

26. In order to optimise the cost-effectiveness of HFC-based systems, foam formulators have developed products containing levels of co-blowing agents higher than have traditionally been used with HCFC-based formulations. The most prevalent co-blowing agent used is CO2 (water) and to a lesser extent hydrocarbons, CO2 (LCD), methyl formate, alcohols, and others. In many applications where limited space prevents an increase in insulation thickness (i.e., domestic and commercial refrigerators, closed cell spray foam insulation for existing building envelopes, building panels, and insulated transport containers), HFCs are selected as the blowing agent in order to provide the best available energy efficiency. In many cases the energy efficiency requirements are dictated by regulation, building codes or voluntary programmes[5].

Methyl formate

27. Methyl formate marketed by Foam Supplies Inc. (FSI) of the United States as Ecomate, is an emerging technology that could be of interest in Article 5 countries due to its reported high efficiency and low cost. Information available from the suppliers indicates that methyl formate seems an ideal replacement for HCFC-141b in integral skin foams because it has a desirable combination of boiling point and solubility to mimic those of HCFC-141b. Its boiling point just above ambient, allows good skin formation without expensive cooling. Spray and pour foams made with methyl formate are also said to have good physical properties, good fire resistance and good stability[6]. However, other market information appears to contradict some of the supplier information indicating that while Ecomate technology is interesting and promising it does not appear to be proven for many foam applications and at this stage could be more expensive than HCFC-141b, although it could be more cost competitive in the long run. Activities to optimize the technology for use in Multilateral Fund projects would be desirable.

28. The chemical is considered "extremely flammable but not explosive". FSI indicates that process emissions from Ecomate systems are so low as not to require special precautions in the manufacturing area. As Ecomate is normally sold as a system to foam producers, any flammability issues would be restricted to the systems supplier. Shipping of the systems is possible without "flammable" tags.[7]

29. Ecomate is exclusively licensed to Purcom[8] for Latin America, to BOC Specialty Gases for the United Kingdom and Ireland and to Australian Urethane Systems for Australia, New

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[4] TEAP Progress Report. May 2008.

[5] Several analyses have been carried out on these applications that demonstrate that the Life Cycle Climate Performance (LCCP) associated with the use of HFCs is, in many cases, favourable and no worse than neutral in others compared to low GWP alternatives, even when all of the blowing agents contained in the foams are deemed to be emitted over the lifecycle. The situation is further improved when measures can be adopted to minimise emissions, particularly at end-of-life.

[6] Dennis Jones, BOC Ltd., Ecomate – A Revolutionary yet Economical New Blowing Agent.

[7] John Murphy, Mark Schulte, Buck Green, Ecomate® Foam Blowing Agent, API Polyurethanes 2005 Technical Conference, 10/18/2005 (page 302ff); John Murphy – Foam Supplies, Inc and Dennis Jones, BOC Ltd. Ecomate - The Revolutionary New Blowing Agent for Europe, Utech 2006, Paper #18, March 28, 2006.

[8] Juan Valásquez - São Paulo – Brazil. International Gazeta, Purcom acquires foam suppliers license (Mjzanon's IP Newsletter - September 2005).

Zealand and the Pacific Rim. The price of methyl formate worldwide is reported to be in the same range as of the price of pentanes but not affected by the price pressures of crude oil on pentanes. Methyl formate has zero ODP and relatively low GWP[9], likely to be similar to other hydrocarbons.

Other technologies

30. Other alternatives technologies to HCFC-141b have been introduced in non-Article 5 countries[10], including:

(a) Super-critical CO_2 spray foam technology. This technology has been established mainly in Japan with a market penetration of no more than 10 per cent. The technology is yet to make any significant market penetration beyond Japan. The Green Procurement Law has also promoted the greater uptake of CO_2 (water), which is particularly suited to the Japanese market and growth of this technology has exceeded that of super-critical CO_2;

(b) A new low-GWP blowing agent, HBA-1, has been launched (Honeywell), where hydrocarbons cannot be used to replace HFC-134a for one-component foams for safety and performance reasons. This blowing agent will be commercially available in July 2008, in time to enable compliance with the requirements of the European F-Gas Regulation;

(c) The use of not-in-kind technologies such as fibrous insulation has increased in insulation markets as a result of the greater thermal efficiency of foam insulation and improvements in fire performance (greater use of polyisocyanurate technologies);

(d) The alternative technologies for HCFCs by extruded polystyrene board producers in the United States are likely a combination of HFCs, CO_2, hydrocarbons and/or water.

Costs associated with the financing of HCFC phase-out in the foam Sector

31. The costs associated with the financing of HCFC phase-out in the foam sector would include:

(a) Initiation costs: Costs associated with preparatory/enabling activities such as formulation validation activities and other initiatives to demonstrate the feasibility, performance and acceptability of alternative technologies, and investigate and establish inherent costs of conversion;

(b) Investment costs: ICC and IOC , including technical assistance and training, site preparation, trials, testing, installation and commissioning; and

[9] The supplier's claim of zero GWP is based on the US EPA SNAP evaluation which described the GWP of methyl formate as 'likely to be negligible'. However, no actual testing was carried out to support this. Indeed, there is no chemical reason why the value should not be similar to that of other hydrocarbons.
[10] TEAP Progress Report, May 2008.

(c) Management costs: Costs for supervision, monitoring, reporting, evaluation, verification, agency coordination, as a component of the overall HCFC management plan.

32. As the management costs are expected to be addressed as part of the preparation of the various HCFC management plans (HPMPs) only the initiation and investment costs are discussed in this paper. As the initiation activities are precursors to the investment activities the associated costs have been addressed as a whole. The main initiation activity under the HCFC phase-out programme is the validation of HCFC alternative foam formulations involving systems houses and foam chemical suppliers. The cost of this activity has been estimated and is attached as Appendix II to this Annex. The components of the investment cost, namely ICC and IOC are discussed below.

Range of ICC for phasing-out HCFCs

33. For purposes of funding the phase-out of HCFCs, the recipient enterprises may be put into the following categories, namely

(a) Enterprises that have converted their foam production from CFC-11 to HCFC-141b with the financial and technical assistance of the Multilateral Fund;

(b) Enterprises that have converted their foam production from CFC-11 to HCFC-141b through their own resources and/or enterprises that might have established new foam production plants or installed new foaming equipment based on HCFC-141b.

34. The second category of enterprises consists of the following:

(a) Enterprises that established CFC-based foam production facilities after the cut-off date of 25 July 1995 using low pressure machines and have subsequently converted to HCFC-141b-based production by replacing the low pressure machines with high pressure ones and enterprises that established CFC-based foam production facilities after the cut-off date of 25 July 1995 using high pressure machines and have converted to HCFC-141b;

(b) Enterprises that established CFC-based foam production facilities after the cut-off date of 25 July 1995 using low pressure machines and have subsequently converted to HCFC-141b-based production on the same machines or enterprises that established HCFC-141b-based production on low pressure machines and continue to produce on the same machine;

(c) Enterprises that have converted part of their CFC-based foam production to HCFC-141b with the assistance of the Multilateral Fund while the other part on low pressure foaming capacity established after the July 1995 cut-off date did not receive assistance but continues to be used to produce HCFC-141b-based foam without any changes.

35. Against the background of the technical upgrades of enterprises that received assistance from the Multilateral Fund and of the discussion above regarding categories of enterprises that

may potentially receive assistance from the Fund, the Secretariat made two parallel ICC estimates based on retrofit of existing equipment or replacement of existing equipment. The following considerations informed the calculations of the ICC:

(a) Conversion from HCFC-141b to liquid blowing agents, such as HFC-245fa, HFC-365mfc, HFC-365mfc/HFC-227ea blend, water/CO_2 or methyl formate, should be based on retrofits of the existing foaming machine in the baseline. The need for replacement of existing production equipment should be technically demonstrated and considered on a case-by-case basis[11];

(b) Conversion to hydrocarbon technology should be based on retrofit or replacement of existing foam dispenser and pre-mixers as technically required. Additional equipment for storage of hydrocarbon and for safety is included.

36. Thus the ICC were determined on the basis of the following:

(a) Calculations were based on a unit operation (i.e., one dispenser and associated manufacturing equipment);

(b) The majority of enterprises rely on premixed systems instead of premixing in-house for each application segment. Thus, the cost of a new premixer or retrofit of existing premixer was included in the list of equipment for those enterprises that do not rely on premixed systems;

(c) The minimum cost was based on retrofit of all required equipment items except when an item has to be replaced for technical reasons such as the conversion to hydrocarbon-based blowing agent. The maximum cost was based on installation of new equipment or replacement of old equipment with new ones without any deductions for counterpart contribution. Also, the minimum and maximum cost levels represent the absolute levels;

(d) The cost of technology transfer, training and trials were estimated at a higher level than the levels during the transition from CFC to HCFCs due to anticipated need for more activities for finessing foam formulations with potentially higher cost of trials than was the case with transition to HCFC-141b;

(e) The ICC for integral skin foam sub-sector were calculated based on retrofits only except in the conversion from HCFC-141b to hydrocarbon-based technology where new production equipment is required.

37. Detailed calculations and breakdown for the various segments are provided in Appendix I.

[11] For example, the cost of a new storage tank could be an eligible incremental capital cost where the baseline tank is not suitable to safely handle HFC-245fa. Any need for retrofit or replacement of any existing equipment or installation of additional equipment for conversion from HCFCs to non-ODS alternatives would have to be technically justified and fully demonstrated.

Range of IOC

38. The level of IOC for conversion from HCFCs to non-ODS-based technologies would depend on the nature of the new formulations that would produce foam of a similar quality as in the baseline formulation, the relative prices of chemicals required for the manufacturing of the foam; the expected increase in foam density; potential incremental maintenance, insurance and energy usage costs when using hydrocarbon-based technologies; and the price and quantities of in-mould coating chemicals when used during production of water-blown integral skin foam.

39. The proportions of the main chemical ingredients in foam formulations (namely blowing agent, the polyol and MDI) and their prices are the key determinants of the level of incremental costs or savings. From an analysis of several Multilateral Fund projects, it was observed that small changes in material ratios and/or price differential could result in substantial incremental operating costs for one enterprise but incremental operating savings for another enterprise for the same type and amount of foam produced. Increase in foam density which translates into the cost of additional foam material also has a significant impact on IOC, representing in some cases 50 per cent or more of the total operating costs. The levels of increase in foam densities associated with different foam applications were approved at the 31st Meeting of the Executive Committee (decision 31/44) with the view to revisit the issue in future and make modifications where necessary. The increases in foam densities were based on the transition from CFC-11 to HCFC-141b and need to be revisited for the transition from HCFC-141b to other alternative technologies, especially since there are indications that for some of the alternatives increase in foam density following conversion may no longer be the case.

40. Cost ranges of IOC were calculated for the following alternative technologies: water-based systems, hydrocarbons, both pentane and cyclopentane, HFC-245fa and methyl formate. The precise levels of IOC can only be fully quantified when all the cost elements are known, including the cost of all the component chemicals (polyol, isocyanate, blowing agents), formulation ratios, foam densities. This information is available only at the time of review and evaluation of actual projects. Thus in the absence of actual projects the IOC were estimated on the basis of the following assumptions and considerations:

(a) Prices of chemicals for pentane and water-based technologies for which the Secretariat has extensive experience and a large body of information from project completion reports, prices were derived from project completion reports completed between 2000 and 2006. The information was complemented with information on prices provided by some Ozone Units through bilateral and implementing agencies;

(b) Prices of HFC-245fa and methyl formate were obtained from the relevant companies (Honeywell and Foam Supplies Inc.);

(c) Calculations were based on the relationship between HCFC-141b and the replacement chemicals based on ratios of 1:0.50 and 1:0.75 for HFC-245fa and 1:0.50 for methyl formate consistent with information obtained from the suppliers; 1:1.5 for water-based systems; 1:0.5 for pentane and cyclopentane in rigid foam; and 1:0.3 for integral skin foam similar to the method used in approved projects;

(d) Given the limited time available for the preparation of this paper, the direct association between increases in foam density from HCFC-141b to other technologies for the various rigid polyurethane insulation foam application segments could not be subject to a thorough review. Therefore, no increase in density was factored into the calculation for HFC-245fa and methyl formate. However, as stated earlier, increase in foam density may not be a factor in reality. Based on observations made upon review of calculations of the IOC of hydrocarbon-based projects a 10 per cent increase in foam density was factored into the calculations for pentane and cyclopentane-blown foams;

(e) The cost of in-mould coating chemical was included in the calculations for the integral skin foam as it is a component of the foam processing chemicals accounting for up to about 70 per cent of the total IOC;

(f) Costs associated with incremental maintenance, insurance and energy usage of hydrocarbon-based technologies were also included in the calculation for integral skin foam consistent with the practice in approved projects.

41. The IOC were calculated for enterprises with HCFC-141b consumptions of 5, 25, and 75 metric tonnes (0.55, 2.75 and 8.25 ODP tonnes) to represent the rigid foam sub-sector and enterprises with consumptions of 10 and 30 metric tonnes (1.1 and 3.3 ODP tonnes) for the integral skin foam sub-sector. Calculation per kg of HCFC-141b eliminated was also made. The calculations were checked against approved projects to ensure consistency and accuracy of the methodology.

42. The detailed calculations as well as its application to typical consumption levels as indicated above for rigid and integral skin foams can be found in Appendix 1.

Strategies for viable and sustainable HCFC conversion in the foam sector

43. In rigid and integral skin polyurethane foam production, most enterprises rely on polyols commercially premixed with the blowing agent and other essential ingredients (premixed polyols)[12] that are provided by companies known as systems houses. While enterprises with pre-mixers on site have the flexibility to vary their foam formulations to meet their customers' end-product requirements, SMEs have to rely on systems houses to meet their customers' requirements. In that regard access to a systems house becomes critical to the competitiveness and/or productivity of a foam producer and above all the sustainability of the conversion programme overall. During the first phase of CFC phase-out, systems houses played a key role in the market penetration of HCFC-141b in Article 5 countries.

44. Eleven group projects involving 290 SMEs centered around local indigenous systems houses were approved in four countries at a total cost of US $7.2 million. The direct impact of involvement of the systems houses was a phase-out of over 1,300 ODP tonnes of CFC-11. Table III.2 provides basic information on the systems houses assisted through the Multilateral Fund.

[12] Data on approved CFC-based integral skin and rigid foam projects shows that about 80 to 85 per cent relied on premixed polyol. Also, over 60 per cent of foam enterprises relying on premixed polyol were SMEs consuming between 0.2 and 20.0 ODP tonnes CFC-11 per year.

Table III.2. Systems house activities in the phase-out of CFCs

Country	Systems house	Number of enterprises	Sector/sub-sectors	Project cost (US$)	Impact (ODP tonnes)	Substitute blowing agent
Brazil	JNP	25	Rigid PU, integral skin/ flexible molded PU	636,400	80.3	HCFC-141b
Brazil	Plastquim	50	Rigid PU, integral skin/ flexible molded PU	721,500	153.4	HCFC-141b
Brazil	Polsul	14	Rigid PU	536,892	55.0	HCFC-141b
Colombia	GMP	29	Rigid PU	449,130	56.6	HCFC-141b
India	Polymermann	80	Rigid PU	1,403,921	290.0	HCFC-141b
India	Shevathene Linopack	28	Rigid PU	699,139	105.7	HCFC-141b
Mexico	Comsisa	20	Rigid PU, integral skin	424,055	68.7	HCFC-141b
Mexico	Orca	11	Integral skin shoe sole	1,321,500	190.0	Hexane
Mexico	Productos Eiffel	10	Rigid PU spray foam	345,000	100.0	Water/CO2
Mexico	Pumex	19	Rigid PU spray foam	519,750	167.7	HCFC-141b
Mexico	Valcom	5	Rigid PU spray foam	122,440	44.3	HCFC-141b
Total		291		7,179,727	1,311.7	

45. In collaboration with implementing agencies' experts, systems houses not only provided suitable foam systems to their customers but also they undertook technology transfer and training of the downstream foam enterprises as technology partners.

46. The infrastructure already put in place at some system houses should be utilized to continue to facilitate the phase-out of HCFCs, through the development, optimization and validation of formulations with non-HCFC blowing agents suited to their local markets and possibly neighboring countries where low levels of HCFC consumption would not make a systems house operation feasible. This validation should include checking processing characteristics; product performance; commercial availability; safety; environmental performance; and related incremental costs. The estimated costs of the proposed validation range from US $145,000 to US $210,000 per systems house project for non-flammable blowing agents technology and from US $200,000 to US $320,000 per systems house for flammable blowing agents technology. Once the validation process has been completed and new non-HCFC based pre-blended polyols are developed, systems houses would provide technology transfers and training for a selected number of downstream foam enterprises (i.e., no more than 10 enterprises per systems house and should include, if possible, different foam applications). Based on the experience gained in the introduction of the new non-HCFC based polyols, actual ICC and IOC for the conversion of foam enterprises could then be fully assessed. A detailed analysis of the costs can be found in Appendix II to this Annex III.

Appendix I

ICC CALCULATIONS

ICC ranges for conversion of panels, pipe in pipe foam, thermoware, domestic refrigerators (US $)

Foam application	**Alternative technology**
Panels	HFC-254a, pentane
Pipe-in-pipe	HFC-254a, water (limited applications), pentane
Thermoware	HFC-254a, water, pentane (limited application)
Domestic refrigerator	HFC-254a, pentane

Equipment item	**HFC-245fa**		**Water/CO2**		**Pentane**	
	Low	**High**	**Low**	**High**	**Low**	**High**
Production						
Replacement of low pressure with high pressure dispenser	60,000	100,000	60,000	100,000	90,000	170,000
Retrofit of high pressure dispenser	10,000	15,000	10,000	15,000	60,000	100,000
Retrofit of pre-mixing unit (where eligible)	-	10,000	-	10,000		
Replacement of pre-mixing unit	20,000	60,000	20,000	60,000	55,000	85,000
Modification of press					15,000	25,000
Hydrocarbon tank and accessories (piping and pumps, ventilation)					20,000	55,000
Buffer tank for polyol					10,000	15,000
Nitrogen supply system					10,000	40,000
Plant safety						
Ventilation and exhaust system (fans, piping, ductworks, grounding, electrical boards/connections)					15,000	85,000
Heating, ventilation and enclosure for cabinet plant (domestic refrigeration)					40,000	50,000
Heating, ventilation and enclosure for door plant (domestic refrigeration)					40,000	50,000
Gas sensors, alarm, monitoring system for entire plant					25,000	50,000
Fire protection/control system for the plant					-	10,000
Lightning protection and grounding					15,000	25,000
Antistatic floor					-	5,000
Safety audit/Safety inspection & certification					10,000	25,000
Stand-by electric generator					-	15,000
General works						
Civil work/plant modifications					20,000	25,000
Technology transfer/training	10,000	20,000	5,000	10,000	20,000	30,000
Trials and commissioning	10,000	15,000	10,000	20,000	10,000	20,000
Total						
Total retrofit	30,000	60,000	25,000	55,000	375,000	710,000
Total replacement	100,000	195,000	95,000	180,000	385,000	780,000

ICC ranges for conversion of spray foams and discontinuous block foam (US $)

Equipment item	Low	High	Low	High
	Low-output dispenser		High-output dispenser	
Production: Spray foam (*)				
Replacement of low pressure with high pressure spray foam dispenser (7 kg/min) (with standard accessories)	15,000	20,000		
Replacement of low pressure with high pressure spray foam dispenser (12-15 kg/min) (with standard accessories) (***)			25,000	40,000
Retrofit of high pressure spray foam dispenser	-	15,000	-	15,000
Replacement of pre-mixing unit (where eligible)	20,000	40,000	20,000	40,000
Retrofit of pre-mixing unit (where available)	-	10,000	-	10,000
Production: Discontinuous blocks (**)	**Dispenser option**		**Boxfoam option**	
Replacement of box foam (handmix) with large output low pressure dispenser	50,000	70,000		
Replacement of box foam with semi-automatic boxfoam unit			50,000	65,000
Retrofit of low pressure dispenser	-	15,000	-	-
Retrofit of semi-automatic boxfoam unit			-	10,000
Replacement of pre-mixing unit (where eligible)	20,000	40,000		
Retrofit of pre-mixing unit (where available)	-	10,000	-	-
General works				
Technology transfer and training	5,000	10,000	5,000	10,000
Trials and commissioning	10,000	20,000	10,000	20,000
Total				
Total retrofit spray foam	15,000	55,000	15,000	55,000
Total replacement spray foam	50,000	110,000	60,000	110,000
Total retrofit discontinuous blocks foam	15,000	55,000	5,000	40,000
Total replacement discontinuous blocks foam	85,000	140,000	65,000	95,000

* Hydrocarbon technology not included.
** Hydrocarbon technology not included as availability in this segment is uncertain.
*** For SMEs having spray foam and pour-in-place operations.

ICC ranges for integral skin foams (US $)

Equipment item	HFC-245fa		Water/CO2		Pentane	
	Low	High	Low	High	Low	High
Production						
Retrofit of dispenser for refrigerated thermal control	10,000	15,000	10,000	15,000		
Retrofit of dispenser for variable ratio control	10,000	15,000	10,000	15,000		
Penta-foam dispenser					90,000	120,000
Premixer with polyol and buffer tank					65,000	85,000
Pentane tank (500-1,000 l) with auxiliaries					25,000	35,000
In mold coating high-volume low-pressure spray system			10,000	15,000		
Mold preheating oven	5,000	10,000	5,000	10,000		
Infrared coating drying system			10,000	15,000		
In mold coating exhaust booth			10,000	15,000		
Plant safety						
Process ventilation					20,000	30,000
Electrical grounding					5,000	10,000
Pentane monitoring/alarm system					20,000	40,000
General works						
Technology transfer/training (foam)	5,000	10,000	5,000	10,000	10,000	30,000
Technology transfer, training (coating)			5,000	10,000		
Trials and commissioning	10,000	20,000	10,000	20,000	5,000	10,000
Safety audits					10,000	20,000
Miscellaneous local works					15,000	25,000
Total						
Retrofit	40,000	70,000	75,000	125,000	265,000	405,000

IOC: Rigid polyurethane foam (US $)

Chemical	**Prices US $/kg**		**Ratio (*)**	**Consumption (metric tonnes)**		
	Low	**High**		**Plant 1**	**Plant 2**	**Plant 3**
HCFC-141b	2.50	3.80	1.00	5.00	25.00	75.00
HFC-245fa(**)	10.40	12.00	0.50	2.50	12.50	37.50
HFC-245fa (**)	10.40	12.00	0.75	3.75	18.75	56.25
Methyl formate	2.20	3.20	0.50	2.50	12.50	37.50
Water-based systems	3.00	3.50	1.50	7.50	37.50	112.50
Pentane	1.90	2.50	0.50	2.50	12.50	37.50
Cyclopentane	2.10	3.30	0.50	2.50	12.50	37.50
MDI (pentane)	3.00	3.50	0.10	0.50	2.50	7.50

(*) Ratio between HCFC-141b and the alternative blowing agent
(**) The lower and higher prices represent bulk price and small package price allowing for 15% difference.

Description	**Plant capacity: 5 tonnes**		**Plant capacity: 25 tonnes**		**Plant capacity: 75 tonnes**	
Before conversion						
HCFC-141b	12,500	19,000	62,500	95,000	187,500	285,000
After conversion						
HFC-245fa (50%)	26,000	30,000	130,000	150,000	390,000	450,000
HFC-245fa (75%)	39,000	45,000	195,000	225,000	585,000	675,000
Water-based system	22,500	26,250	112,500	131,250	337,500	393,750
Methyl formate	5,500	8,000	27,500	40,000	82,500	120,000
Pentane	6,250	8,000	31,250	40,000	93,750	120,000
Cyclopentane	6,750	10,000	33,750	50,000	101,250	150,000
One year IOC						
HFC-245fa (50%)	13,500	11,000	67,500	55,000	202,500	165,000
HFC-245fa (75%)	26,500	26,000	132,500	130,000	397,500	390,000
Water-based system	10,000	7,250	50,000	36,250	150,000	108,750
Methyl formate	(7,000)	(11,000)	(35,000)	(55,000)	(105,000)	(165,000)
Pentane	(6,250)	(11,000)	(31,250)	(55,000)	(93,750)	(165,000)
Cyclopentane	(5,750)	(9,000)	(28,750)	(45,000)	(86,250)	(135,000)
Two year IOC						
HFC-245fa (50%)	23,490	19,140	117,450	95,700	352,350	287,100
HFC-245fa (75%)	46,110	45,240	230,550	226,200	691,650	678,600
Water-based system	17,400	12,615	87,000	63,075	261,000	189,225
Methyl formate	(12,180)	(19,140)	(60,900)	(95,700)	(182,700)	(287,100)
Pentane	(10,875)	(19,140)	(54,375)	(95,700)	(163,125)	(287,100)
Cyclopentane	(10,005)	(15,660)	(50,025)	(78,300)	(150,075)	(234,900)

Notes
1. For pentane projects to the IOC should be added the following costs:
   (a) Incremental maintenance of 5 per cent of net incremental investment
   (b) Incremental insurance of 0.5 per cent of net incremental investment
   (c) Extra power of 5 kW/dispenser, 10 kW for premixer, 10 kW for ventilation for 2,000 hr/year at 0.10/kW
2. The prices of HFC-245fa and methyl formate are global prices as provided by manufacturers

IOC: Integral skin foam (US $)

Chemical	Prices US $/kg		Ratio (*)	Consumption (metric tonnes)	
	Low	High		Plant 1	Plant 2
HCFC-141b	2.50	3.80	1.00	10.00	30.00
HFC-245fa(**)	10.40	12.00	0.35	3.50	10.50
HFC-245fa (**)	10.40	12.00	0.40	4.00	12.00
Methyl formate	2.20	3.20	0.30	3.00	9.00
Water-based systems	3.00	3.50	1.50	15.00	45.00
Pentane/Isopentane	1.90	2.50	0.30	3.00	9.00
In-mold coating	1.20	2.10			

(*) Ratio between HCFC-141b and the alternative blowing agent
(**) For water-based systems.

Description	Plant capacity: 10 tonnes		Plant capacity: 30 tonnes	
Before conversion				
HCFC-141b	25,000	38,000	75,000	114,000
After conversion				
HFC-245fa (50%)	36,400	42,000	109,200	126,000
HFC-245fa (75%)	41,600	48,000	124,800	144,000
Water-based system	99,000	162,750	297,000	488,250
Methyl formate	6,600	9,600	19,800	28,800
Pentane	23,089	31,434	34,489	46,434
One year IOC				
HFC-245fa (50%)	11,400	4,000	34,200	12,000
HFC-245fa (75%)	16,600	10,000	49,800	30,000
Water-based system	74,000	124,750	222,000	374,250
Methyl formate	(18,400)	(28,400)	(55,200)	(85,200)
Pentane	(1,911)	(6,566)	(40,511)	(67,566)
Two year IOC				
HFC-245fa (50%)	19,836	6,960	59,508	20,880
HFC-245fa (75%)	28,884	17,400	86,652	52,200
Water-based system	128,760	217,065	386,280	651,195
Methyl formate	(32,016)	(49,416)	(96,048)	(148,248)
Pentane	(3,326)	(11,425)	(70,490)	(117,565)

Notes;

1. For pentane conversion projects to the IOC should be added the following operating costs:
   Incremental maintenance & insurance (minimum) = 5.5% of 85% of $265,000
   Incremental maintenance & insurance (maximum) = 5.5% of 85% of $405,000
   Incremental energy @ 25kW for 2000hrs/year (US $0.1/kWh)
2. For water-based systems the cost of in-mold coating is 1.2 to 2.1 times the cost of MDI, depending on whether in-mold coating is used before and after conversion or only after conversion with water-blowing. Price of in-mold coating taken as US $10.0/kg.

Appendix II

SYSTEM HOUSES PROJECTS TO VALIDATE HCFC ALTERNATIVE FOAM SYSTEMS

Description	Low (US $)	High (US$)
I.1 Preparatory work		
Preparation cost (participants, profile, contacts, arrangements for workshops	20,000	25,000
Technology transfer*	40,000	50,000
Technical (training) workshop	30,000	50,000
Sub-total preparatory work	**90,000**	**125,000**
I.2 Items for non-flammable blowing agents technology		
Analytical equipment	10,000	15,000
Blending equipment	10,000	20,000
Trials	20,000	30,000
Sub-total non-flammable blowing agents	**40,000**	**65,000**
I.3 Items for flammable blowing agents technology		
Analytical equipment	10,000	15,000
Blending equipment	60,000	100,000
Packaging and distribution costs for pre-blended polyol	15,000	30,000
Trials	10,000	20,000
Sub-total flammable blowing agents	**95,000**	**165,000**
I.4 Summary cost for systems house		
ICC per systems house project for non-flammable blowing agents technology (I.1 + I.2) including contingency (at 10 per cent)	**145,000**	**210,000**
ICC per systems house for flammable blowing agents technology demonstration, (I.1 +I.3) including contingency (at 10 per cent)	**200,000**	**320,000**
II. Project cost for each participating enterprise		
II.1. ICC for non-flammable blowing agents		
Retrofit cost	10,000	15,000
Trials	2,000	3,000
Sub-total	12,000	18,000
Contingency (at 10 per cent)	1,200	1,800
Total ICC for non-flammable blowing agents	**13,200**	**19,800**
II.2 ICC for flammable blowing agents(**) with retrofit option for use of premixed polyol		
Retrofit of foaming machine (polyol side) (including mix head)	70,000	85,000
Trials	2,000	3,000
Subtotal	72,000	88,000
Contingency (at 10 per cent)	7,200	8,800
Total ICC for flammable blowing agents with retrofit option	**79,200**	**96,800**
II.3 ICC for flammable blowing agents(**) with equipment replacement option		
New production equipment	120,000	150,000
Trials	2,000	3,000
Subtotal	122,000	153,000
Contingency (at 10 per cent)	12,200	15,300
Total ICC for flammable blowing agents with equipment replacement option	**132,200**	**165,300**

(*) Does not include licensing fee, where such is required.
(**)Henncke-Krauss Maffei, Experiences and potentials in replacing rigid foam manufacturing equipment in Article 5 countries. Presented at the HCFC Technical Meeting, Montreal, 6 April 2008
IOC for the participating downstream enterprises will be based on relative systems costs. These will be calculated following the first stage of the project involving the systems formulations at the systems houses.

ANNEX IV

DETAILED ANALYSIS ON TECHNICAL AND COSTS ISSUES RELATED TO THE REFRIGERATION SECTOR

A. INTRODUCTION

1. Annex IV is meant to provide technical and cost considerations relevant when replacing HCFC-22 in the refrigeration and air-conditioning sector with alternatives, with support by the Multilateral Fund. HCFC-22 is by far the predominant HCFCs in the refrigeration and air-conditioning sector, with an estimated share of more than 97.2 per cent of the total HCFCs consumption (metric tonnes) in the refrigeration sector. Table 1 shows the estimated HCFCs consumption in the refrigeration and air-conditioning sector by substance.

Table 1: Estimated HCFCs consumption in the refrigeration and air-conditioning sector, by substance

Substance	Consumption (metric tonnes)	Uses	Estimated consumption in the refrigeration and A/C sector	
			(metric tonnes)	(% of total)
HCFC-22	247,200	Refrigeration and A/C, foam	217,610	97.2%
HCFC-123	3,700	Refrigeration and A/C	3,700	1.7%
HCFC-124	940	Refrigeration and A/C	940	0.4%
HCFC142b	31,230	Foam, refrigeration and A/C	1,640	0.7%

2. The Secretariat has assessed the use pattern of HCFCs in the refrigeration and air-conditioning sector. In Article 5 countries, HCFC-22 is in particular used for air conditioning and, to a somewhat smaller extent, for a wide range of applications subsumed under commercial refrigeration. There are a number of other HCFCs which feature in the refrigeration sector, in particular HCFC-123 in centrifugal chillers, and HCFC-124 and HCFC-142b in drop-in alternative refrigerants for CFC-12. Since it appears that there are no dedicated manufacturing capacities in Article 5 countries for products using these refrigerants, and since the quantities used in the servicing of refrigeration equipment are very small compared to HCFC-22, these HCFCs have not been further investigated in this paper.

3. There is insufficient consistent information available about the HCFC-22 use patterns in developing countries, in particular how much HCFC-22 consumption is associated with the different sub-sectors. Aside from issues related to the definition of sub-sectors, data which would allow an estimate is neither collected by the Fund Secretariat nor by the Ozone Secretariat, and is not available commercially or from associations. An estimate was attempted based on indicative market figures available for the trade in air-conditioning equipment in the year 2006. These figures suggest that the consumption in new air-conditioning systems might have amounted in

the year 2006 to between 80,000 and 100,000 metric tonnes of HCFC-22. The remaining consumption of about 130,000 metric tonnes might have been split approximately equally between commercial refrigeration manufacturing and service sectors.

4. This Annex will, after an introduction and a review of past experience, provide information on the different sub-sectors and some alternative technologies, before providing cost information and other considerations for the manufacturing and service sectors.

Experience

5. To date a total of 30,831.2 ODP tonnes of CFCs have been phased out from the domestic and commercial refrigeration sub-sectors through individual and umbrella projects, including 22,471.5 ODP tonnes of CFC-11 and 8,359.7 ODP tonnes of CFC-12. For some of the projects, HCFCs were used as alternatives to CFC. The refrigeration projects frequently had a component related to the insulation foam, where CFC-11 was often replaced by HCFC-141b.

6. Table 2 provides an overview of alternatives approved in Multilateral Fund conversion projects in the refrigeration manufacturing sectors, including domestic and commercial refrigeration.

Table 2: Alternative technologies in approved stand-alone Multilateral Fund refrigeration projects

Replacement	Projects	ODP tonnes phased out	%age total	ODP tonnes phased in
Refrigerant component				
Drop-in blend	5	137.0	1.6	2.52 (approx.)
HCFC-22	9	818.4	9.8	45.01
HFC-134a	439	6,188.9	74.1	0
HFC-152a	1	80.0	1.0	0
HFC-152a/HCFC-22	1	70.0	0.8	1.28 (approx.)
HFC-404A	2	0.6	0.0	0
Isobutane	22	983.3	11.8	0
Propane	1	11.5	0.1	0
R-401A	1	70.0	0.8	1.89
Total refrigerant component	481	8,359.7	100.0	50.7
Foam component				
Cyclopentane	120	14,260.9	63.5	0
HCFC-141b	336	8,210.6	36.5	903.17
Total foam component	456	22,471.5	100.0	903.17

7. In addition to projects in refrigeration manufacturing sectors, 42 conversions of CFC-12 compressor production plants to alternative refrigerants in ten Article 5 Parties have been approved by the Executive Committee. Such compressor projects were supported on one hand in cases where the compressor was the technology-defining element in the production chain leading to CFC refrigeration equipment; this is often the case if small assemblers use compressors and other components to produce, frequently on site, refrigeration equipment. On the other hand

these projects were supported when compression production was integrated with equipment production, in particular in the domestic refrigeration sector. In the particular case of China, the Executive Committee agreed on a sector approach and funded the conversion of 24 compressor manufacturing enterprises to alternative refrigerants with an associated phase-out, on the understanding that the Government of China would not seek any assistance from the Multilateral Fund for the conversion of commercial refrigeration manufacturing plants. Of the 24 compressor projects in China, 18 were converted to HCFC-22 refrigerant with an associated phase-out of 361 ODP tonnes of CFC-12 (calculated phase-in: 19.86 ODP tonnes), and three were converted to HFC-134a with an associated phase-out of 253 ODP tonnes. The alternative refrigerant selected for the remaining of these 42 compressors projects were HFC-134a (18 projects), isobutane (two projects) and HCFC-22 (one project).

8. The total funding approved for stand alone training programmes for refrigeration service technicians and customs officers, recovery and recycling projects and RMPs in all Article 5 countries amounts to US $52.7 million (i.e., US $29.6 million for LVC countries and US $23.1 million for non-LVC countries). An additional US $235.0 million is associated with TPMPs for LVC countries and national/sectoral phase-out plans for non-LVC countries addressing the total remaining consumption of CFCs, mainly used in the refrigeration servicing sector[1] .

B. TECHNOLOGY

<u>Characteristics of the Air-conditioning sub-sectors</u>

General

9. Air-cooled air conditioners ranging in capacity from 2.0 to 700 kW are used in residential and commercial applications for cooling or heating (if combined with air-conditioning heat pumps), representing probably the largest sub-sector of HCFC-22 consumption in Article 5 countries. For the purpose of this document the sub-sector is further split between unitary equipment and chillers.

Unitary equipment

10. The majority of both the existing installed capacity and new production is of the unitary equipment type. Unitary air-conditioning equipment is a broad category of air-to-air air-conditioning systems, including:

(a) Room air conditioners (window-mounted, through-the-wall and mobile units). A unit has a capacity between 2 kW and 10.5 kW and contains between 0.5 and 2 kg of HCFC-22, with an average of 0.75 kg. These units are manufactured and charged typically in large plants with quality control and leak tests, leading to low leakage rates in the order of 2.0 to 3.0 per cent of the initial charge per year;

[1] Several national phase-out plans and a few TPMPs address small amounts of CFCs used in small foam and refrigeration manufacturing enterprises or small amounts of other ODSs, mainly CTC and/or TCA.

(b) Ductless split systems, both mini-splits for one room and larger systems, have usually multiple indoor evaporator/fan units connected to a single outdoor unit, 4 kW refrigerating capacity and above. These air conditioners have average HCFC-22 charge about 1.2 kg per system. These systems are normally produced in large manufacturing plants as well, with the associated quality control and leak tests. However, the systems are installed on-site using pre-charged lines and connectors, which lead to a higher average leak rate for these systems;

(c) Residential split ducted central air-conditioning systems and heat pumps consist of a condensing unit (compressor/heat exchanger) installed outside of conditioned space, that supplies refrigerant to one or more indoor heat exchangers installed within the building’s air duct system. The refrigerating capacity of such systems is generally between 5 kW and 18 kW containing on average about 3.25 kg of HCFC-22 per system; and

(d) Packaged air-to-air systems and split systems for commercial air-conditioning, ranging in refrigerating capacity from 10 kW to more than 350 kW. Commercial rooftop air conditioners fall into this category. The average HCFC-22 charge is about 10.8 kg per system.

11. Representative leakage rates for the last three categories of split systems are in the literature mentioned to be 4-5 per cent of the nominal charge per year, although anecdotal evidence suggests emissions as high as 15 per cent of the annual charge. The higher leak rates are related to the limitations of installation into existing buildings, including a higher number of connections.

Chillers

12. Chillers are compact refrigeration systems designed to cool down water or a brine for the purpose of air-conditioning or, less often, process cooling for manufacturing of goods or chemicals. The cool water or brine is distributed to the cooling equipment, in case of air-conditioning to heat exchangers distributed throughout a building. The refrigerating capacity ranges from 7 kW for water cooled chillers equipped with reciprocating and scroll compressors to chillers of about 700 kW and above, which are usually built as centrifugal chillers. Centrifugal chillers, which use a turbo-compressor and have been only rarely built using HCFC-22 as refrigerant, are not considered in this document. HCFC-22 has been used for manufacturing virtually all non-centrifugal chillers with screw, scroll and reciprocating compressors. While chillers based on R134a, HFC-407C and R 410A have started penetrating the market in non-Article 5 countries, users in Article 5 countries continue to be supplied with HCFC-22 chillers. Since chillers are often manufactured and quality controlled in large plants, and since their operating conditions tend to be very favourable, chillers can last for several decades before being in need to be replaced. While the HCFC-22 needs for service and repair are normally small per system, the large number of chillers and their long lifetime prolongs the dependence of countries on HCFC-22.

Characteristics of the commercial refrigeration sub-sector

13. Commercial refrigeration systems are a broad category of refrigeration systems. The sub-sector covers refrigerated equipment found in retail food sector such as supermarkets, convenience stores, restaurants, and other food service establishments. In the context of the Multilateral Fund, every commercial use of refrigeration systems which did not belong to another sub-sector (industrial, chiller, air-conditioning, transport, domestic) was subsumed under commercial refrigeration. Commercial refrigeration systems in Article 5 countries are often locally or regionally made products, catering to the specific need of one or a small group of users. In other cases, products like water fountains, chest or bottle coolers might be produced in medium, sometimes even large quantities as commercial refrigeration products. Commercial refrigeration equipment can be sub-divided into the following broad categories: stand-alone equipment, condensing units and centralized refrigeration systems.

14. The category of stand-alone equipment consists of serial products where all the components are integrated, produced and typically charged in manufacturing facilities and plants. It includes, e.g., commercial-sized refrigerators and freezers, water coolers, chest coolers, ice cream freezers, ice making machines, display cabinets, and hotel mini bars. Currently, HCFC-22 is still widely used as the refrigerant in manufacturing of stand-alone equipment in Article 5 countries. Along with R 134a and HFC-404A, in recent years, hydrocarbons (isobutane and propane) have been introduced to the market for stand-alone units up to 1 kW capacity. The small filling and the opportunity to undertake leak testing and quality control at the manufacturers premises leads to typically reasonable or better quality of production and only relatively small leakage.

15. CFC-12 had been the most important refrigerant in stand-alone equipment in Article 5 countries. The conversion of manufacturing of stand-alone equipment in those countries to non-CFC technology has been addressed through approval of more that 260 investment projects and activities by the Executive Committee. The Secretariat has used its experience gained in reviewing the above projects in assessments of possible incremental costs related to the manufacturing of HCFC-22 – based equipment.

16. Condensing units are the main component of split refrigeration systems. Such a unit, comprising a compressor, a condenser, and a receiver holding the refrigerant in the liquid phase, is typically being pre-manufactured in medium to large quantities, but not charged. On site, such a unit is located typically in a way that the condenser can be cooled by outside air, and is connected via refrigerant-containing tubing to the cooling equipment. This may include one or several display cabinets and walk-in cold rooms or other refrigeration uses. Several condensing units can be installed side-by-side in a machinery room to cool different equipment, reaching up to 50 kW refrigeration capacity. The use of several condensing units is less energy efficient than the installation of one specifically designed centralized system, while the installation of centralized systems requires compressors of larger capacity, and more design and engineering know-how.

17. The use of condensing units is a preferred solution for many end-users in Article 5 countries because these systems are technically simple and easy to install and maintain, locally available and attractive in terms of low initial investments. HCFC-22 remains the

refrigerant of choice in manufacturing condensing units in Article 5 countries. Condensing units are suitable for HFC refrigerants, while the use of hydrocarbons is problematic because of the distance between condensing unit and equipment, which increases refrigerant filling and requires certain site-specific safety considerations.

18. Centralized refrigeration systems are similar to condensing units, only that one unit with normally several compressors serves a large number of parallel sets of cooling equipment, often on several different temperature levels. Such systems are used in particular in medium and larger super markets, to lower energy consumption and increase redundancy. In a configuration similar to the one used for HCFC-22, they are suitable for HFC refrigerants, and the use of CO_2 is under development for moderate climatic conditions. In comparison to condensing units, centralized refrigeration systems have challenging leak testing and large refrigerant filling. These make centralized refrigeration systems in their standard configuration no suitable candidate for hydrocarbon use.

19. There are alternative configurations for centralized systems which allow using refrigerants such as hydrocarbons or ammonia. One can for example use for refrigerating applications (at around 4°C) a cold brine, which reduces the amount of refrigerant and contains it in the machine room, greatly simplifying leakage and safety issues and allowing use of hydrocarbons or ammonia, but on the expense of higher investment cost, increased complexity, and an increase in energy consumption of 5 per cent to 10 per cent. It should be noted that anecdotal evidence suggests that in several industrialized countries, the overall greenhouse emissions of such a system using e.g. a hydrocarbon would still be lower than that of a standard configuration HFC-404A system, which is the commonly used non-HCFCs refrigerant for centralized systems in non-Article 5 countries. For deep-freezing applications (i.e. for keeping goods at -18°C) it is possible to use CO_2 in a cascade system, where another refrigerant provides cooling at around 4°C, and a CO_2 cycle is used in a cascade system in conjunction with another refrigerant to supply deep-freezing temperatures. The necessary know how for these systems is complex. A number of systems are running in Europe. It appears doubtful if the necessary know how and infrastructure will be available in Article 5 countries in time for any significant contribution of these technologies to the 2013 and 2015 compliance requirements.

Characteristics of other sectors

20. Decision 31/45 defined the sub-sector for assembly, installation and charging of the refrigeration equipment. This sub-sector covers activities related to installation of condensing units and centralised systems as well as the predominant part of the industrial and transport refrigeration sectors, and establishes eligibility exclusively for capital incremental costs. The guidelines contain an element relating to a cut-off date of July 1995, and might therefore be in need of endorsement should a separate cut-off date be established.

21. Since there are no indications for significant use of HCFC-22 in the industrial and transport refrigeration sectors, this document does not introduce the related sectors further.

Alternative refrigerants to HCFC-22 and suitability considerations

Introduction

22. HCFC-22 has been used since the 1930s as a refrigerant, predominantly for air-conditioning systems. It remains in this sector by far the predominantly used technology world wide until to date. When the consumption of CFC, in particular CFC-12 was reduced and subsequently phased out under the Montreal Protocol, HCFC-22 was one of several possible replacement technologies.

23. This document considers a number of alternatives for the replacements of HCFC-22, namely several HFC, ammonia, carbon dioxide and hydrocarbons. The list has been assembled using the criteria of commercial and widespread use or large scale prototype use in the field in sub-sectors with a significant use of HCFC-22 as refrigerant. Further, the criteria for technical suitability specified in the next paragraph had to be fulfilled. A number of technically possible alternatives have therefore not been included in this document because they did not fulfil these criteria. It should also be noted that these assessments, despite representing best efforts and based on broad exchange with experts, still are the result of a subjective judgement; that is similarly true for the selection of whether a refrigerant is suitable for a given application or not. The Secretariat is prepared to extend the lists of alternatives or reassess the applicability if requested by the Executive Committee.

24. To establish the technical suitability of the different alternatives, the following aspects were taken into account:

(a) Likely availability of the refrigerant in the mid- and long term;

(b) Suitability for the temperatures for air-conditioning, refrigerating (around 4°C) and deep-freezing (-18 °C) of food;

(c) Available experience with the use of the refrigerants in actual applications;

(d) Influence of the technology onto equipment cost;

(e) Necessary requirements towards manufacturers and service companies;

(f) Safety related aspects;

(g) Energy consumption;

(h) Environmental aspects;

(i) Capability to be used at high ambient temperatures; and

(j) Status of development and current availability of technology making the refrigerant a candidate to contribute to achieving compliance with the 2013 and 2015 HCFCs consumption reduction requirements.

25. Table 3 provides an overview of some important characteristics related to HCFC-22 and its replacements.

Table 3: Properties of zero-ODP refrigerants and HCFC-22

Refrigerant	Type and/or name	GWP (100a)[2]	Safety classification[3]	Temperature-glide [K]	Condensing temperature at 26 bar [°C][4]
HCFC-22	*HCFCs*	*1810*	*A 1*	*0*	*63*
HFC-134a	HFC	1430	A 1	0	80
HC-290	Propane (HC)	20	A 3	0	70
HFC-404A	HFC-blend	3900	A 1	0,7	55
HFC-407C	HFC-blend	1800	A 1	7,4	58
HFC-410	HFC-blend	2100	A 1	0	43
R-417A	HFC-HC blend (Drop-in)	2300	A 1	5,6	68
R-422A	HFC-HC blend (Drop-in)	3100	A 1	2,5	56
R-422D	HFC-HC blend (Drop-in)	2700	A 1	4,5	62
HFC-507A	HFC-blend	4000	A 1	0	54
HC-600a	Isobutane (HC)	20	A 3	0	114
R-717	Ammonia	0	B 2	0	60
R-744	CO_2	1	A 1	0	-11
HC-1270	Propylene (HC)	20	A 3	0	61

Alternative refrigerants

26. For refrigeration and air-conditioning, presently the most widely used HFC options for HCFC-22 replacement in new equipment are HFC-134a, HFC-404A, HFC-407C, and HFC-410A. All these HFC and HFC blends are non-toxic, non-flammable and require the use of different compressor lubricants as compared to HCFC-22 to ensure satisfactory operation and durability; typically, these are synthetic polyolester-based (POE) oils. These lubricants have a higher cost than those used for HCFC-22, and need more careful handling to avoid contamination. The related issues (training and equipment needs) are known from the introduction of HFC-134a into the market as part of the CFC-12 phase-out efforts. Due to incompatibility with the oils used for HCFC-22, the need for a new lubricant also implies that

[2] According to the 2006 Report of the Refrigeration, Air-conditioning and Heat Pumps Technical Options Committee

[3] Toxicity:
Class A: refrigerants for which toxicity has not been identified at concentrations less than or equal to 400 ppm; Class B: refrigerants for which there is evidence of toxicity at concentrations below 400 ppm.
Flammability: Class 1: no flame propagation; Class 2: lower flammability limit of more than 0.10 kg/m3 and heat of combustion of less than 19 kJ/kg; Class 3: lower flammability limit of less than or equal to 0.10 kg/m3 or a heat of combustion greater than or equal to 19 kJ/kg

[4] Common upper working pressure for refrigeration equipment

these refrigerants cannot be used as drop-ins for existing equipment, but would require a complex retrofit procedure in order to be used in existing equipment. In comparison to HCFC-22, the HFC and HFC blends mentioned have the following characteristics:

27. HFC-134a is globally available, and can be used for refrigerating at around 4°C in commercial refrigeration, in small units (up to 2 kW to 4 kW capacity) for commercial refrigeration / deep-freezing and for smaller room air conditioners, as well as where previously CFC-12 has been used and where HCFC-22 has been only an interim solution. There is considerable practical experience in its application in Article 5 countries. In comparison to HFC blends and propane / propylene, HFC-134a requires larger compressors and larger tubing. The energy consumption is similar to HCFC-22 equipment, while the direct greenhouse gas emissions are expected to be lower due to lower GWP, lower pressures and lower risk of pressure oscillations in the tubing[5]. HFC-134a is suitable for very high ambient temperatures.

28. HFC-404A and HFC-R507A are very similar and can therefore be assessed jointly. Both refrigerants have been used in non-Article 5 supermarkets for a number of years and are well suited for refrigerating and deep-freezing applications, in particular in condensing units and centralized commercial plants. While the medium term availability is certain because of the needs of the installed equipment base and the continuous use of these refrigerants, the long term availability depends strongly on the policies regarding industrial greenhouse gas emissions since both substances have a particularly high GWP. The costs of assembly of centralized commercial plants using R404A/R507A are similar to HCFC-22, while the costs for refrigerant and refrigeration oil are higher. In order to use these refrigerants in on-site installations, experience to reduce pressure oscillations in high pressure tubing are meaningful. The energy consumption is slightly higher than with HCFC-22 equipment for refrigerating, slightly lower for deep-freezing. The high GWP leads to a higher emission of greenhouse gases as compared to HCFC-22. In case of very high ambient temperatures the equipment might have to be built for higher than standard working pressures.

29. HFC-407C is a refrigerant with a significant temperature glide and is therefore not suitable for equipment with a large refrigerant filling or accumulators, such as condensing units, centralized systems and certain chillers; in other applications, the temperature glide still needs to be taken into consideration in design and service. It is widely used in Europe as HCFC-22 replacement in air-conditioning equipment, and will therefore likely be available in the medium to long term. The costs of manufacturing HFC-407C equipment are very similar to the costs for HCFC-22 equipment except for the higher costs for refrigerant and refrigeration oil. In case of very high ambient temperatures the equipment might have to be built for higher than standard working pressures. The GWPs of HCFC-22 and HFC-407C are similar, therefore the overall emissions of greenhouse gases attributed to the equipment should remain similar.

[5] Pressure oscillations on the high pressure side of refrigeration equipment depend on the outdoor temperature and can lead to vibrations, resulting potentially in material fatigue of the tubing and subsequent ruptures. These might take place after a relatively short operating time of some days, and would lead to the emission of the full refrigerant charge. As compared to HCFC-22, the risk increases with HFC-404A and HFC-507A, and increases further with HFC-410A. A trial and error approach to avoid these risks can be used for equipment produced in a series. For on-site installations, experience, training and marksmanship of the technician are the factors reducing the risk of such ruptures.

30. HFC-410A is a commercially available refrigerant blend used in newly designed air-conditioning equipment, which has been commercially available within the capacity range of 2 kW to 175 kW from major manufacturers for a number of years. It seems likely that this refrigerant will be available in the medium to long term. The high refrigerating capacity permits often small, more compact components to be used. A typical hermitic or semi-hermetic compressor designed for HCFC-22 cannot be used with HFC-410A, which might also be true for some other components in the system. The costs information provided for HFC-410A systems suggests a cost increase for the components, which might also include costs for design upgrades independent of the refrigerant. While the higher operating pressure can be addressed in the design of new systems, this refrigerant is inappropriate for retrofit of existing HCFC-22 systems. Units using HFC-410A have demonstrated higher energy efficiency than HCFC-22 units; it should be noted that this might include the effort of optimisation of components and upgrading of technology as part of the development of newly designed systems. HFC-410A is not universally accepted for use in high ambient temperatures due to its elevated pressures and relatively low critical point, which might lead to lower energy efficiency at such temperatures as compared to e.g. HFC-134a or HC-290.

31. HFC-417A, HFC-422A and HFC- 422D are relatively recent developments based on HFC mixtures with some isobutane, allowing drop-in conversion of existing HCFC-22 refrigeration equipment, using the same refrigeration oil. They are unlikely to find widespread use for new refrigeration equipment due to certain compromises regarding their overall properties and performance. These HFC refrigerants have a temperature glide and are therefore not suitable for equipment with large refrigerant filling or accumulators, such as condensing units, centralized systems and certain chillers. HFC-422A can be used for refrigerating and deep-freezing, HFC-417A and HFC-422D for refrigerating. The practical experiences with all three refrigerants are so far very limited. Experience of service technicians with refrigerants with temperature glide is necessary. In case of very high ambient temperatures the equipment might have to be built for higher than standard working pressures; the GWPs of all three refrigerants is higher than that of HCFC-22. It should be noted that despite wide encouragement, drop-in replacements for CFC-12 have established themselves only in very few markets in Article 5 countries, therefore the situation with drop-in replacements for HCFC-22 might well be similar. Consequently, the short-term availability for specific markets is not known, and the availability of these fluids beyond the mid-term remains unlikely due to their transitory nature.

32. Ammonia, NH3 (R717) has been used for more than 100 years as refrigerant, and is common in many countries in large industrial and food processing applications. It is toxic, but usually easily avoidable because of its stench well below the toxicity level. Due to their capacity and specific characteristics, these applications fall under the sub-sector “industrial refrigeration”, not commercial refrigeration. Since industrial refrigeration has not systematically used HCFC-22 as refrigerant, it is not further assessed as part of this paper, although it should be noted that the use in industrial refrigeration ensures the refrigerants long-term availability. Ammonia as refrigerant is suitable for refrigerating, less well for deep-freezing. It can be used in large centralized commercial refrigeration plants and in large chillers; the refrigerant is less well suited for deep-freezing temperatures. The installation costs of ammonia plants are significantly higher than for HCFCs or HFC plants, since parts, assembly and the necessary brine cycles and require different and more complex manufacturing skills, in particular welding. According to experts,

there is some possibility that ammonia could extend from the industrial refrigeration sector into chillers or the commercial refrigeration sector, but only if the technology has already a strong technician base in the country. Despite the good energetic performance characteristics for most except very hot climates, the need to use brines increases energy consumption as compare do HCFC-22 direct cooling applications. Since ammonia has a GWP of 0, the overall greenhouse gas emissions are usually more favourable than with HCFC-22.

33. HC-290 (Propane), HC-1270 (propene) and HC-600a (isobutane) are hydrocarbons and have in several aspects similar characteristics. Isobutane is suitable for small stand-alone refrigerating units, HC-290 and HC-1270 both for refrigerating as well as for deep-freezing applications in stand alone units up to about 1 kW refrigeration capacity and in centralized supermarket systems using brines. While as such very good refrigerants, the flammability of these substances is a problem which requires additional efforts in design, manufacturing and service of the equipment. The flammability leads to a tendency to use hydrocarbons only in small or equipment with relatively small refrigerant filling, or in systems where a brine is being used. While for the production of stand-alone equipment the safety requires only limited efforts and therefore the associated costs are also limited, centralized equipment leads to substantially higher investment costs for the brine cycle and the safety equipment, and requires a high degree of experience with flammable substances. The energy consumption for stand-alone units tends to be similar or lower than with HCFC-22, while for the centralized systems the brine cycle leads to increased energy demand as compared to HCFC-22. The overall climate impact is likely to be lower than with HCFC-22 equipment, in case of stand-alone equipment significantly lower. HC-290 is also well suited for high ambient temperatures.

34. Carbon dioxide, CO_2, as refrigerant has been used in a limited number of centralised commercial systems, also in food processing, and on a medium scale in light commercial applications (vending machines) and for hot water heat pumps. It is suitable both for refrigerating and deep freezing applications. For deep freezing the refrigerant can be used in a cascade system, limiting the working pressures of the equipment. Should the condenser of CO_2 equipment be cooled with ambient air, then working pressures will be above 75 bar and different components will be needed. For outdoor temperatures above approximately 20°C for larger, centralised systems and above 32°C for smaller systems, the energetic performance of CO_2 equipment is lower than HCFC-22 equipment. Its performance tends to decrease more rapidly with increasing temperatures, which can lead in warmer climates to significantly higher annual energy consumption as compared to HCFC-22. From preliminary assessments it appears that the overall climate impact of CO2 refrigeration systems in warm climates might be significantly worse than that of HCFC-22 systems. The optimisation of this new technology and the measurements regarding its energy efficiency are still ongoing, therefore a final assessment of its climate impact in warm climates can not be made at this point in time. Since the working principle differs significantly from that of other refrigerants, and because of the very high working pressures about six times above those for HCFC-22, manufacturing and service has to undergo major changes in equipment, practices and know-how in order to use this technology. A component supply base does not currently exist for manufacturing CO_2-based air-conditioning systems, and therefore the costs for CO_2 equipment other than cascade systems for centralised commercial-refrigeration systems is presently significantly higher than for HFC or HCFCs systems; this is expected to change should there be market acceptance, subsequently leading to

high quantities of standardized components. Cascade systems might have similar costs as HCFC-22 systems.

35. Due to the low performance in warm climates for air cooled systems, the limited applicability for centralized cascade systems in Article 5 countries, and the only slowly emerging market for components, CO_2 as a replacement for HCFC-22 has been seen as unlikely to contribute to reaching the 2013 and 2015 compliance requirements and has therefore not been considered in the costing part of the document.

Suitability overview

36. It appears that at least for the initial stage of HCFCs phase-out, the above presented alternatives will represent all of the potential choices. Developments are reported for some low GWP refrigerants with no flammability and low toxicity, but presently it remains unclear when these will be available and if they will actually eventually be commercialised. CO_2 is under development as an alternative refrigerant for the last 20 years, and is presently used in demonstration trials. It remains unclear if and under which circumstances it will be used on a larger scale, since it has fundamentally different design, component and, in particular, service characteristics than other refrigerants. The analysis of the above factors will lead to the selection of the appropriate technology by the different manufacturers in Article 5 countries. Table 4 shows an indication for the suitability of alternative refrigerants for widespread use in new equipment in Article 5 countries; the use of the transitory drop-in refrigerants HFC-417A, HFC-422A and HFC- 422D has not been considered since they are meant to be used in existing, not new equipment. The typical applications for HC-1270 and HC-600a do presently not appear to be manufactured on a significant scale in Article 5 countries; therefore they are not further shown in Table 4.

Table 4: Suitability of alternative refrigerants for widespread use in new equipment in Article 5 countries

	Suitability of alternative refrigerants for widespread use in new equipment (indicative only)*						
	HFC-134a	HFC-404A / 507A	HFC-407C	HFC-410A	HC-290	R-717 Ammonia	CO_2
Commercial							
Commercial stand-alone	+	+	o	o	+	-	o/-
Commercial condensing	+	+	+/o	o	-	-	-
Commercial centralized systems	+	+	o	o		o/-	-
Commercial deep freezing - one stage	-	+	-	o	-	-	-
Commercial deep freezing - two stage/supermarket	-	+	-	o	-	-	o
Air-conditioning							
Room A/C	o	-	+	+	+	-	-
Ductless split systems	o	-	+	+	o/-	-	-
Residential split ducted central air-conditioning systems	o	-	+	+	o/-	-	-
Packaged air-to-air systems and split systems for commercial air-conditioning	-	-	+	+	-	-	-
Small chiller (scroll)	-	-	+	+	o/-	-	-
Large chiller (screw)	+	-	+/o	+	-	+	-

*The symbols denote that, according to this preliminary assessment, the different technologies are: +: from a technical perspective suitable or even preferable to be employed widely; o: from a technical perspective not well suited, but can be employed if certain disadvantages are accepted; -: Hardly possible to employ, or can be employed only with significant economic, technical or use limitations

37. It should be noted that systems using a secondary fluid have relatively poor performance at low (deep freezing) temperatures. This lead to a lower assessment for a number of systems with HC-290 and R-717 (ammonia) for supermarkets.

C. GENERAL ISSUES RELATING TO INCREMENTAL COST IN THE REFRIGERATION SECTOR

38. The Multilateral Fund has assisted many domestic refrigerator and freezer companies and a number of commercial refrigeration companies in Article 5 countries in converting their manufacturing process to HFC-134a and hydrocarbon refrigerants within the stand-alone projects. The experience gained in the review of such projects formed the basis for the following first assessment of the incremental costs associated with the phase-out of the use of HCFC-22 in the manufacturing of refrigeration and air-conditioning equipment.

39. This assessment had to be developed based on a limited set of information. The incremental capital costs for an individual project are typically influenced by:

(a) The existing equipment in a manufacturing facility; or alternatively

(b) What could be expected as a minimum to be existing;

(c) The need of upgrade or replacement of or amendment to this equipment; and

(d) The cost of the associated activities, in particular the costs for hardware.

40. At the present point in time, information is not accessible about typical levels for the first three factors. In order to overcome this shortcoming, the Secretariat decided to define model enterprises, meant to represent what might turn out to be typical conversion cases for the different sub-sectors, or what might demonstrate the level and spread of costs for conversions. Consequently, the calculation of incremental costs in the refrigeration manufacturing sector in Article 5 countries has been undertaken on the basis of model enterprises in the sub-sectors air-conditioning, chiller and the commercial sector. Each of these activities, sectors and sub-sectors had to be considered individually to make it possible to apply existing Executive Committee policies for better presentation of associated incremental costs.

41. This first attempt to calculate incremental costs has focused on what was perceived to be likely refrigerant choices while at the same time representing cost issues which could be, if needed, relatively easily be transferred to several other refrigerants. The refrigerants choices assumed when calculating incremental cost were HFC-410A, HFC-407C and HC-290 (propane) refrigerants.

42. A higher significance than expected is associated with the incremental operating costs, which are paid based on the incremental, eligible cost difference in the operating cost of the manufacturing plant and are therefore proportional to the duration for which they are being paid. The Executive Committee defined different durations for the incremental operating costs for different sectors and sub-sectors. These ranged from zero months to 48 months; guidelines assigned duration to the commercial sector of 24 months, but the decision specified that guidelines would not be valid for HCFCs phase-out projects. For the air-conditioning and chiller sub-sectors, durations were never determined. Therefore, for the refrigeration and air-conditioning sector all incremental operating costs calculations have been carried out on the basis of one year, i.e. as incremental operating costs per annum, of to allow easy conversion to any duration of incremental operating costs that the Executive Committee might consider. The Secretariat would like to explicitly point out that this is the exclusive reason to show this specific duration, and that there is no reason to prefer this duration to any other duration the Executive Committee might wish to consider.

43. It should be noted that for the refrigeration and air-conditioning sub-sectors, the estimation of incremental operating costs at the present time associated with very high uncertainties is highly problematic. While in this paper significant efforts have been undertaken to arrive at realistic estimates, e.g. by using historical data, the error margin in the estimates of incremental operating costs for this Annex remains significant, and the values should only be

looked at as indicative. Better data will only be available once the Secretariat can actually fully assess cost data, e.g. during the review of a project proposal.

44. It should be noted that for the use of several alternative technologies, calculation of incremental operating costs for components (compressor, heat exchangers, etc.) in the context of this paper cannot sufficiently take into account the issue of energy efficiency. For example, for the new technology of HFC-410A, the technological gap between previous (HCFC-22) designs and the newly developed (HFC-410A) technology is considerably larger than in the case of CFC-12 to HFC-134a. In order to achieve comparable energy efficiency, or to increase energy efficiency, the balance between the characteristics of the various components need to be established anew, and changes in several components might be necessary. For the purpose of this paper, cost-effective solutions with an assumed likeliness of achieving similar energy efficiency have been used, based on discussions with experts. However, this presents a considerable uncertainty because of two reasons:

(a) The actual costs experienced and reported in publicly accessible documentation combine costs related to the conversion with the cost for technological upgrades. It is difficult to separate out the different cost elements, in particular because the cost know-how forms an important part of the intellectual property of an enterprise; and

(b) Paragraph 11 (b) of decision XIX/6 of the Meeting of the Parties requested the Executive Committee, when developing and applying funding criteria for projects and programmes, to give priority to cost-effective projects and programmes which focus on, *inter alia*, substitutes and alternatives that minimize other impacts on the environment, including on the climate, taking into account global-warming potential, energy use and other relevant factors. As pointed out above, conversions which did take place in Article 5 countries for export to non-Article 5 countries have achieved gains in energy efficiency on the expense of higher operating costs. It remains so far unknown whether and how the Executive Committee will deal with the issue of incremental operating costs if those are related to, *inter alia*, energy efficiency improvements.

45. The incremental cost of compressor is an important component of overall production cost. The Executive Committee dedicated a great deal of attention to the issue of incremental cost for compressors while dealing with CFC phase-out in the refrigeration sector. The existing policy allows an Article 5 country to claim either incremental operating costs of the compressor or the cost of conversion of its compressor manufacturing facilities, or both on a proportional basis. The Article 5 country has to make a decision regarding its approach and inform the Executive Committee. Currently, several Article 5 countries have compressor production facilities for air-conditioning equipment. Related compressor manufacturing conversion costs are not assessed in this paper.

Incremental cost in manufacturing room and mini-split air-conditioning units

46. As an example, a hypothetical conversion of a production line manufacturing 250,000 units per year of room/mini-split air-conditioners of 4 kW cooling capacity has been

considered for calculation of incremental capital costs and incremental operating costs, assuming a conversion to HFC-410A, R-407C and R-290 (propane) refrigerants. It is assumed that production is set up for three shifts, 250 working days in a year. All the costs are estimates made on certain assumptions and judgments on the basis of experience from conversion from CFC-12 to HFC-134a in the domestic refrigeration sector.

Conversion to HFC-410A refrigerant technology

47. Incremental capital costs associated with the replacement and/or adaptation (retrofit) of production equipment will not vary significantly in production of room and split ductless air-conditioning units. Therefore, these two categories of product are considered as one case study. Incremental capital costs are related to the cost of model redesign, investment in new refrigerant and leak detecting equipment, retooling of the production line, including adaptation of the evacuation system, technology transfer, training, commissioning and engineering. Incremental capital costs are calculated in the range of US $275,000 (Scenario 1) to US $950,000 (Scenario 2) depending on the availability of the new design, the baseline and set-up of the production line.

48. Incremental operating costs (IOC), however, are closely related to the capacity of the air-conditioning units increasing with higher capacity due to the increased size and cost of the compressor, amount of the refrigerant charge and additional material used. Incremental operating costs will need to be adjusted to reflect particular characteristics of the manufactured product. Incremental operating costs in the manufacturing of ducted commercial and packaged air conditioners may be significantly different from residential air conditioners. The border line between residential and commercial applications is established by ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers) at 19 kW of cooling capacity. These units are being typically installed by contractors, including the charging of the system after the ducting and piping was completed according to the customer requirements. While the manufacturer therefore does not incur incremental costs associated with higher priced refrigerant, there is incremental cost associated to the higher price of compressors.

49. Incremental operating cost is calculated on the basis of the following assumptions:

(a) The average charge in the room air-conditioner is 1.35 kg of HCFC-22 similar to the charge used in the HCFCs Study for China;

(b) The baseline cooling capacity is 4 kW;

(c) The price of HCFC-22 is US $1.4/kg (HCFCs Study for China);

(d) The charge of HFC-410A will be 10 per cent less than the baseline (1.21 kg);

(e) The price of HFC-410A is US $13.8/kg (HCFCs Study for China);

(f) Savings in the cost of material due to reduction in size of heat exchanger are estimated and included;

(g) Incremental cost of compressor is estimated at US $5.00 on the basis of consultations with industry experts (Scenario 1). The incremental cost of compressor in the HCFCs Study for China is calculated as a surplus of US $27.62 in the price of HFC-410A/HFC-407C compressor over the average price of HCFC-22-based compressor (Scenario 2); and

(h) Estimated savings due to size reduction of heat exchangers by 3 square feet, resulting in savings of US $10.00.

50. The energy efficiency ratio (EER) of HFC-410A-based unit exceeds the EER of a HCFC-22 unit by about 5 per cent (an average conservative estimate). There is a potential for further improvements in the system efficiency and costs through use of smaller diameter tubes, use of micro-channel technology, additional compressor optimization and reducing of charge. Energy savings have not been calculated as part of incremental operating costs.

51. Incremental operating costs for duration of 12 months will range from US $2,660,000 (Scenario 1) to US $8,320,000 (Scenario 2). The following table shows the results of calculations of incremental costs:

Table 5: Incremental cost of conversion of the production line of 250,000 unit per year to HFC-410A refrigerant (estimate)

Category of incremental cost (US $)	Scenario 1	Scenario 2
Incremental capital cost	275,000	950,000
Incremental operating cost/year	2,660,000	8,320,000

Conversion to HFC-407C refrigerant technology

52. Since the working pressure of HFC-407C is very close to HCFC-22 refrigerant, only minor changes are expected in the design of the product and the manufacturing process. Incremental capital costs associated with the replacement and/or adaptation (retrofit) of production equipment will not vary significantly in production of room and split ductless air-conditioning units. The incremental capital costs for conversion of a production line of 250,000 unit/year capacity to HFC-407 blend have been calculated to be within the range of US $190,000 to US $250,000, depending on the local availability of testing facilities at the enterprise. For comparison, the incremental cost of conversion (rebuilding) of the production line of 500,000 unit/yr capacity to HFC-410A/HFC-407C refrigerants is estimated to be US $104,000 in the HCFCs Study for China, excluding costs of model redesign.

53. Incremental operating costs for the category of room and split ductless air-conditioning products is calculated on the following assumptions:

(a) The average charge in the room air-conditioner is 1.35 kg of HCFC-22 similar to the charge used in the HCFCs Study for China;

(b) The baseline cooling capacity is 4 kW;

(c) The price of HCFC-22 is US $1.4/kg (HCFCs Study for China);

(d) The charge of HFC-407C will be 5 per cent less than the baseline (1.28 kg);

(e) The price of HFC-407C is US $10.77/kg (HCFCs Study for China); and

(f) The incremental cost for HFC-407C compressor of US $5.0/unit has been used in the incremental operating costs calculations as an indicative only. HCFCs Study for China indicates to a significantly higher surplus of R407C compressor over HCFC-22 compressor. This scenario has not been considered. The existing price difference for HCFC-22 and HFC-407C compressors needs further investigation.

54. The annual incremental operating costs will be US $4,250,000. Table 6 shows calculations of incremental costs:

Table 6: Incremental cost of conversion of the production line of 250,000 units per year to HFC-407C refrigerant (estimate)

Category of incremental cost (US $)	Scenario 1	Scenario 2
Incremental capital cost	190,000	250,000
Incremental operating cost/year	4,250,000	4,250,000

Conversion to hydrocarbon alternative technology

55. For the purpose of calculation of incremental costs, the conversion of production of a small room air-conditioner of 1 kW cooling capacity is considered from HCFC-22 to HC-290 (propane) refrigerant. The refrigerant charge would be about 150 g which might be acceptable in some countries meeting the established safety standards. The capacity of a production line is assumed to be 250,000 units a year. It is assumed that compressors equipped with the necessary electrical features are commercially available.

56. The incremental capital costs will cover the cost of model redesign or alternatively the technology transfer fee, new refrigerant charging boards incorporating the necessary safety features, a refrigerant transfer system, the installation of gas detecting and ventilation systems, new leak detectors, refrigerant storage, training and safety inspection. Incremental capital costs are calculated within the range of US $545,000 and US $670,000.

57. Incremental operating costs for the small room air-conditioner are calculated on the following assumptions:

(a) The average charge in the room air-conditioner is 1.0 kg of HCFC-22;

(b) The baseline cooling capacity is 1.0 kW;

(c) The price of HCFC-22 is US $1.4/kg (HCFCs Study for China);

(d) The charge of HC-290 will be 0.15 kg;

(e) The price of HC-290 (refrigeration grade) is US $27.6/kg (HCFCs Study for China). The high price of refrigeration grade propane in China is due to low demand and is likely to be substantially reduced in the future if R290 technology is widely accepted and commercially used;

(f) The incremental cost of the HC-290 compressor plus the incremental cost to upgrade electrical components to meet safety requirements amount to US $15/unit, based on information received by a manufacturer; and

(g) The incremental operating costs for duration of 12 months amounts to US $4,312,000.

58. The result of an estimation of the total incremental cost of the conversion of a production line of 250,000 units' capacity to R290 refrigerant is shown in Table 7.

Table 7: Incremental cost of conversion of the production line of 250,000 unit per year to HC-290 refrigerant (estimate)

Category of incremental cost (US $)	Scenario 1	Scenario 2
Incremental capital cost	545,000	670,000
Incremental operating cost/year	4,312,000	4,312,000

<u>Conversion of manufacturing of ducted commercial and packaged air-conditioners</u>

59. Incremental capital costs have been calculated for the conversion of a manufacturing facility producing 1000 units of ducted split residential and commercial air conditioners of an average 15 kW cooling capacity and 100 units of packaged commercial units of 70 kW cooling capacity. Two HFC alternative refrigerants are considered: HFC-410A and HFC-407C. Ducted commercial and packaged air-conditioners are being typically installed by contractors with charging the system after the ducting and piping was completed according to the customer requirements

Conversion to HFC-410A refrigerant technology

60. Incremental capital costs for conversion of a production line of ducted commercial and packaged air conditioners to HFC-410A refrigerant primarily will involve costs associated with redesign, prototyping, pilot scale production and test trials to accommodate a higher working pressure of a new refrigerant in the design as well as cost for retooling, leak detector, and adaptation of the evacuation system. No or low cost will be associated with refrigerant charging equipment since no refrigerant charging operations are entailed on a production site.

61. The incremental capital costs are estimated to be in the range of US $145,000 and US $245,000.

62. The manufacturer will not incur incremental costs associated with higher priced refrigerant. There will be savings in the cost of heat exchanger material. The incremental cost for compressors, new filter/dryer and new expansion valve will be part of the incremental operating

costs. The incremental operating costs for both parts of production are estimated to be US $36,000. The results of an estimation of the incremental costs are shown in the following table.

Table 8: Incremental cost of conversion of manufacturing of ducted commercial and packaged air-conditioners to HFC-410A

Category of incremental cost (US $)	Scenario 1	Scenario 2
Incremental capital cost	145,000	245,000
Incremental operating cost/year	36,000	36,000

Conversion to HFC-407C refrigerant technology

63. Since the working pressure of HFC-407C is very close to HCFC-22 refrigerant, there are limited changes in the design of the product and the manufacturing process. This factor might be especially important for conversion of the higher capacity range equipment. The incremental capital costs are calculated to be in the range US $80,000 to US $100,000.

64. Incremental operating costs involve higher price of compressors, and a new filter/dryer, amounting to US $30,000. The incremental costs are shown in the following table.

Table 9: Incremental cost of conversion of manufacturing of ducted commercial and packaged air-conditioners to HFC-407C (estimate)

Category of incremental cost (US $)	Scenario 1	Scenario 2
Incremental capital cost	80,000	100,000
Incremental operating cost/year	30,000	30,000

Chillers

Conversion of manufacturing of chillers to HFC-410A refrigerant

65. The conversion of the manufacturing line of HCFC-22 500 kW water cooled chillers equipped with screw compressors is considered as an example. The direct expansion evaporator is assumed to the part of the system design. The alternative refrigerant is HFC-410A. The annual output is assumed to be 200 units.

66. Incremental capital costs for conversion of a production line of screw chillers of 500 kW capacity has been calculated using assumed costs since the Secretariat has never assessed the conversion of chiller production. The incremental capital costs include the cost of redesigning, prototyping, pilot scale production, test trials, set of equipment for manufacturing the HFC-410A prototype and training. The incremental capital costs are estimated between US $80,000 and US $300,000 depending on the source of the new design.

67. These units are typically being installed by contractors, with charging of the system after the ducting and piping is completed according to the customer's requirements. Therefore, the manufacturer does not incur incremental costs associated with higher priced HFC-410A

refrigerant. The incremental cost for compressors is the major incremental operating cost item. In manufacturing of units of about 500 kW cooling capacity, the components will need to have a higher pressure rating than for HCFC-22. This moderate additional cost is likely to be offset by the lower cost for the screw compressor. The total incremental operating costs per unit for this category of air-conditioning will therefore be likely zero. Consequently, the annual incremental operating costs resulting from conversion of production of 200 units would be also zero. The incremental costs are shown in Table 10.

Table 10: Incremental cost of conversion of manufacturing of ducted commercial and packaged air-conditioners to HFC-407C (estimate)

Category of incremental cost (US $)	Scenario 1	Scenario 2
Incremental capital cost	80,000	300,000
Incremental operating cost/year	0	0

Commercial refrigeration - stand-alone equipment

68. As an example, the incremental cost has been calculated for the conversion of manufacturing of stand-alone commercial-sized freezers of 1.0 kW cooling capacity to HFC-404A refrigerant and beverage vending machines to propane refrigerant.

Conversion of manufacturing of stand-alone commercial-sized freezers to HFC-404A refrigerant

69. HFC-404A is presently the preferred choice for medium and low temperature applications. The conversion of a production line of 10,000 units per year will entail capital incremental cost for model redesign, prototype trials, a new refrigerant charging board, a leak detector, adaptation of the vacuum system, training and technical assistance amounting to US $66,000. Incremental operating costs will cover the additional cost of new refrigerant with the charge 0.75 kg/unit, compressor, capillary, and filter/dryer, amounting to US $140,000 per year.

Conversion of manufacturing of small stand-alone commercial-sized freezers to R-290 (propane) refrigerant

70. HC-290 (propane) can be a choice in manufacturing of small commercial-sized freezers. HC-290-based compressors are commercially available which are capable to provide up to 0.5 kW cooling capacity at evaporator temperature of -30 C. The refrigerant charge will not exceed 0.15 kg determined as a safety threshold in such appliances by international regulations. The conversion of a production line of 10,000 units per year will cover capital incremental cost for model redesign associated with safety requirements, prototype trials, a new refrigerant charging board designed for safe handling of flammable refrigerant, a new leak detector, safety features in the production area, safety inspection, training and technical assistance amounting to about US $320,000. The incremental operating costs will cover the additional cost of a refrigerant charge of 0.15 kg/unit, compressor, incremental and the cost of specific electrical components. On that basis the incremental operating cost is estimated to be within the range of US $230,000 for twelve month duration, leading to a total incremental cost in the range of US $550,000.

Conversion of manufacturing of beverage vending machines to isobutane (R-600a) refrigerant

71. Beverage coolers and small commercial refrigeration equipment based on hydrocarbon (HC) refrigerants such as isobutene (HC-600a), propane (HC-290) or HC blends have been developed in several non-Article 5 countries. Through developmental efforts, it was possible to reduce the refrigerant charge to limits required by safety standards in several non-Article 5 countries. An example of conversion of a manufacturing facility with an annual output of 10,000 units was used for the calculation of incremental cost. The cooling capacity of the refrigeration system is assumed to be 0.25 kW with the refrigerant charge of 0.25 kg.

72. The incremental capital costs will cover the cost of model redesign or alternatively a technology transfer fee, new refrigerant charging boards incorporating the necessary safety features, a refrigerant transfer system, the installation of gas detecting and ventilation systems, new leak detectors, refrigerant storage, training and safety inspection. The incremental capital costs are estimated to be within the range of US $500,000 to US $800,000.

73. The incremental operating costs will be associated with the higher price of the refrigerant, new compressor and the cost of safety features in the design. The overall incremental operating costs will be dependent on the source and availability of hydrocarbon compressors and refrigerant. The annual incremental operating costs will be in the range US $150,000 to US $200,000.

Table 11: Incremental cost of the conversion of manufacturing of beverage vending machines to isobutane (R-600a) refrigerant

Category of incremental cost (US $)	Scenario 1	Scenario 2
Incremental capital cost	500,000	800,000
Incremental operating cost/year	150,000	200,000

<u>Commercial refrigeration - condensing units</u>

74. Currently, HFC-404A is the leading choice of refrigerant in manufacturing new condensing units. HFC-134a is also used mainly for medium temperature applications. The incremental capital costs are estimated for the conversion of a production line of 5,000 condensing units a year. The cost will be associated with the redesign and testing of the new product and the cost of new production equipment and retraining the personnel to handle more hygroscopic lubricant. It is assumed that middle-sized companies have the in-house technical expertise to cope with the redesign challenge. The estimated cost is within the range of US $55,000 and US $60,000, depending on the baseline.

75. In order to be eligible for both capital and operating costs from the Multilateral Fund, the production at the particular enterprise needs to be recognized as one belonging to the manufacturing sector. In its decision 31/45, the Executive Committee established Guidelines for definition of the sub-sector for assembly, installation and charging of the refrigeration equipment and the calculation of incremental operating costs. It is assumed that the company is considered under the rules pertaining to the commercial refrigeration sector and eligible for incremental operating costs. The cooling capacity of condensing units varies from 1 kW for deep freeze

applications to 20 kW. For this cost estimation, the assumed compressor size is sufficient for a refrigeration capacity of 5 kW, and the average charge to be 5 kg per system. The incremental operating costs for one year duration are estimated in the range of US $390,000 to US $415,000 depending on the source of supply of new compressors. Table 12 presents the results of the estimation of incremental costs.

Table 12: Incremental cost of the conversion of the manufacturing of commercial refrigeration – condensing units (estimate)

Category of incremental cost (US $)	Scenario 1	Scenario 2
Incremental capital cost	55,000	60,000
Incremental operating cost/year	390,000	415,000

D. SERVICE SECTOR

General considerations

76. Consumption of HCFC-22 in the service sector is likely to take place in every Article 5 country that has HCFC-22 equipment. In particular, HCFC-22 room air conditioners can be assumed to exist in every but very few countries. Therefore it is safe to assume that, with potential minor exceptions, every Article 5 country uses HCFC-22 for servicing.

77. On an enterprise basis, the distinction between the service sector and the sub-sector for assembly, installation and charging of the refrigeration equipment is very blurred; even the distinction to the commercial refrigeration manufacturing sector is not always clear. It can be assumed that a large number of smaller enterprises fall into service sector as well as into one or both of the other categories and are likely to be addressed only through service sector activities such as training and equipment support. Service sector activities were for most Article 5 countries addressed together with awareness, legislative and enforcement activities in RMPs and TPMPs. This section of Annex IV is therefore also covering to some degree those activities.

78. The service sector is particular in its very broad spectrum of enterprises covered, their often informal structure, the large amount of enterprises and the small consumption per enterprise. The service is predominantly performed at the customers' site, i.e. not at the premises of the service enterprise. Contrary to activities in the manufacturing sector, where the ODS consumption of the beneficiary can be monitored, these characteristics make it virtually impossible to monitor whether an enterprise phased out the use of HCFCs; the problem that their customers might be dependent on continued use of HCFCs in the service of their equipment is a sub-set of this issue. Experience indicates that instead of direct phase-out enforcement, refrigerant supply and, in particular, refrigerant costs are the main drivers leading to phase-out of ODS use in the service sector.

79. Experience in the phase-out of CFCs suggests that if refrigeration manufacturing enterprises and the service sector compete for a limited supply of refrigerant, the service sector is likely to be able to pay higher refrigerant costs since it is easier to pass the costs onto the consumer. This might indicate that in countries where both HCFC-22 refrigeration manufacturing and servicing sectors are present, the contribution of the service sector for phase-out will initially be low, and phase-out will predominantly be achieved in the

manufacturing sectors. This is particularly important when planning phase-out activities to meet the compliance targets of 2013 and 2015, and might lead to a differentiation in activities in the service sector between countries with and without a HCFC-22 refrigeration manufacturing sector.

80. Approaches to reduce supply are performed on a national level by restricting imports or requesting that a certain minimum amount of ODS produced has to be exported. Such restrictions on the national level have become increasingly effective in the last few years. Verification reports reviewed by the Secretariat demonstrate significant improvements in the co-ordination between the NOU, licence issuing bodies, customs and importers. The monitoring of imports is also improved greatly, and more and more countries are using a computerised data basis for customs. It appears therefore likely that governments can control successfully the HCFCs imports into their countries, and thus achieve compliance with their phase-out obligations. Nevertheless, this can not be interpreted as removing the need for assistance to the service sector because of two reasons:

(a) The service sector is eligible for funding of incremental cost. The eligibility has been established in the indicative list of incremental cost ("cost of providing technical assistance to reduce consumption and unintended emission of ozone depleting substances"), as well as in the practice and guidelines of the Executive Committee; and

(b) It might be viewed as a precondition before a government takes regulatory action to reduce the supply of HCFCs that there is an understanding that the country will be able to cope with the reduced supplies. Activities for the service sector provide the necessary assurance to governments.

81. Some Article 5 countries have already completely phased out CFC consumption, the remaining are implementing CFC phase-out activities in the servicing sector. These activities are i.e., customs officers and technicians are being trained; training centres are being properly equipped; refrigeration associations and project monitoring units have been established; and recovery/recycling, retrofits and other technical assistance programmes are also under implementation. Activities in the service sector related to HCFCs phase-out commencing at about the time of the CFC phase-out will maintain the momentum gained and capacity established beyond 2010 and will thus facilitate the cost effective phase-out of HCFCs.

82. Every HCFC-22 dependent refrigeration system imported into an Article 5 country will lead to a broadening of the HCFC-22 dependent equipment base and will subsequently lead to the need of HCFC-22 for service, to the need for retrofit or to premature retirement. It is therefore meaningful to consider how to avoid growth of and, subsequently, reduce the size of the HCFC-22 equipment base. This might require import restrictions, taxing of equipment and/or subsidies/tax breaks for equipment operating with HCFC-22 alternatives. The earlier such restrictions and incentives are decided upon by a government, the easier will be the transition away from HCFC-22 consumption in the service sector. Such legislative measures can be effective only under the circumstances when HCFCs-free refrigeration equipment is made available at a competitive price. Timely conversion of refrigeration equipment manufacturing facilities existing in some Article 5 countries might facilitate meeting the demand for

non-HCFCs equipment and reduce the dependence on HCFC-22 refrigerant in all Article 5 countries.

83. A number of activities in the service sector, in particular the non-investment activities, are recurring activities. Customs officers and, on a slower rate, refrigeration technicians are rotating out of their jobs, new arrivals need to be trained. In addition, training might need repetition or amendments relating to new developments. During CFC phase-out, service sector activities occurred on a large scale from about 1995 on, i.e. from 15 years before the final phase-out. Due to the need to achieve significant consumption reductions in the service sector in more than 70[6] of the Article 5 countries from 2010 onwards to comply with the 2013 and 2015 reduction steps, such activities will commence 30 years before the final phase-out date. The recurring nature of many activities and the long duration until final phase-out might suggest assessing which might be the best approaches to achieve sustainable, cost effective support for the service sector; these might differ from previously used approaches.

Existing experience

84. Phasing out CFC use in the refrigeration servicing sector has long been one of the Executive Committee's priorities. The Executive Committee was approving training programmes for refrigeration technicians, and recovery and recycling projects for this purpose as early as 1991. Since then, recovery and recycling projects and stand-alone training programmes have been replaced by refrigerant management plans (RMPs) and more recently by national/terminal phase-out management plans (NPPs/TPMPs) which has been a tool used by Article 5 countries to achieve compliance with the control measures established by the Montreal Protocol[7].

85. At its 31st Meeting, the Executive Committee decided on the modalities for approving funding for the preparation and implementation of RMP projects (decision 31/48). Subsequently, at its 45th Meeting the Executive Committee decided to approve further funding for phasing out CFC consumption post-2007 period (i.e., 15 per cent of the CFC consumption baseline) in LVC countries through the preparation and implementation of terminal phase-out management plans (TPMPs) (decision 45/54). Through this decision, the Executive Committee, *inter alia*, established maximum funding levels on the basis of the CFC baseline consumption of LVC countries on the understanding that individual project proposals would still need to demonstrate that the funding level was necessary to achieve complete phase-out of CFCs.

86. The total funding approved for stand alone training programmes for refrigeration service technicians and customs officers, recovery and recycling projects and RMPs in all Article 5 countries amounts to US $52.7 million (i.e., US $29.6 million for LVC countries and US $23.1 million for non-LVC countries). An additional US $235.0 million is associated with TPMPs (for LVC countries) and national/sectoral phase-out plans (for non-LVC countries)

[6] There are 70 Article 5 countries with HCFC-22 consumption below 150 metric tonnes (8.25 ODP tonnes) which is believed to be predominantly or exclusively used in the refrigeration servicing sector.
[7] At its 31st Meeting, the Executive Committee decided on the modalities for approving funding for the preparation and implementation of RMP projects to achieve the 2005 and 2007 allowable levels of CFC consumption (decision 31/48). Subsequently, at its 45th Meeting the Executive Committee decided to approve further funding for phasing out CFC consumption post-2007 period (15 per cent of the CFC consumption baseline) in LVC countries through the preparation and implementation of terminal phase-out management plans (TPMPs) (decision 45/54).

addressing the total remaining consumption of CFCs, mainly used in the refrigeration servicing sector.[8]

Good practices in refrigeration

87. The Multilateral Fund has invested significant funding in the improvement of refrigeration servicing practices of CFC-based systems through the implementation of RMP and TPMP activities. Servicing practices for CFC and HCFC based systems are very similar; in both cases, there are additional measures that could be considered where appropriate to reduce emissions from refrigeration equipment.

(a) In many Article 5 countries preventive maintenance of air-conditioning and refrigeration equipment is not a routine practice. Regular preventive maintenance and repair of the system can significantly reduce the leakage rate; and

(b) Substantial resources have been allocated for introduction of recovery and recycling operations in Article 5 countries. Despite the introduction predominantly for the purpose of CFC recovery and recycling, many countries report higher amounts of HCFCs recovered/recycled than of CFCs; this might be related to the fact that even small air-conditioning systems have significant refrigerant content and that room air conditioners are often transported to a repair location, where equipment is available. It could be assessed whether additional efforts are meaningful to optimise the usefulness of recovery and recycling of HCFC-22; these might include better monitoring and creating appropriate incentives for owners of equipment and servicing technicians.

Retrofit and replacement activities in end-user sector

88. The HCFC-22 equipment base can be reduced by retrofit of HCFC-22 equipment, reducing future service demand and, in certain cases, making recovered HCFC-22 from the converted equipment available to the service sector. This is particularly relevant for equipment in commercial refrigeration. Conversions and retrofit activities in the end-user sector have been defined in decision 32/28. In addition, it appears meaningful to expect certain circumstances which must prevail before priority can be accorded to end-user conversions. Such potential pre-conditions for the funding of retrofitting activities might be e.g. that the country has banned the production and import of new HCFC equipment, or that the costs for using HCFC is comparatively higher than the costs of alternative technologies available in the country. For the next years until 2015, it is unlikely that these circumstances prevail in a significant number of countries; nevertheless, some additional considerations are provided below.

89. In order to assess whether a retrofit is meaningful, the remaining life-time of each system needs to be considered and a cost-benefit analysis should be performed. Since HFC alternatives are presently more costly than HCFC-22, there is a significant risk of a reverse retrofit back to HCFC-22. There are several possibilities to provide incentives against a reverse retrofit, which

[8] Several national phase-out plans and a few TPMPs address small amounts of CFCs used in small foam and refrigeration manufacturing enterprises or small amounts of other ODSs, mainly CTC and/or TCA

need to be integrated into the design of the retrofit scheme; these would include long-term subsidies and long-term monitoring of the equipment. The retrofit schemes currently used would similarly subsidize the installation of new equipment with alternative technologies.

90. The administration of retrofit incentive projects is complex since inherently they provide a large incentive for inappropriate use, and require therefore careful monitoring of activities related to relatively small amounts of funding to ensure eligibility and sustainability. The Secretariat calculated in detail the costs associated with retrofits and came to a cost effectiveness of between US $300/kg ODP and US $650/kg ODP (US $16.50 and US $35.75/kg, respectively) for the actual retrofit alone, i.e. without accounting for administrative procedures. This figure is based on the assumption that the Multilateral Fund would cover 50 per cent of the costs, and the equipment owner the remaining, as is the case in existing retrofit schemes.

Cost information

91. The costing of HCFCs phase-out plans in the refrigeration servicing sector is influenced significantly by the prevailing circumstances in the country concerned, such as the size of the country in terms of population and surface area and the geographical distribution of the main economic activities; the actual amounts of HCFCs consumed in the servicing sector by type of equipment; and the characteristics of the refrigeration servicing sector including the number of service workshops and their geographical distribution. At present, some of this basic information is not available, and will only be known when Article 5 countries submit their HCFCs phase-out plans.

92. In spite of the limitations in the availability of information, the Secretariat has attempted a preliminary estimate on the incremental costs based on the Multilateral Fund experience in CFC phase-out activities.[9] The estimation is meant to cover the funding needs for service sector activities and other non-investment activities until the 2015 reduction step, and was used exclusively to provide an approximation of the potential costs so as to better inform the on-going discussion of the Executive Committee. It was assumed that the service sector activities would be targeted to enable a reduction of consumption in the service sector proportional to the necessary national consumption. The level of detail in which the information is provided would allow also understanding the financial implications if countries with a HCFC-22 equipment manufacturing capacity would not commence service sector related activities immediately, but would rather concentrate on their manufacturing sectors. The following estimate assumes providing additional funding for reviewing ODS legislation, as well as training programmes at a level of funding estimated according to the level of HCFCs consumption in the year 2006.

[9] Since the inception of the Fund, the total funding approved by the Executive Committee for stand alone training programmes for refrigeration service technicians and customs officers, recovery and recycling projects and RMPs in all Article 5 countries amounts to US $52.7 million (i.e., US $29.6 million for LVC countries and US $23.1 million for non-LVC countries). An additional US $235.0 million is associated with TPMPs (for LVC countries) and national/sectoral phase-out plans for non-LVC countries addressing the total remaining consumption of CFCs, mainly used in the refrigeration servicing sector. Several national phase-out plans and a few TPMPs address small amounts of CFCs used in small foam and refrigeration manufacturing enterprises or small amounts of other ODSs, mainly CTC and/or TCA.

Further, funding for technical assistance estimated at US $18.20/kg ODP (US $1.00/kg) of consumption, and additional funding (about 20 per cent of the total costs) for monitoring and reporting are assumed. The details of this estimate are presented in Table 13 below.

Table 13: Cost estimate for the refrigeration service sector as well as legislative, enforcement and monitoring activities to comply with the 2013 and 2015 HCFCs reduction steps, by national HCFC-22 consumption in 2006 in metric tonnes

	HCFC-22 consumption in 2006							
Consumption (metric tonnes):	Below 30	Up to 100	Up to 300	Up to 500	Up to 1,000	Up to 5,000	Up to 8,000	Above 8,000
Activities (in US $):								
Legislation	10,000	10,000	10,000	20,000	30,000	50,000	50,000	80,000
Custom training	20,000	40,000	50,000	60,000	80,000	120,000	140,000	160,000
Technicians training	30,000	60,000	70,000	100,000	160,000	240,000	300,000	400,000
Technical assistance	30,000	100,000	300,000	500,000	1,000,000	5,000,000	8,000,000	11,000,000
Monitoring	20,000	40,000	90,000	140,000	250,000	1,000,000	1,700,000	2,300,000
Total (in US $)	**110,000**	**250,000**	**520,000**	**820,000**	**1,520,000**	**6,410,000**	**10,190,000**	**13,940,000**

ANNEX V

ENVIRONMENTAL ISSUES

V1. Characteristics of the ‘functional unit’ approach

1. One of the advantages of the ‘functional unit’ approach is a simplified and transparent derivation of lifecycle impacts. It should be noted that, in contrast to an LCCP approach, the purpose is not to calculate the precise climate impact for each and every application, but to characterise these impacts to the extent that they can be used for the purpose of comparing technologies. It is therefore desirable to fix as many of the potential variables as possible across a sector or sub-sector and only allow those which have clear localised character (e.g. average carbon loading of energy) to be modified routinely.

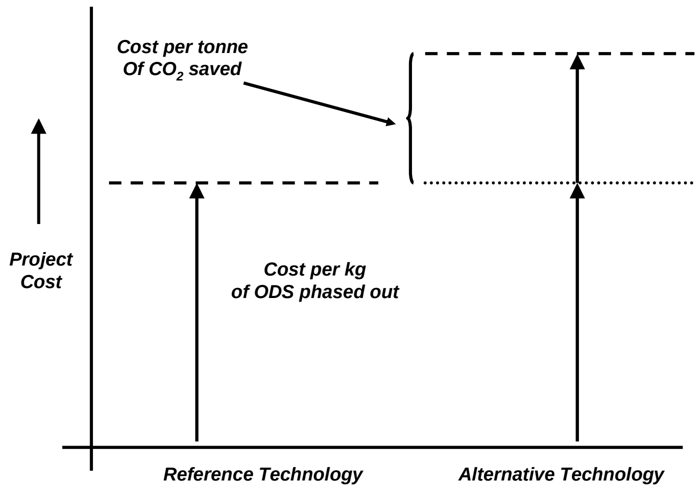
2. In practice, the primary output from any ‘functional unit’ approach would be a comparative assessment of lifecycle climate impacts taking into consideration the GWP of the ODS substitutes involved, the charge size, the energy used in operation, the emission functions through the various phases of the life-cycle and any efforts anticipated for recovery at end-of-life. The normal comparison would use the HCFC-based technology as the baseline, in order to assess whether the alternative technology offers better or worse climate performance

V.2 Analysis made possible by the ‘functional unit’ approach

3. Carrying this approach forward into a practical analysis, some alternative technologies offer the capability of continuous adjustment. An example of such a technology would be HCFC-245fa-blown foams, co-blown with CO_2 (water). Since the level of co-blowing can, in theory, at least, be modified between 0 and 100 per cent, it is possible to envisage a range of climate impacts from ‘low-to-high’ associated with this range of technology options. At a certain point (in this case about 43.3 per cent co-blowing with CO_2 (water)) climate neutrality is reached with the HCFC-141b technology being replaced, based on the outputs of the ‘functional unit’ analysis. It is proposed that this technology is referred to as a “reference technology” for the transition and will be defined for each project or sector. Interestingly, the identity of the ‘reference technology’ is independent of the size of the enterprise being considered, since the analysis is based on a ‘functional unit’.

4. In some sectors, it may not be possible to identify a technology capable of continuous adjustment. In such instances, the “reference technology” could be defined in terms of the closest such technology to climate neutrality. Although this could be defined as the closest either side of neutrality, some might prefer to see only those technologies with ‘better than neutral’ climate performance adopted as “reference technologies”.

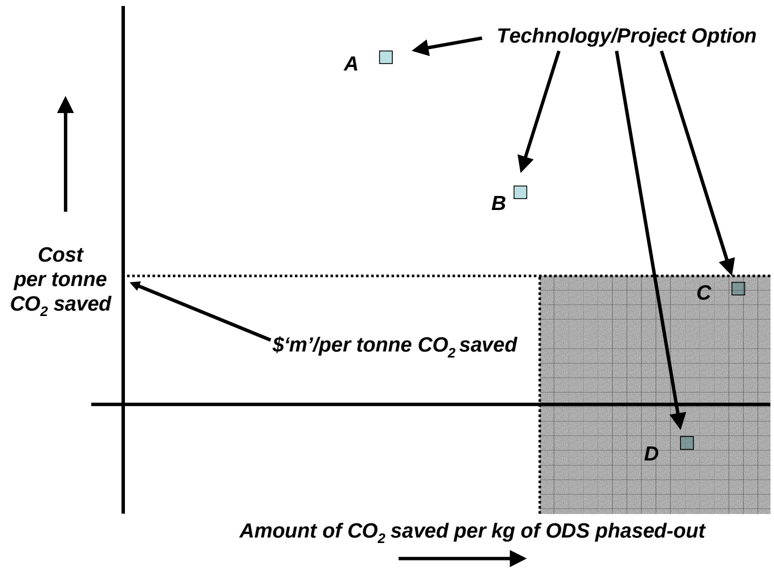
5. By evaluating the cost of implementing the “reference technology” using the existing Incremental Capital Cost (ICC) and Incremental Operating Cost (IOC) analysis, it is possible to derive the cost of an ‘ozone only’ transition, where the climate impact is broadly neutral. The analysis therefore delivers a cost per kilogramme of ODS phased-out (see graph below)



6. Against this benchmark any alternative technologies can be evaluated. In some instances the cost of alternative technologies may be less, even in cases where they deliver a climate benefit and there are no incremental costs. In other cases, such as that shown in the graph above, the alternative technology might be more expensive. In such circumstances, it is appropriate to consider the additional cost to be that required to achieve the additional climate benefit and a cost per tonne of CO_2 saved can be derived.

V.3 Possible funding mechanisms arising from the 'functional unit' approach

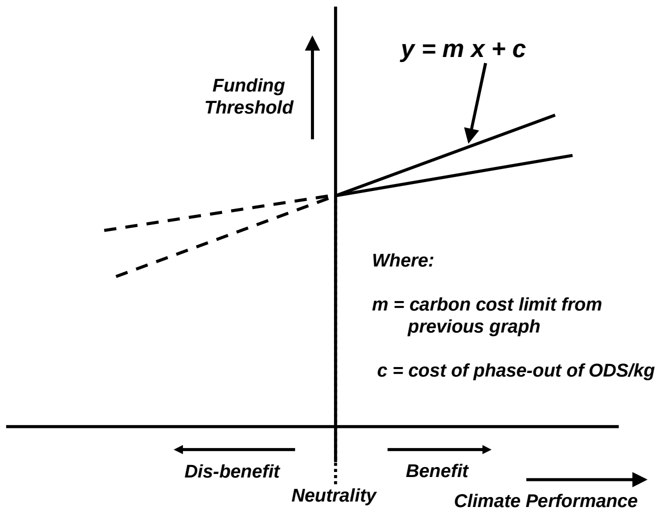
7. The Executive Committee might like to evaluate the output of such analyses on a number of different technology options for a project or programme in order to decide whether it is appropriate to provide funding for additional climate benefits over and above the reference scenario. To facilitate such an evaluation, there is a need to plot the unit cost of the saving in carbon terms against the 'potency' of the measure (i.e. the amount of CO_2 saved per kg of ODS phased-out). The following graph illustrates what this analysis might look like.



8. Using this approach, Executive Committee members could make decisions on the criteria for investment in additional climate benefits in terms of potency and climate benefit (as defined by the shaded area). In the example shown above, Technology A might be a blowing agent technology delivering poorer thermal performance, although being based on a low GWP blowing agent, whereas Technology C might be a similar low GWP technology delivering better thermal performance. It is useful to note, that this analysis would also take into consideration the size of the project envisaged. Therefore, Technology C might be situated in the shaded area for a 50te/yr plant, but outside of the shaded area (higher in terms of cost per tonne of CO_2 saved) for a 10te/yr plant.

9. Executive Committee members would have the ability to define these criteria by sector and region, with the additional ability to cross-reference the cost of the savings against other climate measures adopted by their own governments.

10. Having considered all aspects, the Secretariat believes that it would provide best use of Multilateral Funds to retain the existing ICC and IOC approaches in assessing the overall cost of a project or programme rather than reward climate benefits through market-based mechanisms based on carbon itself. However, it could be possible to use the upper bound of the permitted investment ($'m'/ per tonne CO_2 saved) to drive cost effectiveness thresholds, as shown in the diagram below:



11. Such an approach would not only provide an incentive, in terms of funding threshold, for climate benefits, but could also be used to determine lower thresholds for technologies creating climate dis-benefits against those offered by the “reference technology”. However, the Executive Committee would need to satisfy itself that such an approach would still meet the obligations of the Multilateral Fund in terms of phasing out the relevant HCFC consumption targeted under decision XIX/6

12. As noted in earlier paragraphs, the ‘functional unit’ needs further evaluation across a wider range of sectors to provide assurance that the basic methodology can be applied more widely. The Secretariat therefore seeks the mandate to continue this work on the current path, or as revised by the Executive Committee in order to present a more concrete set of proposals at a future Meeting of the Executive Committee.

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ANNEX VI

COMMENTS RECEIVED FROM MEMBERS OF THE EXECUTIVE COMMITTEE ON DOCUMENT UNEP/OZL.PRO/EXCOM/54/54: "Preliminary discussion paper providing analysis on all relevant cost considerations surrounding the financing of HCFC phase-out (decision 53/37 (I))"

Comments from the German Constituency, 30 April 2008

We do understand the time constraints under which Document 54/54 was produced. We therefore would like to propose the following considerations as constructive suggestions to improve the paper.

General comments

1. We thank the secretariat for presenting historic data, which is crucial for the identification of a methodological approach. In fact we would appreciate an even more in-depth analysis of historic cost developments under the MLF, not only averages, but tables providing more fundamental background information[1]. Illustrating cost developments over time in the past could help to support certain assumptions on future application of innovative solutions and typical scenarios of cost adjustment for innovative technologies.

2. An analysis of the **incremental operating costs** raises serious concerns on the role of operational cost reimbursement. Operational costs appear to be detrimental in two ways,

- By covering operational costs, the use of higher cost HFC substances with high GWP (e.g. 245fa, 404a) may be promoted, instead of sustainable low GWP, low environmental impact substances, which may require higher capital investment but have subsequently lower operational costs and are overall cost effective, helping A 5 countries to keep product prices long term at a low level.

- Providing more cash for high IOC's of high GWP, HFC alternatives contradicts economic decision making for sustainable investments. Even though cash contributions of IOC's will be granted only for a short period of two years, the subsequent increase in production costs bears the high risk and economic incentive for enterprises to pursue illegal, continued use of HCFCs.

In conclusion, the incentive provide from incremental operational cost in doc. 54/54 appears to be in conflict with dec. XIX/6 by providing higher IOC's for high GWP alternatives bearing a high risk for illegal demand of HCFC. Therefore, in light of dec. XIX/6 in the case of the HCFCs, IOC's should not be eligible.

[1] For example, comprehensive back ground tables could be provided on historic development of consumption overall and in each individual (major) sub sectors (e.g. manufacturing, servicing), use of refrigerants in sub sectors, most common replacements in a sub sector, prices, products, cost overview for sub sectors in relation to impact ODP/GWP; alternative/technology; individual/multiyear/umbrella; ICC/IOCs; enterprise/production level;

3. Furthermore, as the **price of alternative technologies** will decrease over time, there should be an option for flexibility over time.

4. In general, calculations and developments of **cost effectiveness thresholds** in the different sub sectors should be made more transparent. In some of the cost samples of doc 54/54 (ANNEX III and IV) the cost per kg ODS for HCFC's are evaluated higher than historic costs per kg ODS for CFC's. It would be helpful to provide an analysis of the most cost effective sub sector projects. This will necessarily include activities of the MYA, because the HCFC phase out activities will be implemented within the frame work of Multiyear plans. Also, there might be lessons to be learned by comparing historic cost differences between individual and sector plan activities. Such comparison should pay specific attention to examples where long term low GWP solutions where applied in various sub sector.

5. Such exercise should include the influence of **end-of-life scenarios**. This would show how replacements made at the equipment's end-of-life and the loss of residual equipment value would influence the incremental costs calculation.

Foam Sector

6. The estimates provided in Annex III for **incremental capital costs** of low GWP technologies seem to be too high. Unfortunately, the document does not disclose any sources, references and authors to verify the validity of such information. During the EC HCFC-workshop in Montreal for example, suppliers indicated in their presentations that costs for low GWP technologies could be less than half of those stated in ANNEX III of doc 54/54. Doc. 54/54 should take into account the latest development in CO2, ammonia and/or hydrocarbon technology use for medium to small scale foaming and in refrigeration.

7. **Small scale users** might be better served by concentrating the MLF support on system house solutions rather than individual enterprise funding.

Refrigeration and air conditioning sector:

8. Future **Economies of scale** need to be factored in. For example, cost differences for compressors disappear when entering economies of scale through mass production. One cost difference between 22 and HC technology for example is not due to the compressors, but because of the need for additional ex-protected and safety components. These components however should contribute only to marginal cost differences. Experiences exist (e.g. with the Italian manufacturer Delonghi).

9. Based on past experience, fund assistance could be more effective by providing long term technology only to enterprises that **demonstrate sustainable business patterns**. Providing short term (high GWP) solutions to enterprises that are obviously operating ad hoc and with short term arrangements should be avoided. Criteria should be developed to assess these options, including business rationalization. Experiences from evaluating National Phase Out and Sector Plans indicate that a significant large number of enterprises funded in the past were apparently not operating on long term basis. Specifically in the refrigeration manufacturing sector many small

and medium enterprises have operated only on a temporary basis[2]. Considering the long time period of the HCFC phase out, these situations must be dealt with appropriately while describing eligibility of sub sector projects.

Environmental considerations and cost implications

10. Decision XIX/6 calls for the Parties "to promote the selection of alternatives to HCFCs that minimize environmental impacts, in particular impacts on climate as well as meeting other health, safety and economic considerations". **Energy efficiency effects** and respective savings of different technologies need to be considered therefore in any discussion of relevant cost considerations of funding HCFC projects. It should not be assumed however that the MLF should fund additional costs that relate solely to climate benefits resulting from energy savings, since this is not the purpose for which the MLF was established. Germany looks forward to further discussion of this issue at Excom 55. For example, where there is a case for additionality of the energy efficiency gains, consideration might be given to support countries to encourage their enterprises to apply for CDM projects or seek finance through the voluntary carbon market or through other sources. It will remain very important however to have an approach to assess the cost-effectiveness of HCFC phase-out projects that is consistent with Decision XIX/6.

11. It is for further consideration, whether the inclusion of TEWI or LCA in project analysis is required. It would complicate the process of MLF project approval. On the other hand, **environmental considerations** could be factored into threshold limits. For example, the higher the GWP of an alternative, the lower the funding threshold would be to pay for it unless there were significant compensating energy savings.

12. In the continuing process of approving cost-effective HCFC phase out projects there needs to be a mechanism in place ensuring responsible use of the funds for **sustainable, overall positive impact** on climate as per dec. XIX/6.

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[2] For example in the various evaluation studies investigators have repeatedly found that small enterprises in the refrigeration sector were closed down shortly after conversion.

Comments from the Government of Lebanon
E-mail received on 30 April 2008

I refer to the ExCom document 54/54 appreciating an earliest revised version of this document to be posted on the MLF website the soonest in order for a wider range of parties can be involved and have enough time to read and discuss it before the OEWG meeting. Please find below my general comments on this document:

1. The paper contains substantial technical information, however, the crucial part of this document limits itself to only investment costs for actual phase-out, we think that this document should be more extensive in identifying all the relevant sources and categories of costs such as, Initiation costs, Management costs and other Non-investment costs (i.e: Demo projects, cost for preparation of HPMPs, costs for formulation of regulation and policy actions…..etc).

2. Although HCFCs use is relatively low in the Aerosol, Firefighting and solvents, while the document covers only the Foam and Refrigeration sectors, , a need for a revised detailed sectors should be included.

3. The document addresses Foam and Refrigeration sectors, with detailed technical information on the alternatives, incremental operating costs, cost benefits…etc , however there should be a demonstration of the technical and commercial viability of the technology options in A5 situations.

4. The stipulated freeze by 1-1-2013 is close, there is a need of combined efforts to assist A5 countries to achieve this milestone, by considering guidelines for Demonstration projects (Pilot projects) in order to better address the use of good cost-effective new technologies or adaptation from existing technologies that will help in overcoming any potential delays for reducing HCFC demand.

5. More concrete guidance related to financing HCFC phase-out activities are needed in this document.

6. The document should propose initial fast-track investment projects, which could help in providing early motivation to enterprises for participating in HCFC phase-out activities.

7. The funding provided for CFC phase-out under the MLF has created infrastructures that may to some degree facilitate HCFC phase-out. However the preliminary cost estimate for phasing-out HCFCs is considered low compared to the CFCs phase-out cost (In general).

8. Approval at the earliest of funding for phase-out activities, in particular in the servicing sector, could maximize potential benefits from currently funded, or soon to be funded phase-out activities.

9. The document should provide a roadmap on how the information related to costs as provided therein, can be translated into usable criteria for funding of projects in various sector/sub-sectors.

Comments from the Government of Dominican Republic
E-mail received on 30 April 2008

On behalf of Dominican Republic Delegation and in attention to the issue of Funds for HCFC Demo and Pilot projects implementation that is supposed to be discussed at the 55th ExCom meeting, we are sending to you our shared comments on it.

Considering the importance to A5 countries of testing new technologies which are not mature nor available in developing countries so far, we consider as critical that the Secretariat develops and includes draft funding criteria for pilot/demo projects, so ExCom members can consider such criteria in the context of 54/54 doc discussions supposed to discuss at the 55th ExCom. Without draft criteria being discussed at the 55th meeting, the ExCom will not be in the position to consider Business Plan of such projects at the 56th meeting.

Comments Submitted by Australia on behalf of Australia and Canada
E-mail received on 28 April 2008

Factual comments on the final draft study on the collection and treatment of unwanted ODS in A5 and non-A5 countries prepared by ICF International

Page 2, Exhibit ES-1	The table should include "ticks" for Australia in the following columns: • Explicit requirement to recover refrigerant prior to building demolition – Regulation 111(2)(c) of the Ozone Protection and Synthetic Greenhouse Gas Management Regulations 1995 provides this explicit requirement • Standard for Refrigerant recovery at appliance servicing and disposal – regulation 135 (Table 135 – Standards) provides that licence holders must conform to Australian Standards 4211.1 and 4211.3 which require gas removal from motor vehicle and commercial/domestic refrigeration systems.
Page 11, line 34	The study mentions significant amounts of unwanted ODS in Article 5 countries and even provides an estimated amount per country. This estimation needs to be sourced or referenced. Assuming there is a source, it is doubtful if 5 tonnes per country is "significant", especially considering that this amount has accumulated over the 20+ years. As well, averaging an estimated total number of unwanted ODS by the number of Article 5 countries can be very misleading.
Page 17, line 27	Australia should be included as a country that has compliance and verification regimes in place at the government level. In the case of Australia, the Australian Refrigeration Council conducts audits under contract and on behalf of the Government.
Page 18, Exhibit 4-2	In relation to domestic appliances and MAC, Australia has a PSS $$ scheme in place as per bulk.
Page 37, section 8.1	This section assumes a central government will be doing things. Private sector considerations should be included here, for example, an international, free-market mechanism for collecting, reclaiming and disposing of unwanted ODS could also be an option.
Appendix A - Australia	Page 61, line 23 – delete reference to July 2005 and August 2005 amendments, as these were very minor amendments. Page 66 – A-Gas system box – this box appears incomplete, perhaps just a formatting problem Page 67 – PLASCON box – same problem Page 67, footnote 19 – delete the estimation in brackets entirely, as this estimation is unfounded. Page 70 line 2 – delete "HFC", so the phrase reads "as an increasing number of systems…" Page 73, line 26 – the proper name of the Act is the "Ozone Protection and Synthetic Greenhouse Gas Management Act 1989".

环 境 保 护 部

MINISTRY OF ENVIRONMENTAL PROTECTION, P.R.C.
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FACSIMILE COVER SHEET AND MESSAGE

Date: April 30, 2008
To:
Ms. Maria Ulana Nolan
Chief Officer
Secretariat of the Multilateral Fund for the Implementation of the Montreal Protocol
Tel.: +514 282 1122
Fax: +514 282 0068

No. of Pages:
From:
Mr. Wen Wurui
Deputy Director General
Foreign Economic Cooperation Office
Ministry of Environmental Protection

Tel: 86-10-88575088
Fax:86-10-88577789

Subject: Comments on UNEP/OzL.Pro/ExCom/54/54

Dear Ms. Maria Nolan,

In responding to decisions made at the 54th ExCom meeting regarding the "Preliminary discussion paper providing analysis on all relevant cost considerations surrounding the financing of HCFC phase-out", the Ministry of Environmental Protection has consulted relevant associations and industrial experts in the review of the above-mentioned paper and also asked the opinions from the opted members of China. Here I have the honor to present you China's comments on the document UNEP/OzL.Pro/ExCom/54/54, and we hope these comments will be considered and helpful while the Secretariat makes revisions to the paper to be submitted to the next ExCom meeting. Please don't hesitate to contact us in case you have any questions.

Sincerely yours,

Wen Wurui
Deputy Director General
FECO/MEP

Comments on UNEP/OzL.Pro/ExCom/54/54
"Preliminary discussion paper providing analysis on all relevant cost considerations surrounding the financing of HCFC phase-out (Decision 53/37(I))"

I. General

1. The paper mainly covers the cost analysis of two major sector, namely the foam and refrigeration sectors, without touching smaller sectors including the solvent sector, the aerosol sector, etc.; and in the analysis to the refrigeration sector, it talks mainly about the phase-out of HCFC-22, and no detailed analysis has been made on other HCFCs such as HCFC-123 and HCFC-133. We understand that these sectors and substances account for a small part in the phase-out of HCFCs, however, since we will also have to deal with them in our HCFC phase-out efforts, their relevant information should be included in this discussion paper.

2. While analyzing relevant substitute technologies, very little attention is given to new potential technologies, such as CO2 in the refrigeration sector. We have learned that progress has been made in the development of the CO2 technology as it is used in certain products and applications in the developed countries. Therefore, we hope that more attention would be given to this technology in this discussion paper.

3. There is a great difference in some of the cost calculations and the prices of some chemicals between what is written in the paper and the situation we understand, which leads to substantial gaps between some of the conclusions in the paper and the actual situation as we have known.

4. The recommendation section in the discussion paper should be in a more detailed way so that it could help the ExCom to make more concrete decisions to promote the HCFC phase out.

II. Executive summary

Para 1

After the second sentence "These HCFCs are…in the refrigeration servicing sub-sector", add one more line ", and a small portion of them are used in sectors including the solvent and aerosol sectors".

Para 2

In this paragraph and some later parts of this paper, methyl formate is considered as "a technology appears to have high prospects of meeting the foam production needs of A5 countries enterprises and at lower costs". However, we are not so convinced with this point. According to our experience, in China, the biggest foam market, there is no previous example using methyl formate as blowing agent. In addition, according to the presentations in the Technical Meeting on HCFC Phase-out held on April 5-6 in Montreal, there are some limitations with regard to the use of methyl formate, because this technology will lead to poor insulation performance of foams, and will not have promising future in the substitution of HCFCs. Besides, as we know that methyl formate is a flammable chemical, and we should consider the safety issues when using methyl formate, therefore, we think it is inappropriate to list it as one of the main substitute technologies in the foam sector when there are no adequate supporting data. We would suggest that the Secretariat conduct a survey into this technology, and if it is not appropriate for the substitution of HCFCs, we should delete relevant part from the paper.

It is also mentioned in this paragraph that "For HCFC-22 in the refrigeration sector, the situation is similar, and HFC and hydrocarbon replacements are available." As far as we know, in most refrigeration sub-sectors, some HFC technologies have actually been introduced commercially, however, for hydrocarbon, the application of this technology is still quite limited and far from being introduced commercially.

Para 4

We can not agree with the first two sentences of the paragraph. These two sentences give us the impression that most foam projects will not need any investment on equipment in future. However, the actual situation is that the HFCs are likely to be controlled in future for their high GWP, methyl formate and water based technologies are limited in the use of areas because of their performance and nature, and the most sustainable potential substitute technologies maybe the hydrocarbons, however, these technologies will need substantial investment in terms of equipment replacement and safety related equipment. In addition, in the conversion from CFCs to HCFCs, some small enterprises haven't changed their equipment to high pressure machines. Therefore, we can only have a better understanding of the situation of the whole sector after conducting the survey in the preparation of the HPMP. We would like to suggest the Secretariat to change the wording of the first two sentences of this paragraph, and words like "overall", "no additional funding" and "most of the alternatives" should be avoided.

Para 5 (a)

Before the ExCom has made any new decisions to the IOC, the cost calculations should be based on the previous experiences for CFCs phase-out. In some sectors, due to patent issues, the substitutes to HCFCs are really expensive, so that the IOC is the main incremental costs for the industries and enterprises in these sectors. And without IOC, it will be difficulty to implement the projects.

Para 5 (b)

If we put equipment reaching the end of its useful life as a recondition for project approval for the HCFC projects, it will bring great risks and difficulty for the governments to manage their compliance efforts. We have learnt that most enterprises are not so active in the substitution of HCFCs, and in addition, the determination of the useful life of equipment is a complicated issue, if we have a guideline like this, the enterprises will use this policy as an excuse to postpone their substitution. For example, for some enterprises, the equipment need retrofit or replacement is only a part in their production line while the life for the whole production line is very long; and for some other enterprises, they have different sets of equipment purchased at different times, but we will have problems if we carry out projects in different phases in some of these enterprises.

Para 5 (c)

We agree with the idea that different CE thresholds should be applied to different applications to provide incentives for the adoption of hydrocarbon technologies. In addition, we would like to point out that in the non-appliance foam sub-sector, we should also encourage then enterprises that wish to go for the hydrocarbon technologies by providing them with incentives in the cost.

Para 6

Regarding the indicators for environmental impacts, we think that it is appropriate that the A5 countries should take a comprehensive look at this issue while preparing their HPMPs. Since the indicators are not only for the A5 countries, before the MOP has made any decisions on this issue, we think the ExCom should not apply any compulsory environmental indicators to the projects for A5 countries.

Para 7

Regarding the co-financing issue, we suggest that these paragraphs to be revised according to the relevant decisions made by the 54th ExCom meeting. And we fully agree that the use of co-financing modalities should not be applied for projects related to the 2013 and 2015 targets since it will need a lot of time and lead to some difficulties in project implementation.

III. Foam sector

Para 19

The Article 5 countries in line 5 should be non-Article 5 countries.

Para 22

As methyl formate is flammable, we think it should not be in the same category with HFC and water-based systems.

Para 22 (a)

It should also be pointed out that according to Decision XIX/6, the ExCom should make necessary changes to the eligibility criteria to the second conversions.

Para 25, Table II.1

As far as we know, the water-based systems are not suitable for substitution in spray foam, as well as in the panels and domestic and commercial refrigeration applications, therefore, we suggest deleting the cost calculations for the water-based systems in the abovementioned sectors. And in China, water-based systems have limited applications in the pipes and integral skin foam sub-sectors.

Para 27, Table II.2

The price for MDI is too low, and the USD 1.5/kg price has not been seen in the market in the recent years. We've learnt that the price for MDI is similar in the global market. China has the capacity to produce MDI and the price for MDI in China is relatively low compared to the other parts of the world. The current price is around USD 3.44/kg.

The price for pentane in the table is also low than the current market price. With the growth in the oil price and the depreciation of the US dollar, the price for pentane in China has doubled from the one on which we did the CFC phase-out projects. The current market price for pentane is around USD 1.9/kg, and since the foam prices have to pay for a high transportation fee as pentane has to be transported as dangerous chemicals, the price when pentane arrives at the manufacturing enterprises is much higher than the one when it leaves the producer.

Para 29-30 Table II.3

We are not clear how these calculations are made. Generally speaking, we think the conclusion from the Table II.3 (in the Corrigendum) that we will have IOC saving converting to pentane and cyclopentane is not correct. When converting to pentane or cyclopentane, there are needs to increase the associated amount of MDI and polyol, the density of the foams and the consumption of power, to change process agents and to add more and better retardants, and these needs lead to an increase in the IOC which has been noticed in the production of the enterprises. The following data is provided by a domestic appliance enterprise indicating its increase in the IOC after converting to cyclopentane in its production:

For every kilogram of blowing agent, 7.4-7.7 kg of pre-mixed polyol and 10.1-10.4 kg of MDI are needed. Due to its performance and nature, the amounts needed for pre-mixed polyol and MDI for cyclopentane are 2.5% and 2.6% more than for HCFC-141b. We could make a calculation based on the current market prices of these main materials, namely UDS 2/kg for pre-mixed polyol and USD3.44/kg for MDI, to substitute HCFC-141b with cyclopentane will lead to an increase of IOC of USD 1.3/kg.

And for other rigid foam products, since the need for retardant will be greater, the IOC will be further increased.

IV. Refrigeration sector

Para 41

Though the equipment with HCFC-123, HCFC-124 and HCFC-142b are mainly produced by non-A5 countries and the quantities are small compared with HCFC-22, there are still a large number of users of these kinds of equipment in the developing countries. So the paper should also address how the accelerated phase-out of HCFCs will impact these users.

Para 42

The last sentence is not complete, because though there are some large enterprises in the air conditioning sector, still, in the A5 countries, there are a large number of SMEs in this sector.

Para 46 (a)

The last sentence of this paragraph is not so correct. It is sure that hydrocarbons have been successfully used in refrigerators, however, in the mobile air conditioners and small commercial refrigeration equipments, hydrocarbons are not widely used except for in some individual products.

Para 49-52

In these paragraphs and relevant paragraphs in Annex IV, the cost calculations have not considered the cost for equipment recycle, there is no clear description of the technical assistance activities, and the calculations are relatively low. Since the amount of HCFCs for servicing is big and the number of users of these kinds of equipment is huge, and compared with CFCs, the phase-out of HCFCs in the servicing sector will face more and bigger challenges, which will lead to higher costs. We mentioned in paragraphs above that we have to protect the rights of the users for HCFC-123 and HCFC-124 equipment, and we think this should be done in the servicing sector.

Para 56, Table III.1

We are wondering if it is still necessary to recommend R407 in the table as it is stepping out of the air conditioning market due to its disadvantage in performance and nature. The cost calculations for commercial refrigeration is obviously too low, and we would suggest more detailed survey to be undertaken for this sector. In addition, the conversion of compressors is an important part in the HCFC phase-out in the refrigeration sector, but it is not mentioned adequately and there are no cost calculations for the conversion of compressors in this paper. We believe that without conversion projects done in the compressor sector, it will pose great challenge for the smooth phase-out of HCFCs in the refrigeration sector.

We got the following information on the cost calculations from the China Refrigeration Association and the China Household Appliances Association, mainly on the Annex IV to this paper (the paragraphs mentioned in below refer to those in Annex IV):

Para 56

Concerning the IOC for the small air-conditioners, we suggest that when calculating the IOC for air-conditioners with R290 as the refrigerants, the following aspects should also be considered:

1. The incremental costs for the air-conditioner to meet the safety requirements. The inner electric control system in the air-conditioners need to be improved, for example, the electric box cover must has airproof and fireproof quality, and important electric parts must be explosion proof.

2. The incremental costs for the installation of the air-conditioners to meet the safety requirements. For example, the connecting valves should be used, however, due to patent issue, the connecting valves are expensive.

3. The incremental costs for after sales services. If the amount of refrigerants in the air-conditioners with HCFC-22 or HFC-410a is not enough, they could be recharged directly by drop-in new refrigerants. However, for air-conditioners with R290, the recharging is much more difficult and expensive.

In addition, when making the cost calculations for conversions to R290, the paper assumes the charge of refrigerant to be 0.15kg, however, we think that when converse the equipment with 1kg charge of HCFC-22 to R290, the charge should be 0.45kg.

Para 58

The conversion in the industrial and commercial refrigeration sector mainly includes the conversion to the ducted commercial and packaged air conditioners, chillers, compressors, and condensing units.

Regarding the ducted commercial and packaged air conditioners, two technologies are considered, namely HFC-410A and HFC-407C. However, from the utilization of these two technologies, except for servicing, HFC-407C is seldom used in the new products in the industrial and commercial refrigeration sector now, and the main substitute in this sector in HFC-410A in the global market.

Para 59

Actually, in the production of ducted commercial and packaged air conditioners in China, the refrigerant charging operations are done on the production site.

Para 60

The IOC is calculated for the conversion of a manufacturing facility producing 1000 units of an average of 15 kW cooling capacity or even lower capacity. However, the actual situation is that the product specifications and quantities of production of the industries' are larger than the 1000/15kW capacity.

For ducted commercial and packaged air conditioners, if we make the calculation assuming that one factory has 1000 sets capacity (15kW and 10 production specifications) and the average IOC is $ 2000 of each machine, then we get the IOC (including compressors, refrigerant, heat exchangers, refrigeration parts, valves, piping, etc.) totaling about $ 200,000 per year, and the IOC here of a single machine is 10-15% higher than HCFC-22 machines. And the ICC (including design fees, prototype, testing, pilot production, tooling equipment, training) is about $300,000.

For chillers, the refrigerants include R134a and R410A, and the refrigerants are charged by manufacturers in China. The ICC here is approximately $ 610,000, including design fees, prototype, testing, pilot production, tooling equipment, training etc. and the IOC is about $ 812.000 a year, with that of a single machine 10-15% higher than HCFC-22 machines.

Para 72

For commercial refrigeration and condensing units, the ICC (including design fees, prototype, testing, pilot production, tooling equipment, training etc.) is approximately USD 300,000. And the IOC is about USD 75,000.

For the conversion of the compressors, if we calculate the ICC for a production line with the capacity of 2000 sets of 500kW capacity equipment per year in 5 production specifications, the ICC will amount to $460,000.

V. Other considerations and co-financing

Para 68

We would suggest that this paragraph be deleted.

Para 69-75

We would suggest that these paragraphs be revised according to relevant decisions made in the 54th ExCom.

VI. Recommendations

We suggest that this section should be reconsidered and restructed, and take into account the following recommendations:

Para 76 (a)

We suggest that before the ExCom makes new decisions for IOC, the pilot projects and the HPMP should follow the previous experience in the phase-out of CFCs including the duration for payment of IOC, etc.

Para 76 (b)

We would suggest that this paragraph be deleted.

Para 76 (c)

At present, it is not applicable to oppose rigid environmental indicators for MLF funded projects. And the prioritization of these indicators should also allow flexibility, and could let the countries to take into consideration of their different country status, different nature of respective industries, the availability of the substitute technologies, etc.

Para 76 (d)

We agree with (i) and think that the cut-off date should be decided soon, otherwise it will bring great difficulty to the A5 countries in their preparation for the HPMPs and future work, and policy principles should also be made clear as soon as possible for second conversions. And we would suggest deleting (ii).

In addition, we suggest that the following issues to be considered in the paper:

1. What's the function and objective of this paper?
2. As it is pointed out in this paper that due to lack of experience in HCFC phase-out, it is difficult to provide appropriate guidance in terms of technology recommendation and cost calculations. We quite agree with this point and suggest that the ExCom approve some pilot projects to testify the technologies and to gain relevant cost information.
3. Detailed recommendations should be provided regarding how the 56th ExCom could review pilot projects.