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执行蒙特利尔议定书
多边基金执行委员会
第七十二次次会议
2014 年 5 月 12 日至 16 日，蒙特利尔

增编

情况报告和履约情况

本文件印发是为了增加一节，内含要求提出具体报告的项目。

1. 本节涉及在以前各次会议上要求提出具体报告的项目和活动以及需要执行委员会注意的项目和活动。这些报告放在以下几个部分：

第五部分： 氟氯烃示范项目

第六部分： 中国哈龙、氟氯化碳生产和泡沫塑料行业计划财务审计报告

第七部分： 菲律宾国家氟氯化碳淘汰管理计划（财务报告）

第八部分： 尼日利亚氟氯烃淘汰管理计划（第一阶段，第三次付款）（制冷行业泡沫塑料制造企业转型的执行计划）

第九部分： 伊朗伊斯兰共和国执行国家氟氯化碳淘汰管理计划：政策和监管组成部分

2. 每一部分载有关于进展情况的简介以及秘书处的评论和建议。

第五部分: 氟氯烃示范项目

中国: 美的室内空调机制造商公司从 HCFC-22 转型为丙烷的示范次级项目 (工发组织)

<u>背景</u>

3. 执行委员会第六十一次会议核准中国的示范次级项目，在美的室内空调机制造商公司室内空调压缩机的制造方面，从 HCFC-22 转型为丙烷[1]。 执行委员会第 71/13 号决定注意到该次级项目的临时报告[2]， 请工发组织向第七十三次会议提出最后报告，但有一项谅解，该报告只载列关于增支经营成本的初步数据。在第七十三次会议举行前，工发组织已经提交给第七十二次会议关于增支经营成本的资料。将向第七十三次会议提出一份合并所有资料的报告。

<u>进展报告</u>

4. 提交给第七十一次会议的临时报告谈到美的室内空调机制造商公司转型一条制造室内空调机的生产线，使用 HC-290 (丙烷)为制冷剂；转型已经在 2013 年 7 月完成。此项活动包括：生产线转型，安全认证，研制新产品和生产流程，安全审计师认证，以及中国当局取得产品和生产线证书的活动。该报告说明了转型的增支资本费用。

5. 关于增支经营成本的资料载于一个表格，列出在制造和安装过程中不同步骤的主要成本差异。因此，可以计算出单位增支经营成本。提交的报告还包括一个表格，列出生产流程的具体步骤所需的时间；额外的生产时间直接与生产成本增加有关。每台空调机的增支经营成本是 41.95 美元；按照每单位 1.2 千克计算（根据项目提案），HCFC-22 的淘汰成本是每千克 34.96 美元。

6. 转型导致在增支经营成本方面取得一些节省，特别是热交换器和制冷剂的成本。增支经营成本的 45% 用于安装一个 HC-290 部件需要多花的时间（大约多花 37 分钟，技术员的时间费用是每小时 34.10 美元，总的成本增加在 20 美元以上）。其次要增加的成本（大约每个部件 15 美元）是必须密封电子部件以免易燃气体接触到火花。根据制造商广东美芝压缩机有限公司的数

[1] UNEP/OzL.Pro/ExCom/61/32 号文件。
[2] UNEP/OzL.Pro/ExCom/71/6/Add.1 号文件。

据，这种压缩机比使用 HCFC-22 的类似型号大约贵 7.50 美元。这种压缩机是从另一个示范项目的转型的生产设施购买；不过，该项目还没有提出增支经营成本的报告。

秘书处的评论

7. 秘书处质疑，密封电子部件增加的成本是按照小规模或大规模生产计算。秘书处认为，对于生产以百万计的空调机来说，元件成本往往只由材料成本决定。工发组织建议，空调机采用气密式电子盒，用胶水密封。工发组织确认，目前的成本与产品刚刚开始生产有关，将来会下降。此外，工发组织建议，还可以改进采取安全措施的方法。

8. 秘书处还质疑，这种压缩机是否比 HCFC-22 压缩机更有能效。工发组织回答，这种压缩机的能效比以前使用 HCFC-22 的压缩机高 2%到 3%。由于能效改进有限，第 61/44 号决定所说的压缩机的主要特点大致维持不变。

影响

9. 本示范项目有助于显示，HC-290 技术可以成为小型空调机系统、特别是住宅空调机市场的单分体式系统的替代品。与 HCFC-22 或 HFC-410A 相比，HC-290 在应用于空调机时成为 HCFC-22 的主要替代品，几乎完全消除了制冷剂的全球变暖潜能值。本示范项目导致中国氟氯烃淘汰管理计划第一阶段的室内空调机行业使用 HC-290 作为 HCFC-22 的主要替代品。在相关行业计划中，目前正在执行九个转型活动，每年大约生产 310 万台，使用 HC-290 的总消费量达 3,741 公吨。此外，在同一行业计划中，正在支持三家压缩机制造商转型使用 HC-290 技术。将来还有九家设备制造商转型使用 HC-290 技术。空调机行业好几个转型项目都在考虑以 HC-290 作为可能选项，但是否采用往往取决于能否从其他制造商购买到生产包，特别是因为地方制造商只是把生产包组装到空调机去，然后注入和测试质量。要等到更多制造商转型生产并取得必要的生产设计和生产技术诀窍之后，才能在市场上买到这种生产包。

10. 工发组织提供的资料指出，HC-290 系统的能效与 HCFC-22 技术相似。相较于继续使用 HCFC-22，本示范项目淘汰的 240 公吨 HCFC-22 加上（受本示范项目影响）氟氯烃淘汰管理计划的转型活动，每年将减少 701 万吨二氧化碳的温室气体排放。

秘书处的建议

11. 执行委员会不妨：

(a) 注意到 UNEP/OzL.Pro/ExCom/72/11/Add.1 号文件所载工发组织提交的关于中国美的室内空调机制造商公司从 HCFC-22 转型为丙烷的示范次级项目的其他资料；和

(b) 请工发组织依照第 71/13 号决定向第七十三次会议提出最后报告。

中国: 清华同方人工环境有限公司利用 HFC-32 技术制造小型商用气源冷却机/热泵示范项目(开发计划署)

背景

12. 执行委员会第六十次会议核准中国在清华同方人工环境有限公司利用 HFC-32 技术制造小型商用气源冷却机/热泵示范项目，由开发计划署执行[3]。执行委员会第 71/15 号决定注意到关于示范项目的临时报告[4]，请开发计划署向第七十二次会议提出最后报告，但有一项谅解， 报告只载列关于增支经营成本的初步数据。关于该示范项目的最后报告已经由开发计划署提交第七十二次会议，现在列为本文件的附件。

进展报告

13. 清华同方人工环境有限公司把 HCFC-22 转型为 HFC-32 技术的工作已经顺利完成。该项目包括产品重新设计和研制、实验室检测和效益评估、原型测试、更改制造设备以及处理 HFC-32 易燃性的新设备、安全和其他措施。示范项目的目的是评估 HFC-32 技术用于单一和多连接的商业空调机和热泵的技术可行性和经济可行性。

14. 清华同方人工环境有限公司每年制造 5,000 台气源热泵和冷却机，功能在 13 到 60 千瓦之间，分为 13、30 和 60 千瓦三种型号，HCFC-22 注入量 5.1 到 24 千克。除了本项目的转型产品，该企业还有能力每年制造约 8,000 台各种型号的冰箱，制冷能力 13 千瓦到 3 兆瓦，HCFC-22 注入量达 90 千克。

15. 本项目由中国政府与清华同方人工环境有限公司于 2011 年 1 月签订合同后开始执行。三种型号在 2011 年全部重新设计，不仅解决了物质的易燃性问题，而且解决了压缩结束时高温问题，因而改变了设计。生产线在 2012 年转型，包括：改变热交换器的加工，管径从 9.5 厘米缩小为 7 厘米（因而导致生产线的一些改变），注入区的隔离（包括通风良好和火警系统以便安全使用易燃气体）。生产流程引进了氦气检漏仪。质量检验、特别是电子系统的安全检验得到更新，并修改适用于易燃气体。该企业培训了 230 名人员。清华同方人工环境有限公司于 2013 年 12 月通过了国家验收；这使得执行时期总共达到 36 个月。

16. 执行委员会核准的增支资本费用原来的预算是 733,530 美元。这个费用是在关于热交换器的第 66/52 号决议通过之前确定的，当时热交换器转型只得到部分供资（随后的项目中热交换器转型获得全额供资）。投资部分的符合资格的费用总额是 745,802 美元。此外，报告中载有关于不符合资格的费用的资料。所有预算项目的实际费用都低于以前的估计数；不过，根据执行委员会决定的现行做法，热交换器转型的全部费用都由预算支付。

17. 报告还载列关于增支经营成本的资料如下：13 千瓦型号的增支经营成本是每台 163 美元（或每千克 32 美元），30 千瓦型号的增支经营成本是每台 177 美元（或每千克 14.8 美元），60 千瓦型号的增支经营成本是每台 286 美元（或每千克 11.9 美元）。根据三种型号的平均费用，增支经营成本的 65%来自压缩机费用，35%来自密封电子部件。热交换器和制冷剂实现了增加经营节省。

[3] UNEP/OzL.Pro/ExCom/60/24 号文件。
[4] UNEP/OzL.Pro/ExCom/71/6/Add.1 号文件。

<u>秘书处的评论</u>

18. 秘书处质疑，随着产量增加，压缩机的成本是否可能下降。开发计划署认为，如果扩大使用范围，价格的确可能下降；不过，这种压缩机仍然可能比 HCFC-22 压缩机贵。部分原因是 HFC-32 的工作压力比较高，因此需要加强压缩机的一些结构。此外，易燃性引起的改变（消除点火源）以及针对 HFC-32 高温排气采取的措施也使成本增加。关于密封电子部件，开发计划署还说明，这个事项包含一些关于该系统电子部件的不同成本。除了气密电子盒，还要加大风扇以增加空气流量，而且要能够防爆。

19. 报告又提到，项目的成功执行提供了一个无害环境且具有成本效益的替代品。开发计划署随后澄清，这是拿 HFC-32 与其他低全球变暖潜能值（即 HFO-1234yf）比较。开发计划署又认为，HFC-32 原型的能效比以前的 HCFC-22 系统在制冷模式时高 3%到 5%，比在在制热模式时高约 3%。该企业假设，进一步改进压缩机的设计并使压缩机更加适应 HFC-32 的性能，将更能提高能效。

20. 秘书处曾经质疑安全标准在该系统销售方面的作用。开发计划署表示，目前新的 HFC-32 系统是小量生产，非经常生产，没有在市场销售。虽然顾客对这些新产品有兴趣，但该企业不能出售新产品，因为受到现行标准的限制。按照现在的计划，只能由工厂培训的维修人员来安装和维修新产品，至少在向市场引进新产品时要这样做。

21. 开发计划署还建议，国家标准 GB 9237 "用于冷却和加热的机械制冷系统–安全要求"是中国的一个制冷基本安全标准，其中限制出售和运营使用易燃制冷剂的设备；GB 9237 是国际标准化组织 (ISO) 5149-1993 的中国版。ISO 5149 目前正在修订，预计在 2014 年 4 月后生效。中国环境保护部对外经济合作办公室正在审查 GB 9237 标准，预期在今年完成审查。

<u>*影响*</u>

22. 本项目有助于表明 HFC-32 技术是中型空调机系统的替代品。HFC-32 具有易燃性，但由于总体易燃性低于碳氢化合物，与使用碳氢化合物的系统比较更容易设计、销售和运营。同时，HFC-32 的全球变暖潜能值只有 HCFC-22 的 38%，HFC-410A 的 35%，在空调机应用方面成为 HCFC-22 的主要替代品。

23. 示范项目直接导致在中国氟氯烃淘汰管理计划第一阶段的工业和商用制冷行业计划中使用 HFC-32 为 HCFC-22 的主要替代品。中国目前正在执行六个转型活动，累计消费量达 3,000 公吨 HCFC-22，改为使用 HFC-32。此外，一家压缩机制造商正在接受支持，改为使用 HFC-32 技术。第二家压缩机制造商和另外六家设备制造商都将改用 HFC-32 技术。印度尼西亚氟氯烃淘汰管理计划第一阶段也确认 HFC-32 是替代技术，那里的三家制冷制造商和五家空调设备制造商正在从 HCFC-22 转型到 HFC-32，相关消费量达 550 公吨 HCFC-22。阿尔及利亚(8.3 公吨 HCFC-22)和泰国(1,036 公吨 HCFC-22) 的氟氯烃淘汰管理计划第一阶段都核准了 HFC-32 技术的转型活动（秘书处尚未收到关于该转型活动已经开始的执行报告）。

24. 开发计划署的资料指出，能效与 HCFC-22 技术相似。与继续使用 HCFC-22 比较，本示范项目淘汰了 61.9 公吨 HCFC-22，加上目前正在执行并影响到技术选择的其他项目，每年将减少 394 万吨二氧化碳的温室气体排放。

秘书处的建议

25. 执行委员会不妨：

(a) 注意到开发计划署关于中国在清华同方人工环境有限公司利用 HFC-32 技术制造小型商用气源冷却机/热泵示范项目的最后报告，该报告载于 UNEP/OzL.Pro/ExCom/72/11/Add1 号文件；和

(b) 请双边机构和执行机构在协助第 5 条国家就中小容量空调应用、包括小型商用气源冷却机/热泵淘汰 HCFC-22 方面准备项目时，考虑到关于从 HCFC-22 技术转型为 HFC-32 技术以制造小型商用气源冷却机/热泵的报告。

中国: 烟台冰轮股份有限公司从 HCFC-22 技术转型为氨/二氧化碳技术以制造应用于冷藏和冷冻的两级制冷系统的示范项目（开发计划署）

背景

26. 执行委员会第六十次会议核准中国烟台冰轮股份有限公司从 HCFC-22 技术转型为氨/二氧化碳技术以制造应用于冷藏和冷冻的两级制冷系统的示范项目[5]，由开发计划署执行。执行委员会第 71/16 号决定注意到关于该示范项目的临时报告，[6] 请开发计划署向第七十二次会议提交最后报告，但有一项谅解，该报告只载列关于增支经营成本的初步数据。开发计划署已将最后报告提交第七十二次会议，现在列为本文件的附件。

进展报告

27. 烟台冰轮股份有限公司的转型工作已经顺利完成。转型表明，温度较高侧用氨和温度较用二氧化碳的两级制冷系统是应用于大型冷藏和冷冻的 HCFC-22 技术的可行替代品。

28. 转型的生产线每年可以生产 100 台。这些系统的 HCFC-22 平均注入量是 205 吨。大型制冷系统的核心是螺杆压缩机。转型工作包括：设计三个压缩机用于压力较低侧的二氧化碳制冷剂，三个压缩机用于压力较高侧的氨。制冷系统必须既能适用于静止时的高压，也能适用于制冷剂循环时的低压。

29. 制造了大中小三种原型并进行测试和交付，制冷量为 1 兆瓦零下 55 摄氏度。除了转型活动，还举办技术人员培训活动，参加展览会以传播技术。生产线正在商业运行，增支经营成本将在下两年发放给烟台冰轮股份有限公司，金额视转型系统的出售数目而定。

30. 本项目于 2011 年 5 月中国政府与烟台冰轮股份有限公司签订合同时开始执行，于 2013 年 7 月通过国家验收后结束，执行时间共 26 个月。项目在执行时采用以效益为基础的付款机制，企业是转型项目的关键执行者，负责有关转型的所有活动。报告指出，中国政府和开发计划署不曾插手企业的采购活动，只在商定的付款日期和在实现里程表时分次付款给企业，以支付采购和转型费用。

31. 示范项目最初商定的增支资本费用预算是 307.8 万美元，部分资金由企业提供。增支资本费用的最终支出清单是 410 万美元，比最初预算多了 36%（增加费用由企业支付，比最初商定由

[5] UNEP/OzL.Pro/ExCom/60/24 号文件。
[6] UNEP/OzL.Pro/ExCom/71/6/Add.1 号文件。

企业承付的费用多了 321,000 美元）。主要费用项目包括：更改压缩机生产线（28%），生产原型（27%），更改产品功效测试仪器（22%），更改压力容器生产线（11%）。产品和加工重新设计占总费用的 8%，培训和技术传播占 5%。转型费用超过最初估计数主要原因是制造原型费用约 590,000 美元（比最初费用增加一倍多）。更改压缩机生产线使费用增加了 230,000 美元（比最初估计超出 21%）。其他增加的费用来自更改产品功效测试仪器（13%）和更改压力容器生产线（6.7%）。核准的预算只比开发计划署最初提出的预算少 8%，显示原来没有想到需要增加费用。

32. 该项目已经经过审核，转型的制造设施经认证符合安全规定。已经签订了交付约 60 台使用氨/二氧化碳技术制冷系统的合同。报告指出，该系统比现有 HCFC-22 系统提高能效 20%以上。同时，由于使用开放式压缩机而产生的 HCFC-22 严重泄漏的问题得到解决。

<u>秘书处的评论</u>

33. 秘书处要求提供关于以前制造的 HCFC-22 系统一般泄漏率的更多资料。秘书处根据所得资料估计，HCFC-22 系统每年总泄漏率是 13%，即 320 公克。

影响

34. 全球制造这样规模的系统的公司数目极为有限，秘书处预计将来很少会有这样子的项目出现。可是，通过转型将会彻底消除每年注入 250 公吨 HCFC-22 的问题。由于替代技术几乎不产生全球变暖潜能值，因此每年就避免了 441,000 吨二氧化碳温室气体的排放。而且，系统的能耗似乎减少了 20%，导致节能运行；如果这些系统全在中国运行，将导致在每年生产能源（100 个单位）时减少排放 50,000 吨二氧化碳。

35. 此外，该项目允许两级制冷系统技术，二氧化碳可以在低级阶段存在。这种系统也适合其他一些应用，例如较小型冷藏和冰冻系统与超级市场。项目表明，该系统可以主要由第 5 条国家研制和适用。

<u>秘书处的建议</u>

36. 执行委员会不妨：

(a) 注意到开发计划署提交的关于中国烟台冰轮股份有限公司从 HCFC-22 技术转型为氨/二氧化碳技术以制造应用于冷藏和冷冻的两级制冷系统的示范项目的最后报告，该报告载于 UNEP/OzL.Pro/ExCom/72/11/Add.1 号文件；和

(b) 请双边机构和执行机构在协助第 5 条国家就应用于冷藏和冷冻的两级制冷系统淘汰 HCFC-22 技术准备项目时，考虑到从 HCFC-22 技术转型为氨/二氧化碳技术以制造两级制冷系统的报告以及关于其他替代品的资料。

第六部分：　　中国哈龙、氟氯化碳生产和泡沫塑料行业计划的财务审计报告

37.　　世界银行按照第 71/12 号决定代表中国政府向第七十二次会议提出关于氟氯化碳生产行业、氟氯化碳聚氨酯泡沫塑料行业和哈龙行业的资金余额预算[7]。

氟氯化碳生产行业

38.　　表 1 显示氟氯化碳生产行业按照活动类别和计划完成日期分列的资金余额。

表 1. 中国氟氯化碳生产行业2009年后活动工作计划进展情况和资金分配 (美元)

编号	类别	供资	计划完成日期
1	征聘用于技术支持的国内和国际专家，安排关于消耗臭氧层物质替代品的技术讲习班，等等	365,505	2014 年
2	中国履约中心业务费用	2,996,831	已完成
3	消耗臭氧层物质进出口管理活动	455,900	2014 年
4	消耗臭氧层物质替代品的研究和开发	4,453,200	2016 年
5	监测和管理	224,604	2016 年
共计		8,496,040	

39.　　第 (1) 类包含各种活动，例如实施咨询、审计和培训讲习班，包括评估中国遵守《蒙特利尔议定书》的成就和环境效益，调查氟氯烃原料的使用情况，以及编写项目完成报告的咨询服务。

40.　　第 (2)类是发放给中国履约中心业务费用的资金总额。

41.　　第 (3)类是在消耗臭氧层物质进出口管理办公室和海关办公室之间建立专用光学数据传输系统，进一步提高消耗臭氧层物质进出口管理能力。这项资金大约已经发放了 90%。

42.　　第(4)类实施关于低全球升温潜能值的消耗臭氧层物质替代品的支持研究和开发方案。选择了九个提案来支持研究和开发活动。

43.　　第(5)类是分配给监测和管理活动的资金，包括咨询、培训、评价和 核查。

中国氟氯化碳聚氨酯泡沫塑料行业

44.　　表 2 显示氟氯化碳聚氨酯泡沫塑料行业按照类别和计划完成日期分列的资金余额。

[7] 执行委员会决定请中国政府提供：（一）通过世界银行给第七十二次会议一份报告，说明为什么 2012 年审计报告的余额高于第五十六次和五十七次会议核准的哈龙和聚氨酯泡沫行业的预算，以及关于解决提交给第六十五次会议的核查报告所述法律问题的资料，说明按照第 65/10（一）、（二）号决定的要求运送回收的哈龙到哈龙库以供回收和再循环的情况；（二）通过有关执行机构，在今后按照第 56/13 号决定提交财务审计报告时列出关于中国政府持有准备发放给最终受益人的多边基金所有资金的数据，以及中国政府所持余额的应计利息，包括加工剂二行业计划、溶剂行业计划和制冷维修计划的数据；（三）关于行业计划工作计划进展情况的综合资料以及关于如何使用可能的余额的提案，供执行委员会第七十二次行业审议。

表 2. 中国氟氯化碳聚氨酯泡沫塑料行业2009年后活动的工作计划进展情况和资金分配 (千美元)

编号.	类别	供资	计划完成日期
1	筛选和评估无氟氯化碳的替代品，开发新替代品	2,660,000	2016 年
2	其他省一级泡沫塑料活动 (建设地方当局的能力)	3,100,000	2016 年
3	提供给泡沫塑料企业技术服务，以便更好地应用新替代品	1,400,000	2015 年
4	继续监测泡沫塑料行业的氟氯化碳淘汰活动	1,050,000	2016 年
5	其他技术援助活动	713,000	2016 年
共计		8,923,000	

45. 2009 年年度报告载列 680 万美元的余额。世界银行解释说，这是一个估计数，因为一些公司在执行前关闭，所以余额增加到 892.3 万美元；现在正在执行一些被推迟的技术援助活动。

46. 第 (1) 类活动包括十个项目，分属两类研究： 1) 开发低成本泡沫塑料发泡剂，具有零 ODP 和低全球升温潜能值，符合泡沫塑料隔温性能标准；和 2) 研究含替代发泡剂的预混多元醇配方，以优化多元醇的稳定性和性能，提高泡沫塑料的热传导率

47. 第 (2)类收集从执行聚氨酯泡沫塑料行业的氟氯化碳淘汰活动取得的成功和经验，分发给利益攸关方，帮助地方当局建设能力，包括讲习班、培训、宣传活动、数据收集和监督。

48. 第 (3) 类将资助一些配方厂家的合同，为最佳做法提供技术服务，以应用泡沫塑料企业使用的新替代品。

49. 第 (4) 类是对外经济合作处支持作为大多数泡沫塑料公司和配方厂家所在地的湖北、河南、山东和天津四个关键省市，让它们参观化工经销商、配方厂家和和泡沫塑料企业。以收集发泡剂、预混多元醇和最终泡沫塑料制品的样品，并检查各企业在各自省市使用的原材料。

50. 第 (5) 类活动提供资金对项目执行、培训会议、宣传活动、核查活动、项目评价和项目投产进行监测。

哈龙行业计划

51. 表 3 显示中国哈龙行业计划按照类别和计划完成日期分列的资金余额。

表 3. 中国哈龙行业计划2007年后活动的工作计划进展情况和资金分配 (美元)

编号	活动		预算
1	哈龙库活动	哈龙 1211 的库存维持和泄漏防止	1,500,000
		哈龙库管理中心的成立和运作	1,000,000
		哈龙-1301 再循环中心的成立和能力建设	1,000,000
		哈龙-1211 再循环示范中心的更新和改进	300,000
		哈龙库信息系统的发展和管理	300,000
		库存调查和全国哈龙用户登记	2,000,000
		收集、运输、再循环和再生的经营成本	2,000,000
		哈龙污染物和残留物的处置费用	1,456,397
		小计	9,256,397
2	关于哈龙库的技术援助和可持续淘汰		1,403,888
3	中国履约的能力建设	建立总体消耗臭氧层物质管理信息系统	500,000
		监督和管理包括培训和讲习班等活动的能力建设.	700,000
共计			**11,860,285**

52. 中国政府没有进一步说明哈龙行业计划的预算类别或每项活动的完成日期，只表示由于“任务的性质复杂，可能必须继续到 2015 年以后”。

<u>秘书处的评论</u>

关于加工剂二、溶剂和氟氯化碳制冷维修行业的数据

53. 2014 年 2 月在蒙特利尔召开机构间协调会议时，秘书处讨论了第 71/12 号决定，提供了一份让各机构在答复时使用的格式。秘书处还发出要求和催问信，请所有执行机构提交关于加工剂二（世界银行）、溶剂（开发计划署）和氟氯化碳维修行业（工发组织、环境规划署和日本）的资料。各机构表示，中国将向第七十三次行业提出答复。

提交第七十次和七十一次会议的氟氯化碳生产、氟氯化碳聚氨酯泡沫塑料和哈龙行业的财务审计报告

54. 秘书处要求在提交第七十次会议的财务审计报告中就四个主要专题提供资料。但在提交给该次会议和第七十一次会议的报告中都没有看到答复。

55. 2014 年 3 月 18 日，秘书处通过世界银行就中国政府的申请提出关于氟氯化碳生产、氟氯化碳聚氨酯泡沫塑料和哈龙行业的 27 个问题要求澄清。截至 2014 年 4 月 14 日，没有看到任何答复。

利息

56. 秘书处注意到，文件中没有提供关于利息的资料。

氟氯化碳生产

57. 关于氟氯化碳生产行业的资料显示，已经发放了一些资金，但没有表明对所有预算项目发放了什么资金。曾经要求按照合同提供用于研究和开发的 440 万美元的资料。对于这项资金应该进一步说明它在所签订合同中的用途以及它与氟氯化碳生产行业的替代品或与消费行业有什么关系。而且，秘书处希望知道，这项研究和开发与另外合同所述的氟氯烃有什么关系。

58. 还要求提供分配给监测和管理活动的资料，以及提供相关项目的完成日期，以便进行监测。

泡沫塑料行业

59. 表 2 中的预算分配到多少资金也不清楚；因此，秘书处要求中国提供截至 2013 年年底的结余。

60. 中国的报告曾经指出，2009 年 的余额是 680 万美元，但报告的实际余额是 892.3 万，因为一些“受益”公司在设施转型前关闭。秘书处希望知道，这一笔 212.3 万美元为什么没有退还给基金。秘书处还询问个别合同的价值和目的，总额达 266 万美元。

61. 关于开发替代发泡剂，秘书处询问这些项目与执行委员会已经核准的、特别关系到 HCFC-141b 发泡剂（包括碳氢化合物预混多元醇）替代配方的稳定性和性能的项目的区别何在。秘书处想知道，由多边基金付款的这些研究和开发成果如何散发给其他各方。秘书处也要求提供资料，说明这些计划的活动与聚氨酯和/或挤塑聚苯乙烯氟氯烃淘汰行业计划的关系。

62. 鉴于此项资金是在淘汰后四年才提出申请，请说明必须为地方当局建设能力的理由。而且，不清楚为什么对无氟氯化碳发泡剂的使用进行检查是淘汰后的增量成本。

63. 秘书处关注资金将用来支持配方厂家，希望知道这将对氟氯烃消费量产生什么影响。

64. 秘书处又询问以前的监测费用，以便评估每年 105 万美元的分配款项。同样也询问以前的监测费用，以便了解分配给培训、宣传、核查、项目评价和项目投产的 71.3 万美元是否合理。

哈龙行业

65. 对于哈龙行业，委员会连续三次会议要求提供资料，说明在现行法规下运输受污染的和未回收的哈龙的情况。如果没有能力运输使用过的哈龙，就不可能回收哈龙。文件指出，2007 年建立了哈龙库，但不清楚自 2007 年以来进行了什么活动。秘书处还想知道，自第七十一次会议以来有哪些活动。

66. 关于计划的活动，秘书处要求提供每一活动的完成日期，就像以前就氟氯化碳生产行业和氟氯化碳聚氨酯泡沫塑料行业的不同类别提供的那样。

67. 要求进一步说明以下的费用项目：库存维持和泄漏防止（150 万美元），收集和运输哈龙（200 万美元），建立哈龙库中心（100 万美元），能力建设（70 万美元），更新示范中心（30 万美元）。关于哈龙库存用户的费用（200 万美元），秘书处指出，通过对行业计划项目准备的调查，发现这是重复计算，请说明是否有其他理由。

68. 还要求提供关于处理哈龙费用（150 万美元）的资料。也请说明，为什么管理信息系统有两项费用（30 万美元和 70 万美元），而且参考中国关于其他消耗臭氧层物质的管理信息系统，请说明为什么需要这样数额的资金。

结论

69. 中国政府没有通过世界银行提供秘书处要求的资料，因此秘书处无法评估要如何使用中国氟氯化碳、哈龙和四氯化碳淘汰的余款。执行委员会不妨审议，如果没有收到所要求的任何澄清，是否应该在 2014 年年底关闭这些账户，向 2015 年的第一次会议提出项目完成报告。执行委员会还不妨要求提交关于加工剂二、溶剂和氟氯化碳制冷行业的 2010、2011、2012 和 2013 年财务审计报告，以便在 2014 年年底要求退回未使用的余额，并向 2015 年第一次会议提出项目完成报告。

秘书处的建议

70. 执行委员会不妨;

(a) 注意到中国政府按照第 71/12 号决定通过世界银行提交的关于哈龙、氟氯化碳生产和泡沫塑料行业计划的财务审计报告，该报告载于 UNEP/OzL.Pro/ExCom/72/11/Add.1 号文件；

(b) 决定：

(i) 关闭氟氯化碳生产、哈龙、氟氯化碳聚氨酯泡沫塑料和哈龙行业计划，要求退回这些行业计划在 2014 年年底的余额，并向 2015 年 第一次会议提出项目完成报告；和

(ii) 要求向第七十三次会议提出关于加工剂二、溶剂和氟氯化碳制冷行业的 2010、2011、2012 和 2013 年财务审计报告，要求退回这些行业计划在 2014 年年底的余额，并向 2015 年 第一次会议提出项目完成报告。

第七部分: 菲律宾国家氟氯化碳淘汰管理计划（财务报告）

背景

71. 执行委员会第七十一次会议审议了国家氟氯化碳淘汰计划剩余部分的执行报告，考虑到先前对本项目做出的决定，并决定请环境规划署向第七十二次会议提出关于国家氟氯化碳淘汰计划到 2013 年 12 月 31 日的财务报告，将剩余款项退回多边基金（第 71/18（b）号决定）。本报告就是根据该决定提出。环境规划署代表菲律宾政府提交本财务报告。

秘书处的评论

72. 财务报告显示，到 2013 年 12 月有余额 275,987.53 美元；承付款共 260,575.90 美元，预计到 2014 年 5 月完全发放；估计余额 15,411.63 美元将退回多边基金。

73. 秘书处在审查支出报告和承付款时要求澄清以下几点：

(a) 该财务报告是菲律宾政府认可的国家氟氯化碳淘汰计划的正式最后财务报告，或只是反映环境规划署的财务报告要求；

(b) 说明工作人员费用必须延长到 2014 年 5 月的理由；

(c) 说明在预算项目之间重新分配确定的余额的理由；

(d) 说明将只在 2014 年付出大批承付款的理由；和

(e) 确认国家氟氯化碳淘汰计划的活动是否到 2013 年 12 月完成，而剩余的承付款是这些已完成活动的拖欠付款。

74. 环境规划署在答复时说明，财务报告是项目管理股按照环境规划署的财务报告要求编写，是根据支出估计数作出的指示性报告。国家氟氯化碳淘汰计划的正式财务审计目前正在进行，预计到 2014 年 5 月完成。届时项目的实际结余就会知道，并开始退回多边基金的程序。

75. 环境规划署还澄清，政府要求延长项目管理股工作人员的任务，特别是与财务有关的人员，目的是协助关闭账目和账户的工作。

76. 关于重新分配款项到别的预算项目，环境规划署澄清，菲律宾政府认识到执行委员会决定到 2013 年 12 月底结束项目，于是决定把款项用来购买维修设备，分发到遭受海燕台风灾害的地区的服务店。这些设备是在 12 月底以前订购，由环境与自然资源部区域办事处确认使用的对象。

77. 关于有义务支付/承诺支付的大批款项，环境规划署表示，这些财务义务是在 2013 年 12 月之前作出。延迟付款的主要原因是 2013 年的货物和服务（讲习班/培训费用）的发票来迟了。环境规划署确认，已经审查了证明文件，认为这些财务责任符合规定。此外，环境规划署说明，这些责任符合政府的会计规则和条例。

78. 秘书处鼓励环境规划署及时完成项目的财务审计，一旦审计完成就向秘书处提交审计副本。

<u>秘书处的建议</u>

79. 执行委员会不妨：

(a) 注意到环境规划署提交的菲律宾国家氟氯化碳淘汰计划的工作计划到 2013 年 12 月的支出财务报告，该报告载于 UNEP/OzL.Pro/ExCom/72/11/Add.1；

(b) 核准把项目管理股工作人员及其相关业务费用的任务从 2014 年 1 月延长到 2014 年 5 月的要求，为此目的的累计支出不得超过 31,000 美元；

(c) 要求：

(一) 菲律宾政府通过环境规划署至迟在 2014 年 6 月前提交由一个独立的或政府认可的审计师正式签署的正式财务审计报告；

(二) 环境规划署确保在第七十三次会议之前根据审计报告把未用余额退回多边基金；和

(三) 菲律宾政府和环境规划署把项目完成报告提交给执行委员会 2015 年第一次会议。

第八部分: 尼日利亚氟氯烃淘汰管理计划(第一阶段，第三次付款) (制冷行业泡沫塑料制造企业转型的执行计划)

背景

80. 执行委员会第六十二次会议核准了尼日利亚的氟氯烃淘汰管理计划第一阶段。根据执行委员会与尼日利亚政府签订的协定和氟氯烃淘汰管理计划的整体执行计划，由工发组织执行的 109 家制冷泡沫塑料企业的转型打算淘汰 310.2 公吨 (34.12 ODP 吨) 的 HCFC-141b，把发泡作业转型为甲酸甲酯预配制系统，增支成本为 1,759,080 美元。通过在 2012-2013 年执行了氟氯烃淘汰管理计划第一和第二次付款，工发组织向 30 个受益者援助聚氨酯低压发泡注塑机，共淘汰 86.35 公吨 (9.50 ODP 吨) HCFC-141b 消费量。不过，工发组织在第二次付款的进展情况报告和第三次付款的执行计划中表示，核准给该行业的资金不足以淘汰原来计划的全部 310.2 公吨 HCFC-141b 的消费量，因此建议只援助某些企业。

81. 秘书处建议工发组织调整战略，选择更具成本效益的方法和适当的技术，援助所有符合资格的企业。工发组织咨询尼日利亚政府后提议，向 46 家消费量超过 2.2 公吨的企业提供低压发泡机，向较小型的企业提供技术援助，包括培训如何使用甲酸甲酯基配方、个人防护装备和增支经营成本。这样的做法使得项目的组成部分覆盖所有受益企业，并实现原来的淘汰计划。据此，执行委员会第七十一次会议核准了尼日利亚氟氯烃淘汰管理计划的第三次付款，请工发组织至迟在 2014 年 2 月 15 日之前提出制冷行业泡沫塑料制造企业转型的执行计划，相关消费量 310.2 公吨 HCFC-141b，包括提供覆盖的企业的资料、资金的分配、要进行的活动和时间表（第 71/30 号决定）。

情况报告

82. 工发组织提交的执行计划确认，45 家企业在第三次付款期间接受援助，总消费量 130.15 公吨 (14.32 ODP 吨) HCFC-141b，费用 645,172 美元，成本效益为每千克 4.96 美元。经修订的计划于 2014 年 1 月开始执行。设备已经开始购买，出价正在评估。预计设备将于 2014 年 7 月交付，2014 年 8 月进行安装、试运行、培训和投产。

83. 该计划还指出，对小型企业提供技术援助以解决剩余的 93.7 公吨 HCFC-141b 计划在第四次付款时进行，提供资金 193,908 美元。将提供培训和个人防护装备。

秘书处的建议

84. 基金秘书处建议执行委员会注意到工发组织提交的尼日利亚制冷行业泡沫塑料制造企业转型的执行计划，该计划载于 UNEP/OzL.Pro/ExCom/72/11/Add.1。

第九部分: 伊朗伊斯兰共和国执行国家氟氯化碳淘汰计划：政策和监管组成部分

85. 2004 年 9 月，环境规划署与伊朗伊斯兰共和国签订金额为 100,000 美元的谅解备忘录，以执行关于“执行国家氟氯化碳淘汰计划：政策和监管组成部分”的项目(IRA/PHA/41/TAS/161)。环境规划署转移给伊朗伊斯兰共和国 90,000 美元，但受援政府迄今只说明了 30,000 美元的用途。

自 2008 年 9 月以来，环境规划署一直定期地跟踪政府，在访问该国时以及在区域/全球会议的间隙递交正式信件和与政府官员讨论，要求说明 60,000 美元的用途。

秘书处的评论

86. 环境规划署的报告指出，2014 年 3 月 2 日在德黑兰与伊朗伊斯兰共和国就氟氯烃淘汰管理计划举行会议，环境规划署和国家臭氧机构在会议期间通知开发计划署、工发组织和德国政府（双边合作），将就此问题要求更新报告，并由环境规划署采取措施，避免今后出现类似情况。国家臭氧机构正与政府其他部门协商，找出今后的道路。环境规划署为了防止氟氯烃淘汰管理计划出现类似情况，已要求设立政府的专门银行账户，用来转移今后执行活动的资金。除了伊朗伊斯兰共和国的情况，环境规划署也采取以下一般性措施来减少再次出现这种情况的风险：

(a) 2008 年以后，环境规划署对每一次付款都提出额外财务报告；

(b) 到 2014 年， 与政府和其他伙伴签订执行活动的新法律协定，预付现金用于六个月的活动。随后的付款要在收到可接受的财务报表和进度报告证明取得必要执行进度之后才会发放；和

(c) 直到完全符合现行协定的条件并顺利完成活动，才会与政府签订新的协定。

秘书处的建议

87. 执行委员会不妨请环境规划署向第七十三次会议提出情况报告，说明与伊朗伊斯兰共和国政府讨论执行国家氟氯化碳淘汰计划：政策和监管组成部分 60,000 美元用途不明一事的情况。

DEMONSTRATION PROJECT FOR HFC-32 TECHNOLOGY IN THE MANUFACTURE OF SMALL-SIZED COMMERCIAL AIR-SOURCE CHILLERS/HEAT PUMPS AT TSINGHUA TONG FANG ARTIFICIAL ENVIRONMENT CO., LTD.

FINAL REPORT

March, 2014

Executive Summary

Demonstration project for HFC-32 technology in the manufacture of small-sized commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co., Ltd. was approved by the 60th Executive Committee meeting at a funding level of US$1,229,336.

This demonstration project was successfully implemented, and established the suitability of HFC-32 technology as a viable replacement for HCFC-22 as a refrigerant in the manufacture of commercial air-source chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd.

The project activities includes product redesign and development, manufacturing equipment modifications and additional equipment, safety and other measures to handle the flammability and high discharge temperatures of HFC-32, laboratory testing and performance evaluation, product trials, prototype testing, production line conversion, technical assistance and training.

The successful completion of the demonstration project contributes towards promotion of this technology for unitary and multi-connected commercial air conditioning and heat pump equipment and enables cost-effective conversions at other similar manufacturers in this sub-sector.

1. Introduction

In 2007, the 19th Meeting of Parties of the Montreal Protocol agreed on accelerated phase-out of HCFCs. To achieve the compliance goal, China is implementing HCFCs phase-out sector plans in Industrial & Commercial Refrigeration and Air-conditioning (ICR) sector from 2012. The Tong fang project was established as a demonstration earlier in 2010 for preparation and support of the sector plan implementation.

The Executive Committee approved the Tong fang demonstration project in the 60th meeting in 2010 at a funding level of US $ 1,229,336. The project's implementing agency is UNDP. The national agency implementing this project is Foreign Economic Cooperation Office (FECO), Ministry Of Environmental Protection, China.

The objective of this demonstration project is to establish the suitability of HFC-32 technology as a viable replacement for HCFC-22 as a refrigerant in the manufacture of small-sized commercial air-source water chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd.

As a result of the conversion project, about 61.9 tons of HCFC consumption will be phased out, reducing greenhouse gas emission by 170,000 tons CO2 eq.

1.1 Background

The Industrial and Commercial Refrigeration and Air Conditioning (ICR) Sector in China has experienced remarkable growth in the past two decades, averaging at about 12% annually, due to the steep growth in the demand for consumer, commercial and industrial products, resulting from rapid overall economic development. This sector includes several sub-sectors, namely: compressors, condensing units, small-sized air-source chillers/heat pumps, commercial and industrial chillers/heat pumps, heat pump water heaters, unitary commercial air conditioners, multi-connected commercial air conditioners, commercial and industrial refrigeration and freezing equipment, mobile refrigeration and air conditioning equipment and refrigeration and air conditioning components and parts. The 2008 estimated HCFC consumption in the sector based on field surveys was about 42,000 metric tonnes.

Small-sized commercial air-source chillers/heat pumps are typically used in commercial establishments such as hotels, restaurants, shops and offices, both for cooling and heating, with low energy consumption and no water use. The self-contained design requires no separate plant or machine room. With the current emphasis on energy conservation and environment protection, the market for these products experiences rapid growth. Based on data from field surveys, the production of such small-sized air-source chillers/heat pumps in 2008 in China was about 110,000 units, with a total HCFC-22 consumption of about 1,200 metric tonnes in about 12-15 enterprises.

Tsinghua Tong Fang Artificial Environment Co. Ltd. was established in 1989 and is located in Zhongguancun Science and Technology Zone, Beijing. The enterprise is a state-owned company, specializing in research and development, manufacturing and sale of the environmental products and systems. In the air conditioning field, the company actively carries out research and development of environmental control products, green construction, energy efficiency in buildings and renewable energy technologies. The enterprise employs 554 persons, which includes 84 managerial staff and 81 technical and research staff. The enterprise has five national product inspection centers, laying the foundation for sound research and development in this field.

Tsinghua Tong Fang Artificial Environment Co. Ltd. is the national leader in heat pump technology. The enterprise comprises a unique amalgam of industry, academia and research, and is abreast of the latest scientific progress on technology and environment.

Tsinghua Tong Fang Artificial Environment Co. Ltd. currently manufactures a range of heating and cooling products, with production capacity valued at about US$ 3 billion and manufactured on six production lines for various products as tabulated below:

Production Line	Products	Refrigeration Capacity	Installed Capacity	Actual production	Average refrigerant charge (kg)	HCFC-22 consumption (2009-tonnes)	Application
Water/ground source heat pumps/chillers	Water-source heat pumps	150 - 3000 kW	700 units	227	90	26.9	Heating/cooling in large buildings such as offices, malls, hotels
	Ground-source heat pumps	120 - 3000 kW		29	75		
	Chillers	400 - 2000 kW		54	80		
Large air-source heat pump/chillers	Screw	260 - 500 kW	700 units	34	75	2.55	
Medium air-source heat pump/chillers	Scroll	60 - 200 kW	1500 units	399	40	15.96	Heating/cooling in medium-sized buildings
Small air-source heat pump/chillers	Scroll	10 - 60 kW	5000 units	4073	15.2	61.9	Heating/cooling in small commercial spaces up to 1000 sqm
Air handling units	Central station air handling units	2000 to 20000 cum/hr	5000 units	NA	NA	NA	Large and medium sized buildings
Fan coil units	Various sizes	340 - 2380 cum/hr	5000 units	NA	NA	NA	Small buildings and individual spaces
Total						**107.31**	

Of these, one production line with a capacity of 5,000 units annually (as highlighted above) is for manufacturing small-sized commercial air-source chillers/heat pumps in the range of 10 to 60 kW. This production line was installed in 1999. The total production in 2009 was 4,073 units, with HCFC-22 consumption of 61.9 metric tonnes at an average HCFC-22 charge of 15.2 kg per unit. These units are manufactured in three models/configurations as below:

	60kW	30kW	13 kW
Unit Configuration			
HCFC-22 charge (kg)	24	12	5.1

This product range (small-sized air-source heat pump/chillers) has been selected for this project considering the relative small amount of refrigerant charge volumes, allowing flexibility for selection of alternative technologies.

1.2 Technical Choice

Some of the zero-ODP alternatives to HCFC-22 currently available for this application are listed below:

Substance	GWP	Application	Remark
Ammonia	0	Industrial refrigeration and process chillers	Flammability and toxicity issues. Material compatibility issues. Regulatory issues.
CO_2	1	Supermarket refrigeration in a secondary loop and in stationary and mobile air conditioning systems	Major redesign of system components needed. Investment costs are prohibitive
Hydrocarbons	<15	Small-capacity domestic and commercial refrigeration equipment	Flammability issues. Not widely used in large capacity systems
R-32	675	Small and medium-capacity commercial refrigeration and air conditioning applications	Single component refrigerant. Mildly flammable. Higher working pressures than HCFC-22. Higher refrigeration capacity per unit charge. Main component of R-410A
R-134a	1,300	Domestic, commercial refrigeration medium-temperature applications	Not efficient in low-temperature systems and industrial refrigeration applications. Needs synthetic lubricants
R-407C	1,520	Most air conditioning applications	Properties closely match R22. Temperature glide, synthetic lubricants needed, slightly less efficient than R22. Non-azeotropic mixture creates issues.
R-410A	1,710	Most air conditioning applications	Near azeotropic blend of R-32 and R-125. Higher pressures, better cooling capacity, low temperature glide, high GWP, synthetic lubricants needed
R-404A	3,260	Low temperature applications	High GWP, less efficient at medium temperatures, synthetic lubricants needed
R-507	3,900	Low temperature applications	Azeotropic non-flammable blend of HFC-125 and HFC-143a. Refrigerating capacity comparable to R-502. Good heat transfer characteristics at low temperatures

Tsinghua Tong Fang Artificial Environment Co. Ltd. carefully considered and applied the multiple factors and concluded that R-32 technology is most suited for application to its heat pump products, due to its expected technical performance and significant potential benefit with respect to global warming impact as compared to HCFC-22 (i.e., direct impact through adoption of low-GWP substance compared to HCFC-22 and indirect impact due to potential energy efficiency gains through system improvements). In addition, the enterprise had also carefully studied the international regulatory and market scenario, and noted that R-32 may potentially have wide acceptability in this particular market segment.

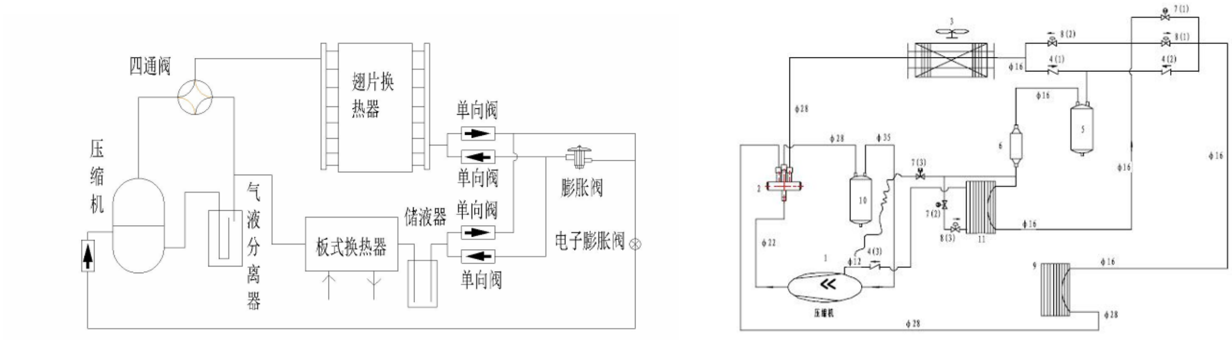
2. Project Implementation

The project was approved by 60th Executive Committee meeting in 2010 at a funding of US $ 1,229,336. The project implementation started at 2011, the conversion project was completed by the end of 2012, and all the progress milestones required were reached and verified by the end of 2012. The project successfully passed national acceptance in December, 2013.

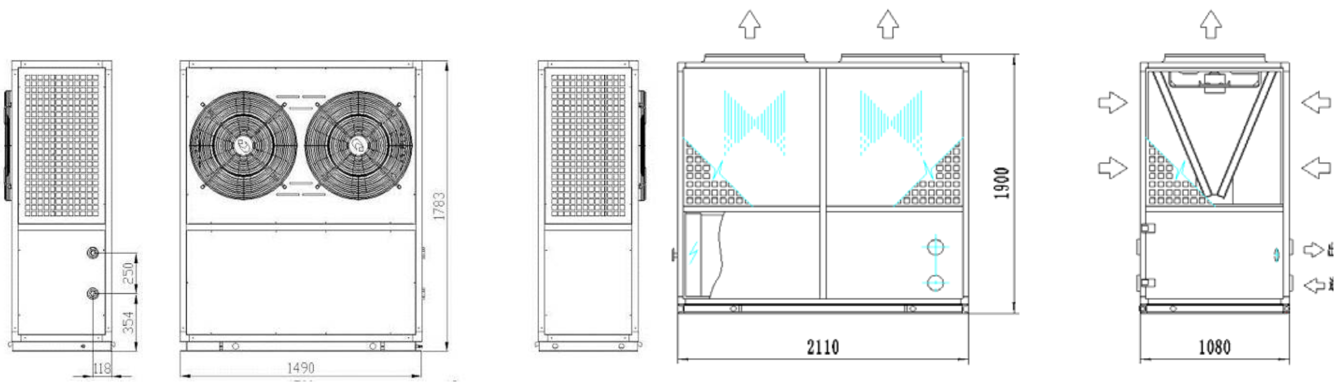
According to the project implementation plan, the following activities were carried out: Product and process redesign, Conversion of production lines, Prototype production trails and testing, and Processing and safety training, etc.

2.1 System, Components and Process Redesign

Three models (60kW, 30kW and 13 kW) of R32 systems redesign was completed in 2011, The redesign work included design and calculations, simulation and control software, remodeling of the compressors, expansion valves, finned tube heat exchanger, water-side heat exchanger, unit structure, electrical systems, prototype manufacturing, test runs, compilation of production process, blueprint and complete bill of materials. Two kinds of design proposal was designed, one is liquid injecting cooling, and the other is air-supplying enthalpy-adding The redesign program passed evaluation of sector experts' team in October 21.



Liquid injecting cooling program and air-supplying enthalpy-adding program



Structure design

2.2 Conversion of the Production Line

The production line conversion is composed of Heat Exchanger Processing, Sheet Metal Processing, Product Assembly, and Quality inspection, testing and finishing, etc. the whole conversion was completed by the end of 2012.

2.2.1 Heat Exchanger Processing

Due to the lower charge and higher pressure with HFC-32, the finned tube diameter was reduced from 9.52 mm to 7 mm. Accordingly the finned tube punch dies and tube expander changed either. The tube straightening/bending machine (fin threading) was modified. A new brazing line for the heat exchanger suited for HFC-32 was introduced. Since HFC-32 is flammable, the grease left on the heat exchanger was removed for fire safety. For this, degreasing and dehydrating equipment was introduced.

Φ7 vertical tube expanding machine

Φ7 tube bending machine

2.2.2 Sheet Metal Processing

The sheet metal processing dies changed, including dies for end-plate hole punching and dies for end-plate rim bending and dies for rim bending.

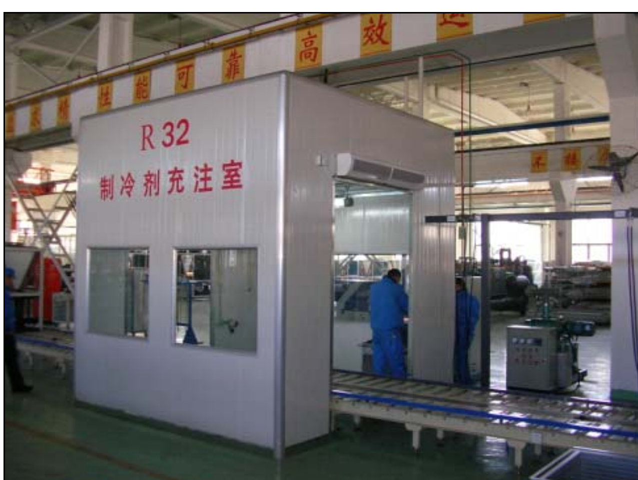
Die for end-plate hole-punching

Die for end-plate rim-bending

Die for rim-bending

2.2.3 Product Assembly

Due to the flammability of HFC-32, the charging area was isolated, with adequate ventilation, fire safety and alarm systems and explosion-proof fittings. The existing Halogen leak detectors cannot be used with HFC-32, because it contains no Halogen. Therefore Helium leak detectors were introduced.



R32 charging room

R32 units assembly line

Helium leak detector

Helium refrigerant recovery machine

Roots vacuum pump

R32 charging machines

2.2.4 Quality inspection, testing and finishing

The safety inspection of electrical systems was enhanced by introducing appropriately sensitive devices with protective features. The inspection area was isolated with adequate ventilation, fire-safety and alarm systems and explosion-proof fittings. The existing test rig for HCFC-22 based products can be used with R32, and it modified such as test room ventilation and fire-safety, high-pressure sensor and sensor for monitoring HFC-32 concentration levels.

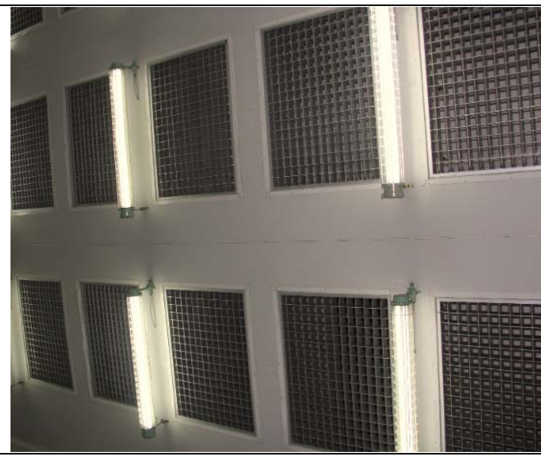
Assembly line inspection modification:

R32 products operating testing room

Testing equipment for electronic safety performance

Testing room modification:

Electric explosion-proof cabinet



Explosion-proof lamps

Explosion-proof exhaust fans

Explosion-proof motor

	
Explosion-proof pressure sensors	**Explosion-proof RH testers**

2.3 Prototype production trials and testing

A pilot-level quantity of the selected models was subjected to prototype production, trials and testing to establish the process and fine-tune as needed and establish product performance through testing.
Three types of HFC-32 air-source chiller/heat pumps including 13kW, 30kW and 60kW were built in 2011.



13kW **30kW** **60kW**

The prototypes were tested by Tong Fang in 2011 and tested by third party test institution (Hefei General Machinery & Electrical Products Inspection Institute) in Feb 2012. The results of the test were qualified.

2.4 Process and safety training

Process and safety training were provided to the manufacturing, installation and maintenance personnel. It was verified that the internal technical acceptance were completed and technical commissioning and relevant personnel training were finished.

Tong fang Co. has organized 37 times of technical commission and personnel trainings under this project. Totally 23,202.5 class hours training were taken and 1454 persons/times were trained.


2.5 Management

The project was under the overall management and coordination of the Foreign Economic Cooperation Office, Ministry of Environment Protection of China. UNDP was the implementing agency for the project, which provided international coordination and technical assistance.

The project employs the Performance-based Payment (PBP) mechanism in its implementation. Under the PBP mechanism, the enterprise tasked to carry out the conversion would play the role as a key executer, which is responsible for all the activities related to the conversion. The procurement was organized fully in line with the marketing principle ensuring cost-effective and timely installation of equipment for R-32 based manufacturing operations.

FECO and UNDP were not involved in the procurement activities of the enterprise by any means other than make payment to the enterprise in tranches for the costs of procurement and conversion, at agreed payment dates given in the payment schedule, and when milestones prerequisite for the tranche have all been achieved on time.

Before each payment, FECO invited independent experts to verify whether the performance for each milestone that the payment depends on have been satisfying. The verification reports were submitted and accepted by UNDP as the main supporting documents for requesting the installment of payment.

During the projects implementation, FECO and UNDP organized 4 verification missions combined with monitoring and evaluation at Tong Fang factory - once in 2011 and thrice in 2012. The experts group included technology experts and finance experts, FECO staff and UNDP staff as well. The experts team traced the project implementation situations, evaluated the project technical issues and progress, and verified whether the performance for each milestone that the payment depends on have been satisfying. Each verification activity was carried out in a process of planning, preparation, data confirmation, technical material checking, on-the-spot investigation, result confirmation and conclusion.

3. Outcomes

The project has been completed and has successfully passed national acceptance in December 2013. The production line is commercial running, and the IOC will be disbursed to enterprise in the next 2 years according to new products sales quantity. The suitability of HFC-32 technology as a viable replacement for HCFC-22 as a refrigerant in the manufacture of small-sized commercial air-source water chillers/heat pumps at Tsinghua Tong Fang Artificial Environment Co. Ltd. was established

The following are the salient outcomes of the project.

- The enterprise completed the redesign of system, components and production process in 2011.
- The performance test rig was modified to meet the requirements of testing products with flammable refrigerants in 2011.
- The prototypes were manufactured, tested and adjusted in 2011.
- Training, technology communication, and advertisement were finished in 2012.
- Equipment for modification of heat exchanger and sheet metal processing was procured in 2012.
- Product assembly line and testing facilities converted and verified in 2012.
- Technical commissioning was completed successfully and relevant personnel were trained in 2012.
- The project successfully passed national acceptance in December 2013

4. Technical performance

- R-32 has ODP of 0.
- R-32 has GWP of 675, about a third of that of R-410A.
- R-32 is a mature refrigerant with a large knowledge base on its properties.
- R-32 is produced domestically and has assured commercial availability as reasonable prices.
- R-32 is a single substance with good heat transfer capacity, volumetric refrigerating capacity and theoretical energy efficiency.
- For the same refrigeration capacity, the charge quantity for R-32 is 60-80% of that of R-22 depending on the application.
- The actual efficiency of R32 system in this project is 3%-5% higher than former R22 system, and the performance efficiency will grow along with optimizing in deeper application and promotion of compressors and other accessories.
- The cost of system is over 20% than R22 system, but the cost will reduce along with large-scale applications of R32.
- The R32 compressors of this project were supplied by several compressor companies in China. The compressors were redesigned and modified based on R410A, and the performance has potential to be

promoted.

5. Project management and monitoring

5.1 Project progress

The project was implementing smoothly according to the program schedule, and was completed by the end of 2012. It successfully passed national acceptance in December 2013. The capacity of the production line has been converted to use substitute refrigerants and is capable of manufacture the converted products.

Each of milestones was achieved and verified, the details are as follows:

Milestones		Status
1st	Signing of the contract	FECO and the enterprise signed contract in January 2011
2nd	Completion of designs of products and pass the evaluation of experts	Finished in October 2012
3rd	Completion of the test facilities	Finished and verified in April 2012
4th	Prototypes are built and tested	
5th	Completion of conversion heat exchanger and metal plate process	Finished and verified in December 2012
6th	Assembly line and delivery inspection process are completed	
7th	Technical commissioning completed successfully and relevant personnel trained	Finished and verified in December 2012

5.2 Conversion cost

Total Project Costs

The total contract amount with the enterprise is US$ 1,122,870, including ICC US$ 733,530, and IOC US$ 389,340.

Incremental Capital Costs

The actual incremental capital costs for conversion was US$ 830,344.71, among which US$ 733,530 was funded by the MLF, and the US$ 96,814.71 was co-financed by the enterprise.

The details of ICC are as follows:

No	Cost Head		Actual cost (US$)
1	**System, component and process redesign**		
	Redesign	Product redesign	21,313.82
	Software	Outsourced simulation and control software	13,071.90
		sub-total	**34,385.72**
2	**Prototype testing**		
	Prototype materials	Cost of materials/process for 3 prototypes	34,596.34
	Testing	Third party laboratory testing	17,017.72
		sub-total	**51,614.06**
3	**Production line conversion-**		
	Heat exchanger processing	Dies for 7 mm diameter tubes	80,065.36
		Modification of tube bending machine	5,538.24
		New vertical tube expanding machine	208,428.10
		Degreasing furnace	-

	Sheet Metal Processing	Die for end-plate hole-punching	1,895.42
		Die for end-plate rim-bending	561.27
		Die for rim-bending	2,941.18
	Product Assembly	Suction gun Helium leak detector	74,017.65
		Charging room isolation/fire protection	84,542.11
		Two R-32 concentration sensors	56,045.75
		R-32 automatic charging machine	70,261.44
		Refrigerant recovery machine for R-32	8,006.54
	Quality inspection, finishing and testing	Testing equipment for safety performance	10,294.12
		Two R-32 concentration sensors	
		sub-total	**602,597.17**
4	**Prototype production trials and testing**		
	Testing	Modification of performance test rig	45,751.63
		Isolation of test rig room/fire protection	57,189.54
	Trial production	Cost of trial production for 3 units	20,958.54
		sub-total	**123,899.72**
5	**Process and safety training**		
	Manufacturing	Training for 233 manufacturing personnel for 86 training hours	17,848.04
	Installation and maintenance	Training for 86 installation and maintenance personnel for 30 training hours	
		sub-total	**17,848.04**
6	**Contingency**	for enterprise	**0**
ICC for enterprise		**TOTAL**	**830,344.71**
		Total fund by MLF	**733,530**
		Co-financing by enterprise	**96,814.71**

Incremental Operating Costs

The agreed total incremental operating costs calculated for one-year duration amount to US$ 389,340. The production line is commercial running, and the IOC will be disbursed to enterprise in the next 2 years according to new products sales quantity. The data of IOC is preliminary value.

The cost for the baseline HCFC-22 based two-stage systems are summarized as below:

1. HCFC-22 price is US$ 2.20/kg
2. HFC-32 price is US$ 2.94/kg
3. HFC-32 charge quantity for the three models is 16 kg (for 60 kW), 8.4 kg (for 30 kW) and 3.5 kg (for 13 kW)

Incremental Operating Cost Source	Incremental Costs/Savings (US$/unit)		
	60 kW unit	30 kW unit	13 kW unit
Compressors	236.00	118.00	96.00
Finned tube heat exchangers	(19.00)	(9.50)	(4.50)
Tube-in-tube/plate heat exchangers	(13.50)	(6.80)	(3.10)
Refrigerant	(5.90)	(2.90)	(1.00)
Electrical components (ex-proofing)	88.40	78.20	75.60
Net costs (savings)	**286.00**	**177.00**	**163.00**
Agreed	**73.93**	**45.75**	**42.13**

Incremental Operating Costs	Amount (US$)
60 kw unit: US$ 151.19/unit X 1,858 units/year	280,917
30 kw unit: US$ 75.56/unit X 858 units/year	64,827
13 kw unit: US$ 32.13/unit X 1,357 units/year	43,596
Total	**389,340**

6. Impact

The project was completed and 61.9 metric tonnes of HCFC-22 usage was phased out. Over a 15-year life-span of the refrigeration systems manufactured by the enterprise and covered by this project, direct and indirect emission reductions amounting to about 170,000 CO2-eq tonnes will be achieved, thus contributing to protection of both the ozone layer and the climate system.

The successful implementation of this demonstration project provides an environmentally safe and cost-effective alternative for enabling replication of this technology in similar applications in this sub-sector in China.

DEMONSTRATION PROJECT FOR CONVERSION FROM HCFC-22 TECHNOLOGY TO AMMONIA/CO2 TECHNOLOGY IN THE MANUFACTURE OF TWO-STAGE REFRIGERATION SYSTEMS FOR COLD STORAGE AND FREEZING APPLICATIONS AT YANTAI MOON GROUP CO. LTD.

FINAL REPORT

March, 2014

Executive Summary

Demonstration project for conversion from HCFC-22 technology to Ammonia/CO2 technology in the manufacture of two-stage refrigeration systems for cold storage and freezing applications at Yantai moon group co. Ltd. was approved by the 60th Executive Committee meeting at a funding level of US $ 3,964,458.

This demonstration project was successful completed, and established the suitability of Ammonia/CO2 technology as a viable replacement for HCFC-22 technology in the manufacture of integrated two-stage refrigeration systems for cold storage and freezing applications at Yantai Moon Group Co. Ltd.

The project covers product redesign and development, production line conversion, process tooling modifications, testing and performance evaluation, product trials, prototype testing, production line conversion, technical assistance and training, to convert one production line of capacity 100 units annually.

The successful completion of the demonstration project contributes towards promotion of this technology for replacing two-stage HCFC-22 based refrigeration systems in cold storage and freezing applications and enable cost-effective conversions at other similar manufacturers in this sub-sector.

1. Introduction

In 2007, the 19th Meeting of Parties of the Montreal Protocol agreed on accelerated phase-out of HCFCs. To achieve the compliance goal, China is implementing HCFCs phase-out sector plan in the Industrial & Commercial Refrigeration and Air-conditioning (ICR) sector from 2012. The Yantai project was established as a demonstration earlier in 2010 for preparation and support of the sector plan implementation.

The Executive Committee approved the Yantai demonstration project at the 60th meeting in 2010 with a funding level of US $ 3,964,458. The project's implementing international agency is UNDP, and implementing national agency is Foreign Economic Cooperation Office (FECO), Ministry Of Environmental Protection, China.

The objective of this demonstration project is to establish the suitability of Ammonia/CO_2 technology as a viable replacement for HCFC-22 technology in the manufacture of two-stage refrigeration systems for cold storage and freezing applications at Yantai Moon Group Co. Ltd.

As a result of the conversion project, about 250 tons of HCFC consumption will be phased out, reducing greenhouse gas emission by 1.66 million tons CO2 eq.

1.1 Background

The Industrial and Commercial Refrigeration and Air Conditioning (ICR) Sector in China has experienced remarkable growth in the past two decades, averaging at about 12% annually, due to the steep growth in the demand for consumer, commercial and industrial products, resulting from rapid overall economic development. This sector is categorized into several sub-sectors, namely: compressors, condensing units, small-sized air-source chillers/heat pumps, commercial and industrial chillers/heat pumps, heat pump water heaters, unitary commercial air conditioners, multi-connected commercial air conditioners, commercial and industrial refrigeration and freezing equipment, mobile refrigeration and air conditioning equipment and refrigeration and air conditioning components and parts. The 2008 HCFC consumption in the sector was about 42,000 metric tonnes.

The industrial and commercial freezing and refrigerating equipment sub-sector (including compressor condensing unit) covers applications widely used in food refrigeration, industrial refrigeration systems, fruit and vegetable preservation, food processing and infrastructure construction projects. With improving living standards, the demand for food processing and cold storages infrastructure is increasing at an annual rate of over 10%. Due to sustained economic development, oil and chemical industry, energy, construction and other infrastructure-related investments are rising rapidly, enhancing the demand in emerging market. The demand for industrial refrigeration equipment in pharmaceuticals, mine freezing, water dams and coal-bed gas liquefaction is also expanding. The current and potential demand for large-scale low-temperature freezing and cold storage equipment in all these fields is significantly high. In recent years, the average annual growth rate of large-scale industrial freezing and cold storage equipment has been over 15%. The total HCFC consumption in this sub-sector during 2008 was about 4,000 metric tonnes, making it one of the largest sub-sectors in the ICR sector.

Yantai Moon Group Co. Ltd. was established in 1956, specializing in manufacturing of air conditioning and refrigeration products and engineering design, installation, commissioning and technical advisory services in the areas of frozen foods, food processing, industrial refrigeration, central air conditioning and fruit and vegetable preservation technologies. In 1998, Yantai Moon Group Co. Ltd. was listed on Shenzhen Stock market. The enterprise has independent intellectual property rights for some models of its refrigeration compressor manufacturing technology. Yantai Moon Group Co. Ltd. is located in the Shandong province and employs 2,989 persons, of which 640 are technical staff. Yantai Moon Group Co. Ltd. focuses on self-reliance in technology development, but at the same time also has many partnerships with international companies, to bring the latest technologies into the Chinese market. Yantai Moon Group Co. Ltd. offers integrated systems for Freezing and cold storage equipment, Industrial refrigeration systems and Central air-conditioning equipment etc.

In 2009 Yantai Moon Group Co. Ltd. manufactured the following HCFC-22 based integrated refrigeration systems:

No	Product Line	Evaporating temperature (^{o}C)	Quantity (Nos.)	HCFC consumption (metric tonnes)
1	Water Chillers	+2	190	N/A
2	Brine Chillers	-15	320	N/A
3	Low-temperature secondary inlet	-25 to -40	120	N/A
4	Low-temperature two-stage	-35 to -55	100	250

Of the above, the last, namely, two-stage low-temperature refrigeration systems (highlighted above), each with an average HCFC-22 charge quantity of about 2,500 kg, is the target for conversion in the current project.

1.2 Technical Choice

Some of the zero-ODP alternatives to HCFC-22 currently available for this application are listed below:

Substance	GWP	Application	Remark
Ammonia	0	Industrial refrigeration and process chillers	Flammability and toxicity issues. Material compatibility issues. Regulatory issues.
CO_2	1	Refrigeration in a secondary loop and in stationary and mobile air conditioning systems	Major redesign of system components needed. Investment costs are prohibitive
R-404A	3,260	Low temperature applications	High GWP, less efficient at medium temperatures, synthetic lubricants needed
R-507	3,900	Low temperature applications	High GWP. Azeotropic non-flammable blends of HFC-125 and HFC-143a. Refrigerating capacity comparable to R-502. Good heat transfer characteristics at low temperatures. Synthetic lubricants needed.

Comprehensive considering technical factors, commercial factors, health and safety factors, and environmental factors, Yantai Moon Group Co. Ltd. selected a combination of Ammonia/ CO_2 in a cascade design as the technology of choice for its low-temperature two-stage integrated refrigeration systems, considering the favorable environmental and thermodynamic properties of these two alternatives.

1.3 Technical Solution

The NH3/CO2 cascade refrigeration system is constituted by two separate refrigeration circuits; the high temperature circuit and the low-temperature circuit. The low temperature circuit with CO2 as refrigerant is used for the actual cooling. The high temperature circuit with NH3 as the refrigerant is used to condense the CO2 of the low temperature circuit. The two circuits are thermally connected to each other through a cascade condenser, which acts as an evaporator for the high temperature circuit and a condenser for the low temperature circuit. After absorbing heat from the brine in the CO2 evaporator, the refrigerant CO2 in the low temperature circuit is compressed in the CO2 compressor, which increases the enthalpy of CO2. The discharged CO2 refrigerant from the compressor rejects the heat to NH3 of the high temperature circuit in the cascade condenser. Then the cooled CO2 refrigerant is throttled by the expansion valve, and enters the CO2 evaporator. The heated NH3 in the cascade condenser is compressed in the NH3 compressor, which increases the enthalpy of NH3. The discharged NH3 refrigerant from the high temperature NH3 compressor unit flows into the NH3 condenser, in which NH3 rejects the heat to the cooling water system or air cooled condenser. The relevant schematic is as below:

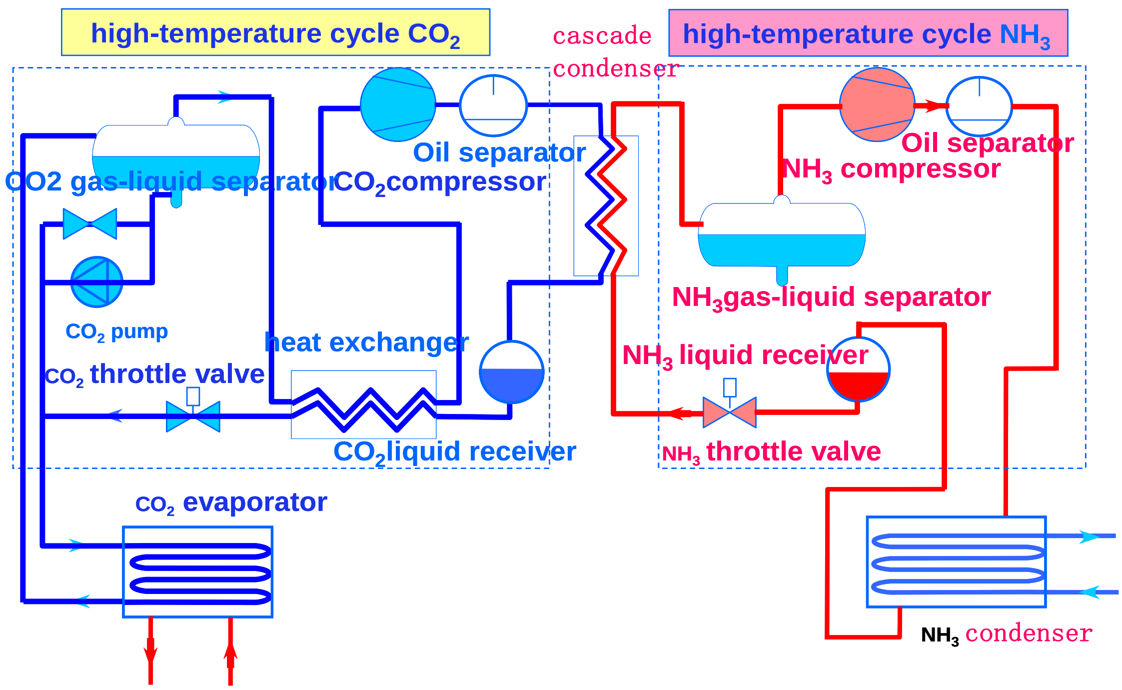


Fig 1. System schematic

As the characteristics of CO_2 are different from conventional low-temperature refrigerants, the key points of this technical solution are as follows:

- Develop intermediate-pressure compressor with CO_2 as the refrigerant;
- Design and manufacture mid-pressure vessel for higher pressure;
- Develop CO_2 heat exchangers which match large unit volume refrigeration capacity and high latent heat of $CO_{2;}$
- Design and develop heat exchangers of the low-temperature side which can withstand high pressures and low temperature;
- Develop fully automatic, safe, efficient and reliable control system for the refrigeration system.

2. Project Implementation

After the project was approved in 2010, FECO and UNDP signed the Project document in January 2011, and the Contract between Yantai Moon Group and FECO was signed in May 2011. After one year and a half period of implementation, the conversion project was completed by the end of 2012, and all the progress milestones required were reached and verified by the end of 2012. The project successfully passed national acceptance in July, 2013, and the production line is commercial running now.

According to the project implementation plan, the following activities were carried out: Product and process redesign, Modification of production lines, Modification of test devices for product performance, Manufacturing of prototypes, Personnel training, and technology dissemination, etc.

2.1 Product and process redesign

The project completed redesign of NH_3/CO_2 cascade refrigeration systems with twin-screw compressors by November 2011, including design of CO2 compressors (see the table below), design of system components in the CO2 refrigeration system, and modification of the existing product lines of compressor and pressure vessels, design of test devices for CO2 refrigeration system, design of user demonstrations for the early users of NH_3/CO_2 cascade refrigeration systems.

The three specifications of CO2 screw compressors for the project are as below:

Model	Theoretical displacement (m3/hr)	Status
LG12R	152	Design completed
LG16R	300	Design completed
LG20R	600	Design completed

The details of redesigns are as follows:

The refrigeration system design parts:

- Design of screw compressor rotor profiles and structural design of compressor
- Design of high pressure vessel matching with CO2 screw compressor units
- Design of pressure vessels for high pressure, high-pressure low-temperature and other components matching with NH_3/CO_2 cascade refrigeration system with twin screw compressors
- Design of electric control and application software control
- Design of performance tests
- Design of demonstration for the first user of NH_3/CO_2 cascade refrigeration system

The process design parts:

- Design of casting and forging manufacturing process for CO2 screw components;
- Design of CO2 screw compressor shell strength test device;
- Design of strength test device for CO2 pressure vessel of high-pressure low-temperature;
- Design of machining process includes design of CO2 compressor housing, rotors, oil pump parts and tube sheet of heat exchanger;
- Design of the welding technology of CO2 pressure vessel of high-pressure low-temperature, shell and tube heat exchanger;
- Design of CO2 finned tube air cooler for high pressure and low temperature process including design of outer shell sheet metal process and expanding tube process;
- Design of product assembly process, including assembly, pipe connections, air tightness testing

- Blank manufacturing of CO2 compressor components, including design of casting model, casting box, forging dies
- Design of CO2 finned tube of high-pressure low-temperature fin dies, dies baffle for punching, and half of the stamping dies for baffle;
- Design of special high-strength alloy machining tools for the high-strength components such as CO2 compressor housing, special measuring tools and special inspection equipment tools, including design of special cutter for compressor rotor machining, a variety of special boring tool and milling cutter for compressor shell processing, special boring tool for tube plate holes, fin-hole punch, as well as the design of special measuring tools and detection tools for machining process
- Special process equipments for CO2 compressor and high-pressure low-temperature CO2 pressure vessel, including fixtures for all kinds of mechanical processing, positioning fixtures of welding and expansion joint, working sleeves matching with the products and station apparatus for turnover and store of parts;
- Design for modifying product line of the existing conventional refrigeration system, including processing arrangements, products site planning and special equipment layout for the added CO2 compressors and high-pressure low-temperature CO2 pressure vessels

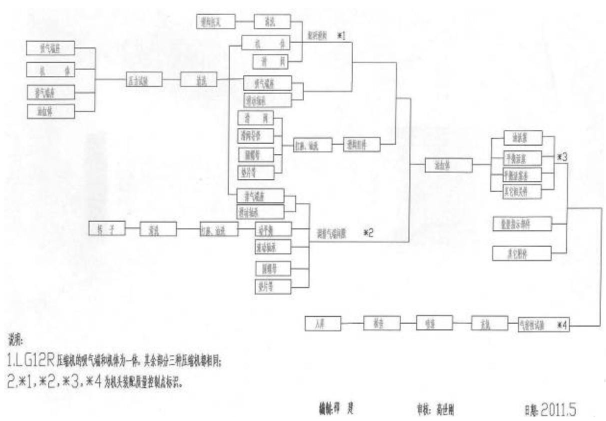


Fig 2. Technical process diagram

存档申请单

YB/Y(Z)10.006-0

申请部门: 　2011 年 5 月 17 日　编号:

产品名称			产品代号	
总张数	A_0	A_1	A_2	A_3	A_4
存档时间	(　)年	等级(　)	一般(✓)	机密(　)	绝密(　)
备注					入库确认
申请人		接收人		批准人	

Fig 3. Drawings documents recording

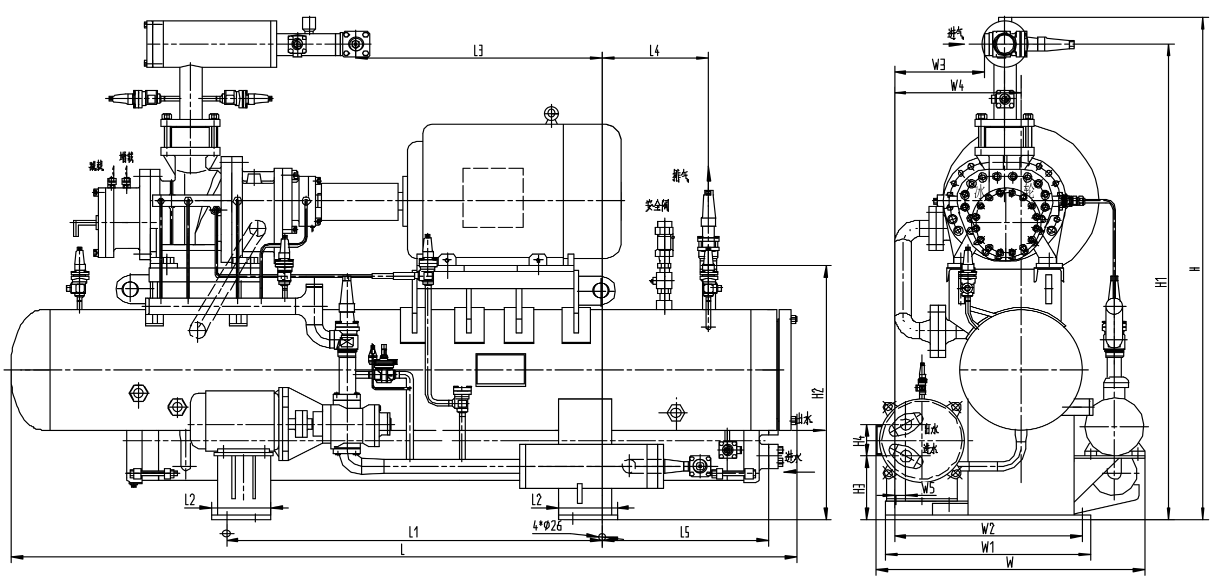


Fig 4. System structure

The technical programs were partly supported by university research institutions, and all the technical programs were passed internal assessment.

2.2 Modification of production lines

The production lines modification is composed of two key parts, compressors producing lines modification and pressure vessel producing line modification.

2.2.1 Compressors producing lines modification

The former compressor producing lines are at designed working pressure is 20 bar and the CO_2 compressor designed pressure is 50 bar. So the producing line were modified according to the high pressure requirements, and some dedicated devices were manufactured or procured and installed in the producing line, including high-strength processing tools, cutters, compressor cast models and cast boxes, etc.

Fig 5. Compressor housing cast model and rotor cast box

Fig 6. Compressor tooling and cutters

Totally 44 cast models (16 for shell, 6 for rotors and 22 for other) and 44 cast boxes (16 for shell, 6 for rotors and 22 for other) are manufactured based on the new technical renovation. The processing tools and the cutters have been purchased and positioned in the compressor product line, including 49 sets of tools and 13 kinds of cutters that, more than 16000 sets of cutters, cover all processes of compressor manufacturing.

2.2.2 Pressure vessel producing line modification

As the former manufacturing lines of the pressure vessels was below the pressure of 20 bar, the relevant parts of vessel producing lines were modified, including production process link of the added high-pressure low-temperature CO2 pressure vessel, such as CO2 oil separator, CO2 liquid receiver, oil filters, suction filters, tube processing and welding for shell and tube heat exchanger, oil cooler, cascade heat exchanger, CO2 regenerator, heat exchanger for defrost, tube expander, welding and assembly for CO2 shell and tube evaporator.

As materials of tube sheet and cylinder for the CO2 pressure vessels of high-pressure low-temperature are different from the conventional components materials, the corresponding process equipment and control were added during production and test process, such as welding, expanding joint and inspection. The strength test and air tightness test were built for the high-pressure low-temperature pressure vessel. And the test environment of cold shock in the low temperature was also built up. Welding equipment of stainless steel container and high-pressure low-temperature vessel were added, as well as welding test plate and assessment method of high-pressure low-temperature vessel.

Fig 7. Welding machine

Fig 8. Tooling

Fig 9. High pressure test equipment for CO2 vessel

2.3 Modification of test devices for product performance

As a new refrigeration system, the high temperature refrigeration system can be tested in the existing performance test laboratory after product commercialization, while the product test device of the CO2 refrigeration system requires new facility construction.

The modification of test equipment was completed in 2012. The test devices of CO2 compressor housing strength and air load were added.

Fig 10. Testing equipment

2.4 Manufacturing of prototypes

Prototype assembling of two types of compressors and manufacturing of sample products were finished in 2012. Two types of prototype compressors have been assembled and sample products were also manufactured.

Fig 11. L20R compressor and system

Fig 12. L20R800 compressor and system

Fig 13. Prototype

The performance parameters of prototypes are as follows:

LG12R (152.4 m3/h)

Tc / Te	Refrigerating capacity(kW)					Power(kW)				
	-5	-10	-15	-20	-25	-5	-10	-15	-20	-25
-55	90.6	110.7	123.8	139.1	182.3	77.1	59.4	45.4	39.4	34.3
-50	118.8	140.0	160.3	181.6	227.8	80.3	62.3	48.2	41.4	34.9
-45	156.1	182.4	207.6	226.3	273.0	69.1	56.1	46.8	40.4	32.7
-40	199.6	234.7	262.7	288.9		69.7	57.2	48.4	38.9	
-35	255.8	291.7	318.6	346.3		66.0	54.1	41.9	33.4	
-30	312.6	351.6	379.5	412.4		57.7	47.1	35.3	25.3	
-25	372.1	425.9	454.3	488.2		55.6	39.3	26.9	14.3	

LG16R（603.8 m3/h）

Tc / Te	Refrigerating capacity(kW)					Power(kW)				
	-5	-10	-15	-20	-25	-5	-10	-15	-20	-25
-55	358.8	438.4	490.4	551.3	722.5	305.6	235.4	180.0	156.2	135.8
-50	470.8	554.5	635.0	719.4	902.8	318.1	247.0	191.1	164.0	138.4
-45	618.6	722.6	822.5	896.6	1081.6	273.7	222.1	185.3	160.1	129.7
-40	790.9	929.8	1041.0	1144.5		276.3	226.6	191.8	154.0	
-35	1013.7	1155.9	1262.4	1372.2		261.7	214.4	165.8	132.2	
-30	1238.5	1393.1	1503.5	1634.2		228.8	186.7	139.7	100.4	
-25	1474.4	1687.6	1799.9	1934.5		220.4	155.8	106.6	56.8	

LG20R(803.1 m3/h）

Tc / Te	Refrigerating capacity(kW)					Power(kW)				
	-5	-10	-15	-20	-25	-5	-10	-15	-20	-25
-55	477.2	583.1	652.2	742.3	972.5	406.5	313.0	239.4	210.4	182.7
-50	626.1	737.5	844.6	956.8	1200.7	423.0	328.5	254.2	218.2	184.1
-45	822.7	961.1	1093.9	1192.4	1438.5	364.0	295.4	246.5	213.0	172.5
-40	1051.9	1236.7	1384.5	1522.2		367.5	301.4	255.1	204.8	
-35	1348.2	1537.4	1679.0	1825.0		348.1	285.1	220.6	175.9	
-30	1647.2	1852.7	1999.7	2173.4		304.2	248.3	185.8	133.5	
-25	1961.0	2244.4	2393.9	2572.9		293.2	207.2	141.8	75.6	

2.5 Personnel Training

The personnel trainings were carried out during project implementing, and the trainings are including design, production, marketing and debugging. The following personnel were included in the training:

- Related designers, technicians.
- Production management persons, manufacturing workers.
- Product application engineer.
- Technician for installation and debugging, equipments maintenance personnel.
- Related user operators, equipment administrative personnel.

Yantai Moon carried out a total of R&D personnel training 4 times, manufacturing personnel training 4 times, the marketing personnel training1 times, product application engineer training 3 times, the user training for equipment administrative personnel and equipment maintenance personnel 2 times. 734 persons were trained.

Designers and technicians training

Manufacturing workers training

Application engineer training

Equipment maintenance personnel training

Fig 14. Training

2.6 Technology Dissemination

Yantai Moon carried out several activities in technology dissemination to promote market. The details activities are as follows:

- Technical communication with engineering design companies, introduction of product, and promotion and recommendation plan.
- Technical communication with construction companies, product promotion and recommendation, and application technology.
- Application promotion in relevant industry associations.
- Organize product release conference, and display product and application technology.
- Communicate with government environmental protection departments to enhance publicity campaign.
- Advertisement and promotional brochures.

- Participate in exhibitions, such as International Refrigeration Exhibition in China, Chinese Fisheries Exposition, and Chinese Food Processing Exposition; display the product and application technology.
- Provide free technology, debug and maintenance to users of the demonstration project.

Totally, 13 times of technology exchange and products exhibition were organized and participated, such as Fujian Food Processing Exposition and Chengdu cold storage construction conference etc.

Fig 14. Technology Dissemination

2.7 Marketing

The producing line is commercial running. The NH3/CO2 cascade refrigeration systems have come into the markets, and about 60 units of refrigeration systems sales contracts were signed.

Fig 15. Running NH3/CO2 system in customer

3. Outcomes

The project has been completed; it has successfully passed national acceptance in July 2013. The production line is commercial running, and the IOC will be disbursed to enterprise in the next 2 years according to new products sales quality. The suitability of Ammonia/CO2 technology as a viable replacement for HCFC-22 technology in the manufacture of two-stage refrigeration systems for cold storage and freezing applications at Yantai Moon Group Co. Ltd.is established.

- The product and testing lab designs were completed in 2011. The tools and process equipment for the pressure vessel production line were installed.
- The design of key components and the production line were completed in 2012. The conversion of the production line was also completed in this year.
- The high pressure test equipment for CO2 vessel was completed in 2012. The prototype building and testing equipment were completed. Training and technology dissemination are finished.
- Training, technology communication, and product promotion including advertisements were completed in 2012.
- The project was audited by the National Audit Office in the first quarter of 2013.
- The financial and performance verifications, including the milestone verifications and the final verification, were completed.
- The producing line is under commercial production. The NH3/CO2 cascade refrigeration systems have come into the markets, and about 60 units of refrigeration systems sales contracts were signed.

4. Technical performance

- The normal range for large-scale low-temperature industrial refrigeration applications is between -35℃ to -55℃, and this is exactly the best operating evaporation temperature bracket for NH3/CO2 cascade refrigeration system, in which the NH3/CO2 system will has great efficiency.
- NH3/CO2 cascade refrigeration system technology can effectively address the toxicity exposure issue of ammonia. Comparing with the pure NH3 refrigeration system, the new systems use NH3 and CO2 cascade system and the toxicity is reduced greatly. The new system only use one tenth of quantity of the old system's NH3. Besides, HN3 is only cycle operating inside the refrigerating unit at the machine room which is separated from persons in the operator access area. And CO2 (non-toxic) is cycle operating inside the tubes from machine room and operator access area.
- Compared with normal refrigerating systems (R22, NH3), the system with CO2 as refrigerants can exert great efficiency in low temperature conditions. But in normal temperature condition, CO2 has some problems such as low efficiency, high pressure, large volume of system, and high cost.
- NH3/CO2 cascade refrigeration system technology can overcome the disadvantages of pure CO2 system and toxicity of NH3. Furthermore, the energy efficiency is promoted more than 20% compared with the old system.
- The system can be used at any normal climate conditions and produce low-temperature from 0℃ to -55℃.
- Most of the large-scale low-temperature refrigeration systems use open-type compressors and open system design, with a significant amount of leakage and low recovery rate of refrigerant during maintenance, thus annual consumption of HCFCs in servicing for such systems is very high. Thus, replacing HCFCs in such applications gains high priority from an environmental standpoint.

5. Project management and monitoring

The project was under the overall management and coordination of the Foreign Economic Cooperation Office, Ministry of Environment Protection of China. UNDP was the implementing agency for the project, which provided international coordination and technical assistance.

The project employs the Performance-based Payment (PBP) mechanism in its implementation. Under the PBP mechanism, the enterprise tasked to carry out the conversion would play the role as a key executer, which is responsible for all the activities related to the conversion. The procurement was organized fully in line with the marketing principle ensuring cost-effective and timely installation of equipment for NH3/CO2 systems based manufacturing operations.

FECO and UNDP were not involved in the procurement activities of the enterprise by any means other than make payment to the enterprise in tranches for the costs of procurement and conversion, at agreed payment dates given in the payment schedule, and when milestones prerequisite for the tranche have all been achieved on time.

Before each payment, FECO invited independent experts to verify whether the performance for each milestone that the payment depends on have been satisfying. The verification reports were submitted and accepted by UNDP as the main supporting documents for requesting the installment of payment.

During the projects implementation, FECO and UNDP organized 4 verification missions combined with monitoring and evaluation at Yantai Moon factory (i.e., 25 November 2011, 19 February 2012, 18 June 2012 and 6 December 2012). The experts group included technology experts and finance experts, FECO staff and UNDP staff as well. The experts team traced the project implementation situations, evaluated the project technical issues and progress, and verified whether the performance for each milestone that the payment depends on have been satisfying. Each verification activity was carried out in a process of planning, preparation, data confirmation, technical material checking, on-the-spot investigation, result conformation and conclusion.

The project also passed national audit in March, 2013.

5.1 Project progress

The project was implementing smoothly according to the program schedule, and was completed by the end of 2012. It successfully passed national acceptance in July 2013 and national audit on site in March, 2013.

The capacity of the production line has been converted to use substitute refrigerants and is capable of manufacture the converted products. The converted products came into markets and have been put into use by users in Yantai, Weihai, and Dalian, etc. The market has expressed interest.

Each of milestones was achieved and verified, the details are as follows:

Milestones		Status
1st	Signing of the contract	FECO signed contract with the enterprise in May 2011
2nd	Designs of products and performance test lab; Installation of process equipment and tools of pressure vessel product line;	Finished and verified in November 2011.
3rd	Cast models and cast boxes; Completion of high pressure test equipment for CO2 vessel; Manufacturing of components of CO2 high-pressure low-temperature vessel for performance test equipment;	Finished and verified in February 2012.
4th	Positioning of special tools and special cutters for compressor product line; Installation and debugging of performance test equipment; Prototype assembling of two types of compressors; Manufacturing of sample products;	Finished and verified in June 2012.
5th	Reconstruction of rest device, and purchasing and manufacturing of test tolls of compressor product line; Reconstruction of pressure vessel product line; Training, technology communication, advertisement and project verification.	Finished and verified in July 2013.

5.2 Conversion cost

Total Project Costs

The total contract amount with the enterprise is US$ 3,698,236, including ICC US$ 2,490,936, and IOC US$ 1,207,300.

Incremental Capital Costs

The actual incremental capital costs for conversion was US$ 4,188,630, among which US$ 2,490,936 was funded by the MLF, and the US$ 1,697,694 was co-financed by the enterprise.

The details of ICC are as follows:

No.	Cost Head		Actual cost (US$)
1	**Product and process redesign**		
	System	System redesign	32,130.95
	Process	Process redesign	
	Miscellaneous	Documentation and research	
	Compressor	Compressor redesign	166,666.67
	Software	Heat exchange analysis software	93,133.14
	Certification	Testing and certification	49,019.61
		Sub-total	**340,950.37**
2	**Modification of production lines**		
	Compressor	Compressor parts casting model	148,962.42
		Compressor parts casting box	39,491.17
		Tooling for CO2 compressor	192,900.29
		Measuring and inspection tools	19,117.65
		CO2 compressor machining tool	500,578.38
		CO2 compressor casing test device	78,675.59
		Co2 compressor air load test device	180,392.16
	Pressure vessels	Equipment for stainless steel parts	110,351.31
		Tooling for stainless steel containers	16,425.16
		High-pressure testing of CO2 vessels	57,026.14
		Testing for CO2 U-tub	134,836.60
		Tooling for CO2 U-tube	
		Development cost for CO2 U-tube	
		CO2 high pressure air drying system	13,316.99
		Magnetic flaw detector for CO2 vessels	6,045.75
		Universal shock testing for CO2 vessels	5,555.56
		Impact testing for CO2 vessels	3,594.77
		Low-temperature test room	79,084.97
		Welding test plate for CO2 vessels	39,183.01
		Sub-total	**1,625,537.91**
3	**Modification of test devices for product performance**		
	Test devices	Materials and installation of test devices	910,926.47
	Pressure vessel parts	Components of pressure vessels ten types	
	Instruments	74 different test device instruments	
	Software	Test software and debugging	
	Consumables	Refrigerant and lubricants	
	Commissioning	Test device commissioning	
		Sub-total	**910,926.47**
4	**Manufacturing of prototypes**		

	CO2 compressor	Four sets/specification x 2 specifications	344,207.24
	Pressure vessels	Matching pressure vessels and parts	365,867.65
	Pressure vessels	System pressure vessels	377,366.38
	Ammonia system	High temperature ammonia system	-
	Controls	Electrical and other controls	32,065.48
		Sub-total	**1,119,506.75**
5	**Personnel training**		
	Training	Training for about 300 persons	62,847.88
		Sub-total	**62,847.88**
6	**Technology dissemination**		
	Workshop	Technology dissemination workshop	128,860.46
	Communication	Technology communication	
	Events	Participation in exhibitions	
		Sub-total	**128,860.46**
7	**Contingencies**	For enterprise	0
		Sub-total	0
ICC for enterprise		**TOTAL**	**4,188,630**
		Total fund by MLF	**2,490,936**
		Co-financing by enterprise	**1,697,694**

Incremental Operating Costs

The agreed total incremental operating costs calculated for one-year duration amount to US$ 1,207,300.
The production line is commercial running, and the IOC will be disbursed to enterprise in the next 2 years according to new products sales quantity. The data of IOC is preliminary value.

The cost for the baseline HCFC-22 based two-stage systems are summarized as below:

No.	Item	Cost (US$)
1	Low pressure screw compressor units	21,250
2	High pressure screw compressor units	14,779
3	Condenser	8,853
4	Siphon tank	1,338
5	High-pressure liquid receiver	2,470
6	Intercooler	1,853
7	Low-pressure cycle barrel	3,706
8	Canned motor pump	1,176
9	Piping and auxiliary materials	9,750
10	Valve	4,368
11	System control cabinet	3,176
Total		**72,720**

The cost for the NH3/CO2 cascade systems to replace the above would be as below:

No.	Item	Cost (US$)
1	NH_3 screw compressor units	15,000
2	Condenser	8,852
3	NH_3 liquid receiver	1,030
4	NH_3 oil receiver	250
5	CO_2 screw compressor units	15,808

6	CO_2 condenser evaporator	5,206
7	CO_2 gas-liquid separator	3,294
8	CO_2 Low-temperature cryogenic pumps	2,030
9	CO_2 liquid receiver	2,470
10	CO_2 heat exchanger	3,118
11	CO_2 auxiliary heat exchanger	2,059
12	Heat exchanger for defrosting	1,765
13	Heat source pump for defrosting	1,471
14	Auxiliary cooling units	4,426
15	Piping and auxiliary materials	6,338
16	Valve	7,794
17	System control cabinet	3,882
Total		**84,793**

6. Impact

The project was completed and 250 metric tonnes of HCFC-22 usage was phased out. Over a 15-year life-span of the refrigeration systems manufactured by the enterprise and covered by this project, direct and indirect emission reductions amounting to about 1.66 million CO2-eq tonnes will be achieved, thus contributing to protection of both the ozone layer and the climate system.

The technology route is innovative, the resulting product has significant advantages in terms of environment friendliness and energy efficiency, and the safety performance is greatly improved. Thus, the market prospect and competency of the products are sound. The project has been a good demonstration and promotion of advanced HCFC alternative technologies in the industrial and commercial refrigeration sector.