

United Nations Environment Programme

FUEL CELL MARKET PROSPECTS AND INTERVENTION STRATEGY OPTIONS
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EVALUATION REPORT

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Acronyms

UNEP/DTIE	UNEP Division of Technology, Industry and Economics
FCB	fuel cell bus
FCDPG	fuel cell distributed power generation
UNEP/DGEFC	UNEP Division of Global Environment Facility Coordination
GEF	Global Environment Facility
IEA	International Energy Agency
IFC	International Finance Cooperation
IPCC	Intergovernmental Panel on Climate Change
MSP	Medium-sized Project Brief
OECD	Organisation for Economic Co-operation and Development
SRES	special report on emission scenarios
STAP	Scientific and Technical Advisory Panel
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme

Executive summary

1. The project under evaluation, “Fuel Cell Market Prospects and Intervention Strategy Options” was developed to address the need to identify strategy options for Global Environment Facility (GEF) intervention relative to fuel-cell applications in developing countries. The project was designed to support GEF Operational Programme 7, “Reducing the Long-term Costs of Low Greenhouse Gas Emitting Energy Technologies”, and Operational Programme 11, “Promoting Environmentally Sustainable Transport”. This evaluation was conducted in November and December 2002 in collaboration with the Evaluation and Oversight Unit of UNEP. The findings of the evaluation are based on desk review of the project documents and monitoring reports, desk review of specific project outputs, including reports and workshop summaries, and telephone and e-mail interviews with staff of the United Nations Environment Programme (UNEP), the World Bank, the International Finance Corporation (IFC), the United Nations Development Programme (UNDP), the Scientific and Technical Advisory Panel (STAP), the GEF secretariat and other project participants.
2. This project resulted from a decision by the GEF secretariat to consolidate various activities related to fuel cells. The project was initiated and coordinated by the UNEP Division of Technology, Industry and Economics (UNEP/DTIE) and is consistent with its mission to encourage decision makers in Government, local authorities and industry to develop and to adopt policies, strategies and practices that are cleaner and safer and make efficient use of natural resources. Initially, the project was managed by the UNEP Division of Global Environment Facility Coordination (UNEP/DGEFC) in agreement with the coordinator of the UNEP/DTIE Energy Programme. UNEP/DTIE had an information and awareness-raising activity that predated the project and was enhanced through it. When a key project staff member in UNEP/DGEFC moved to UNEP/DTIE, the role of project management also shifted to UNEP/DTIE.
3. The project was a collaborative effort bringing together UNEP, UNDP, IFC, GEF and industry experts to develop information to support policy decisions by GEF and national Governments in this area of technology. The objectives of the project were to review the climate change mitigation potential of fuel cell applications in distributed electricity generation and on urban transport and to develop strategy options for market interventions supporting early achievement of lower-cost, higher-volume production. The project had four tasks which were jointly implemented by the executing partners. The project period was April 2000 to August 2001.
4. The process facilitated by this project was effective in putting input from agencies, industry and users in developing countries together into a cohesive whole. It brought the agencies together and produced useful results that were considered very helpful in presenting a comprehensive strategy to GEF. In particular, interviewees commented that the IFC concept of the stationary fuel cell programme could not have been developed and accepted without the process provided by this project. In addition, the fuel cell bus (FCB) strategy note was described as critical to getting approval of the GEF Council for several FCB project documents.
5. The approach to the project was a set of tasks coordinated by a number of agencies, which allowed each partner to have a broader perspective and to contribute to a larger collaborative process in order to achieve more productive outcomes than could have been achieved individually. UNEP provided a value-added service by facilitating greater inter-agency cooperation, which would otherwise not have been possible. Given the strong environmental benefits of fuel cell technology for both stationary and transport applications, the project is very consistent with the UNEP/DTIE strategy to “promote the development, use and transfer of environmentally sound technologies”.
6. Most interviewees considered the level of stakeholder involvement and participation in project activities, in particular workshops, to be adequate and appropriate to the needs of the project. Several partners commented that with respect to stationary applications, the manufacturers and users were very cooperative and provided important insights. A significant conclusion was that GEF could best influence fuel cell markets by identifying strategic market niches, which were different for each application.

7. Not all partners were convinced that the coordination by UNEP of their jointly executed tasks was the best approach. Several believed that stronger leadership and coordination was needed. Because the project was jointly executed, there was no clear, single line of responsibility. The project could have flowed better, although the final outcome was not compromised. From the perspective of other partners, however, the problem was that the cooperative execution process was inherently difficult to control. Some of the partners had their own agendas and wanted to control the process, and given that the various contractors reported to different partners, coordination was difficult. This made it hard for UNEP to provide effective coordination. The different styles and characters of the agencies also constituted a hindrance.

8. The conclusion of this evaluator is that the project was quite successful despite of some implementation difficulties and that the process used by the project was quite valuable and should be replicated to facilitate the development and acceptance of GEF programme strategies. The rating of the execution of the project is “very good”, or 2 on a scale of 1 to 5, with 1 being the highest rating and 5 the lowest. In summary, the project outputs were attained in a timely manner and the project was executed within the budget. The project activities were largely completed in accordance with the scope of work, but most importantly, the project appears to have achieved the desired short-term impact. Any final analysis of a sustainable long-term impact, however, cannot be determined at this moment. It is too early to evaluate the impact of the programmes developed in support of the fuel cell technology strategy. The rating of the project is shown in the table below.

Table 1
Rating of the project

Evaluation item	Rating
Timeliness	3
Attainment of outputs	2
Completion of activities	1
Project executed within the budget	2
Impact created by the project	2
Sustainability	3
Overall score	2

9. The following are the key recommendations of the evaluation:

(a) GEF should continue to use a collaborative approach to identify priorities and to establish the operational activities to implement them;

(b) GEF and the implementing agencies should review the coordination process prior to the start-up of any future collaborative project and establish clear lines of communication and responsibility;

(c) Either a single implementing agency should coordinate the project, with contractual responsibility over all the subcontractors to ensure effective coordination, or a single outside contractor should be mandated to provide coordination and to report to a steering committee composed of GEF and the implementing agencies. The outside entity would hold all the subcontracts and coordinate all the activities of the subcontractors to meet the project objectives;

(d) At the start up of such a collaborative project, GEF and the implementing agencies should also review the overall project objectives and outputs to be sure they are clear and focused;

(e) GEF should consider the idea of UNEP playing a similar role in finding the next big objective for Operational Programme 7: Reducing Long-term Costs of Low Greenhouse Gas emitting Energy Technologies.

I. INTRODUCTION AND SCOPE

10. The project under evaluation, “Fuel Cell Market Prospects and Intervention Strategy Options”, was developed to address the need, as expressed by the GEF Council, to identify strategy options for fuel cell applications. The project was designed to support GEF Operational Programme 7, “Reducing the Long-term Costs of Low Greenhouse Gas Emitting Energy Technologies”, and Operational Programme 11, “Promoting Environmentally Sustainable Transport.” The project was initiated and coordinated by UNEP/DTIE and is consistent with the mission of the latter, which is to encourage decision-makers in Government, local authorities and industry to develop and to adopt policies, strategies and practices that are cleaner and safer and make efficient use of natural resources. This evaluation was conducted in November and December 2002 in collaboration with the Evaluation and Oversight Unit of UNEP.

A. Background of the project

11. The objectives of the project under evaluation were to:

(a) Review the climate change mitigation potential of fuel cell applications in distributed electricity generation and in urban transport;

(b) Develop strategy options for market interventions supporting early achievement of lower-cost and higher-volume production.

12. This project and its proposed strategies were to serve as a reference outlook on fuel cell market intervention to facilitate the decisions of GEF on projects in this area of technology and to provide publicly available information for national policy-makers. Specific fuel cell projects in the pipeline for GEF funding, which have built upon the results of this project, include a number of fuel cell bus (FCB) projects through UNDP and fuel cell distributed power generation (FCDPG) projects through IFC.

13. The project was a collaborative effort bringing together UNEP, UNDP, IFC, GEF, the World Bank and industry experts to develop information in support of policy decisions by GEF and national Governments in this area of technology. The project had four tasks, as indicated in table 1, which were jointly implemented by the executing partners. UNEP/DTIE was responsible for the overall project execution, but in agreement with the UNEP/DTIE Energy Programme coordinator, the UNEP/DGEFC task manager performed the overall task management. UNEP/DTIE participated in some of the meetings and was kept informed of the progress of the project but left task management to UNEP/DGEFC. When a key member of the project staff moved to UNEP/DTIE, the role of task management was shifted to UNEP/DTIE. The project was driven by GEF and delegated to UNEP in its corporate responsibility to GEF to perform assessments and as an independent entity. The project duration was April 2000 to August 2001.

B. Scope of the evaluation

14. The objective of this evaluation is to establish the impact of the project and to review and evaluate the implementation of planned project activities, outputs and outcomes to date against actual results and to indicate their likelihood of contributing to the broader objectives of the GEF programme. The terms of reference for the evaluation are reproduced in annex I.

15. The performance indicators provided in the log frame/project planning matrix were used together with the evaluation parameters of appropriateness, effectiveness and efficiency, impact and sustainability in accordance with the guidelines provided in the UNEP project formulation, approval, monitoring and evaluation manual. The following items were considered for the purpose of the evaluation:

(a) Timeliness;

(b) Attainment of outputs;

- (c) Completion of activities;
- (d) Execution of project within budget;
- (e) Impact created by the project;
- (f) Sustainability.

Table 2

Project tasks, activities, executing agency and funding

Task	Activities	Executing agency	Funding
Task 1	Review of fuel cell bus technology <ul style="list-style-type: none"> • Workshop on FCBs in developing countries • Expert review of FCB technology and global market development 	UNDP	\$170,000 UNEP/GEF trust fund + \$60,000 co-funding
Task 2	Forecast market prospects for FCDPG <ul style="list-style-type: none"> • Time-frame report for commercial availability of fuel cells for stationary applications • Expected cost reduction profile report • Estimated incremental costs and resources report • Options for GEF intervention report 	IFC	\$319,000 UNEP/GEF Trust Fund + \$105,000 co-funding
Task 3	FCDPG assessment <ul style="list-style-type: none"> • FCDPG global market assessment • Assessment of the policy climate for FCDPG • Workshop on FCDPG 	Imperial College, London	\$202,000 UNEP/GEF Trust Fund + \$60,000 co-funding
Task 4	Consolidate the FCB and FCDPG analyses <ul style="list-style-type: none"> • Final report on FCB and FCDPG market prospect and intervention strategy options 	Imperial College, London	

C. Approach of the evaluation

16. The findings of the evaluation were based on the following:

- (a) Desk review of the project documents, outputs, monitoring reports and relevant correspondence, including GEF Council references, documents and project pipeline. Annex II contains a list of the relevant project documents reviewed;
- (b) Desk review of specific products, including reports of the sessions highlighting presentations, case studies, technical information and recommendations for action on topics selected for discussion;
- (c) Telephone and e-mail interviews with UNEP, the World Bank, IFC, UNDP, STAP, the GEF secretariat and other project participants, including workshop participants. See annex III for a list of the staff interviewed and annex IV for the list of the questions asked during the interviews.

II. PROJECT EVALUATION

A. Appropriateness to the mission of UNEP

17. The mission of UNEP/DTIE is to encourage decision-makers in Government, local authorities and industry to develop and to adopt policies, strategies and practices that are cleaner and safer, make efficient use of natural resources, particularly energy and water, ensure sound management of chemicals and incorporate environmental costs. The strategy of the subprogramme is to promote the development, use and transfer of environmental policies and related environmentally sound technologies, economic instruments and managerial practices.

18. The “Fuel Cell Market Prospects and Intervention Strategy Options” project was developed to address the need, as expressed by the GEF Council, to identify strategy options for fuel cell applications that support GEF Operational Programme 7, “Reducing the Long-term Costs of Low Greenhouse Gas Emitting Energy Technologies” and Operational Programme 11, “Promoting Environmentally Sustainable Transport”. Given the strong environmental benefits of fuel cell technology for both stationary and transport applications, the project is fully consistent with the strategy of UNEP/DTIE to promote the development, use and transfer of environmentally sound technologies”.¹

B. Accomplishment of project objectives

1. The goal of the project

19. The goal of the project was to “facilitate specific new proposed GEF operations where cost-effective, complementary and demand-driven.” The project directly led to the two specific outcomes discussed below. This evaluator is therefore of the view that the goal of the project was met.

20. In April 2002, the Environmental Markets Group of IFC released a concept paper entitled “Fuel cells financing initiative for distributed generation applications”, which defined an initiative to accelerate the market for fuel cell technology in distributed, stationary power applications by facilitating the reduction of the long-term costs of the technology and promoting its use in GEF-eligible countries. The concept paper was in line with one of the outputs of the project: “Market prospects and intervention strategies to accelerate the deployment of fuel cells in distributed power generation in developing countries”, which was presented to the GEF Council at its December 2001 meeting. In November 2002, IFC announced a GEF-funded programme entitled “Private-sector financing programme for stationary fuel cell applications in selected GEF-eligible developing countries”, and requested expressions of interest or proposals from consortiums of fuel cell vendors and project developers.

21. A specific output of this project, a report entitled “Toward a GEF strategy to develop fuel cell buses for the developing world”, was instrumental in gaining the approval by the GEF Council of a coordinated series of projects in Brazil, Mexico, China and Egypt.

22. The IFC programme for stationary fuel cell applications is a market-driven approach to facilitate early introduction of near-commercial fuel cell systems in developing countries and is consistent with the goal of the project. In addition, both the IFC programme and the FCB demonstration projects of UNDP are consistent with the “technology leapfrogging” strategy of Operational Programme 7.

¹ UNEP 2001 Activity report: Division of Technology, Industry and Economics, United Nations Environment Programme.

2. Needs and expectations of partners

23. The assessment of whether the project met the needs and expectations of partners (UNEP, UNDP, IFC, the World Bank and GEF) was based on the results of interviews with the responsible managers in those organizations, other key project participants and representatives of STAP. The results of these interviews are consolidated and summarized in the sections below.

24. There was a consensus that the project was effective in putting together a number of disparate pieces into a cohesive whole. Fuel cells were identified as a technology worth supporting by GEF nearly 10 years ago in its working papers, which later became part of its operational programmes. The situation has since evolved rapidly and the partners needed a strategy and the resources to carry out the analyses required to back up the strategy. This project brought together a wide range of experts and helped to develop a clear strategy for fuel cells, in an open consultative process, that might not have been developed otherwise.

25. The project results were considered to be very helpful in presenting a cohesive and comprehensive strategy to GEF. In particular, some interviewees commented that the IFC stationary fuel cell programme concept could not have been developed and accepted without the process provided by this project. In addition, the FCB strategy note was described as critical to getting GEF Council approval for several of the project documents. From the perspective of UNDP, however, the project would have been more helpful if it had been organized sooner in relation to the development of the FCB project. Key partners described the project results as quite helpful in developing their submission and information notes to the GEF Council.

26. There was also agreement that even though the key questions addressed by the project evolved over time, the project was effective and accomplished its goal. The strongest criticism of the project was that the process was somewhat chaotic, that at times UNEP leadership was unclear and a great deal of communication was therefore needed, and that many changes were made. The coordination of the project's activities were a constant challenge.

27. The final products were very good. The reports were considered useful and informative by all the interviewees, although a few of those interviewed commented that they had been "frozen" a little sooner than they should have been. The workshops were judged to be particularly valuable and quite productive. A frequent comment was that while the information developed by the project was useful, the process of collaboration involving the manufacturers and users was most valuable. The project helped the partners to understand the window of opportunity for GEF interventions in the area of fuel cells and helped to forge a link between the stationary and transport sectors.

C. Usefulness of project outputs

28. The evaluation of the accuracy, quality and usefulness of the project's outputs was based on a combination of interview results and review of the project outputs, GEF project implementation reviews, partner evaluation reports and STAP assessments. These results are given in table 2. All the project outputs were attained and it is the conclusion of this evaluator that they were useful in achieving the goal of the project. One project output (2.2) was not achieved in the manner initially anticipated, but the results achieved were useful. The project rating for attainment of outputs is "very good."

Table 3

Evaluation of project outputs

Output	Deliverable	Evaluation
1.1 Opinion and review of current state-of-the-art technology and opportunities in major cities of developing countries in a workshop report	Workshop report	The workshop provided UNDP with an open consultative process that gathered the inputs of industry, users and agencies for the development of a cohesive and comprehensive strategy. The participation of the private sector and developing countries was significant and adequate for the requirements of the tasks.
1.2 An integrated global market prospect including the UNDP country studies and expert reviews for Japan, North America and Europe in a Task 1 report on the FCB market	FCB strategy note	The strategy note appears to have been effective in helping UNDP to communicate to the GEF Council and others a fuel cell vehicle programme design that actualized the leapfrogging elements of the strategy of Operational Programme 7 for transportation.
1.3 Results of interviews and literature search on the policy environment with intervention strategies to obtain sustainable global benefits in a Task 1 report	Three additional background papers	The reports provided a summary of policy options, a quantitative analysis of fuel cell vehicle commercial introduction costs, benefits and timing and an indication of long term greenhouse gas reduction potential for fuel cells. The reports were made available on the web and were reasonably well integrated into the final report. See evaluation of Output 4.
2.1 Summarized interviews with fuel cell suppliers	Final report on FCDPG	The report summarizes results of interviews with 49 fuel cell companies, presents current strategic alliances, market positions and product information. The material is quite comprehensive.
2.2 Normalized or averaged information on fuel cell technology developments and cost projections		Interviews with suppliers did not produce the desired level of information. Developers were unwilling to provide detailed information on expected or current cost. Independent cost analyses by Arthur D. Little and others were the main source of capital cost estimates used in the present report.
2.3 The aggregate incremental cost of a fuel cell market intervention		The costs and resources needed to accelerate cost reductions were estimated, intervention options were identified and the issues related to the timing and level of market intervention of multilateral lending agencies were developed.
2.4 A report on optional financing mechanisms for market interventions		Nine different co-finance and concessionary investment programmes were evaluated and the full chain of project marketing, development and financial intermediation was analysed in order to identify the most effective points for market intervention.

Output	Deliverable	Evaluation
3.1 A top-down market assessment including total projected market potential and estimates of a possible market share	Preliminary report on global fuel cell decentralized generation market assessment	The top-down methodology produced preliminary estimates that were considered highly speculative. In particular, the fuel cell demand curves, compiled on the basis of expert consultations, were not considered useful by several interviewees. However, the fuel cell decentralized generation (FCDG) market penetration over the period to 2020 implies an average learning factor for the various capacity ranges of 89 per cent, which is quite reasonable.
3.2 Interviews and information gathered from multilateral and bilateral agencies	Preliminary report on fuel cell policy climate assessment	The report is a framework for policy development, outlining the policy instruments that can be applied and the ways in which they may fit together to fulfil the requirements of GEF and to meet the needs of developing countries. The framework was presented at workshops held from 22 to 24 May 2001 to elicit comment. However, it is not clear from either the preliminary report or the workshop reports that the views and information from multilateral and bilateral agencies were gathered or represented in other than a very general manner.
3.3 A report on the workshop detailing the advice and comments of industry and developing country experts	Workshop report	The workshop provided a forum for the partners and participants to discuss opportunities, barriers and risks associated with the introduction of fuel cells in developing countries and provided a basis for developing a possible strategy for supporting stationary fuel cell applications. The participation of the private sector and developing countries was significant and the report effectively documented the presentations and discussions.
4. An integrated report including possible synergies between FCB and FCDPG market interventions	Final report on fuel cell market prospects and intervention strategies	The report provides a strategic programmatic framework to focus and to govern GEF support in the area of FCBs and FCDPG, including goals and stages of programmatic intervention that extend beyond a single project or set of projects.

D. Adequacy of project activities

29. The review of the project activities focused on determining if they had been accomplished in accordance with the project document, particularly focusing on timeliness, completeness and performance within budget. As no budget issues were identified for any of the tasks or activities and the project ran slightly under budget, the project rating for execution within budget is “very good.” It is possible that the remaining funds could have been spent productively, as noted below. The schedule in the medium-sized project brief and the three project documents indicated project start up in March 2000 and completion in December 2000. The fuel cell bus workshop was held on schedule, but the FCDPG workshop was not held until May 2001. Given the typical delays in getting subcontractors on board and coordinating activities, this extension of the schedule is not considered significant and the project rating for timeliness is “good.” Regarding the completeness of project activities, all the project activities were performed in accordance with the task statements in the project documents, the workshops were held and the reports were delivered. Overall, the outputs are considered to be of high quality and the project rating for completion of activities is “excellent”. The following sections summarize the project activities in relation to those factors.

1. Activity 1.1: Hold a workshop on fuel cell buses in developing countries

30. A workshop entitled “Commercialization of fuel cell buses: Potential roles for GEF” was held on 27 and 28 April 2000 at United Nations Headquarters in New York. Coming only three weeks after the official approval of this medium-sized project by GEF, this timing reflects a rapid start-up of project activities.

31. The workshop brought together over 50 participants from 14 countries, including representatives from the GEF fuel cell bus pipeline projects in developing countries (15 per cent of the participants), the fuel cell and fuel supply industry (42 per cent), the public sector (17 per cent), academia (12 per cent) and GEF. Presentations at the workshop examined the role of FCBs in relation to other greenhouse gas mitigation strategies in urban mass transport in developing countries, the status of the development of FCBs and associated fuel supply options and prospective FCB commercialization trajectories. The workshop assisted in identifying strategic options for GEF interventions to help catalyse the commercialization of FCBs in GEF-eligible countries. In addition, it collected and presented information from FCB project development activities in five developing countries.

32. A 39-page workshop proceedings report was prepared by UNDP and GEF staff. Dated 6 June 2000, the report documents the agenda, the participants, the opening statements, summaries of presentations and summary conclusions from the workshop. It indicates that background papers and the full presentations are available on request. The activity (workshop and proceedings) was timely, effective in attracting the desired range of participants and generated the intended output.

2. Activity 1.2: Perform an expert review of FCB technology development scenarios

33. At the request of UNDP, STAP provided an opinion on the above workshop (in which a STAP member participated), the workshop report and the proposals for a series of GEF-supported projects in five developing countries. The opinion of STAP supported the recommendations of the previous STAP and the positions of Operational Programmes 7 and 11 that fuel cells for both stationary and mobile applications were and should be eligible for GEF support. However, STAP highlighted three issues that needed to be taken fully into account. First was the cost and timing of using hydrogen as a transportation fuel in relation to a broad transition to an integrated hydrogen economy. Second was ownership of the technology. Given that the technology was currently developed and owned by a few firms from industrialized countries and also the view that developing countries should not be passive recipients of the technology, STAP agreed that everything should be done to ensure that there is local ownership in relation to the GEF projects. It was, however, unclear whether “local ownership” should cover the fuel cell technology itself or rather the “electric vehicle” component of the projects. The third concern was that electric vehicles did not have to be powered with fuel cells but could use batteries or even hybrid technologies and that the portfolio of Operational Programme 11 might become unbalanced by the proposed fuel cell programme. STAP was of the view that other types of projects should be considered and developed simultaneously.

3. Activity 1.3: Define options for GEF intervention and national policies that would support the development of a market for FCBs

34. Based on the results of the FCB workshop and the STAP review, a long-term strategic vision was prepared outlining GEF programmatic support of FCBs in developing countries. A strategy note entitled “Toward a GEF strategy to develop fuel cell buses for the developing world” was finalized by the staff of UNDP and GEF and released on 29 September 2000. The development objective of the proposed GEF strategy is to reduce long-term greenhouse gas emissions from the transport sector in GEF programme countries by providing support for the commercialization of FCBs. The strategy centres on a partnership between GEF, private industry and local/national Governments in GEF programme countries, with GEF playing three important roles. The first role is funding the incremental costs of FCB projects in recipient countries. The second is facilitating the process of FCB commercialization in developing countries by convening various parties to discuss, to collaborate in and to finance the commercialization programme. The

final role is that of enabling information exchange within and between programme countries, industry and other FCB demonstrations in both donor and recipient countries.

35. At the May 2001 FCDPG workshop (activity 3.3), several issues were identified that needed to be addressed in the development of an overall GEF strategy for fuel cells in the transportation sector. Those issues were explored in detail in three subsequent analyses that were performed as part of this activity. The results from these three additional analyses were incorporated into the final project report under activity 4.

36. The first report, "Assessment of policies to support fuel cell buses and the transition to the hydrogen economy one", was prepared for UNDP by the Stockholm Environment Institute in Boston, Massachusetts, United States of America. The report explored the numerous challenges and barriers that would need to be overcome if fuel cells were to achieve their promise as a clean and efficient energy conversion technology for urban bus fleets throughout the world. The barriers identified included those that arose for any new energy technology, such as the lack of economic consideration for environmental and other societal benefits, continued availability of cheap fossil energy, limited global demand for clean technologies, and an inability to achieve economies of scale at current levels of production. It also explored barriers that were unique to fuel cell technology, such as premature development of fuel cell design and manufacturing technology, inadequate hydrogen infrastructure, high initial costs, lack of adequate storage technology, an inadequate regulatory framework and poor public perception. Finally, it evaluated the additional challenges and barriers to commercial introduction of fuel cell buses in most developing countries, such as lack of investment capital, modest institutional capacity and low levels of awareness.

37. The report explored policies at the national level that could be put in place in both industrialized and developing countries with the aim of overcoming those barriers and promoting commercialization of fuel cell technology. The policies included support for research, development and demonstration, which aims to foster breakthroughs in fuel cell technology and applications by making funding available from either the public sector or through public-private partnerships. Government mandates such as emission standards and technology controls can help to ensure that FCBs are considered as an option in relation to conventional technologies. Other policy options are fiscal incentives such as taxes and subsidies. Finally, awareness-raising can help educate the public at large on the merits of moving to a hydrogen economy and the use of fuel cell technology. The report concludes that accomplishing a transition to a hydrogen economy for tomorrow, and thus reaping the associated local and global environmental benefits, will depend on making the right policy choices today.

38. The second report, "Review of the current state and future projections of fuel cells in the automotive sector," was prepared for UNDP by the Princeton Environmental Institute, Princeton University, Princeton, New Jersey, United States of America. The report assesses possible commercialization strategies for fuel cell automobiles, leading towards long-term use of hydrogen. In particular, the report examines the following issues:

(a) Various fuel strategies have been proposed for commercializing fuel cell vehicles. The implications of using gasoline, methanol and hydrogen as initial fuels for fuel cell vehicles are examined with specific reference to the pre-commercialization phase of fuel cell vehicles. In addition, a strategy for pursuing hydrogen as a fuel for fuel cell vehicles is examined with specific emphasis on the needs of a hydrogen fuel delivery infrastructure;

(b) Based on recent data, the report develops a "learning curve" model to estimate how the cost of fuel cell drive trains might evolve with cumulative mass production. From the learning curve, it estimates the number of fuel cell cars that must be produced to reach a market-clearing cost level, for example, parity on a life-cycle cost basis with a baseline gasoline internal combustion engine hybrid vehicle. Then it calculates the "buy-down" cost required to reach market-clearing costs for hydrogen, methanol and gasoline fuel cell vehicles. The buy-down cost is the cumulative life-cycle cost difference between the fuel cell vehicles and reference vehicles while costs are being reduced to competitive levels. Finally, it discusses the least-cost fuels strategy for commercializing fuel cell vehicles, comparing hydrogen, methanol and gasoline as initial fuels for fuel cell vehicles;

(c) The report develops an optimistic scenario for determining how fast hydrogen fuel cell vehicles might potentially penetrate automotive markets, assuming that fuel cell vehicles reach cost and performance goals and that strong policies are put in place to encourage zero-emission vehicles. This provided an upper bound estimate of the potential for hydrogen fuel cell vehicles which reached about 8 per cent of the total vehicle fleet by 2025;

(d) The report outlines possible policy options to assist with research, development and demonstration, early deployment and eventual widespread dissemination of hydrogen fuel cell vehicles.

39. Based on the above analyses, the report concludes that hydrogen fuel cell vehicles could become life-cycle-cost competitive with other low-polluting vehicle options such as indirect combustion engine hybrids. Initial use of hydrogen in fuel cell vehicles appears to offer the lowest-cost route to buying down fuel cell costs, primarily because of higher vehicle costs for gasoline and methanol fuel cell vehicles, even though infrastructure costs are projected to be lower, at least initially. It is unclear if gasoline fuel cell vehicles will be able to compete against gasoline indirect combustion engine hybrids that are projected to have lower costs and almost as many environmental benefits. Centrally refuelled fleets (including buses and light-duty vehicles) appear to be an attractive initial market for hydrogen fuel cell vehicles and might be large enough to accomplish a significant cost reduction of fuel cells, while avoiding the costs of a widespread hydrogen infrastructure, during the buy-down period. Once fuel cell vehicle costs are reduced, the widespread use of fuel cells and hydrogen could be encouraged through zero-emissions vehicle mandates and economic incentives.

40. An optimistic scenario for market penetration of hydrogen fuel cell automobiles, based on rapid technical progress and strong policies to encourage zero emission vehicles, indicated that hydrogen fuel cell vehicles might comprise 8 per cent of the automotive fleet by 2025. Policies are needed to encourage research, development and demonstration of advanced concepts, to encourage early deployment of hydrogen fuel cell vehicles in fleet markets and to assist in widespread dissemination of hydrogen fuel cell vehicles once they reach market-clearing cost. These might include strong zero-emission vehicle mandates coupled with rebates. Coordination between industrialized and developing countries is needed to bring hydrogen fuel cell vehicles to the markets of developing countries once costs are reduced.

41. The third report, prepared for UNDP by a consultant, Clean Energy Commercialization of Annapolis, Maryland, United States of America, analyses key reports of the Intergovernmental Panel on Climate Change (IPCC) on climate change mitigation and summarizes material in those reports in relation to fuel cell technology. In particular, three reports of IPCC were reviewed - the second assessment report, the special report on emission scenarios (SRES) and the third assessment report. Information in those reports regarding the costs, efficiencies, market penetration rates and fuels used by fuel cells is reported and a bibliography of referenced reports has been prepared. Finally, the write-up discusses strategic opportunities for GEF to provide long-term support for fuel cell technology and applications.

42. The report notes that specific IPCC modelling scenarios indicate that when fully commercialized, hydrogen fuel cells can play an important role in the stabilization of greenhouse-gas emissions by 2100. The potential cumulative CO₂ reduction by 2100 for all hydrogen fuel cell systems is calculated from the SRES scenario outputs to be 85 gigatonnes in the A1B scenario and 270 gigatonnes in the A1T scenario, assuming that all the hydrogen is produced from renewable, nuclear or fossil fuels with CO₂ sequestration. Those values represent 5 per cent and 25 per cent reductions of cumulative emissions for the A1B and A1T scenarios respectively. Therefore, GEF programmatic support for FCBs in developing countries can be a significant contributor to the achievement of total long-term greenhouse gas emission reduction.

4. Activity 2.1: Projected time frame for commercial availability of fuel cells in stationary applications

43. Each of the four activities under task 2 was incorporated into the report entitled “Market prospects and attendant intervention strategies to accelerate the deployment of fuel cells in distributed power generation for developing countries”. This 133-page report was prepared for IFC by Spencer Management Associates and several supporting contractors, including Arthur D. Little and Winrock International. Finalized in October 2001, the report was developed in close cooperation with the activities of task 3, in particular the FCDPG workshop held in Paris in May 2001.

44. With regard to the time frame for commercial availability of fuel cells, the report uses interview results and published information to estimate the current cost of the first generation of fuel cells at around \$4000/kW (factory cost). This first-generation technology will reach Organisation for Economic Co-operation and Development (OECD) markets within the 2002-2006 time frame, depending on the developer and the type of fuel cell. The early system costs do not compare well with conventional power generation. Currently, however, fuel cells are still in various stages of prototype testing and demonstration. These initial unit costs are therefore based on very low production volumes, i.e., tens to hundreds of units, and are not necessarily indicative of the ultimate potential.

45. The report notes that fuel cell developers are all working to reduce installed power generation capacity costs through some combination of technological improvements and increased levels of production. Assertions by the manufacturers and the manufacturing-cost estimates of Arthur D. Little indicate that factory costs will likely be reduced to a range of \$900/kW to \$2,000/kW by a 2004-2008 time frame, depending on the type of technology and the level of improvements achieved. System operation costs vary by fuel cell type and by application depending on the efficiency of the system, the fuel cost and the maintenance and replacement costs of the fuel cell stacks and catalytic systems. Currently, data on the durability of those components are insufficient, but most manufacturers expect stack life to exceed five years of operation.

46. The report contains a significant amount of descriptive information on fuel cell technology, the fuel cell industry and its products and current levels of the teaming arrangements of private investment and industry. It also contains a country-based analysis of fuel cell market conditions for several developing countries. All this material supports the assessment of 2004-2008 as the time frame for commercially available fuel cells.

5. Activity 2.2: Determine the cost reduction profile over time

47. The report analyses the cost of power from fuel cells in distributed generation applications by analysing the cost of the components of the fuel cell system, including initial installed cost, annual fuel cost, operating and maintenance costs, including stack replacements, and the use of co-generation.

48. The report notes that most developers are unwilling to provide detailed information on expected or current costs, although some are willing to share cost targets. However, Arthur D. Little and others have carried out independent cost analyses on most of the major fuel cell types. Such analyses are the main source of information used to arrive at the factory-cost estimates (\$900/kW to \$2,000/kW) used in the report. The early system costs do not compare well with conventional power generation technology, which ranges in cost from around \$200/kW for large gas turbines to around \$1,200/kW for state-of-the-art coal-fired power plants. Competing distributed generation technologies, predominantly engines and microturbines, have costs in the middle of that range. The lower end of the fuel cell factory costs projected for all the technologies, with the exception of the phosphoric acid fuel cell, are consistent with approaching the \$1,500/kW installed cost target generally viewed as necessary for the initiation of large markets.

49. The report provides an economic analysis of the benefits and costs for countries seeking to adopt fuel cell technologies. Two countries, the Philippines and South Africa, which exemplify high and low fuel cost cases respectively, were chosen for a detailed analysis. In both cases, fuel cell plants were installed at the interface of the transmission and distribution systems at approximately \$2,000/kW. Both the economic internal rate of return for the plant investment and the smoothed electricity cost are analysed under base, optimistic, pessimistic and GEF-grant conditions. For some of the cases, most notably the optimistic cases of the solid oxide fuel cell and the proton exchange membrane, the fuel cell cost of generation compares favourably with almost any conventional peak-period generation technology.

6. Activity 2.3: Estimate aggregate incremental costs

50. The report notes that the current spending in the fuel cell industry, which amounts collectively to about \$500 million to \$1,000 million per year, dictates that incremental funding from the multilateral lending agencies should be directed to catalysing and accelerating cost reductions for applications in developing countries rather than sponsoring them. Also, the report asserts through market examples that the long-term impact of any market intervention by multilateral lending agencies would be greater with an earlier rather than a later schedule.

51. The report assesses the environmental benefits of stationary fuel cell technology compared to competing technologies and shows that environmental considerations are a strong driving force behind the development of fuel cell systems for transport and stationary applications. The advantages of fuel cell systems with regard to energy, CO₂ and regulated emissions for distributed and base-load electricity are more consistent than for transport applications, with reductions in regulated pollutants generally larger than one order of magnitude compared to competing technologies. For combined heat and power applications, the advantages of fuel cell systems with regard to regulated pollutants remain large. The advantages in terms of energy efficiency and CO₂ emissions are reduced, however, depending largely on the assumptions made for the heat/power ratio and the system comparison.

7. Activity 2.4: Evaluation of financing modalities

52. The report examines programme designs and finance strategies for a proposed GEF-funded IFC programme to promote the commercialization of fuel cells for stationary distributed power generation. Because the ultimate goals of GEF are improved energy efficiency, energy savings and reduction of greenhouse gas emissions, the report recommends that any programme should give priority to opportunities for greenhouse gas emission mitigation.

53. The report examines nine different co-finance and concessionary investment programmes and assesses the full chain of project marketing, development and financial intermediation in order to determine the most effective points for market intervention by an IFC/GEF programme. It recommends that the immediate objective of an IFC/GEF programme should be the development and financing of fuel cell applications and that the programme should engage fuel cell market actors, support them with targeted capital subsidies, concessionary investments and technical assistance, and use business methods which are judged to have strong prospects of becoming fully commercial and replicable. The report defines the programme's long-term objective as the development of a commercially sustainable fuel cell industry, including the necessary infrastructure and technical capacity building, both globally and in the target countries chosen for the programme. Finally, the report discusses the role of various market players, with specific emphasis on energy service companies.

54. The programme is expected to have the following three major components: capital subsidies or some other forms of targeted subsidies, reflecting the fact that fuel cell systems are pre-commercial and not yet economic; concessionary co-finance, which uses commercial methods and is tied to commercial capacity-building and to strategic programmes ("market launching orders") for fuel cell systems; and direct assistance for a range of capacity-building, policy-making and market-organizing activities.

55. The report concludes with a proposed project concept for sustained commercialization in developing countries that consists of three phases and is projected to require approximately \$165 million of GEF support in constant dollars. Each of the three phases would require in the order of approximately \$50 million, or more, in concessionary support starting in 2002-2004. The variability is dependent upon the rate of technological innovation, the volume-price impacts of the OECD market pool and the degree of concurrent improvements in infrastructure support in emerging economies. The report specifically states that its recommendations are based on consultation with stakeholders at a workshop in Paris co-hosted by the International Energy Agency (IEA) in May 2001, and on the integration of sustainable commercialization strategies together with IFC staff.

8. Activity 3.1: Global market assessment for fuel cell distributed power generation

56. The aim of this activity was to perform a global, top-down market assessment of FCDPG applications, with an emphasis on GEF programme countries. This activity produced a draft report, "Fuel cell bus and distributed power generation market prospects and intervention strategy options", which was prepared for UNEP and Imperial College, London by E4Tech UK Ltd. and incorporated into the final report produced as part of activity 4.

57. The market assessment was carried out on a regional basis based on the geographic breakdown used by IEA in its world energy model (World Energy Outlook, 2000) and other sources. The results were then aggregated to provide global estimates. The analysis covers the period 1997-2020. A spreadsheet model was developed to provide an estimate of the potential FCDPG market. The model is divided into three main modules, the FCDPG potential being calculated from a forecast of distributed generation potential which is derived from the IEA projections of overall growth in electricity generating capacity.

58. The FCDPG potential module calculates the fuel cell installed capacity in four capacity ranges (1-100kW; 100kW-1MW; 1-10MW; 10-50MW) using fuel cell demand curves compiled on the basis of expert consultation, including input from Task 2. Critical to these are the estimation of cost reductions for the various fuel cell types, their split over the capacity ranges considered and the estimation of the fuel cell share of the distributed generation market as a function of fuel cell installed cost. The report estimates a global distributed generation market of 380GW in 2020 with a FCDPG market share of 340GW. These estimates are highly speculative but the FCDPG market penetration over the period to 2020 implies an average learning factor (the rate of cost reduction with every doubling of cumulative production) for the various capacity ranges of 89 per cent, which most experts would consider quite reasonable.

9. Activity 3.2: Assessment of the policy climate regarding power generation

59. The objective of this activity was to examine the policy framework, in general, that will have a bearing on GEF investment strategies, assess policies that may help or hinder the introduction of FCDPG, and understand whether a global template of policies that could be applied to enhance their introduction into and acceptance by the market can be produced. The analysis examines the framework for policy development, the policy instruments that can be applied and the way in which they may fit together to fulfil GEF requirements while also matching the needs of developing countries.

60. A preliminary report, "Fuel cell policy climate assessment," was prepared for UNEP by Imperial College, London to make it possible for specific areas of policy to be discussed in greater detail at the FCDPG workshop from 22 to 24 May 2001 and to elicit comment regarding suitable regions in which to site possible early demonstrations. The report concludes that the policy framework in which FCDPG may be effective is varied and complex and that no single policy is likely to be either necessary or sufficient to enable fuel cell systems to penetrate distributed generation markets. Rather, a portfolio of policy measures would be appropriate. Also, the report concludes that GEF support is more likely to be effective in a market that already has established policies that are favourable to distributed generation.

10. Activity 3.3: The fuel cell distributed power generation workshop

61. A workshop was held in Paris and organized in two sessions: “Fuel cell distributed power generation in developing countries: Opportunities and market intervention strategies”, 22-23 May 2001; and “Overall fuel cell market prospects and strategy options for the Global Environment Facility”, 24 May 2001.

62. A total of 50 participants attended the workshop, representing fuel cell and related industries, the finance community, international organizations, academia and Governments. It was attended by participants from the following developing countries and countries with economies in transition: Bangladesh, Brazil, China, India, Philippines, Russian Federation, South Africa, Trinidad and Tobago.

63. The first session focused on the presentation of a report managed by Spencer Management Associates and conducted by a team of organizations and individuals. The overriding issues of the session were whether GEF should facilitate investment in fuel cells in developing countries and, if so, what the main elements of a GEF strategy should be and how it could complement IFC investment in fuel cells. The workshop addressed the following issues in order to provide some insight into answering these questions:

- (a) Fuel cell technology status, short term developments and outlook;
- (b) Global and developing country market prospects for fuel cells in distributed generation, including short-term niche markets and broader, long-term opportunities;
- (c) The relationship between cost, volume and commercial viability;
- (d) Economic and environmental issues and modalities for interventions that maximize global benefits and ensure long-term progress;
- (e) Infrastructure and other market-enabling requirements, for example, policies and capacity-building;
- (f) Roles for GEF as a market facilitator and opportunities for IFC investment.

64. The participants discussed the opportunities, barriers and risks associated with the introduction of fuel cells in developing countries and provided a basis for developing a possible strategy for supporting fuel cells.

65. The second workshop aimed at understanding the perspective of the developing countries and integrating possible FCDPG and FCB projects in terms of synergies between transport and power generation technologies and overall opportunities for the GEF strategy. Presentations were made by the representatives of China, India, the Philippines, South Africa, the Russian Federation and Trinidad and Tobago, and also by representatives of UNDP, the World Bank and IEA on transport initiatives in general.

66. A 28-page workshop summary report was prepared for IFC and UNEP by the Imperial College Centre for Energy Policy and Technology, documenting the background, the introductory remarks, the presentations, the discussions, the perspectives of developing countries and the concluding remarks.

11. Activity 4: Consolidate the FCB and FCDPG analyses

67. This activity produced a final report entitled “Fuel cell market prospects and intervention strategies” which was prepared for UNEP by the Imperial College Centre for Energy Policy and Technology. The report provides a strategic overview of the long-term environmental goal for deployment of fuel cell technology, identifies the synergies between stationary and transport applications, discusses the market and policy climate for early fuel cell applications, identifies the major challenges to the commercialization of fuel cells and suggests a coordinated GEF strategy to promote FCDPG. It concludes that the primary opportunity of GEF to influence price reduction in FCDPG applications is by opening the door to the large markets in developing countries and catalysing increased investment.

68. The 146-page report, finalized in January 2002, consolidates the three additional analyses identified at the May 2001 workshop and funded under activity 1.3. It also consolidates and finalizes the two draft reports developed under activities 3.1 and 3.2. It then identifies the following roles that GEF must play if it decides to support the process of commercialization of FCBs and FCDPG in GEF-eligible countries:

(a) GEF should help to fund the incremental costs of the FCB and FCDPG demonstration(s) in its programme countries;

(b) GEF should join with other multilateral organizations such as IEA and serve a role as a facilitator to the process of FCB and FCDPG commercialization in developing countries. GEF can act both as a convenor and as a financial facilitator;

(c) GEF should act as an agent for information exchange. Lessons drawn from one demonstration should be shared with activities being carried out in another.

69. The report then defines a set of basic principles that should be applied as part of the underlying strategy. It concludes that the programmatic intervention of GEF will extend beyond a single project or set of projects and will encompass the following stages of support: the preparatory phase, the demonstration phase and the commercialization phase. GEF should monitor progress carefully and may decide to increase or decrease its participation in the programme, depending on changing circumstances and conditions. The report defines each phase and develops criteria for projects under each phase.

E. Effectiveness of inter-agency cooperation

70. The approach to the project was a multi-agency, coordinated set of tasks which allowed each partner to have a broader perspective in order to contribute to a larger collaborative process. Several interviewees commented that carrying out the individual tasks alone would not have been as productive. UNEP provided a value-added service by facilitating greater inter-agency cooperation, which would otherwise not have occurred.

71. There was a consensus that the degree of inter-agency cooperation was generally adequate because the project outputs were achieved. The process, however, was difficult and not as effective as it should have been because people were busy, leadership roles were not always clear and it was difficult to coordinate the division of the scope of work. Lack of coordination and communication led to certain inefficiencies and some minor friction. The principal source of the leadership problem was the lack of any real consensus regarding who was in charge.

F. Impact on policy decisions

72. Several partners commented that the project was helpful but not significant in disseminating general information on fuel cell technologies. All agreed, however, that it was very useful in getting the agreement of the GEF Council and in facilitating the policy decisions of GEF and the implementing agencies. The clearest impact was considered to be the impact on the development and approval of the IFC proposal for the development of stationary fuel cells.

73. There was also consensus that the project had little impact on national Governments' policies in support of fuel cell technology and market development. Several partners commented that national Governments were not a target for the project and they therefore did not consider this point to be relevant. As a result, the project rating for impact is "Very good."

G. Level of involvement of stakeholders

74. Most interviewees considered the level of involvement and participation of stakeholders in project activities, in particular workshops, to be adequate and appropriate to the needs of the project. Several partners commented that with regard to stationary fuel cell applications the manufacturers and users had been very cooperative and provided important insights.

H. Effectiveness of institutional arrangements

75. Most of the partners considered the effectiveness of the institutional arrangements and administrative and financial support provided by UNEP to be reasonably effective after some initial problems. There was a great deal of confusion and a little friction initially as the participating agencies sorted out their different procedures, but things were worked out and proceeded smoothly afterwards.

76. One partner commented that this was where most of the problems occurred. The partner felt that there was little follow-up by UNEP and that the executing agencies had had to carry out almost all the follow-up because UNEP leadership was so very weak. This view was not shared by other partners, who felt that the cooperative execution process itself was inherently difficult to control because some of the partners had their own agendas and wanted to control the process. To improve the management of the project, UNEP hired Imperial College, which did a good job, although it was basically a contractor rather than a partner in the process.

77. IFC believed it was delayed in getting its stationary fuel cell programme into the implementation phase because of the requirements of the process. Various administrative problems - for example, delays in receiving funds from UNEP - affected the implementation of activities. The reason for these administrative delays is not clear, but it appears that they were partially attributable to difficulties in coordination between UNEP/DGEFC and UNEP/DTIE. It also appears that some of the delay resulted from the different expectations and cultures of UNEP, IFC and UNDP.

III. LESSONS LEARNED

78. In general, none of the partners reported any major problems in the execution of the project. There were some small financial problems at first but they were easily solved. In addition, some difficulties were reported in terms of assigning responsibilities with regard to the May 2001 workshop, but these too were resolved satisfactorily. The following minor problems and lessons learned with regard to project implementation were identified by the interviewees:

(a) The process facilitated by the project was a very productive way of understanding the strategy in such a tricky area. It brought the agencies together and produced useful results;

(b) The overall project objectives needed to be made clearer from the outset. The reports were good but somewhat bulky. The analysis of the competition was weak and the terms of reference were not as clear as they should have been. Some of the contracting organizations had limited knowledge and took a long time to gain momentum;

(c) The greatest impact of the project was the creation of a programme concept for stationary applications. It would have been more useful for the transport applications if the project had been started before the writing of the FCB project documents;

(d) The May 2001 workshop was conducted in a satisfactory manner, but more financial institutions should be involved in the future. One problem concerned whether representatives of Governments of developing countries should attend the workshop in addition to the invited technical experts. While the budget was sufficient to support their participation, in the end, the representatives of developing countries were not invited. Several participants believed that the perspective of the latter on policy and local air quality would have been useful;

(e) Obtaining cost data from the fuel cell manufacturers was very difficult and caused delays. There was some naivness in the project documents. The biggest problem, however, was the fact that the companies were new and very cautious, while their primary asset was their intellectual property and they were not willing to divulge it;

(f) Not all partners were convinced that joint execution and coordination by UNEP constituted the best approach. There was a need for better coordination. The responsibilities were not well demarcated. Although the project could have progressed better, the final outcome was not compromised;

(g) From the perspectives of some partners, the problem was that cooperative execution was inherently difficult to control. Some of the partners had their own agendas and wanted to control the process and the fact that the various contractors reported to different partners made coordination difficult. This made it hard for UNEP to control the process. The different styles and characters of the agencies also constituted a hindrance;

(h) As an example of coordination and planning issues, the parallel assessment of the market size for various fuel cell units was not well coordinated between UNEP and the IFC contractors. As a result, the market forecasts were regarded as optimistic at the May 2001 workshop and somewhat contrary to the pace of the deployment schedule and proposed funding levels elsewhere in the main report. In hindsight, part of the terms of reference for Imperial College could have been contracted for directly by IFC or through its primary contractor, which put together the rest of the team. This was not done initially for reasons of efficiency, as UNEP was already planning to enter into a contract with Imperial College for other services, including integration of the stationary and FCB parts of the study into a separate, overarching aspect of policy.

IV. FINDINGS AND RECOMMENDATIONS

79. On the basis of the evaluation and lessons learned, the findings and recommendations below may help to improve future project results in collaborative projects that are executed by a number of agencies in the area of fuel cell technology.

80. In general, the project results have been broadly used. The reports have been posted on the IFC and UNEP web sites and have been widely reported by the specialized trade press. Other multilateral agencies such as IEA provided the consultants with additional funding to help integrate the report into their plans. The United States Department of Energy, the European Union and the Ministry of Economy, Trade and Industry of Japan have all synergistically factored the project results and outcomes (particularly the IFC stationary fuel cell project) into their own development and commercialization plans for fuel cell technology.

A. Development of the GEF strategy

81. With regard to the development of the GEF strategy, the following recommendations are made:

(a) Given that the process facilitated by this project was considered to be a very productive way to understand the GEF strategy, it is recommended that GEF should continue to use a collaborative approach for identifying priorities and establishing the operational activities for implementing them. Such an operational strategic process could be used to help GEF and the implementing agencies to be more proactive rather than reactive;

(b) GEF and the implementing agencies should review the coordination process prior to the start of the project and establish clear lines of communication and responsibility. If a single implementing agency is to coordinate the project, it should be given contractual responsibility over all subcontractors in order to ensure effective coordination;

(c) Rather than having a single implementing agency lead the collaborative process, a single outside contractor could be tasked with coordinating the process and to report to a steering committee composed of GEF and the implementing agencies. The outside entity would be in charge of all subcontracts and coordinate all subcontractor activities to meet project objectives;

(d) At the start of such a collaborative project, GEF and the implementing agencies should review the overall project objectives and outputs to be sure that they are clear and focused. In addition, the process of selection of the contractors should be reviewed to ensure that qualified contractors are selected in a timely manner;

(e) The coordinators of such efforts in the future should seek to involve more financial institutions in the workshops and to invite representatives of Governments of developing countries to ensure that their perspectives on local air quality and other relevant issues are shared;

(f) Several participants believed that more follow-up was needed. The reports were good, but there is a tendency by the agencies not to implement the recommendations of the reports. Additional effort is needed to look at the ways investments in the technologies might be facilitated by country policies. The environmental benefits, for example, needed better attention. The co-benefits of local air quality are a greater drive than greenhouse gas emission reductions;

(g) Some partners expressed the view that UNEP could play a similar role in finding the next major objective for Operational Programme 7: Reducing Long-term Costs of Low Greenhouse Gas Emitting Energy Technologies. Others noted that a similar international initiative, facilitated by GEF or the World Bank, would be a good formula for determining ways of stimulating the use of new, climate-friendly technologies.

B. Technology support projects

82. With regard to technology support projects, the following recommendations are made:

(a) GEF can best influence fuel cell markets by identifying strategic market niches, which are different for each application. In addition, the difference between a long-term perspective and a short-term perspective of fuel cell markets creates a great deal of tension that was highlighted by the process. Although this was not resolved, this insight was helpful;

(b) For future technology-focused projects, GEF and the implementing agencies should ensure that an analysis of advanced competitive technologies is included in the terms of reference;

(c) One partner concluded that the kind of technology intervention exemplified by the project was not relevant for the transport sector. Costs would continue to be too high for developing countries and movement would not occur within the intended time frame. Based on his experience with the project, the partner concluded that a programme to impact modal shifts in the transportation sector, for example, getting people to shift from cars to buses, would be a more effective approach than one focused on technologies;

(d) Stationary and transport markets are not as firmly connected as originally thought. For transport applications, the cost of fuel cells is the key issue, while for stationary applications the issue is the duty cycle. Stationary applications need 8000 hours per year and the transport applications need only 3000 to 4000 hours per year;

(e) In the future, project coordinators should recognize that getting actual cost data from the manufacturers of advanced technology is generally quite difficult, if not impossible. It is often better to plan to develop such data from the bottom up using experienced consultants.

V. CONCLUSIONS

83. The conclusion of this evaluator is that the project was quite successful despite some difficulties relating to its implementation, and that the process used by the project is quite valuable and should be replicated to facilitate development and acceptance of GEF programme strategies.

84. Industry viewed the project as important in identifying the best strategies to penetrate emerging markets once the technology is ready for the markets. At least one participant felt that the project was helping to reverse the trend in technology projects towards avoidance of emerging markets due to higher costs and greater risks.

85. The degree of flexibility was satisfactory and no partner felt that any activities should have been conducted significantly differently. In fact, most partners stated that they would be willing to enter into a similar collaborative process a second time. A few added the condition that they must know who would be running the project. Others would agree only if the project objective was to further promote fuel cells and several other technologies through concrete follow-up actions leading to investment and supportive policies.

86. The effectiveness of the project was rated according to six evaluation items: timeliness, attainment of outputs, completion of activities, project executed within the budget, impact created by the project and sustainability. Each item was rated on a scale of 1 to 5, with 1 being the highest rating and 5 being the lowest. The ratings for the first five items are discussed in the sections above and summarized in Table 3. The overall project score is 2, or “very good.” In summary, the project outputs were attained in a timely manner and the project was executed within the budget. Project activities were completed in accordance with the scope of work and were of high quality. Most importantly, the project appears to have achieved the desired short-term impact. Any final analysis of a sustainable long-term impact, however, cannot be assessed at the moment. It is too early to determine the impact of the programmes developed in support of the fuel cell technology strategy. The project was successful in attaining significant stakeholder involvement, which improves the likelihood of long-term sustainable results, and the project rating for sustainability is “good.”

Table 4

Project ratings

Evaluation item	Rating
Timeliness	3
Attainment of outputs	2
Completion of activities	1
Project executed within the budget	2
Impact created by the project	2
Sustainability	3
Overall score	2

Annex I

TERMS OF REFERENCE

The evaluation shall be in-depth. The objective of the evaluation is to establish project impact and to review and evaluate the implementation of planned project activities, outputs and outcomes to date against actual results and to indicate its likelihood of contributing to the broader objectives of GEF programmes. The performance indicators provided in the Log Frame/project planning matrix (see table 2 below) should be used together with the evaluation parameters of appropriateness, effectiveness and efficiency, impact and sustainability. Guidelines on evaluation indicators are provided in the UNEP Project Manual pp.13/89-13/99 and are also available on http://www.unep.org/Project_Manual/

The findings of the evaluation will be based on the following:

- (a) Desk review of the project document, outputs, monitoring reports and relevant correspondence, including GEF Council references, documents and project pipeline (see list of relevant project documents below);
- (b) Specific products including reports of the sessions highlighting presentations, case studies, technical information and recommendations for action on topics selected for discussion;
- (c) Telephone interviews with UNEP, the World Bank, IFC, UNDP, STAP and the GEF Secretariat;
- (d) Telephone interviews with the participants of the workshops.

The evaluator shall develop a participatory evaluation approach to carry out this exercise. Specifically, the evaluator shall:

- (a) Assess the overall appropriateness of the objectives of the project to the pertinent UNEP mission, mandate and subprogramme objectives;
- (b) Determine to what extent the project's objectives were met and the expected results were obtained, taking into account the indicators listed and whether it has been a cost-effective way of obtaining these results. Particular attention should be paid to whether the project met the needs and expectation of partners, i.e. UNDP (and its national partners in fuel cell bus demonstrations), the World Bank and IFC (and their potential partners in FCDPG projects), GEF and STAP;
- (c) Determine the extent to which the project activities met those outlined in the project document, particularly focusing on:
 - (i) Interviews with manufacturers to obtain proprietary information;
 - (ii) Consultative processes and linkage to other (previous and current) projects in this area.
- (d) Determine the accuracy, quality and usefulness of the project's outputs such as the analysis, data and estimates used in reports, in particular the following:
 - (i) The fuel cell bus strategy note;
 - (ii) Contributions of the partners to the presentation to the GEF Council and information notes;
 - (iii) The FCDPG briefing note and the extent to which it helped to involve the business sector.
- (e) Establish the effectiveness of inter-agency cooperation and value added through involvement of the GEF implementing agencies;

(f) Establish the extent to which the project has had an impact on the dissemination of information on fuel cell technologies and facilitating the policy decisions of GEF, other agencies and national Governments supporting fuel cell technology market development;

(g) Determine the level of stakeholder involvement and participation in project activities, in particular workshops, and effectiveness in building consensus on a coordinated international strategy of fuel cell deployment;

(h) Assess the effectiveness of the institutional arrangements and administrative and financial support provided by UNEP;

(i) Identify the problems encountered and the lessons learned during project implementation;

(j) Make recommendations on how to improve future project outputs in this particular type of project, which was a study carried out by a number of collaborating agencies, and the area of fuel cell technology.

The evaluation report shall be detailed, written in English, of no more than fifteen pages exclusive of the executive summary and the findings of the evaluation and recommendations and include the following:

(a) A concise summary (no more than two pages);

(b) A separate section on lessons learned;

(c) A separate section on findings and recommendations.

89. All annexes should be typed.

The success of project implementation will be rated on a scale of 1 to 5 with 1 being the highest rating and 5 being the lowest. The following items should be considered for rating purposes:

(a) Timeliness;

(b) Attainment of outputs;

(c) Completion of activities;

(d) Project executed within the budget;

(e) Impact created by the project;

(f) Sustainability.

Each of the items should be rated separately and then an overall rating given. The following rating system is to be applied:

1 = Excellent	(90 % - 100 % achievement)
2 = Very good	(75 % - 89 %)
3 = Good	(60 % - 74 %)
4 = Satisfactory	(50 % - 59 %)
5 = Unsatisfactory	(49 % and below)

Annex II

LIST OF DOCUMENTS REVIEWED

General

- GEF/C.16/Inf. 20, Current Approaches to Financing Fuel Cell Projects under Operational Programmes 7 and 11
- GEF Operational Programmes 7 and 11;
- GEF STAP papers and notes regarding fuel cell technologies;
- UNEP programme objectives.

Project definition

- Medium-sized project brief: Fuel cell bus and distributed power generation market prospects and intervention strategy options;
- Various UNEP programme implementation reviews and internal documents.

Fuel cell bus technology review

- Workshop proceedings: *Commercialization of fuel cell buses: Potential roles for GEF*, April 27-28, 2000
- STAP review of workshop: Commercialization of fuel cell buses - Potential roles for GEF;
- Strategy note: Toward a GEF partnership to develop fuel cell buses for the developing world, UNDP;
- UNDP/GEF fuel cell bus demonstration project proposals for India, Mexico, Brazil, China, Egypt;
- Comments of members of the GEF Council on fuel cell bus projects and GEF Council decisions.

Forecast market prospects for FCDPG

- Market prospects and attendant intervention strategies to accelerate the deployment of fuel cells for distributed power generation in developing countries (IFC/SMA/ADL);
- Concept paper: fuel cells financing initiative for distributed generation applications;
- WB/IFC fuel cell financing initiative concept agreement - review by Eric Martinot.

FCDPG assessment

- Workshop summary: FCDPG and overall market prospects, 22-24 May 2001, CETC/Imperial College;
- Various workshop papers and presentations;
- Preliminary report on Task 3.1: Global fuel cell decentralized generation market assessment;
- Preliminary report on Task 3.2: Fuel cell policy climate assessment;
- Review of IPCC mitigation scenarios relative to a GEF strategy for fuel cells .

Consolidate the FCB and FCDPG analyses

- Assessment of policies to support fuel cell buses and the transition to the hydrogen economy;
- Review of the current state and future projections of fuel cells in the automotive sector;
- Fuel cell market prospects and intervention strategies (UNEP/Imperial College).

Annex III

LIST OF INTERVIEWEES

Tom Hamlin, UNEP
Dick Hosier, UNDP
Eric Martinot, GEF secretariat
Vikram Widge, IFC
Ajay Mathur, World Bank
Byron Washom, SMA
David Hart, Imperial College
Eric Larson, Princeton University
Joan Ogden, Princeton University
Bill Dougherty, SEI-Boston
Dr. Stephen Karekezi, STAP
Dennis Anderson, STAP
Rick Sellers, IEA
Frank Gibbart, H Power
Steven Glaser, World Fuel Cell Council

Annex IV

GENERAL LIST OF INTERVIEW QUESTIONS

1. Was this project appropriate and pertinent to the overall UNEP mission, mandate and sub-programme objectives?
2. Did the project meet the needs and expectation of the partners?
3. Did the project meet its objectives from the perspective of each partner?
4. Did the project meet its objectives from the perspective of the STAP experts involved?
Describe the accuracy, quality and usefulness of the project's outputs. In particular, describe the extent to which certain project activities presented difficulties in execution or were not achievable. Was the activity unrealistic or was the difficulty unforeseen? What would you recommend be done differently in the future?
5. In your opinion, did the project exhibit an effective level of interagency cooperation? Provide an example one way or the other.
6. To what extent has the project had an impact in disseminating information on fuel cell technologies and facilitating policy decisions of GEF and other agencies and national governments supporting fuel cell technology market development?
7. Was the level of stakeholder involvement and participation in project activities sufficient and appropriate? Was it effective in building consensus on a coordinated international strategy of fuel cell deployment?
8. How effective was the institutional arrangements and administrative and financial support provided by UNEP?
9. What were the key lessons learned during project implementation?
10. How would you have improved this study relative to its objectives for fuel cell technology?
11. Would you participate in a similar study carried out by a number of collaborating agencies? Why?
