



# Global Environment Facility

**MOHAMED T. EL-ASHRY**  
CHIEF EXECUTIVE OFFICER  
AND CHAIRMAN

November 5, 2001

Dear Council Member,

UNDP, as the Implementing Agency for the project, *Mexico: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City, Phase I*, has submitted the attached proposed project document for CEO endorsement prior to final approval of the project document in accordance with UNDP procedures.

The Secretariat has reviewed the project document. This project is one of five fuel cell bus projects approved by the Council in the GEF Work Program, consistent with a strategy for development of this technology and a separate assessment of fuel cells undertaken through UNEP. It is consistent with the proposal approved by the Council in February 2001 and the proposed project remains consistent with the Instrument and GEF policies and procedures. The attached explanation prepared by UNDP satisfactorily details how Council's comments and those of the STAP have been addressed. I am, therefore, endorsing the project document.

We have today posted the proposed project document on the GEF website at [www.gefweb.org](http://www.gefweb.org). If you do not have access to the Web, you may request the local field office of the World Bank or UNDP to download the document for you. Alternatively, you may request a copy of the document from the Secretariat. If you make such a request, please confirm for us your current mailing address.

Sincerely,

*for* Mohamed T. El-Ashry  
Chief Executive Officer and Chairman

cc: Alternate, Implementing Agencies, STAP



**United Nations Development Programme**  
GLOBAL ENVIRONMENT FACILITY (GEF)



October 15<sup>th</sup>, 2001.

Dear Mr. El-Ashry,

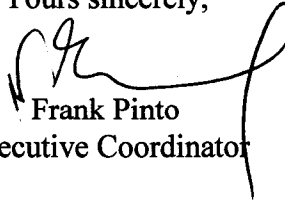
**Subject: “MEX/01/G31: “Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City – Part I” (PIMS # 1415)”**

I am pleased to enclose the UNDP project document entitled: “*Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City*” approved by the GEF Executive Council in the February 2001 Intersessional Meeting. Following the February 2001 Intersessional Meeting, we received written comments from Council Members representing the constituencies of Germany and France. The attached note indicates how Council comments have been reflected in the preparation of project document (Attachment 1). We hope that you will bring this note to the attention of the GEF Council.

As per paragraph 29 and 30 of the GEF Project Cycle, we are submitting this project to you for circulation to the Executive Council Members for comments and, subsequently, for your final endorsement.

Thank you in advance for expediting the review and approval of this project.

Yours sincerely,



Frank Pinto  
Executive Coordinator

Mr. Mohamed El-Ashry  
Chief Executive Officer  
Global Environment Facility  
Room G6005  
1776 G Street N.W.  
Washington, D.C. 20433

Attachment 1: Response to Council Comments  
Attachment 2: UNDP Project Document  
Cc: Mr. Martin Krause, UNDP/GEF Regional Manager  
Mrs. Catherine Vallee, UNDP/GEF Regional Coordinator

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# **MEXICO: DEMONSTRATION PROJECT OF HYDROGEN FUEL CELL BUSES AND AN ASSOCIATED SYSTEM FOR HYDROGEN SUPPLY IN MEXICO CITY**

## **RESPONSE TO COMMENTS FROM COUNCIL MEMBERS**

### **GERMANY**

#### **Comment 1:**

“We are not satisfied with the low level of private sector co-financing. There should be a minimum requirement for private sector co-financing of 20% of total project costs for all fuel cells projects. We strongly request further efforts to fulfill this target”.

#### **Response 1:**

During the implementation of the FCB projects, the buses will be purchased through a standard UNDP competitive procurement process. As such, it will not be possible to know the precise amount of the uncompensated private-sector contribution until the procurement process is completed. UNDP will ask for an estimate of total corporate contribution and a plan for commercialization of FCB’s within the host country as part of the procurement process. Both the estimated contribution and the commercialization plan will be awarded points under the scoring system used in the evaluation of the bids. The estimate of the expected private-sector contribution for the winning bid will be made public at the time that the second part of this project is submitted for approval. We feel that these two items together—the corporate contribution and the plan for FCB commercialization in the local market—will adequately demonstrate the seriousness of the private-sector commitment to the project. In a successful bid situation, we would anticipate that any of the major players would be able to document a 20% contribution to the project. Whatever the final figures turn out to be, we will make those estimates available once the winning bid is selected and the results are made public as Part II of the project moves ahead.

#### **Comment 2:**

“We recommend using the fuel cell buses to undertake a GEF public awareness campaign. Millions of people will see and use the buses. This should be used to make GEF better known. Ideas in this respect should be developed and should be implemented within the existing financial support for the fuel cell projects.’

#### **Response 2:**

Activity 7 (see PRODOC p. 12) addresses the issue of establishing a GEF public awareness campaign within project’s scope. This activity will establish a plan for public awareness efforts, including the preparation of a marketing strategy and communication plan. All marketing initiatives will acknowledge GEF support to the project, and the GEF logo will be displayed on buses.

**Comment 3:**

“We also question the over-optimistic projections of the commercialization of the fuel cell technology in the bus sector in developing countries. The decisive factor will be the role of the private sector, not the GEF.”

**Response 3:**

The GEF strategy for FCB commercialization will involve a partnership between GEF, private industry, and local/national governments in GEF Program Countries. This strategy, therefore, recognizes the pivotal and decisive role that the private sector will play during the commercialization stage of FCBs. In addition, the GEF will play 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, collaborate in, and finance the commercialization program. The final role is that of enabling information exchange within and between program countries, the private sector, and other FCB demonstrations in both donor and recipient countries. By assuming each of these roles, the GEF is placing a reciprocal responsibility on the counterparts in the partnership. Their contributions to the partnership must include the provision of financing, cooperation, and information to the FCB development process.

The GEF’s interest in FCBs is justified on the basis of the reduced GHG emissions that FCBs offer over conventional diesel buses. By supporting the deployment of FCBs in developing countries, GEF is encouraging early adoption of these buses in GEF program countries. This early adoption is consistent with the concept of “technological leapfrogging”, wherein developing countries are supported to develop and adopt technologies earlier in their product cycle. This will lead not only to technologies that are more consistent with the needs and conditions of developing countries, but also to the development of greater technological competence in the developing countries where the early adoption takes place. Thus, apart from the global benefits of reduced future GHG emissions and the local benefits of reduced future air pollution, there are local benefits that will accrue to the countries hosting fuel cell demonstration projects in terms of the development of greater expertise in the development and management of the technology. Furthermore, the ability to produce these FCBs for export to other countries in the region that are also interested in reduced emissions from the transport sector will also pose a considerable economic advantage. This economic rationale, which may be secondary from GEF’s perspective, is still an important one for host governments and provides much of the rationale for local level support.

**Comment 4:**

“Through the fuel cell bus projects OP11 very strongly leans towards fuel cells technology. However, there are many other ways of fostering sustainable transport. Emission reductions of conventional transport technologies is a more significant contribution to GHG abatement in the short and medium term and has important ancillary benefits in the short as well as in the long term. It can be achieved through traffic planning in cities, stringent emission specifications and controls, capacity building for transport authorities, etc. In order to avoid the impression that

OP11 is an operational programme for fuel cells, we strongly recommend undertaking efforts to develop other projects in the transport area.”

**Response 4:**

UNDP is developing projects under OP11 in other areas of transport. We have developed a bicycle transportation MSP in Poland (Gdansk Cycling Infrastructure Project) that was approved last June, and some other initiatives are under preparation in Latin America and Africa.

The importance of transport system planning is recognized by Mexico. For example, the Improved Air Quality Program in the Valle de Mexico (PROAIRE) includes a multi-faceted approach to technological solutions for the urban transport sector in Mexico City. The Metro (subway) is the center of this approach, and planning efforts and new investments will revolve around existing Metro infrastructure. It is important to note that while clean technologies form an integral part of PROAIRE strategy, the overall effort consists in increasing the efficiency of current infrastructure, together with service improvements, better investment planning and deployment of new technologies. The PROAIRE short and long-term transport strategy consists of expanded subway service routes and schedules and improved facilities; improved traffic control systems and safety regulations; the substitution of minibuses for larger passenger buses; and renewal (and in the case of the trolley bus system, replacement) of the bus fleet with deployment of more environmentally friendly technologies. The FCB project has been planned to be consistent with the current transport strategy aimed at emissions reduction and improvement of air quality in Mexico City.

**FRANCE**

**Comment 5:**

“The proposed financial levels and the justification of the impact of this technology on the GHG emissions are not convincing and confirm that in these projects the question of replication still subsists. (The projects will very likely finish after the financial support of GEF ends). Independent evaluations have to be carried out to analyze the real effect of GEF on these technological developments.”

**Response 5:**

By supporting deployment of FCBs in GEF program countries, GEF is fulfilling its role as an important agent of technology transfer in support of the UNFCCC. By encouraging the early adoption of these buses in a process of “technological leapfrogging”, GEF is helping developing countries gain experience with the FCB early in its product cycle. GEF program countries can then develop partnerships with private sector technology developers, thereby increasing technological competence and adapting the technology to local needs. GEF Program countries will also benefit from reduced local air pollution, new export opportunities attributable to local manufacturing, and improved quality of public transit service. Finally, because FCBs are hydrogen fueled, the GEF will also be assisting developing countries in preparing for a future transition to newer, cleaner and more

efficient fuel-supply systems. Therefore GEF investment is intended to catalyze the commercialization of FCBs in developing countries. Independent evaluations will be carried out throughout the projects to monitor ongoing impact on the development of the technology.

## PROJECT DOCUMENT

### 1. IDENTIFIERS

<b>PROJECT NUMBER:</b>	MEX/01/G31/A/1G/99
<b>PROJECT NAME:</b>	<b>Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City</b>
<b>DURATION:</b>	5 years, divided into two implementation segments of 1 and 4 years duration
<b>IMPLEMENTATION:</b>	United Nations Development Programme (UNDP)
<b>NATIONAL COORDINATING AGENCY:</b>	SETRAVI Secretary of Transport of the Mexico City Government
<b>NATIONAL EXECUTING AGENCY:</b>	STE Electric Transport Service of Mexico City
<b>REQUESTING COUNTRY:</b>	Mexico
<b>ELIGIBILITY:</b>	Mexico ratified the UNFCCC on March 11, 1993
<b>GEF FOCAL AREA:</b>	Climate Change
<b>GEF PROGRAMMING FRAMEWORK:</b>	Sustainable Transport, Operational Program No. 11

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### 2. SUMMARY

The immediate objective of this proposal is to foster the development, manufacture and large-scale commercialization of hydrogen-fuel cell buses (HFCBs) in Mexico through the initial operation of a fleet of 10 fuel cell buses in Mexico City during a 5-year period. This project represents the first part of a two-Part project designed to test – under conditions of commercial operation – a zero emissions technological option for public transport in a dynamic metropolitan area situated at 2,200 meters above sea level. A total of 3,000,000 km of accumulated use will be gained by the end of the 5-year demonstration period.

This project has been prepared and submitted in keeping with the *GEF Fuel Cell Bus (FCB) Strategy*, presented and discussed by the Council at its meeting in November 2000. The Mexico project contributes uniquely to the FCB commercialization portfolio in three ways. First, it is the first demonstration project to propose obtaining hydrogen from reforming natural gas. Second, the buses will operate under high altitude conditions, generating vital information for urban areas situated above 1,000 meters above sea level. Third, Mexico represents an important global sub-market for buses, notably the northern Latin American market.

This Project Document relates to activities and financing approved for Project Part I.

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### 3. PROJECT COSTS AND FINANCING (MILLIONS US\$)

		<b>Part I</b>	<b>Part II</b>	<b>Total</b>
GEF	FS PROJECT	5,078,800	6,935,000	12,013,800
	PDF	339,500		339,500
	<b>Sub-Total</b>	<b>5,418,300</b>	<b>6,935,000</b>	<b>12,353,300</b>
CO-FINANCING	Government - STE	2,342,000	6,810,100	9,152,100
	Fares - STE	0	3,002,400	3,002,400
	Private Sponsors	125,000	500,000	625,000
	Private Sector	2,455,000	1,660,000	4,115,000
	<b>Sub-Total</b>	<b>4,922,000</b>	<b>11,972,500</b>	<b>16,894,500</b>
<b>Total Project Cost</b>		<b>10,340,300</b>	<b>18,907,500</b>	<b>29,247,800</b>

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**4. OPERATIONAL FOCAL POINT ENDORSEMENT**

Name: Ricardo Ochoa  
Organization: Ministry of Finance and Public Debt

Title: Director for International Financial  
Organizations  
Date: 25 August, 2000

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**5. IA CONTACTS:**

Richard Hosier, Principal Technical Advisor, Climate Change, UNDP-GEF  
Martin Krause, Regional Manager, Climate Change RBLAC, UNDP-GEF  
Catherine Vallee, Regional Coordinator, Climate Change RBLAC, UNDP-GEF

On behalf of	Signature	Date	Name/Title
SETRAVI	-----	-----	-----
STE	-----	-----	-----
UNDP	-----	-----	-----



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## 1. BACKGROUND AND CONTEXT

### 1.1 CLEAN TRANSPORT STRATEGY IN MEXICO CITY

1. Investments and long-term policy initiatives for airborne pollution control in the greater Mexico City metropolitan area (MCMA) –including the transport sector- are contained in the *Programa para Mejorar la Calidad del Aire en el Valle de México 1995-2000* (Improved Air Quality Program in the Valle de México, or PROAIRE). This is an inter-sectoral program integrated by the Federal District City Government, Mexico State Government, the Federal Secretariat for Environment and Natural Resources, and the Federal Health Secretariat. The PROAIRE policy instrument also exists for other major cities, such as Guadalajara and Monterrey, and several northern border cities.

2. Preparation of the 3rd Air Quality Program (2000-2010) for the (MCMA) is currently under way. Recent electoral results for the Federal District government should prove favorable to continuity in the current policy framework. It is important to note that this program will be in force during a proposed 10-year period, recognizing that longer-term interventions and policy efforts are required to make meaningful impacts on air pollution control.

3. Given the size of the urban transport fleet in the MCMA, it would be unwise to develop and deploy a single technological option, which is why PROAIRE includes a multi-faceted approach to technological solutions for the urban transport sector. The Metro (subway) is the hub for this approach, and planning efforts and new investments will revolve around existing Metro infrastructure. It is important to note that while clean technologies form an integral part of PROAIRE strategy, the overall effort consists in increasing the efficiency of current infrastructure, together with service improvements, better investment planning and deployment of new technologies. To this end, as of January 2000, all STE and RTC bus and trolley bus routes begin or terminate in Metro stations, providing integrated commuter articulation. Initial evaluations have indicated that this strategy is both cost efficient and results in high customer satisfaction, given that the average commuting time has diminished. Also, Metro rider ship has increased as a result of this new strategy, from 4.5 to 4.7 million daily users in the first semester of 2000. The continued consolidation of the strategy consists of the following activities:

- Through the overall plan for the light train system, expanded service routes and schedules, and improved subway facilities, including park-and-ride modalities
- Improved traffic control systems
- The above-mentioned substitution of minibuses for larger passenger buses
- Renewal (and in the case of the trolley bus system, replacement) of the bus fleet upon completion of its life cycle
- Deployment of more environmentally friendly technologies (conversion of buses to compressed natural gas and ethanol -already underway on a pilot basis-, deployment of hybrid electric-combustion engines, dual combustion (CNG-diesel) and fuel cell technology).

## 1.2 ENVIRONMENTAL BENEFITS OF HFCBs IN MEXICO CITY

4. One of the most serious problems facing Mexico City and its surrounding area is air pollution, as is common of megacities in developing countries. Addressing this problem has become a high priority because it affects both the quality of life of its more than 22 millions of inhabitants, and its environmental sustainability.

5. Accelerated demographic growth for the Mexico City Metropolitan area (MCMA) translates into an accelerated expansion of densely populated territories, spilling over into neighboring State of Mexico. On an annual basis, the Valley of Mexico receives 300,000 immigrants from across the country whom, for the most part settle in the State of Mexico, but most often find employment in Mexico City. This flow of commuters yields more than 30 million person-trips per day on public transportation. Additionally, 3 million private vehicles transverse the city. Each year, 160,000 new vehicles are added to this circulating mass, of which 32% is made up with pre-1982 models.

6. Within the area comprising the Federal District alone, nearly 29,575 public transportation buses --fueled by internal combustion engines-- operate daily. However, according to the Federal District Environmental Secretariat, this number has increased to about 64,180 buses when the whole MCMA is reckoned. Of the first group, approximately 22,887 buses of Mexico City are 22 seat gasoline engine minibuses. Another 4051 are 10 to 12 passenger minibuses. The remaining 2,637 are 9 to 12-meter long diesel engine buses. All diesel and gasoline buses, minibuses and minibuses are privately owned.

7. The Electrical Transport Service Authority (STE acronym in Spanish) of the Mexico City government retains ownership of 169 articulated diesel buses plus 20 one-body buses for handicapped people. STE also operates 450 trolley buses and a small lightweight train system (16 trains on a 23-kilometer line). Since February 2000 a new Urban Bus Transport firm owned by the City Government, RTP (acronym in Spanish), under SETRAVI administration, has been established with a total fleet of 1,000 Diesel buses.

8. Studies indicate that approximately 75% of the total emissions of nitrogen oxides, sulfur oxides, carbon monoxide and particulate matter are produced by internal combustion engines of car and buses circulating in Mexico City (whose present number is expected to increase about 40% by the year 2006). These four pollutants are included under the Metropolitan Index for the Quality of Air (IMECA) that was created to monitor major pollutants in Mexico City that cause acute and chronic health effects. The combined usage of transportation and industrial output results in the daily release of 11,700 tons of airborne pollutants, or about 4.3 millions tons per year. Although intensive use vehicles, which include urban transport buses, represent only 25% of the total number of vehicles, they are responsible for 34% of the transport-originated pollution.

9. Mini and minibuses, although representing barely 2% of all vehicles circulating in the MCMA, produce 8.3% of total pollutant emissions, and account for almost 10% of

greenhouse effect emissions (CO<sub>2</sub>, CH<sub>4</sub>, NO<sub>2</sub>), according to the 1996 emissions inventory of the National Ecology Institute.

10. Hydrogen Fuel Cell Buses (HFCB) have become a clear technological alternative to solve air pollution problems in large cities, since they do not emit constituents of atmospheric air pollution, such as toxic emissions, nitrogen, sulfur and carbon oxides, and suspended particulates. Water vapor is the only emission generated by hydrogen fuel cell buses. Their fuel cell and electric propulsion systems have been proved to be the most efficient at motoring both at low and high speeds, as compared to the diesel engines. This feature, combined with their energy conversion efficiency, makes them very suitable for urban public transportation, as they operate with a 400 kilometers per day autonomy, with the compressed hydrogen that they carry in their tanks. Overnight hydrogen refueling can be carried out in the STE bus yard. If compared with trolley buses they do not require overhead electric cables, or AC/DC electrical substations.

11. HFCB technology is considered to be very safe, given the advances in system-wide safety concerns currently being incorporated into the natural gas distribution network. The Secretary of Environment has created special zoning regulations for natural gas distribution, which includes criteria for site selection, civil protection and public awareness. Lessons learned from the operation of two compressed natural gas fueling stations in Mexico City have been taken into account during project preparation. Safety parameters for the proposed reformed natural gas process were also defined during preparation, and a 5-6,000 m<sup>2</sup> open air facility, located 600 m from a natural gas pipeline, has been identified for the reformer plant. The proposed site would exceed local requirement and as it is situated within the STE bus yard, it eliminates the need for transporting hydrogen for fueling needs. Fueling infrastructure was recognized as an important node for the HAZOP analysis (Hazard and Operation Analysis), during project preparation. CNG is 8 times heavier than H<sub>2</sub>, and could form gas clouds with higher explosive capacity (made as a support research for this project). The density difference promotes the dispersion of H<sub>2</sub> in the atmosphere, reducing its explosive energy. It was noted that gaseous hydrogen does not share the potential explosive risks of liquid hydrogen, because in the case of release the gas will rapidly dissipate and rarely accumulates given its relative lightness. Also, simulations were carried under different scenarios to define system parameters at project sites. Information generated from these studies has been included in the project design.

12. In view of the challenges and possible environmental hazards stemming from mini and minibuses, a new Transport Law for Mexico City that was approved by the City Council on November 1999. This new transport law established among other regulations, that the existing micro and mini buses have to be replaced by 9 to 12-meter diesel buses. Individual microbus concessionaires will be provided incentives, including low-interest loans, to create new urban transport firms and to replace existing units.

13. The Federal District Government through its Environment Secretary is finishing negotiations with the French Global Environment Facility (FGEF) for the implementation program to convert gasoline-fueled minibuses to compressed natural

gas. While the long-term transport strategy contemplates a gradual reduction in the use of these vehicles, taking advantage of their efficiency in certain niche markets of the MCMA, it is clear that rapid air quality benefits might be obtained through motor conversion. A total of 150 minibuses are scheduled for conversion on a pilot basis, as well as the development of improved gas distribution centers. Two CNG fueling stations are currently operating in Mexico City, and a third is under construction. Beginning in 1999, the existing stations have provided fueling service for a fleet of 480 CNG-propelled garbage collection vehicles, and 650 patrol cars. This infrastructure will form an important part of the overall transport strategy, beyond the immediate goal of motor conversion, and as seen below will feed into the hydrogen fuel cell project. While distinct, CNG management has provided invaluable experience for the eventual large-scale management of hydrogen production and fueling.

14. The long-term feasibility for hydrogen fuel cell deployment in the MCMA and other urban centers is virtually assured through the expansion of natural gas distribution and management services. Without taking into account the infrastructure associated with trolley buses (overhead cable, A/C D/C substations and purchase of right-of-ways, a trolley bus costs three times more than a diesel bus. Due to this high investment and maintenance cost of the trolley bus system, the current 450 units that will need to be replaced over the next 20 years are ideal candidates for replacement by HFCB. It is estimated that by 2006, approximately 250 units will need to be replaced, coinciding with the proposed second phase of the project. Also, most of the large diesel buses now operating in Mexico City, and their replacements, will become candidates -- due to their significant contribution to air pollution -- for substitution either by HFCB or other near zero-emissions hybrid, dual and electric bus alternatives, during the 2006 to 2010 period.

15. The expected accumulated emissions avoided in the projected life cycle will be 464,640 tons of CO<sub>2</sub>, based on the substitution of 100 DBs/year by HFCBs in Mexico City during five years, utilizing natural gas reforming technology with carbon sequestration process included for hydrogen production. It is expected that expansion of the program to the Guadalajara and Monterrey metropolitan areas from year 2007, as well as the commencement of exports of assembled HFCBs will add an additional 1,500 units in total during phases 2 and 3 (2007-2020). This would allow for a base calculation of a minimum additional rate of substitution of 200 HFC buses per year, resulting in accumulated avoided emissions of 634,218 tons of CO<sub>2</sub> by 2010. Data and technical specifications provided by manufacturers of the technology indicate that the process gas exiting the shift reactor of natural gas-based hydrogen reformers contains 15% to 18% of CO<sub>2</sub>. While expensive, this is a highly desirable and environmentally friendly technique. The actual performance of this process will be closely monitored during project implementation. The captured CO<sub>2</sub> can then be recovered and commercialized. In particular, the market for inert gases in the soft drink industry is enormous in Mexico given high per-capita consumption, and represents a large potential for cost recovery under the project. This means that the net avoided emissions "well to wheel" in hydrogen reformer based on natural gas is effectively zero, to be confirmed through extensive monitoring.

### 1.3 FURTHER EXPANSION POTENTIAL

16. SETRAVI is now firmly convinced to introduce the environmentally cleanest buses in the streets of Mexico City. To do so, it has given the Electrical Transport Service, full responsibility to develop the required research on new technologies, associated to urban bus transport in Mexico City. It is in this framework that STE will operate the first 10 HFCBs of this project during a 5 years period from 2001/2 to 2005/6. Operation will start with 3 HFC buses in 2001/2 followed by 7 HFC buses in the following year. If this technology proves to be competitive in commercial and performance terms, RTP and STE would initiate the acquisition of 100 HFCBs/annum starting in 2006.

17. STE and RTP have proven capacity to incorporate new, high-technology buses on an annual basis, as evidenced by their transport fleet renewal program. During 1997-1999 STE bought 200 high-technology new trolley buses, and for 2000-2001 STE has budgeted the renewal of 60 articulated buses and 100 trolley buses. Also, STE will acquire 65 new low-floor buses during 2000. RTP itself will acquire 500 new DBs in 2000, which will comply with EPA 2000 standards. In summary, in the last 4 years these 2 transport firms together have programmed the renewal of 925 public transport fleet including buses and trolley buses, at an average of 231.25 units per year.

18. In accordance with the fleet renewal process underway and planned, 22,887 gasoline engine minibuses currently owned by private firms and individuals, should be replaced by approximately 7,600, 9 to 12-meter long diesel buses of which about 1,500 buses will have completed its life cycle by the year 2006. This figure should be added to the current private bus fleet of 2,637 whose life cycle will also be completed by the same year. So, by the year 2006, the total Mexico City fleet is expected to be renewed by about 4000 units.

19. SETRAVI reports indicate that the bus program renewal in the State of Mexico (greater metropolitan area), resulted in 6,453 units renewed in 1996, 11,094 units in 1997, and by the year 1999 an accumulated number of 52,608 units were renewed, representing an advance of 75%. The report does not desegregate the units according to the type and size of buses, but it is certainly a mixture of gasoline and diesel micro, mini and large buses.

20. As an integral part of the bus fleet renewal process, this demonstration project, which starts with the operation of 10 HFCBs in the period 2001 to 2005 will be followed by an acquisition of a fleet of 100 HFCBs by STE and RTP in the year 2006. This fleet conversion will expand the HFCBs Mexican manufacturing process (some nationally manufactured parts and national assemblage is expected for phase 1 of this project) and will be self financed through a joint effort of the fuel cell manufacturers, bus manufacturers, hydrogen suppliers, STE and RTP, and the Federal District Government. This bus conversion process is a fundamental part of the clean transport strategy as detailed in PROAIRE 2000-2010), which promotes the simultaneous renewal of the bus fleet with the introduction of more environmentally friendly technologies. After 2006, an acquisition rate of 100 HFCBs per year in Mexico City is expected to occur, within the



diversified clean urban transport program, reaching an accumulated average of about 500 HFCBs by 2010 in the MCMA.

21. Once the commercial and technical viability of the pilot fleet has been fully proved it is expected that the total yearly acquisition of HFCBs would reach 200-600 additional units, taking into account the renewal requirements of other major urban areas (Guadalajara, Monterrey and the greater MCMA in State of Mexico). This would add an additional 1,000 units to the in-country fleet by 2010.

22. Mexico is poised to take advantage of the market niches present in the diverse free trade agreements it has signed with the U.S. and Canada, the European Union, and most of the Latin American region, by assimilating hydrogen cells technology. Local engineering capacity in the transport sector is well developed. Of the 200 trolley buses purchased between 1997 and 1999, 4 were completely manufactured in Japan, and 19 were partially manufactured (chassis, front axis, pneumatic system, power electronics) and totally assembled in Mexico. While electronic drive trains are not currently manufactured by national companies, three international firms have production plants in Mexico, and by 2005 it is expected that the electronics system would be made in Mexico, and only the fuel cell engine will be imported. A fuel cell stack replacement firm situated in Mexico may service fuel cell replacement, even though the firm may import the fuel cell stacks. This will further decrease the price of a Mexican-made HFCB. Complete fabrication and assembly in Mexico provides additional benefits such as lower cost, capacity building and increased local ownership of the technology. Exports of this technology installed and tested under proven conditions, will serve not only to further the world-wide assimilation of the technology, but will also comprise an important part of the dissemination strategy designed under the current proposal. The market for environmentally friendly goods and services, especially in light of quasi-protectionist environmental legislation recently enacted in many developed countries, continues to grow. Accordingly, in addition to meeting the demand of other metropolitan areas, extra production capacity would be dedicated to the export market starting in year 2007, adding an additional 1,000-3,000 HFCBs produced and operating by the year 2010.

23. As discussed above, once the second phase of HFCBs manufactured in Mexico has been taken to a mature stage, estimated to occur by the year 2010, Mexico will be in the possibility to become one of the most important exporting countries in HFCB technology. The present installed capacity of about 40,000 buses/annum, indicates a potential export capacity towards traditional bus chassis markets in North America, the European Union (France, Germany, Great Britain) and Latin America (Chile, Colombia, El Salvador, Guatemala), of 3000 buses per year from 2010 onwards.

24. The full commercial potential of HFCBs will exist only if the predicted manufacture and life cycle costs for Mexican manufactured HFCBs will align with these estimated costs. This will make HFCBs technology not only competitive with updated DBs technology but also with other near-zero emission electrical bus technologies.

25. Research will be carried out at the beginning of the 5-year period of this HFCBs demonstration project. This targeted and applied research is especially important in the sensitive fields related to the reorganization of Mexico City urban transport and its environmental, political and economical impact. Also, all technological studies leading to the mass adoption of HFBC technology are likely to require long assimilation periods and development of high level of local expertise. GEF-financed research activities shall focus on HFBC Mexican prototypes, manufacturing process optimization, series tests certification, technological performance, maintenance and operation analysis, demonstration project management and environmental analysis (including carbon sequestration process), as well as demand and supply of HFBC technology. Local sources will cover specific research on the Mexico City case study on costs and benefits of non-polluting transport in megacities, the politics and economics of bus replacement, diagnostic and solution alternatives, health, and the economics of mass hydrogen production for transport. A research budget is included in the cost of this demonstration project in order to carry out these studies.

#### **1.4 BARRIERS TO MASS SCALE DEPLOYMENT**

26. According to several studies, the HFBC technology can be considered technically demonstrated. However, the costs of the technology have not yet been brought down to commercially competitive levels. Further R & D on increased production and use volumes, for extended domestic and international markets, is required to bring this technology to a commercial competitive status. Only mass-production-and-utilization of such buses technology will overcome these competitive issues on a lifecycle basis. Under such circumstances the application of this technology will also play a major role in diminishing the present days Mexico City pollution levels.

27. STE invested nearly US\$ 50,000,000 to buy 200 trolley buses during 1997 to 1999, at a unit cost of US\$ 250,000 for a 100-person capacity bus. For the Mexico City Government, a second option to increase the transportation capacity is the use of articulated 160-passengers diesel buses, at a cost of US\$ 170,000. A third option is the use of 100-passenger diesel buses at the cost of US\$ 85,000. It is clear that the environmental benefits of the trolley bus option are important, given the present level of air pollution in Mexico City. The diesel bus option is nominally cheaper, without factoring in its high pollution cost.

28. The current capital cost differences between HFBC versus diesel buses is still considerable (about US\$1.45 million versus US\$ 250,000 in North America and European Markets), and represents one of the major barriers to large-scale production and commercialization in Mexico. Therefore, it is essential to promote a clear understanding among entrepreneurs and political leaders that initial “over-costs” of HFBC are justified not only in terms of their environmental benefits, but also in the competitive costs that this technology is expected to reach by year 2007 when using life cycle cost comparison. For the time being, the lack of awareness to support this new technology is also an important barrier that has to be overcome.

29. Another major barrier is the current durability of the fuel cell stacks that generate the electrical power to fit the power electronics control traction motor. Full operating time of the fuel cell stacks before requiring overhaul maintenance is currently calculated at 4,000 hours, versus 30,000 hours of operating time for diesel engines.

30. This gap has yet to be tested in a real commercial environment with a representative number of buses, on one hand, and on the other, this barrier in itself calls for the creation, under local conditions, of a stacks-replacement firm in Mexico, which should further reduce costs. Presently, the absence of such an experience of operating, fueling and maintaining HFC buses in a large scale is still a barrier to overcome. This HFCB demonstration project will therefore open the way for the acquisition of required experience.

### **1.5 THE OVERALL HYDROGEN FUEL CELL BUS PROGRAM**

31. The current proposal has been prepared with the assistance of a PDF-B grant. Relevant aspects of preparatory studies have been included as annexes to the proposal, and all of the studies are available upon request. As part of project development, lessons learned from a previous two-unit demonstration carried out in Mexico City in 1997 and 1998, to measure the effects of altitude on HFC technology, have been incorporated into the final design, and should provide important lessons learned for replication of HFC in higher altitude cities at the global level.

32. The overall hydrogen fuel cell bus program consists of a first phase in which 10 HFCBs will be operated by STE under a revenue-earning regime during 5 years, from 2001 to 2005 (this first phase is divided in Part I and II). During the year 2006 and taking into account the research results of the studies undertaken during the demonstration period, and the competitiveness of the technology, a second phase will initiate with the purchase commitment by SETRAVI of 100 HFCBs/annum, under STE and RTP operation. Concurrently, the HFCBs commercialization process in Mexico will start with the production and operation of an initial 100 HFCBs per year to reach 1,000 – 3,000 HFCBs/annum by the year 2010. This is contingent upon market conditions and technical performance that would allow the expansion of the internal market to include Monterrey, Guadalajara, and the State of Mexico greater metropolitan area, and that international demand warrants the creation of solid export capacity for the HFCBs market.

### **1.6 SIZE, DURATION AND LOCATION OF THE PROPOSED PROJECT**

33. The size and duration proposal of the demonstration project is based on 10 hydrogen fuel cell buses, running under different regimes during 5 years (3 buses will begin operation in 2001/2 and 7 buses in 2002/3). Based on the infrastructure investments needed to support this project, particularly in light of the strong private sector participation, a 10-unit pilot fleet was identified as optimum. Additionally, fleet sample size is consistent with the suggestions of the preparatory studies, which indicate that a

10-bus pilot would provide the minimum statistical degree of confidence, as well as reliable technical parameters for political decision-making.

34. For hydrogen production, three different possibilities were analyzed: supply by trucks, electrolysis generation, and reformer plant from natural gas. From these possibilities, it was decided to use natural gas, due to the following facts. First, natural gas is an abundant and relative cheap resource in Mexico. Second, for phases 1 and 2 the natural gas supply can be obtained from an already existing gas pipe 400 ft distant from the garage facilities. Third, for the long-term planning, natural gas appears to be the cheapest option, and has a low carbon-to-hydrogen ratio. Finally, electrolysis was discarded because of the high proportion of fossil fuel generation in the national energy supply (75%).

35. Although natural gas reform and hydrogen manufacture produce 15% to 18% of CO<sub>2</sub> of the total exit gases, this can be recovered and used. The reforming plant will incorporate a vacuum-swing absorption (VSA) system for CO<sub>2</sub> recovery. Process efficiency will be obtained through increased hydrogen production. This means that the “well to wheel” hydrogen reformer based on natural gas is effectively zeroed. Actual on-site performance will be closely monitored during project implementation.

36. These ten buses will be purchased in two lots, through a two-part bidding process. The first 3 units will be running at a low regime of 2080 hours/year (8 hrs/day, 5 days/week 52 weeks/year, at an average speed of 18.33km/hr). Based on the successful production and acquisition of the first three buses, the bidding process will then be conducted for the remaining 7 buses. The last 7 units will work at a normal regime of 3840 hrs/year (12 hrs/day, 320 days/year, at an average speed of 18.33km/hr). They will run a maximum of 220 kilometers per day, during 320 days per year over a period of 5 years. This gives an accumulative volume operation of 3.036 millions of vehicle kilometers for the entire fleet, or 86% of availability if compared to diesel buses. Fleet size and test phase duration, in addition to assuring statistically valid performance tests, will also produce accumulative knowledge regarding operation, performance, maintenance, and feedback information to manufacturers. At the end of the demonstration project, these 10 HFCBs will continue to run the same route, operated by STE and maintained by joint agreement between STE and the HFCBs manufacturer.

37. One of the most typical bus itineraries, which is very representative of the wide range of transit and environmental problems inherent to Mexico City has been chosen for the test phase of the HFCBs. This is an existing north-south route along Insurgentes Avenue in which 40 articulated STE diesel buses are operating 365 days a year, together with another 130 diesel buses of private transport firms. These buses are out of operation 12% of the year for maintenance purposes, so every unit of the fleet really operates 220 km per day, 12 hours a day, 320 days a year according to the experience of STE. Each diesel bus runs an average of 70,400 kilometers per year at 100% capacity.

## **2. PROJECT OBJECTIVES, ACTIVITIES AND EXPECTED RESULTS**

### **2.1 MEXICO IN THE CONTEXT OF THE GEF STRATEGY ON FCBS**

38. At the GEF Council Meeting in November 2000, the GEF held discussions led jointly by the GEF Secretariat and UNDP on a ‘*GEF Strategy to Develop Fuel-cell Buses (FCB) for the Developing World*’. This meeting summarized the outputs of a series of workshops sponsored under the UNEP Medium-Sized Project “Fuel Cell Bus and Distributed Power Generation Market Prospects and Intervention Strategy Options”. These workshops – which included participants from private industry, public sector transit agencies in both developed and developing countries, and members of the GEF Secretariat and Implementing Agencies – shaped the *GEF FCB Strategy* for the development of FCBS in GEF recipient countries, consistent with the objectives of Operational Program (OP) 11, Sustainable Transport.

39. The Council decision that “...GEF should develop the five fuel cell bus projects currently in its pipeline...” is consistent with the strategy presented. That strategy proposed GEF support for preparatory, demonstration, and commercialization phases. This project, which has met all of the quality criteria developed as part of the GEF strategy development process, represents a demonstration phase project. Its results will be carefully monitored prior to submitting any future commercialization phase proposal.

40. The FCB project in Mexico has several unique features that contribute to the overall GEF FCB portfolio of projects. The Mexico fuel supply will be through natural gas reforming, and the CO<sub>2</sub> produced during the hydrogen manufacture will be recovered. The reforming plant will use a vacuum-swing absorption (VSA) system for CO<sub>2</sub> recovery, and process efficiency will be obtained through increased hydrogen production. This project will examine the impact of high altitudes on both the fuel cell performance and the hydrogen supply system. Finally, the project will explore the Mexican market, which is a significant market unto itself, while allowing for expansion into the Central American and northern South American markets.

41. The Mexico project, as part of the larger GEF FCB portfolio of projects, will benefit from the coordination that is planned between projects. Three key coordination approaches are planned. First, to maximize lessons learned and the sharing of knowledge between the FCB projects, a series of workshops will be organized by the UNDP-GEF that will bring together key stakeholders from the Mexico project with those from other FCB projects. Second, the FCB Private Sector Advisory Group is intended to provide guidance and support to all of the GEF FCB projects, including Mexico. Third, a GEF FCB website will be developed and maintained, and will host information on progress, lessons learned, and research associated with all FCB projects. This website is intended to facilitate communication between the FCB projects.

## **2.2 DEVELOPMENT OBJECTIVE OF THE PROJECT**

42. The rationale underlying this project is that only large-scale deployment of HFCB technology will produce a substantial impact on the reduction of air pollution levels. Nevertheless, full market deployment is pending upon a reduction in the gap between the capital cost (but perhaps more importantly the life cycle cost) of HFCB as compared to conventional internal combustion engine buses.

43. The development objective of this project is to substantially reduce GHG emissions originating from the transport sector, through the full deployment of fuel cell technology in the urban transport fleet in Mexico, an existing production capacity will be used to export and replicate technology in other parts of the world. To this end, the project will initiate and accelerate mass-production development, commercialization and utilization of HFCBs in Mexico. These are compatible with GEF Operation Program 7: “Reducing the Long-Term Costs of Low GHG Emitting Energy Technologies” and Operational Program 11: “Promoting Sustainable Transport”.

## **2.3 IMMEDIATE PROJECT OBJECTIVE**

44. The immediate objective of this project is to demonstrate the operational viability of fuel cell drives in urban buses, together with the requisite re-fueling infrastructure, under Mexican conditions through the initial operational test of 10 hydrogen fuel cell buses. It will begin the process of commercialization and adaptation of the fuel-cell buses in Mexican markets.

## **2.4 PROJECT OUTPUTS AND ACTIVITIES**

45. The timing and sequence of the project outputs and activities are described below.

### **IMPLEMENTATION PART I: YEAR 2001 – 2002**

Output 1: Procurement of initial 3 FCBs and associated refueling infrastructure.

Activity 1: Design the detailed layout and work plan of the project.

Activity 2: Prepare the draft technical and performance specifications of the complete fuel cell electric buses and associated fueling system. Conduct an open pre-bidding consultation, inviting representatives from the fuel cell and urban transit community, and soliciting comments on the draft technical and cost specifications for the tendering. Finalize technical and cost specifications for procurement bundle.

- Activity 3: Issue the international call for tenders. Includes the publication of the technical specification protocol and the invitation to qualified vendors to bid. Tenders from different combinations of fuel cell engines, International and/or Mexican bus chassis/body manufacturers, will be sought and encouraged.
- Activity 4: Select vendor(s). The selection of vendors for HFCBs and associated system for hydrogen supply will be based on lowest costs. It will take into account the vendors fulfilling of technical and performance requirements, and the extent to which cost-reduction objectives of the project will be achieved.
- Activity 5: The selected vendor installs, tests, operates and maintains the associated system for hydrogen supply, consisting of the natural gas based hydrogen reformer, and the equipment for storage and fueling the HFCBs with hydrogen. Its installation and operational tests will precede the arrival of the initial set of 3 HFCBs.
- Activity 6: The selected vendor initiates the manufacturing of the first 3 HFCBs and prepares conditions for the remaining 7 units.
- Activity 7: Establish a plan for public awareness efforts, including developing a marketing strategy and communications plan. All marketing and communications will recognize GEF support for the project, which will include GEF's logo(s) on the actual FCBs. The communications plan will include outreach efforts that will encompass the larger private sector community as a target for the project results and will facilitate engagement of the FCB Private Sector Advisory Group, as outlined in the UNDP-GEF FCB Strategy Note.

In addition to the public awareness activities, a coordinated research effort is planned. A research program will be established during Part I, and will include analysis of, among others: (a) the performance of the natural gas reforming technology with the carbon sequestration process for hydrogen production; (b) the net avoided emissions in hydrogen reformer when examined "well to wheel" (including carbon sequestration process); (c) reorganization of Mexico City urban transport and its environmental, political and economical impact; (d) technical studies on the HFBC Mexican prototypes, manufacturing process optimization, series tests certification, technological performance, maintenance and operation analysis, demonstration project management and environmental analysis, as well as demand and supply of HFBC technology. Associated research, not funded by GEF sources, will focus on research into costs and benefits of non-polluting transport in megacities, the politics and economics of bus replacement, diagnostic and solution alternatives, health, and the economics of mass hydrogen production for transport. The

research results will be disseminated through national and international seminars, and workshops to be held in Mexico.

## **IMPLEMENTATION PART II: YEARS 2002 - 2006**

Output 2: A complete fleet of 10 HFCBs (initial 3 followed by an additional 7) operated over a period of 5 years to obtain reliable information on its performance.

Activity 8: Place an additional 7 HFCB in service, and operate the entire 10 HFCB fleet for 5 years, operating under different regimes in a Mexico City commercial route. Initially, 3 HFCB will be purchased and start operation in 2001/2 for strong prototype monitoring and inspection, and also due to manufacturing constraints. The remaining 7 will start operation in year 2002/3.

Output 3: A significant demonstration of technological, manufacturing capacities and operational viability of fuel cell drives in urban buses and their refueling infrastructure under Mexican conditions.

Activity 9: Formulate the guidelines for the monitoring and evaluation plan (as in paragraph 9 below) for the complete Demonstration Project.

Activity 10: Collect operating data, that includes the collection, analysis and evaluation of the operating, performance data and monitoring information of the whole HFCBs fleet and their associated system for hydrogen supply.

Output 4: A cadre of bus operators and staff trained in the operation, maintenance and management of fuel cell buses and their associated system for hydrogen supply.

Activity 11: Train operating and maintenance personal for both the HFCBs technology and the associated system for hydrogen supply by means of on-the-job training seminars for drivers, maintenance staff, engineers and managerial staff. A sufficient number of trained personnel has to be achieved to ensure the successful execution of phases 1 and the preparation for phase 2.

Output 5: A substantial body of knowledge accumulated on reliability, failure modes and opportunities, permits to undertake an awareness campaign directed at creating an enabling environment for the future FCB market in Mexico.

Activity 12: Carry out the research studies associated to HFCB technology in Mexico. The project team will engage in systematic research related to HFCB



technology in Mexico such as HFCB Mexican manufacturing, HFCB reception tests certification, HFCB technological performance, HFCB operation analysis, and HFCB maintenance analysis. This research will form part of the evaluation of the whole demonstration project. At least one final report of each topic will be issued.

- Activity 13: Carry out the research studies associated to Government transport policies and economics. The project team will engage in systematic research related to Government transport policies and economics such as: Demonstration project management, Technology supply and demand, Zero emissions transport costs and benefits, economics and politics of Bus replacement, and economics of hydrogen production for urban transport. This research will serve both as project evaluation instruments as well as evidences to raise political and social awareness to engage in phase 2.
- Activity 14: Carry out the research studies associated to Environment and Health in Mexico. The project team will engage in systematic research related to environment and health, such as comparative project environmental analysis, zero emissions transport costs and benefits in megacities, Mexico City air pollution alternative solutions, and Mexico City air pollution and health. This research will also serve both as project evaluation instruments as well as evidences to raise political and social awareness to engage in phase 2.
- Activity 15: Carry out the research projects in preparation for future FCB market development in Mexico.
- Activity 16: Disseminate results and adaptive management. It includes the feeding of the obtained data and analysis, back to the vendors, and into the preparation for future FCB market development. It makes public diffusion of these results, and it initiates activities related to the Mexican mass manufacturing of hydrogen fuel cell buses.
- Activity 17: Organize and take part in National and International meetings on HFCB manufacturing technology, operation, maintenance, and management. It includes the organization and participation in National and International meetings on hydrogen fuel cell technology for development and joint entrepreneurial purposes, and for widespread dissemination of results.
- Activity 18: Both the communications and research initiatives initiated during Part I will be continued throughout Part II. The FCB Private Sector Advisory Group will continue to be consulted on a regular basis regarding project results. International meetings on hydrogen fuel cell technology will be attended for development and joint entrepreneurial purposes, and for widespread dissemination of research results. The research results will

be shared with the other GEF FCB projects through meetings and other communications (e.g., FCB Website) coordinated by the UNDP-GEF.

46. The details or sub-activities for each one of the 18 activities, as well as the corresponding responsible personnel and inputs, are provided in Annex D.

### **3. IMPLEMENTATION ARRANGEMENTS**

#### **3.1 PROJECT IMPLEMENTATION AND EXECUTION ARRANGEMENTS**

47. The implementation and execution arrangements for the full-scale project will be developed and institutionalized through the Demonstration Project implementation. The National Coordinating and Supervising Agency is the Transport Secretary of the Mexico City Government (SETRAVI), which manages the whole transport system of Mexico City, will coordinate the whole project and the interactions of the different parties involved. SETRAVI will also carry out the bus replacement policy according to the Transport Law for Mexico City, which will pave the way for the initiation of mass introduction of HFCBs in the Mexico City corridors at the end of this Demonstration Project. It will be also responsible for the dissemination of the project experiences in the other major Mexican urban areas for replication purposes. The National Executing Agency is the Electric Transport Service Authority (STE acronym in Spanish) of the Mexico City government, as the project is concentrated within the urban area of the Federal District in Mexico City, therefore, requiring to be fully managed by STE, whose authority has been obtained through delegation from SETRAVI. This Agency was chosen because of its experience in handling new technology transportation projects, and because the project will be managed and implemented in its facilities. STE will be responsible for the delivery of project results and the use of project funds. These agencies are highly interested in the fuel cell technology as a mean to solve the serious environmental problems that the current fleet of diesel buses is generating. Moreover, SETRAVI provides economic and political support for the initiative in order to demonstrate the viability of fuel cell technology to solve part of the environmental pollution problem in Mexico City attributable to the public transportation system.

48. The GEF Implementing Agency is UNDP that is responsible for receiving and managing the GEF financial resources. UNDP will also be responsible for receiving and managing those STE financial resources devoted to HFCBs, and associated hydrogen supply system and research. UNDP will be responsible for the publication of the International Bid for buying all the equipment for the project, and to organize meetings with STE personnel and the demonstration project staff in order to follow up the project development.

49. A Project Steering Committee (PSC) will meet on a quarterly basis with the role of overseeing project planning, implementation and performance. The Project Steering Committee would consist of representatives from the Secretary of Transport of the

Mexico City Government (SETRAVI), the Director General of the Electric Transport Service of the Mexico City Government (STE), a Representative of the United Nations Development Programme Office in Mexico City (UNDP), a Representative of the Technology Developers, a Representative of the Project Contract, the Consultants Coordinator (who is one of the consultants himself, responsible of one of the associated research projects) and the Manager of this Demonstration Project, the number of the Project Steering Committee members may be increased with invited members according to the Project requirements during implementation. The Project Staff is composed by the coordinator, consultants, advisors, and officers, under UNDP subcontracts, responsible for carrying out the different activities and research associated to the project, the selected SETRAVI and STE personnel to carry out the different parts and activities of the Project, the selected UNDP personnel to carry out the different parts and activities of the Project, and the Project Manager, under UNDP subcontract, responsible for the overall management of the Project.

50. The Project HFCB technology developers and vendors personnel is composed by the responsible people named by the HFCB technology developers and selected subcontract vendors, to be ascribed to the Project. Representatives from the ESIME-IPN, UDLA-P, UAM, UNAM and other higher engineering faculties might participate as consultant for the project implementation. Representatives from the State delegations of ININ, IIE, IMP, PEMEX, SEMARNAP and other government and academic agencies might participate as technical advisors. The researchers and academics of these institutions will provide technical support and will constitute the demonstration project staff.

51. The overall project will assist the City Government, through its Secretary of Transport and the Electric Transportation Service Authority, in providing full feedback to the technology developers to gain meaningful experience in the operation and management of buses powered by fuel cell electric drive trains. It will pave the way for full deployment and assimilation of HFCB manufacturing technology in Mexico, as fuel cell buses become commercially available at competitive prices, relative to other conventional bus technologies. Urban areas such as Guadalajara and Monterrey will be incorporated from year 6 onwards, as the export potential for the fully assimilated and proven technology is identified and exploited. In the long run, such an outcome will make the technology available to both developing and developed countries.

### **3.2. FINANCIAL ARRANGEMENTS**

52. Incremental costs: The incremental costs to be financed by the GEF in project Part I amount to US\$ 5,418,300 complemented by co-financing to the order of US\$ 4,922,000. The existing baseline has been estimated at about US\$ 1,422,000 over the first year of the project, representing a total project cost of about US\$ 10,340,300 for Part I. The co-financing will be contributed by many sources including the Government of Mexico City by the STE, fares, sponsors and private sector.

53. The incremental cost analysis and matrix sets out the rationale for the differential financing of project activities. GEF resources will be targeted to activities consistent with GEF guidelines for incremental funding. This project was prepared at an estimated cost of US\$ 339,500 with the support of UNDP.

### **3.3. LEGAL CONTEXT**

54. This project document shall be the instrument referred to as such in Article 1 of the Standard Basic Assistance Agreement between the Government of Mexico and the Special Fund, then the United Nations Development Programme, signed by the parties on 23rd July 1963. The host country-Implementing Agency shall, for the purpose of the Standard Basic Assistance Agreement, refer to the government co-operating/Executing Agency described in that Agreement. Nothing contained within this document or in contractual documents signed in light of this document, will be interpreted as an explicit or tacit renouncement of the immunity of jurisdiction, privileges, exceptions or other immunity enjoyed by UNDP in virtue of the Convention of prerogatives and immunities of the United Nations, to which the Government of Mexico is signatory. The Government of Mexico will assume the risks associated with the operations initiated by this project, and will respond to any claims made by third parties against UNDP, their employees or other people delivering project services in their name. This disposition will not apply in the circumstances where UNDP and the Government of Mexico can prove that the complaints and the corresponding responsibilities are consequences of serious neglect or international misconduct on behalf of the people mentioned.

55. The following types of revisions may be made to this Project Document with the signature of the UNDP Resident Representative, provided he or she is assured that the other signatories of the Document have no objections to the proposed changes:

- a) Revisions or additions to any of the annexes of the project document;
- b) Revisions which do not involve significant changes in the immediate objectives, outputs or activities of a project, but are caused by the rearrangement of inputs already agreed to or by cost increases due to inflation; and
- c) Mandatory annual revisions, which rephrase the delivery of agreed project inputs or increased expert or other costs due to inflation or take into account agency expenditure flexibility.

## **4. PARTNERS CONTRIBUTIONS**

### **4.1 NATIONAL COORDINATING AND SUPERVISING AGENCY CONTRIBUTION – SETRAVI**

56. The National Coordinating and Supervising Agency will place at the disposal of the project its own technical and administrative personnel for the execution of tasks provided for in this document at no cost to the project, except for travels undertaken by such personnel for service to the project.

57. When the Steering Committee meetings or any other meeting related to the project take place in its premises, this National Agency will provide adequate facilities for the realization of these meetings. Also, telephone services, fax, computer, postal service and other support services will be available for project execution, for as long as these project activities are concerned directly with SETRAVI.

### **4.2 NATIONAL EXECUTION AGENCY CONTRIBUTION - STE**

58. The National Execution Agency will place at the disposal of the project its own technical and administrative personnel for the execution of tasks provided for in this document at no cost to the project.

59. STE will contribute with part of the vehicles cost, garage modifications to adequately accommodate the HFC buses of the project, equipment and tools and furniture facilities for the project. These inputs correspond to the STE contribution of US\$ 1,466,355 that has been already approved.

60. The travels undertaken by its personnel for service to the project as well as the costs of part of the associated studies and research and international seminars and workshops will be covered by the project budget contribution of STE, that amounts to US\$ 875,645.

61. The executing agency will provide adequate facilities for project consultants, technical personnel and the project staff. Also, telephone services, fax, computer, postal service and other support services will be available for project execution.

62. STE will also supply the following:

- Garage for the HFCBs parking and maintenance
- An area in this garage for the installation of the natural-gas-based reformer, H<sub>2</sub> Storage and subsystem to supply the vehicles with hydrogen.
- Work-hand to operate the buses (with training and supervision to be given by the vendor).
- Work-hand for the maintenance (with training and supervision to be given by the vendor).
- Equipment and tools for normal maintenance purposes (it does not include specialized equipment and tools for the replacement of pieces of the system fuel

cells neither for the digital control and power electronics associated to the traction system).

- Electric energy, natural gas and water required for production of the hydrogen.
- Replacement pieces that had gone out of the warranty period, and that they have suffered natural waste during their use, such as brake systems, tires, shocks absorber, etc. (the replacement pieces of the system fuel cell, of the digital control and of the power electronics associated to the traction system are not including in this item).
- Body repair works.

63. All the inputs of the STE described above, correspond to the contribution described under the paragraph of operating costs in the budget of this document. This contribution amounts to US\$ 2,342,000 from STE, plus the contributions of US\$ 2,455,000 from private sector and US\$ 125,000 from private sponsors.

### **4.3 UNDP CONTRIBUTION**

#### **4.3.1 TECHNICAL SUPPORT**

64. UNDP will, jointly with the project National Executing Agency, undertake program support activities, provide advice on planning and implementation as well as carry out technical, substantive, monitoring and evaluation missions in the course of the project execution. UNDP will collaborate in the identification and selection of project professional personnel, who, upon approval by the project coordination, will be hired by UNDP.

#### **4.3.2 SUPPORT TO NATIONAL EXECUTION**

65. Upon request of the national executing agency, UNDP will place at its disposal mechanisms for the acquisition of goods and services for the benefit of the project, in accordance with the corresponding approved budget (and under the appropriate budget lines).

66. The provision of the said physical and human inputs shall be made according to the procedures for national execution of technical cooperation projects, agreed upon by the Mexican Government and UNDP, and may include:

- Recruitment and hiring of national and international consultants and experts, including administration of the corresponding contracts;
- Analysis of personnel terms of reference;
- Subcontracting of public and private sector services;
- Analysis of the technical specifications of equipment;
- Support in the conduct of competitive bidding procedures;
- Evaluation and adjudication of competitive bidding;
- Financial monitoring of projects.

67. The hiring of project professional personnel shall not exceed the duration of the project, and shall not, under any circumstances, constitute an employment link with the executing agency.

68. The rules and procedures for contracting of services, acquisition of non-disposable material and hiring of consultants as well as the regulations on project execution are described in the annexes of terms of references and invitation to bid of this document. These rules, procedures and regulations comply with those contained in the UNDP National Project Execution Manual.

69. The above mentioned assistance not only for technical support but also for support to national execution may be requested by the Project Manager or proposed by the UNDP Resident Representative, as required within the scope of the project document agreed upon with the Government. The financial resources for such assistance are to be provided by the project and its implementation shall likewise follow UNDP financial rules and regulations and, in operational terms, national execution procedures.

#### **4.4 VENDOR CONTRIBUTION**

70. It is expected that all the vendors selected, as well as their suppliers, contribute in the best possible way with the engineering, manufacturing, technology, production know-how and managerial techniques, in order to fulfill the project requirements agreed upon. These contributions include, but are not restricted to the following:

- Initial supply of the natural-gas-based hydrogen reformer together with the H<sub>2</sub> storage and subsystem for hydrogen supply to the HFCBs.
- Initial supply of 3 HFCBs in the first lot and 7 HFCBs in the second lot.
- Initial supply of any additional hardware and software required for the project development.
- The selected vendors are expected to propose an interest of ranging from 20% to 33% of the project's costs, under the rationale explained in the annex of invitation to bid of this document.
- Continuous provision of technical and training support to STE during the course of the project.
- Willingness to respond to problems and suggestions for modifications and improvements, during and after this Demonstration Project.
- Commitments to pursue major cost reductions and improvements in fuel cell stack durability and in the digital controlled power electronics system.

- Immediate and potential long-term commitment to local manufacturing of HFC buses and its associated fueling system.
- A detailed data bank depicting all aspects of the buses performance and their elements (e.g. design, material and parts procurements, quality assurance, inspection, testing and costing).
- Willingness to improve any aspect of the manufacturing processes, and the intermediate and final products that can result in lower costs, or an improved functioning, maintainability or durability of products.
- Continuous commitment towards technological development, safety, materials recycling, waste reduction and a cleaner working environment.
- Willingness to improve their companies' capabilities as the project evolves into more advanced implementation stages.

71. The selected vendors are expected to benefit from their participation in this project, on the following aspects:

- Experience and a strong reference in the application of their technologies.
- Unique feedback into their product and process development.
- Accelerated product and process development.
- A possible head start in bidding for the initiation of the Mexican HFCBs technology commercialization period.

#### **4.5 GEF CONTRIBUTION**

72. The bulk of GEF's financial support is aimed to cover part of the incremental costs for procurement of the 3 HFC buses (Part I), as their current cost over that of conventional diesel buses represents the greatest barrier to the assimilation of the new technology. This will enable the accelerated commercialization in Mexico of HFCB technology with a substantial impact on GHG.

73. In return, GEF will be strengthened in:

- Enabling the development of a major low GHG emitting technology for urban public transport, tested under real operating conditions.
- Accelerating HFCB technology costs reductions.
- Substantially reducing globally GHG emissions in the long term.



#### **4.6 PROJECT MANAGER, PROJECT STEERING COMMITTEE AND PROJECT STAFF**

74. For the realization of all the inherent activities, this Demonstration Project has organized itself so that the decision-making responsibilities on project design and execution will be taken by the following entities and committees.

75. The Project Manager, who shall be accountable for the:

- Overall management to meet the Project objectives and outputs.
- Overall management of the financial, material and human resources of the Project.

76. The Project Steering Committee, which is composed by:

- The Secretary of Transport of the Mexico City Government (SETRAVI),
- The Director General of the Electric Transport Service of the Mexico City Government (STE),
- The Project Manager,
- The Research Director,
- The Programme Officer and Assistant of the United Nations Development Programme Office in Mexico City (UNDP),
- A Representative of the Technology Developers,
- A Representative of the Project Contract,
- The number of the Steering Committee members may be increased with invited members according to the Project requirements phases.

77. The Project Staff, which is composed by:

- The Project Manager, under UNDP subcontract, responsible for the overall management of the Project.
- The Research Director, Research consultants, and Technical Officers, under UNDP subcontracts, responsible of carrying out the different activities and research associated to the project,
- The in-kind SETRAVI and STE personnel (Project Coordinator, Operator and Technical, Administrative and Financial Staff ) devoted to the Project,
- The representatives of the Technology Developers and Vendors

#### **4.7 PROJECT INCREMENTAL COSTS**

78. The incremental cost calculations are discussed in detail in Annex A of the proposal. The baseline costs are those that would be encountered by the STE authorities in operating a fleet of 10 diesel buses (Part I and Part II), to obtain a total of 3.036 million vehicle/km over a 5 years demonstration period. As detailed in tables A.1 and A.2, in

Annex A, the baseline costs add up to approximately US\$ 8,232,200, with a baseline of US\$ 1,422,000 for Part I and US\$ 6,810,200 for Part II.

79. The following are the incremental costs associated with Part I:

- The costs of procuring and maintaining the first 3 bus fleet of hydrogen fuel cell buses, compared to that of providing the equivalent transportation capacity through diesel buses.
- Cost of establishing and maintaining the hydrogen fuel infrastructure, compared to the operational costs of the existing diesel fueling infrastructure; and,
- Research and information dissemination and exchange activities that will be conducted during Part I.

80. The total costs of Part I of the GEF project are estimated at approximately US\$ 10,000,800 (not including the PDF B of US\$ 339,500). The total incremental cost for Part I is US\$ 8,574,000.

Table 4.1. Estimated Budget Allocation for Implementation Part I (1000 US\$)

<b>Part I</b>	<b>Investment (a)</b>	<b>Operating Costs (b)</b>	<b>Research &amp; Information Dissemination (c)</b>	<b>Contingencies</b>	<b>Total</b>
<b>GEF</b>	4.2750	0.3000	0.5038	0.0000	5.0788
<b>Private Sector</b>	2.2950	0.1200	0.0400	0.0000	2.4550
<b>Mexican Sources</b>					
<i>STE</i>	0.4700	1.7195	0.1525	0.0000	2.3420
<i>Sponsors</i>	0.0000	0.1200	0.0050	0.0000	0.1250
<b>Part I TOTAL</b>	<b>7.0400</b>	<b>2.2595</b>	<b>0.7013</b>	<b>0.0000</b>	<b>10.0008</b>

Note:

- Investment includes purchase of vehicles, reformer, H2 storage, garage modifications, additional power equipment and tools, related monitoring, and facilities.
- Operating costs include land rental, natural gas, water, electric power, equipment maintenance, operations and administrative personnel, staff training, vehicle maintenance, facilities maintenance, insurance, route maintenance, and fuel cell stack replacement.
- Research and information dissemination includes associated studies; national and international seminars; workshops; and associated salaries and expenses.

81. The following are the incremental costs associated with Part II:

- The costs of procuring an additional 7 buses, and operating and maintaining the 10 bus fleet of hydrogen fuel cell buses, compared to that of providing the equivalent transportation capacity through diesel buses.
- Cost of operating and maintaining the hydrogen fuel infrastructure, compared to the operational costs of the existing diesel fueling infrastructure; and,
- Research and information dissemination and exchange activities that will be conducted as part of Part II.

82. The total costs of Part II of the GEF project are estimated at approximately US\$ 18,907,500. The total incremental cost for Part II is US\$12,097,900

Table 4.2. Estimated Budget Allocation for Implementation Part II (1000 US\$)

<b>Part II</b>	<b>Investment (a)</b>	<b>Operating Costs (b)</b>	<b>Research &amp; Information Dissemination (c)</b>	<b>Contingencies</b>	<b>Total</b>
<b>GEF</b>	6.9350	0.0000	0.0000	0.0000	6.9350
<b>Private Sector</b>	1.0200	0.4800	0.1600	0.0000	1.6600
<b>Mexican Sources</b>					
<i>STE</i>	0.7350	5.3900	0.6851	0.0000	6.8101
<i>Fares</i>	0.0650	0.0000	0.3094	2.6280	3.0024
<i>Sponsors</i>	0.0000	0.4800	0.0200	0.0000	0.5000
<b>Part II TOTAL</b>	8.7550	6.3500	1.1745	2.6280	18.9075

Note:

(a), (b) and (c) see para. 80.

83. The costs of the full GEF project (i.e., Part I and II) are estimated at approximately US\$ 28,908,300, with a baseline of US\$ 8,232,200. The total incremental costs are estimated at approximately US\$ 20,671,900.

The breakdown of project costs for Part I and Part II is estimated to be as follows:

- STE will contribute with US\$ 9,152,100 in the form of investment (capital costs), facilities, bus operation, maintenance, training, management, equipment, land rental and research.
- STE will contribute also, in cash with US\$ 3,002,400 from their revenue-earnings in the form of future fares from the fuel cell buses.
- The technology providers will contribute with US\$ 4,115,000, which is expected to be transferred to STE.
- The private publicity sponsors will contribute with US\$ 625,000, due to advertisements on the buses.
- GEF will provide US\$12,013,800 (in addition to the already committed PDF-B resources, amounted to US\$ 339,500).

Table 4.3. Estimated Budget Allocation for Full Project (1000 US\$)

A summary of the total budget by contributor is given bellow, including percentage of contribution:

<b>Part I &amp; II</b>	<b>Investment (a)</b>	<b>Operating Costs (b)</b>	<b>Research &amp; Information Dissemination (c)</b>	<b>Contingencies</b>	<b>Total</b>	
<b>GEF</b>	11.2100	0.3000	0.5038	0.0000	12.0138	41.6%
<b>Private Sector</b>	3.3150	0.6000	0.2000	0.0000	4.1150	14.2%
<b>Mexican Sources</b>						
<i>STE</i>	1.2048	7.1096	0.8377	0.0000	9.1521	31.7%
<i>Fares</i>	0.0650	0.0000	0.3094	2.6280	3.0024	10.4%
<i>Sponsors</i>	0.0000	0.6000	0.0250	0.0000	0.6250	2.2%
<b>PART I &amp; II TOTAL</b>	<b>15.7948</b>	<b>8.6096</b>	<b>1.8759</b>	<b>2.6280</b>	<b>28.9083</b>	<b>100.0%</b>

Note:

(a), (b) and (c) see para. 80.

The HFCB technology and hydrogen providers, as well as the fuel cell and bus manufacturers are being invited to participate in the financing of the project. This participation would represent an investment in anticipation of returns that they would gain from their participation in this demonstration project and in the future mass deployment of HFCB technology. According to a maximum private involvement scenario, the private sector will finance 30% of the project. At the present, the private contribution is of 14.2% of project total costs.

## **5. PROJECT ELIGIBILITY AND RELATION TO OTHER IMPLEMENTING AGENCIES**

### **5.1 PROJECT ELIGIBILITY**

84. Mexico ratified the United Nations Framework Convention on Climate Change (UNFCCC) on March 11, 1993 and presented its First National Communication in 1997. The Mexican Congress approved the Kyoto Protocol in April 2000. The National Communication consists of emission inventories, climate-change scenarios and outlines general strategies for GHG mitigation, including elements for improving urban air quality (PROAIRE).

85. The Project has been designed to fulfill OP 7 (reduce cost of prospective technologies) and OP 11 (sustainable transport) operational guidelines. In relation to OP 7, the project has been designed to test and assimilate fuel cell technology aimed at promoting its full-scale commercialization in Mexico, both for domestic and export markets. Fuel cell technology is currently being proposed as a long-term solution for air quality problems in large urban sites in Mexico, together with a diversified mix of technological options, so as to mitigate the risk of failure or unforeseen design problems.

86. With respect to OP 11, the long-term effect of commercial scale deployment of fuel cell buses will help to promote a paradigm shift towards low and zero-emission urban transport modalities. As expressed in PROAIRE, urban transport contributes 37% of the airborne pollutants in Mexico City, and large reductions in this sector will need to be achieved in order to stabilize the country's GHG concentrations.

87. The proposal is also fully consistent with the draft elements for programmatic support for fuel-cell buses, currently under preparation by UNDP. The Mexican project development team actively participated in a workshop held in New York in April 2000, which was financed through a UNEP administered medium-sized grant, "Hydrogen Fuel Cell Buses for Urban Transport". Workshop goals included: to identify the niche participation of HFCBs together with other GHG mitigation strategies in urban mass transport; to examine development of HFCBs and associated fuel-supply systems; to identify possible FCB commercialization routes; and to identify opportunities and strategies for accelerating commercialization of HFCBs. Lessons learned through the exchange of ideas and experiences of participating countries and suppliers have been included in the current proposal.

88. The Mexican project responds to system-wide GHG balance concerns mentioned in the programmatic strategy by capturing and commercializing the CO<sub>2</sub> produced in the reformed natural gas process. The carbon sequestering process will be closely monitored during project implementation to confirm manufactures technical specifications. Additionally, the MCMA's long-term transport strategy provides a perfect vehicle for a programmatic approach, since it addresses a wide variety of system factors, ranging from the phasing out of inefficient units, providing improved infrastructure, introduction of cleaner combustion technologies (better quality gasoline and diesel, use of natural gas

and ethanol), hybrid electric-combustion and dual combustion technologies, and fuel cell technology. Finally, the proposed programmatic criteria for impact, replicability, sector integration, cost sharing, clear success indicators and geographic diversity have been fully addressed and internalized in the Mexican proposal.

## **5.2 RELATIONS TO OTHER IMPLEMENTING AGENCIES**

89. The World Bank is currently developing with STE on a GEF full-sized project proposal for the design and deployment of a pilot fleet of internal combustion engine-electric hybrid buses. This is consistent with the medium-term goal of gradually phasing out diesel buses in the urban transport fleet, and forms part of the multi-faceted strategy for the transport sector as expressed in PROAIRE.

90. The former is associated with the second phase of the World Bank loan-financed Air Quality and Transport project. The project will support the expansion and improvement of the metro system, improved traffic management technology and strengthened institutional capacity of the Mexico City Government and the Metropolitan Environmental Commission.

91. UNDP is currently in negotiations with CONCAMIN (National Chamber of Industry) and the Metropolitan Environmental Commission and the Sustainable Development Network to create a contingency fund that would finance the renovation of the private vehicle fleet in the MCMZ. Participating industries would be exempt from reducing their activities during environmental contingencies.

## **6. PROJECT RISKS, DESCRIPTION, PREVENTION AND CONTROL**

92. The forthright and unbiased identification of risks is necessary to duly prevent or control them during project implementation. At this stage, five major risks have been envisaged, namely: Insufficient and/or inadequate specifications, inadequate procurement process and vendor selection, failure of the vendor to fulfill the specified products and services, increased requirements of resources, and failure of the Mexican institutions to fulfill their commitments. All these risks are examined in detail below.

*Risk 1. Incomplete and/or inadequate specification of the products and services needed (first-time experience risk)*

93. This risk may be considered negligible, because of the recent experience gathered by the institutions involved, from the successful production, implementation and testing of a fleet of 200 modern trolley buses for the Mexico City streets. STE leads the Mexican project team, and brings its practical experience with the trolley bus program to bear on the technical challenges presented in the present proposal, and lessons learned will be applied to all aspects relating to the preparation and dissemination of technical specifications for operation and maintenance needs. Control measures: A suitable information and project management system will endow all parties to control this risk.

Such a system will be equally useful for controlling all other risks. Consequently, this is regarded as a very low-level risk.

*Risk 2. Uncertain vendor participation in procurement process*

94. An analysis focused on the actual manufacturing capabilities of international and locally based bus manufacturers is aimed at minimizing this risk. Besides, the successful production of the trolley buses cited above makes this risk also small. UNDP as the GEF implementing agency has extensive experience in preparing complicated public bids, contracts and procurement procedures. Control measures: wide dissemination of the objectives and scope of this project, and full consideration of all potential vendors. In the event of a reduced number of potential vendors, co-development and open book costing and productivity improvement techniques, standard in the automotive industry, will be employed for ensuring value for money. Therefore, this is regarded as a low-level risk.

*Risk 3. Failure of the vendor to supply the specified products and services*

95. Full disclosure of requirements will be made available to all potential manufacturers. The prospects of this and other follow up projects will induce the most competitive of current potential manufacturers to rapidly increase their capabilities. Detailed examination of the logistic and quality assurance systems within the feasibility analysis, and sound project management can reduce this risk considerably. Control measures: strict and detailed follow up on the manufacturing milestones and datelines will allow timely corrective actions. Fully transparent charges, fees and penalties will be applied in accordance with Mexican standards to ensure prompt delivery of products and services. This constitutes a low to medium level risk.

*Risk 4. Increased requirements of resources*

96. Unexpected delays in the achievement of critical goals or miscalculations of the resources needed may mean a higher expenditure of money, to keep the project within its time frame. In this respect, again, the experience gathered through the recent trolley bus project would prove to be very useful, since some critical manufacturing and managerial aspects have already been identified.

97. Besides, the financial issues of this project are expressed in U.S. dollars, that is expected to be more stable than the Mexican peso. Provisions preventing price changes should be included in all bids, especially for cost dependent components. The most recent cost parameters prepared for a proposed HFCB deployment in the European Community have been used as basis for the project cost tables. Local cost controls are well managed through STE's experience and track record with manufacturers. Control measures: close and detailed follow up of resources expenditures becomes a must. The timely purchase of critical bus components, as well as appropriate bundling of bids should be practiced and properly supervised. Additionally, a 10% contingency line has been included in the budget. With effective provisions and control, this risk is considered to be of low to medium level.

*Risk 5. Failure of the Mexican institutions to fulfill their commitments*

98. Mexican institutions can organize this project with a high degree of autonomy, in order to protect it from political influences. Also, early financial commitments of Mexican institutions will ensure the progress of the project as planned. Clean public transportation services in Mexico City are a top priority for both the local and the federal governments. Control measures: close follows up on financial commitments (amounts and dates). Because of the high priority of this project, the variety of institutional stakeholders and the outcome of recent elections, this is a low risk.

## **7. MONITORING AND EVALUATION PLAN FOR THE ENTIRE DEMONSTRATION PROJECT**

99. The monitoring and evaluation plan of the demonstration project considers a set of parameters that include, *inter alia*, the configuration of a typical route in Mexico City, sea level, altitude, route length, road quality, number of passengers transported, daily distance traveled, monitoring routines, preventive and predictive maintenance routines, training of the operator, of the maintenance staff training, etc. A proposed benchmark set for the monitoring and evaluation plan is listed below:

- Development of a detailed work plan showing the milestones and benchmarks.
- A proposal for timely execution of specification setting, solicitation and procurement activities for the entire demonstration project in the first year.
- Delivery of fuel facilities (generation, storage and bus supply) and development of the work plan to operate such facilities during the demonstration project.
- Certification of manufacturer's data on carbon sequestration for natural gas reformers.
- Certification work plan on delivery of the bus fleet prior to operation.
- Preparations of a detailed work plan for commissioning buses, fueling system, spare inventories, software, etc.
- Development of a work plan for preventive and predictive maintenance for the bus fleet.
- Development of a work plan for preventive and predictive maintenance for all the equipment within the facilities.
- Quarterly reports on achievements of hours and kilometers of operation by individual buses and the fleet as a whole.



- Quarterly reports on the availability of vehicles and on fuel consumption.
- Quarterly reports on meantime between failures and failure mode analysis considering both the vehicle and the fueling system.
- Quarterly reports on proposed engineering modifications, if it is concluded that they are needed, and the communication of these to vendors, plus confirmation of actions taken.
- Quarterly reports on operator and maintenance staff training and achievement.
- As it is intended to cover the selected typical route in Mexico city with HFCBs and diesel buses, a comparative analysis is to be done for both type of buses considering the quarterly reports proposed above.
- Annual review of progress towards fuel cell cost reduction, reliability improvement and increased durability.
- Annual records of communication activities and participation in international meetings.
- Final Report with the independent evaluation of the project.

## **7.1. UNDP MONITORING AND EVALUATION ARRANGEMENTS FOR PROJECT PART I**

### **7.1.1. PROJECT MONITORING AND TRI-PARTITE REVIEW**

100. Project monitoring will be provided in accordance with UNDP established procedures on an ongoing basis. The project monitoring will be followed-up through the quarterly meetings of the Project Steering Committee (PSC), capitalizing on the project management tools developed by the UNDP country office. Activity progress reports will be submitted to UNDP prior to each quarterly meeting of the PSC, on the basis of the information generated on project impact, technical reports, PA monitoring scorecard, and the financial sustainability indicators. Corrective action will be taken in project activities based on recommendations included both in the progress reports and as a result of evaluation of possible exogenous factors influencing project's implementation. Complementarily, a Tri-Partite Review Meeting (TPR) will be held once a year to review overall project progress. During these review meetings, the project performance will be measured against established work plans, expenditures will be reviewed and the overall technical performance will be discussed.

### **7.1.2. REPORTING AND EVALUATION**

101. The Project Manager will prepare and submit to the UNDP Country Office for examination three months prior to the TPR meeting, an Annual Project Report (APR). Additional Annual Project Reports (APRs) are to be submitted every year during life of the project. All reports will be produced in the English language.

102. Annual mandatory evaluation will be performed, as part of the regular programming of the UNDP country office and results will adapt project strategies. A Project terminal Report will be prepared for consideration at the terminal TPR meeting. It shall be prepared in draft sufficiently in advance (two months prior to the meeting) to allow review by Government and UNDP, during the project. The terminal evaluation will document the lessons learned from the project to inform further policy development.

### **8. LESSONS LEARNED**

103. The design of this project has benefited from the experiences of previous fuel cell bus demonstration projects, particularly in the case of Chicago and Vancouver, as reported in “Industrial Progress in Fuel Cell Engine Development, Workshop on Commercialization of Fuel Cell Buses: Potential Roles for the GEF, UN Headquarters, New York City, April 27-28, 2000 (Ref. Ferdinand Panik). Lessons learned include: the statistical degree of confidence decreases when diminishing the sample size, which is why a 10-unit pilot fleet is selected in the Mexican proposal. Likewise, the reliability of technical and operating data depends on focusing on the fleet as a system, rather than on individual unit performance. Thirdly, Chicago Transit Authority's 2-year successful demonstration of three 250kW buses in operation did not run under normal work regimes, rather at 30% availability compared with diesel buses, in spite of the fact that the current technology advance permits sufficient guarantees for more intensive use. In Chicago, only a few minor road calls occurred during the first four months. The following five months saw an increase in failures, however the majority was attributed to non-fuel cell systems. The engine compartment was modified to allow for easier removal and maintenance of fuel cell stacks, and after a year of service, the overall performance improved and reliability is continuing to improve (Ref. Craig Lang, “The Chicago Fuel Cell Experience”, Workshop on Commercialization of Fuel Cell Buses: Potential Roles for the GEF, UN Headquarters, New York City, April 27-28, 2000. Also, the experience of three 120kW HFC bus operating in the Munich airport was evaluated (Ref. Man in motion 3/2000, pages 36-38). See also Joachim Grosse, “PEM-Fuel Cell Demonstration at Siemens” Workshop on Commercialization of Fuel Cell Buses: Potential Roles for the GEF, UN Headquarters, New York City, April 27-28, 2000. The current proposal will place the HFCBs in a full workload regime in one of the most representative bus routes in Mexico City, allowing for reliable data generation on the durability and endurance of fuel cells under intensive use.

104. Two prototype units were placed in operation in Mexico City in 1997. Both units suffered problems attributable to the high altitude conditions present in Mexico City (2,200 masl). Trouble shooting indicated that the amount of oxygen was insufficient, given that the air intake for the fuel cells was designed to operate efficiently with sea-

level atmospheric pressure. The local engineering solution has identified that the compressor used to operate the doors and brakes could be used to increase the oxygen intake pressure to the fuel cells, with an acceptable loss of potential (from 42% to 40%, compared to normal operating potential of 28% for diesel buses). The optimum compression ratio is 760 mmHg/600 mmHg, i.e. 1.26. This pressure increase implies a low power input or the air flow required in the HFC.

105. CNG is handled at several hydrocarbon-processing facilities in Mexico. CNG pipelines are under expansion to eventually supply the most important cities. CNG steam reforming is the basis for all synthesis gas production in the country. Research is underway to increase the sweetening (elimination of H<sub>2</sub>S and CO<sub>2</sub> from the CNG) capacity of PEMEX plants, which will be applied to handling H<sub>2</sub> in the project. Likewise, the operation of a compressed natural gas program in Mexico City provides valuable lessons that can be applied to hydrogen management. Currently two CNG fueling stations are operating commercially within the MCMA, with a third under construction. These fueling stations have been used to service a fleet of 480 garbage collection trucks and 650 patrol cars that have been equipped with CNG motors. STE has garnered practical experience through the operation of both CNG and dual combustion CNG-diesel buses that will serve to facilitate fueling operations of HFCB at the STE bus/yard.

106. Operation of the trolley bus system in Mexico City has provided key experience in both technical and administrative aspects that can be readily applied to fuel cell technology. To determine failure rates of the current fleet of 450 trolley buses operating in the MCMA, extensive monitoring of a test fleet of 50 trolley buses clocking in 220 kilometers/day for 300 days per year (a total of 3,000,000 km/annum, allowing for high statistical reliability) was carried out. The cost of FCB technology does not permit the deployment of 50 test units, however the demonstration fleet of 10 test HFCB will have traveled the 3,000,000 km necessary for establishing full failure rates, based on the lessons learned from trolley bus deployment.

107. The state oil enterprise PEMEX, has years of experience operating natural gas generation, storage and delivery systems, and is also the country's largest hydrogen producer. PEMEX complies with both national and international safety standards for natural gas and hydrogen production and management. This experience has allowed for the formation of highly trained technical corps that can be tapped for safe and secure administration of the natural gas reformer. As STE is a transport authority, full, contractual responsibility for the operation and adequate maintenance of the reformer facilities will rest with the service provider.

108. In recent months the European Union has announced the launching of a demonstration of HFCB involving a fleet of 30 units and approximately 10 cities. This experience has guided the financial analysis assumptions contained in this proposal, and close attention will be paid to issues such as rider comfort and approval rates.

## **ANNEX A: INCREMENTAL COSTS**

### **Broad Development Goal**

The broad development goal being pursued by the Government of Mexico and the STE, besides the provision of public transport services to its urban inhabitants of Mexico City, is to test under actual operating conditions, the new fuel cell technology as applied on urban buses under heavy work.

### **Baseline**

It has being decided by the Mexican Government through STE, to devote a route in Mexico City to the demonstration project for the Hydrogen Fuel Cell Bus. This route crosses over the whole of the city from north to south and vice versa and is a typical one. 40 articulated STE buses plus 130 private firm buses are needed to provide the service. So, 35 STE articulated diesel buses would operate in a business as usual manner. The other required 10 will be HFCBs (1articulated bus = 2 single HFCBs). Any additional service bus requirement for the route will be provided in a business as usual manner by STE.

Based on the distances currently ran in this route over the 5 years testing period and the different HFCBs operating regimes, it has been determined a testing service amounting to 3.036 millions of vehicle-km, and a baseline for this project has been established. The 10 diesel buses which will be substituted by 10 HFCBs, operating for 5 years, as detailed in table A.2, will result in emissions of at least 54.648 tons of carbon monoxide; 39.468 tons of NO<sub>x</sub> emissions; 3.6432 tons of SO<sub>x</sub> emissions; 8.8044 tons of HC emissions; and 3339.6 tons of CO<sub>2</sub> emissions and 2.4288 tons of particles (A diesel bus in Mexico is estimated to emit for every traveled kilometer 18 g of CO, 13 g of NO<sub>x</sub>, 1.2 g of SO<sub>x</sub>, 2.9 g of HC's, 0.8 g of particles and 1.1 kg of CO<sub>2</sub>). New diesel buses operating under normal workloads and fueled with Mexican diesel (50 p/mill sulfur, 3<sup>rd</sup> lowest sulfur content in the world, and 10<sup>th</sup> lowest in terms of volatile organic compounds) have been considered as the business-as-usual scenario. While further purchases of trolley buses are planned, their high cost prohibits massive expansion and they will most likely be replaced in the future by HFCB.

It should be pointed out that, despite the great interest of the Mexican Government, the only way of this project to be carried out is with a solid participation of GEF and the private sector as supporting partners, because of its broad technological scope.

### **Global Environmental Objectives**

In accordance with GEF's Operational Program 7 "reducing the long term costs of low GHG Emitting Energy Technologies", the global environmental objective of this project is the reduction of greenhouse gas (GHG) emissions from the urban transport sector in Mexico. It is proposed, over the immediate term, a project involving the demonstration

and testing of 10 fuel cell buses fueled by hydrogen, obtained from natural gas as a source. It is expected that over a long term, and assuming that this project is satisfactory, it will lead to an increased production of fuel cell propelled buses and eventually, to the reduction in their costs to the point, where they will become commercially competitive with conventional diesel buses. Regarding this objective, this part of the project is consistent with the GEF Operational Program 11 “Promoting Sustainable Transport”.

### **GEF Project Activities**

The GEF project described in this proposal includes the first step of the global project. This project is designed to develop, operate and monitoring the performance of 10 fleet fuel cell buses in Mexico City. It is expected that all these 10 buses will be available for operation at the end of 2002 (with 3 placed in operation in 2001/2 and 7 from year 2002/3 onwards). Necessary operating conditions in Mexico City are contemplated for the buses’ design and it is expected that the 3.036 million vehicle-km demonstration will provide the necessary feedback to bus suppliers for unit optimization, and to establish a firm basis for future, commercial-scale production. This phase of the project will result in the reduction of 3339.6 tons of CO<sub>2</sub>.

In order to meet the global objective of the project, it is absolutely necessary that GEF, the Mexican Government and the private sector maintain their effort and promote the continuous renovation of fuel cell buses, not only in public transport, but in other sectors as well. In accordance with HFCB industry projections, after a total of 2,000 fuel cell buses have been produced, the costs should fall to being roughly competitive with those of modern, clean diesel buses.

### **Costs**

The cost of the project is estimated at US\$28.9084 millions, of which US\$20.6761 millions are considered to be incremental. From this, US\$12.0138 millions are provided by GEF.

### **System Boundary**

Although the boundary for this project heavily relies on the Mexican urban transport sector and more specifically on STE, the project should support and draw upon resources from the global automotive industry. It should also provide important feedback for public transport agencies in other parts of the developing world. It is recognized that one of the most important GEF’s roles is to ensure that the information gathered and experience gained can be shared across national and commercial boundaries. It is felt that this goal is being accomplished.

### **Additional Benefits**

It has been pointed out that the project will demonstrate significant additional local benefits in terms of reduced emission of pollutants dangerous to human health and

habitat. Particularly, the project will reduce the emissions of NO<sub>x</sub>, SO<sub>x</sub>, CO, HC and particles, as detailed in the incremental cost matrix.

Table A.1 Hydrogen Fuel Cell Bus Project – Part I  
(3 HFCB in 2001/2)  
Estimation of Costs, Incremental Costs, and Financing

FCB Project Budget - Part I	Baseline	PROJECT COSTS (US\$M)					Part I total
		Mexican Sources			Private	GEF	
		STE	Fares	Sponsors			
<b>Investment</b>							
Vehicles (a)	0.255	0.315	0.000	0.000	0.335	4.275	4.925
Reformer (b)		0.000	0.000	0.000	1.600	0.000	1.600
H2 Storage (c)		0.000	0.000	0.000	0.300	0.000	0.300
Garage Modifications (d)	0.100	0.100	0.000	0.000	0.000	0.000	0.100
Baseline diesel storage (e)	0.013	0.000	0.000	0.000	0.000	0.000	0.000
Additional Power Equip (f)		0.000	0.000	0.000	0.000	0.000	0.000
Equip and tools (g)	0.075	0.049	0.000	0.000	0.000	0.000	0.049
Monitoring (h)		0.000	0.000	0.000	0.060	0.000	0.060
Furniture Facilities (i)	0.006	0.006	0.000	0.000	0.000	0.000	0.006
<b>Subtotal</b>	<b>0.448</b>	<b>0.470</b>	<b>0.000</b>	<b>0.000</b>	<b>2.295</b>	<b>4.275</b>	<b>7.039</b>
<b>Operating Costs</b>							
Land rental (j)		0.144	0.000	0.000	0.000	0.000	0.144
Baseline diesel fuel (k)	0.153	0.000	0.000	0.000	0.000	0.000	0.000
Nat gas (l)		0.134	0.000	0.000	0.000	0.000	0.134
Water (m)		0.149	0.000	0.000	0.000	0.000	0.149
Elect power (n)		0.028	0.000	0.000	0.000	0.000	0.028
Equip maintenance (o)	0.021	0.014	0.000	0.000	0.000	0.000	0.014
Project management (p)		0.000	0.000	0.000	0.000	0.300	0.300
Oper and admin personel (q)	0.470	0.470	0.000	0.000	0.000	0.000	0.470
Monitoring salaries (r)		0.086	0.000	0.000	0.000	0.000	0.086
Staff training (s)	0.074	0.372	0.000	0.000	0.000	0.000	0.372
Vehicle maint. (parts ) (t)	0.146	0.146	0.000	0.000	0.000	0.000	0.146
Facilit maint (u)	0.029	0.029	0.000	0.000	0.000	0.000	0.029
Insurance (v)	0.046	0.031	0.000	0.000	0.000	0.000	0.031
Route maintenance (w)	0.035	0.115	0.000	0.000	0.000	0.000	0.115
Fuel Cell stack replace (x)		0.000	0.000	0.120	0.120	0.000	0.240
<b>Subtotal</b>	<b>0.974</b>	<b>1.720</b>	<b>0.000</b>	<b>0.120</b>	<b>0.120</b>	<b>0.300</b>	<b>2.260</b>
<b>Research, info dissemination, etc.</b>							
Associated studies and research (y)		0.111	0.000	0.000	0.040	0.504	0.655
National seminars (z)							
salaries		0.000	0.000	0.005	0.000	0.000	0.005
fees		0.000	0.000	0.000	0.000	0.000	0.000
International seminars (aa)							
salaries		0.004	0.000	0.000	0.000	0.000	0.004
expenses		0.022	0.000	0.000	0.000	0.000	0.022
Other (bb)							
salaries		0.004	0.000	0.000	0.000	0.000	0.004
expenses		0.012	0.000	0.000	0.000	0.000	0.012
Workshop in Mexico (cc)							
<b>Subtotal</b>		<b>0.153</b>	<b>0.000</b>	<b>0.005</b>	<b>0.040</b>	<b>0.504</b>	<b>0.701</b>
Contingencies (dd)		0.000	0.000	0.000	0.000	0.000	0.000
<b>TOTAL</b>	<b>1.422</b>	<b>2.342</b>	<b>0.000</b>	<b>0.125</b>	<b>2.455</b>	<b>5.079</b>	<b>10.002</b>

Table A.2 Hydrogen Fuel Cell Bus Project – Part II  
(7 additional HFCB, for 10 total, from 2002/3-2005/6)  
Estimation of Costs, Incremental Costs, and Financing

FCB Project Budget - Part II	Baseline	PROJECT COSTS (US\$M)					Part II total
		Mexican Sources			Private	GEF	
		STE	Fares	Sponsors			
<b>Investment</b>							
Vehicles (a)	0.595	0.735	0.000	0.000	0.781	6.935	8.451
Reformer (b)		0.000	0.000	0.000	0.000	0.000	0.000
H2 Storage (c)		0.000	0.000	0.000	0.000	0.000	0.000
Garage Modifications (d)		0.000	0.000	0.000	0.000	0.000	0.000
Baseline diesel storage (e)	0.068	0.000	0.000	0.000	0.000	0.000	0.000
Additional Power Equip (f)		0.000	0.065	0.000	0.000	0.000	0.065
Equip and tools (g)	0.174	0.000	0.000	0.000	0.000	0.000	0.000
Monitoring (h)		0.000	0.000	0.000	0.240	0.000	0.240
Furniture Facilities (i)		0.000	0.000	0.000	0.000	0.000	0.000
<b>Subtotal</b>	<b>0.837</b>	<b>0.735</b>	<b>0.065</b>	<b>0.000</b>	<b>1.021</b>	<b>6.935</b>	<b>8.756</b>
<b>Operating Costs</b>							
Land rental (j)		0.576	0.000	0.000	0.000	0.000	0.576
Baseline diesel fuel (k)	2.397	0.000	0.000	0.000	0.000	0.000	0.000
Nat gas (l)		0.538	0.000	0.000	0.000	0.000	0.538
Water (m)		0.598	0.000	0.000	0.000	0.000	0.598
Elect power (n)		0.114	0.000	0.000	0.000	0.000	0.114
Equip maintenance (o)	0.049	0.056	0.000	0.000	0.000	0.000	0.056
Project management (p)		0.000	0.000	0.000	0.000	0.000	0.000
Oper and admin personel (q)	1.880	1.880	0.000	0.000	0.000	0.000	1.880
Monitoring salaries (r)		0.345	0.000	0.000	0.000	0.000	0.345
Staff training (s)	0.298	0.000	0.000	0.000	0.000	0.000	0.000
Vehicle maint. (parts ) (t)	0.585	0.585	0.000	0.000	0.000	0.000	0.585
Facilit maint (u)	0.115	0.115	0.000	0.000	0.000	0.000	0.115
Insurance (v)	0.108	0.123	0.000	0.000	0.000	0.000	0.123
Route maintenance (w)	0.540	0.460	0.000	0.000	0.000	0.000	0.460
Fuel Cell stack replace (x)		0.000	0.000	0.480	0.480	0.000	0.960
<b>Subtotal</b>	<b>5.972</b>	<b>5.390</b>	<b>0.000</b>	<b>0.480</b>	<b>0.480</b>	<b>0.000</b>	<b>6.350</b>
<b>Research, info dissmenination, etc.</b>							
Associated studies and research (y)		0.445	0.254	0.000	0.160	0.000	0.859
National seminars (z)							
salaries		0.000	0.002	0.020	0.000	0.000	0.022
fees		0.000	0.054	0.000	0.000	0.000	0.054
International seminars (aa)							
salaries		0.017	0.000	0.000	0.000	0.000	0.017
expenses		0.086	0.000	0.000	0.000	0.000	0.086
Other (bb)							
salaries		0.014	0.000	0.000	0.000	0.000	0.014
expenses		0.048	0.000	0.000	0.000	0.000	0.048
Workshop in Mexico (cc)		0.075	0.000	0.000	0.000	0.000	0.000
<b>Subtotal</b>		<b>0.685</b>	<b>0.310</b>	<b>0.020</b>	<b>0.160</b>	<b>0.000</b>	<b>1.175</b>
Contingencies (dd)		0.000	2.628	0.000	0.000	0.000	2.628
<b>TOTAL</b>	<b>6.810</b>	<b>6.810</b>	<b>3.003</b>	<b>0.500</b>	<b>1.661</b>	<b>6.935</b>	<b>18.908</b>



**Table A.3 Incremental Cost Matrix**

	<b>Baseline</b>	<b>GEF Project</b>	<b>Increment</b>
National impact	<p>3.036 millions of bus-km of public transport service provided with DBs.</p> <p>Diesel fuel consumption continues</p> <p>54.648 tons CO emissions.</p> <p>39.468 tons NO<sub>x</sub> emissions.</p> <p>3.6432 tons SO<sub>x</sub> emissions.</p> <p>8.8044 tons HC emissions.</p> <p>2.4288 tons of particles.</p>	<p>3.036 millions bus-km of public transport service provided with HFCBs.</p> <p>Mexican assimilation of FCB technology accelerated.</p>	<p>Zero.</p> <p>Mexican assimilation of FCB technology accelerated.</p> <p>Diesel fuel use reduced.</p> <p>Zero emissions of CO.</p> <p>Zero emissions of NO<sub>x</sub>.</p> <p>Zero emissions of SO<sub>x</sub>.</p> <p>Zero emissions of HC</p> <p>Zero emissions of particles.</p>
Global impact	<p>Diesel bus emission</p> <p>3339.6 tons CO<sub>2</sub> emissions.</p> <p>No contribution to fuel cell bus cost reduction and commercialization.</p>	<p>Zero CO<sub>2</sub> emissions.</p> <p>Fuel cell bus cost reduction and commercialization accelerated.</p> <p>"Mexicanization" of fuel cell bus technology accelerated.</p>	<p>3339.6 tons CO<sub>2</sub> emissions avoided.</p> <p>Fuel cell bus cost reduction and commercialization accelerated.</p> <p>"Mexicanization" of fuel cell bus technology accelerated.</p>
Cost	<p><b>PART I:</b></p> <p>STE = US\$1.422M</p> <p><b>PART II:</b></p> <p>STE = US\$6.81M</p> <p><b>Total = US\$8.2322M</b></p>	<p><b>PART I:</b></p> <p>STE = US\$2.342M</p> <p>Sponsors = US\$0.125M</p> <p>Private sector=US\$2.4545M</p> <p>GEF=US\$5.079M</p> <p><b>PART II:</b></p> <p>STE = US\$6.810M</p> <p>STE cash (fares) = US\$3.0024M</p> <p>Sponsors = US\$0.500M</p> <p>Private sector= US\$1.6605M</p> <p>GEF= US\$6.935M</p> <p><b>Total = US\$28.9084M</b></p>	<p><b>PART I:</b></p> <p>STE = US\$0.9200M</p> <p>Sponsors= US\$0.125M</p> <p>Private sector=US\$2.45M</p> <p>GEF=US\$5.079M</p> <p><b>PART II:</b></p> <p>STE cash (fares)=US\$3.0024 M</p> <p>Sponsors = US\$0.500M</p> <p>Private sector = US\$1.6605M</p> <p>GEF = US\$6.935M</p> <p><b>Total = US\$20.6719 millions</b></p>

## ANNEX B: LOGICAL FRAMEWORK MATRIX

<b>Project strategy</b>	<b>Objectively verifiable success indicator</b>	<b>Means of verification</b>	<b>Assumptions</b>
<p><b>Development objective: (in 2010)</b> GHG emissions in Mexico will be reduced through massive use of a new energy source and propulsion technology for urban buses based upon fuel cells operating on hydrogen</p>	<p>1,496,140 tons of CO<sub>2</sub> emissions avoided as a result of project replication phases.</p> <p>Accelerated hydrogen fuel cell buses (HFCBs) international cost reduction due to accelerated commercialization and indirect climate change benefits related thereto</p> <p>A demonstrated national capacity for manufacturing, operating and commercializing in national and international markets HFCBs</p>	<p>Phases 2 and 3 technical progress reports</p> <p>International price catalogues and trends</p> <p>HFCBs technical and environmental performance reports</p>	<p>GoM continues to support the development of alternative transport modalities.</p> <p>HFCB technology proves to be commercially and technically feasible.</p> <p>Market prices of technology continue to drop</p>
<p><b>Immediate objective 1: (in 2005)</b> The operational viability of fuel cell drives in urban buses, together with the requisite re-fuelling infrastructure, under Mexican conditions demonstrated through the initial operational test of 10 HFCBs</p>	<p>10 nationally-manufactured buses operating under day to day conditions over a period of 5 years</p> <p>A volume operation of 3 million of vehicle -km by the end of the project</p> <p>HFCB cost reduction attributable to this project</p>	<p>Project plans and project reports</p> <p>Final project report</p> <p>Ex post data obtained from national and international prices obtained in public bidding and information from bus manufacturers</p>	<p>Technology is fully assimilated in Mexican industrial processes</p> <p>Demo HFCB work regime aligns to estimate standards</p> <p>Third party actors outside Mexico go through with planned HFCB purchase</p>
<b>PART I</b>			
<p><b>Output 1:</b> Significant demonstration of the procurement of FCBs and their refueling infrastructure under Mexican conditions</p>	<p>Bids are received and contracts are negotiated with and awarded to the selected suppliers. Initial required infrastructure is put in place.</p>	<p>Annual report and final project reports</p>	<p>The procurement process is adequate so that the buses can therefore be commercially produced.</p>

<b>Project strategy</b>	<b>Objectively verifiable success indicator</b>	<b>Means of verification</b>	<b>Assumptions</b>
<b>PART II</b>			
<b>Output 2:</b> A fleet of 10 hydrogen fuel cell buses operated over a period of 5 years to obtain reliable information on its environmental performance	3,340 tons CO <sub>2</sub> emissions avoided in 5 years 40 tons NO emissions avoided 4 tons SO emissions avoided 9 tons HC emissions avoided 2 tons of particles avoided	HFCB environmental performance reports based on end-of-pipeline emissions monitoring system and reformed natural gas process including carbon sequestration	The procurement process is adequate and the vendor deliver inputs on time  Full service regime is maintained for pilot fleet, with continuous monitoring and evaluation.  Built-in carbon sequestration process for reformed natural gas works appropriately  Metropolitan air quality monitoring system continues to provide reliable information on airborne pollutants.
<b>Output 3:</b> A significant demonstration of technological, manufacturing capacities and operational viability of fuel cell drives in urban buses and their refueling infrastructure under Mexican conditions	An above standards customer satisfaction	A client satisfaction survey	Unfounded fears does not affect users acceptance
	Above standards physical performance indexes	Physical performance monitoring system	Natural gas distribution system is adequate and reliable
	A minimum work regime of 2,080 hours per year for the first 3 buses and of 3,840 hours for the following 7 buses	HFCB work regime sheets	Work regime is feasible and diligently followed
	An average rate of 1700 km between roads calls for maintenance	Road call reports	Vendors provide continuous and timely technical support as part of their contracts. Number of injuries is equal to bus standards
	An acceleration performance from 0 to 30 km/h in 10.95 seconds	Prototype test reports	Speed acceleration prove to be in line with pre -feasibility test
	A hydrogen supply system installed and in operation	Engineering final reports and fields visits	National private sector meets the appropriate commitments on time
	Average energy: efficiency conversion rate of at least 40% (adjusted for Mexico City altitude of 2,200 meters above sea level) as compared with 28% in diesel buses	Energy conversion diagrams	Technical specifications are correct.

<b>Project strategy</b>	<b>Objectively verifiable success indicator</b>	<b>Means of verification</b>	<b>Assumptions</b>
	An average of 3.57 kWh energy consumption per km traveled as compared with 5.71 for diesel buses	Consumption and refueling monitoring sheets	Average energy consumption prove to be in line with pre-feasibility test
<b>Output 4:</b> A cadre of bus operators and staff trained in the operation, maintenance and management of fuel cell buses and their associated system for hydrogen supply.	30 operators trained in the operation of HFCB	Theoretical-practical knowledge survey after training	Bus operators and users assimilate new technology technical peculiarities
	Less than 2 technical failures per 1,000 km	Maintenance technical reports	Technical failures are in line with international prototype test
	20 professionals trained in maintenance and operation management of HFCBs	Theoretical-practical knowledge survey after training.	Suppliers provide good quality technical training as part of their contract
<b>Output 5:</b> A substantial body of knowledge accumulated on reliability, failure modes and opportunities permits to undertake an awareness campaign directed at creating an enabling environment for the future FCB market in Mexico.	The following reports produced and disseminated: (a) An appraisal of Mexican manufacturing process (b) HFCB prototypes and series test certification (c) HFCB technological performance appraisal (d) HFCB operation analysis (e) HFCB maintenance analysis (f) HFCB environmental appraisal (g) Demand and Supply status of HFCB technology (h) HFCB demonstration project management (i) Cost and benefits of non-polluting transport in Megacities. The case of Mexico City (j) The politics and economics of bus replacement (k) Mexico City air pollution diagnosis and solution alternatives (l) Air pollution and health in Mexico City (m) Economics of mass hydrogen pollution for transport	Technical Report, project report and publications	Reporting process and synthesis methodology accurate and followed diligently.  Monitoring equipment accurate and functioning.
	6 seminars and 3 workshops held for demo results dissemination	Project progress report	Demo results are positive as expected
	Relevant decision makers and stakeholders aware of project results and policy proposals	Project progress reports and meeting minutes	Political support for clean technologies is stable and favorable regulations come into action

## ANNEX C: BUDGETS

### C.1. GEF AND CO-FINANCING BUDGET



United Nations Development Programme

MEX/01/G31/A/1G/99 - Fuel Cell Buses

Budget " A "

Main Source of Funds: 1G - Global Environment Trust Fund  
Executing Agency: STE - Servicio de Transportes Eléctricos

GEF and STE cash co-Financing  
PROJECT PART I

Sbln	Description	Implementing	Funding	Total	2001/2
<b>010</b>	<b>PERSONNEL</b>				
<b>016</b>	Mission Costs				
016.01	Other International Travel	STE	STE	Net Amount	16,000 16,000
<b>016.99</b>	Line Total	-----		Net Amount	16,000 16,000
<b>017</b>	National Consultants				
017.01	Project Manager	STE	GEF	Net Amount	300,000 300,000
017.02	Research Director	STE	GEF, STE	Net Amount	90,541 90,541
017.03	Research on HFCB Tech. performance	STE	GEF, STE	Net Amount	45,265 45,265
017.04	Research on HFCB Operation Analysis	STE	GEF, STE	Net Amount	45,265 45,265
017.05	Research on HFCB maint. Analysis	STE	GEF, STE	Net Amount	45,265 45,265
017.06	Research on HFCB Mex. manuf.process	STE	GEF, STE	Net Amount	45,265 45,265
017.07	Research on HFCB Proto/Series Tests	STE	GEF, STE	Net Amount	45,265 45,265
017.08	Research on Proj.Environment Anal	STE	GEF, STE	Net Amount	45,265 45,265
017.09	Demand and Supply on HFCB Technol.	STE	GEF, STE	Net Amount	45,265 45,265
017.10	Research on costs and Benefits	STE	GEF, STE	Net Amount	45,265 45,265
017.11	Research on Politics and Economics	STE	GEF, STE	Net Amount	45,265 45,265
017.12	Research on Diagnostic & Solution	STE	GEF, STE	Net Amount	45,265 45,265
017.13	Research on Air Pollution & Health	STE	GEF, STE	Net Amount	45,265 45,265
017.14	Research on Economics Mass Hyd.Prod	STE	GEF, STE	Net Amount	45,265 45,265
017.15	Supervisor of garage modification	STE	STE	Net Amount	20,000 20,000
017.21	Technical Off. 1 on Data Collection	STE	STE	Net Amount	14,333 14,333
017.22	Technical Off. 2 on Analysis & Rep.	STE	STE	Net Amount	14,333 14,333
017.23	Technical Off. 3 on Project Admin.	STE	STE	Net Amount	14,333 14,333
017.24	Technical Off. 4 on Monitor & Eval.	STE	STE	Net Amount	14,333 14,333
017.25	Technical Off. 5 on Monitor & Eval.	STE	STE	Net Amount	14,333 14,333
017.26	Technical Off. 6 on Monitor & Eval.	STE	STE	Net Amount	14,333 14,333
<b>017.99</b>	Line Total	-----		Net Amount	1,039,719 1,039,719
<b>019</b>	<b>PROJECT PERSONNEL TOTAL</b>	-----		Net Amount	1,055,719 1,055,719
<b>020</b>	<b>CONTRACTS</b>				
<b>021</b>	Contract A				
021.01	Consultancy on Garage Modification	STE	STE	Net Amount	80,000 80,000
<b>021.99</b>	Line Total	-----		Net Amount	80,000 80,000
<b>023.99</b>	Line Total				80,000 80,000
<b>029</b>	<b>SUBCONTRACTS TOTAL</b>	-----		Net Amount	80,000 80,000
<b>030</b>	<b>TRAINING</b>				
<b>032</b>	Other Training				
032.02	International Seminars	STE	STE	Net Amount	26,000 26,000
<b>032.99</b>	Line Total	-----		Net Amount	26,000 26,000
<b>039</b>	<b>TRAINING TOTAL</b>	-----		Net Amount	26,000 26,000
<b>040</b>	<b>EQUIPMENT</b>				
<b>045</b>	Equipment				
045.01	Furniture Facilities	STE	STE	Net Amount	5,500 5,500
045.02	Operations	STE	GEF	Net Amount	147,926 147,926
045.03	Non-Expendable Equipment	STE	GEF, STE	Net Amount	4,590,000 4,590,000
045.04	Equipment and Tools	STE	STE	Net Amount	49,300 49,300
<b>045.99</b>	Line Total	-----		Net Amount	4,792,726 4,792,726
<b>049</b>	<b>EQUIPMENT TOTAL</b>	-----		Net Amount	4,792,726 4,792,726
<b>050</b>	<b>MISCELLANEOUS</b>				
<b>053</b>	Sundries				
053.01	Contingencies	STE		Net Amount	
<b>053.99</b>	Line Total	-----		Net Amount	
<b>059</b>	<b>MISCELLANEOUS TOTAL</b>	-----		Net Amount	
<b>099</b>	<b>BUDGET TOTAL</b>	-----		Net Amount	5,954,445 5,954,445



**United Nations Development Programme**

MEX/01/G31/A/1G/99 - Fuel Cell Buses

Budget " A "

Main Source of Funds: 1G - Global Environment Trust Fund

Executing Agency: STE - Servicio de Transportes Eléctricos

<b>Sbln</b>	<b>Donor</b>	<b>Funding</b>		<b>Total</b>	<b>2001/2</b>
<b>101</b>					
101.01	STE	STE	Net Contrib.	875,645	875,645
			CO Adm. %		3.50
			CO Adm.	30,647	30,647
			Total	906,292	906,292
<b>101.99</b>					
			Net Contrib.	875,645	875,645
			CO Adm. %		3.50
			CO Adm.	30,647	30,647
			Total	906,292	906,292
<b>109</b>					
C/S Total	-----		Net Contrib.	875,645	875,645
			CO Adm. %		3.50
			CO Adm.	30,647	30,647
			Total	906,292	906,292
<b>999</b>					
			Net Contrib.	5,078,800	5,078,800
			Total	5,078,800	5,078,800

## C.2. IN-KIND BUDGET



**United Nations Development Programme**  
Mexico Fuel Cell Buses

PROJECT PART I

Executing Agency: STE - Servicio de Transportes Eléctricos

STE, SPONSORS AND PRIVATE SECTOR IN-KIND CONTRIBUTION

Sbln	Description	Imp.Ag.	Fin. Inst.		Total	2001/2
<b>017</b>	National Consultants					
	Associated Studies & Research	STE	PS	Cont. Neta	40,000	40,000
	Operating Personnel	STE	STE		235,000	235,000
	Administrative personnel	STE	STE		235,000	235,000
<b>017.99</b>	Total National Consultants	-----		Cont. Neta	510,000	510,000
<b>019</b>	Total Personnel	-----		Cont. Neta	510,000	510,000
<b>030</b>	Training					
<b>032</b>	Training (Others)					
	Staff Training	STE	STE	Cont. Neta	206,355	206,355
	National Seminars	STE	Sponsors	Cont. Neta	5,000	5,000
<b>032.99</b>	Total Training (Others)	-----		Cont. Neta	211,355	211,355
<b>039</b>	Total Training	-----		Cont. Neta	211,355	211,355
<b>040</b>	EQUIPMENT					
<b>045</b>	Operation and Maintenance					
	Land Rental	STE	STE	Cont. Neta	144,000	144,000
	H2 Storage	STE	PS	Cont. Neta	300,000	300,000
	Natural Gas	STE	STE	Cont. Neta	134,000	134,000
	Insurance	STE	STE	Cont. Neta	31,000	31,000
	Water	STE	STE	Cont. Neta	149,000	149,000
	Electric Power	STE	STE	Cont. Neta	28,000	28,000
	Vehicle	STE	PS	Cont. Neta	335,000	335,000
	Equipment Monitoring	STE	PS	Cont. Neta	60,000	60,000
	Equipment Maintenance	STE	STE	Cont. Neta	14,000	14,000
	Vehicle maintenance	STE	STE	Cont. Neta	146,000	146,000
	Facilities maintenance	STE	STE	Cont. Neta	29,000	29,000
	Route Maintenance	STE	STE	Cont. Neta	115,000	115,000
	Reformer	STE	PS	Cont. Neta	1,600,000	1,600,000
	Fuel Cell Stock Replacement	STE	Sponsors and PS	Cont. Neta	240,000	240,000
<b>045.99</b>	Total Equipment	-----		Cont. Neta	3,325,000	3,325,000
<b>049</b>	TOTAL EQUIPMENT	-----		Cont. Neta	3,325,000	3,325,000
<b>050</b>	MISCELLANEOUS					
<b>053</b>	Miscellaneous					
	Contingencies	STE		Cont. Neta		
<b>053.99</b>	Total Miscellaneous	-----		Cont. Neta		
<b>059</b>	TOTAL MISCELLANEOUS	-----		Cont. Neta		
<b>099</b>	TOTAL BUDGET	-----		Cont. Neta	4,046,355	4,046,355

**TOTALS BY DONOR**

STE in-kind contribution	1,466,355
Private Sector in-kind contribution	2,455,000
Sponsors in-kind contribution	125,000

## ANNEX D: WORK PLAN/TIMETABLE

### D.1 WORK PLAN

Project Development Objective	The development objective of this project is to substantially reduce GHG emissions originating from the transport sector, through the full deployment of fuel cell technology in the urban transport fleet in Mexico, an existing production capacity will be used to export and replicate technology in other parts of the world. To this end, the project will initiate and accelerate mass-production development, commercialization and utilization of HFCBs in Mexico.
Project Immediate Objective	The immediate objective of this project is to demonstrate the operational viability of fuel cell drives in urban buses, together with the requisite re-fueling infrastructure, under Mexican conditions through the initial operational test of 10 hydrogen fuel cell buses. It will begin the process of commercialization and adaptation of the fuel-cell buses in Mexican markets.



## DEVELOPMENT OBJECTIVES

<p>1. MAIN DEVELOPMENT OBJECTIVE</p> <p>Short Term Objective</p> <p>Medium-term objective</p> <p>Long-term objective</p>	<p>To demonstrate the operational viability of fuel cell drives in urban buses, together with the requisite re-fueling infrastructure, under Mexican conditions through the initial operational test of 10 hydrogen fuel cell buses. It will begin the process of commercialization and adaptation of the fuel-cell buses in Mexican markets.</p> <p>RTP and STE would initiate the substitution of 100 DBs /year by HFCBs from 2006 to 2010. The expected accumulated emissions avoided in Mexico City, considering the expected life cycle of these HFCBs will be 464,640 tons of CO<sub>2</sub>, utilizing natural gas reforming technology with carbon sequestration process included for hydrogen production.</p> <p>According to estimates for replication in other major Mexican urban areas (Guadalajara, Mexico State and Monterrey), a total fleet of approximately 1,610 HFCBs would be accumulated by 2010. The emissions avoided in the expected 12-year life cycle of these buses would be 1,496,140 tons of CO<sub>2</sub>. This will be the commencement of the long-term objective of HFCBs full deployment and commercialization, in order to reduce global warming by lowering CO<sub>2</sub> emissions and by reducing emission of pollutants dangerous to human health and habitat, which otherwise would be produced by conventional diesel oil buses that burn fossil fuel. In particular, to reduce the emission of NO<sub>x</sub> , SO<sub>x</sub> , CO, and particulates.</p>
<p>2. SOCIAL AND ENVIRONMENTAL OBJECTIVES</p>	<p>This Demonstration Project will lay down the foundations for developing in Mexico City and in other major Mexican cities a broad action plan to substitute DBs and other internal-combustion-engine buses by zero or near-zero emission buses, - as HFCBs and other electrical driven buses of advanced technology -. This action will be the correct answer to the perception of the threat of global warming that results, to a great extent from consumption of fossil fuel by the mass urban transport systems</p>
<p>3. TECHNOLOGY DEVELOPMENT OBJECTIVES</p>	<p>Test parameters will generate reliable and invaluable information on the environmental, technical and operational performance of HFCB technology for policy design and decision-making purposes on manufacturing and marketing. Mexico can reach a strong leadership on this technology, since it may dominate these advanced bus manufacturing and operating processes. A powerful push can be detonated for the use of fuel cell technology and fuel supply technology in the automotive industry and their utilization in mass transportation, so that a creation of a substantive increase in competitiveness, within the automotive industry and transit authority can be reached.</p>

**IMPLEMENTATION PART I: YEARS 2001 – 2002**

Output 1: Procurement of initial 3 FCBs and associated refueling infrastructure.

ACTIVITIES AND SUBACTIVITIES	DESCRIPTION	INPUT
<p>1. Design the detailed layout and work plan of the project.</p> <ul style="list-style-type: none"> <li>1.1 Design the garage modifications layout for H<sub>2</sub> production and supply.</li> <li>1.2 Execute arrangements for HFCBs itinerary.</li> <li>1.3 Review details of work plan.</li> <li>1.4 Official conformation of Project Staff and consultants.</li> </ul>	<p>Before the first 3 HFC buses lot arrives in to the STE garage and initiates their first operation hours, all the sub activities under paragraph 1 have to be finished</p>	<p>Project Staff, TORs 01, 05, 15, 16, 20, vendors and sub-contractor,</p>
<p>2. Prepare the protocol for the technical and performance specifications of the complete fuel cell electric buses and associated fueling system.</p> <ul style="list-style-type: none"> <li>2.1 Conduct a stakeholders meeting, inviting representatives from the fuel cell and urban transit community, and soliciting comments on the draft technical and cost specifications for the tendering.</li> <li>2.2 Finalize technical and cost specifications for procurement bundle.</li> <li>2.3 Specification of characteristics of the HFCBs.</li> <li>2.4 Specification of HFCBs technical performance targets.</li> <li>2.5. Specification of characteristics of the fuelling system.</li> </ul>	<p>HFCBs and fueling system technical specifications</p>	<p>Project Staff, TORs 01, 14, 15, 17, 18, 19, vendors and sub-contractor</p>
<p>3. Issue the international call for tenders. Includes the publication of the technical specification protocol and the invitation to qualified vendors to bid. Tenders from different combinations of fuel cell engines, International and/or Mexican bus chassis/body manufacturers and hydrogen reformer producers established in Mexico or elsewhere, will be sought and encouraged.</p> <ul style="list-style-type: none"> <li>3.1 Encouragement of tenders from different combinations of fuel cell engines, bus chassis/body manufacturers and hydrogen reformer producers.</li> <li>3.2 Preparation of tender call and its presentation to UNDP.</li> <li>3.3 Publication of tender call in UNDP business development journal.</li> <li>3.4 Follow-up of Procurement Process.</li> </ul>	<p>Arrangements for appropriated contract and subcontracts</p>	<p>Project Staff, TORs 01, 14, 15, 16, SETRAVI, STE and UNDP</p>

ACTIVITIES AND SUBACTIVITIES	DESCRIPTION	INPUT
<p>4. Select vendor(s). The selection of vendors will be based on the lowest costs on the complete project (HFCBs and associated system for hydrogen supply). It will take into account the vendors fulfilling of technical and performance requirements, and the extent to which cost-reduction objectives of the project will be achieved.</p> <p>4.1 Judgment of proposals and selection of the vendor. 4.2 Contract to supply buses and fuelling system.</p>	<p>Appropriate contract to supply buses and fuelling system</p>	<p>Vendor, subcontractors, UNDP, SETRAVI, STE, Project Staff , TORs 01, 16, 20</p>
<p>5. The selected vendor installs, tests, operates and maintains the associated system for hydrogen supply, consisting of the natural gas based hydrogen reformer, and the equipment for storage and fueling the HFCBs with hydrogen. Its installation and operational tests will precede the arrival of the initial set of 3 HFCBs.</p> <p>5.1 Install and test the refueling infrastructure.</p> <p>5.2 Operate and maintain the re fueling infrastructure.</p>	<p>As part of the main contract, the primary contractor will oversee the assigned area in the STE modified garage, installations, natural gas, power and water supply necessary for the installation of the natural-gas-based hydrogen reformer for hydrogen production and refueling system.</p> <p>Also, As part of the main contract, the primary contractor will oversee the operation and maintenance of the hydrogen production and refueling system.</p>	<p>Vendor, sub-contractor and Project Staff, TORs 01, 04, 15, 17, 18, 19, 20</p> <p>Vendor, sub-contractor and Project Staff, TORs 01, 04, 15, 17, 18, 19, 20</p>
<p>6. The selected vendor initiates the manufacturing of the first 3 HFCBs and prepares conditions for the remaining 7 units.</p> <p>6.1 Design manufacturing plan. 6.2 Execute manufacturing plan. 6.3 Design and execute reception prototype and series tests.</p>	<p>Design, manufacturing and testing of 10 HFCBs.</p>	<p>Vendor, subcontractor and Project Staff, TORs 01, 02, 03, 16</p>

ACTIVITIES AND SUBACTIVITIES	DESCRIPTION	INPUT
<p>7. Establish a plan for public awareness efforts, including developing a marketing strategy and communications plan. The communications plan will include outreach efforts that will encompass the larger private sector community as a target for the project results and will facilitate engagement of the FCB Private Sector Advisory Group, as outlined in the UNDP-GEF FCB Strategy Note. In addition, a research program will be established during Part I, including analysis on (a) performance of natural gas reforming technology with carbon sequestration process for hydrogen production; (b) the net avoided emissions in hydrogen reformer when examined “well to wheel” (including carbon sequestration process); (c) reorganization of Mexico City urban transport and its environmental, political and economical impact; (d) technical studies on the HFBC Mexican prototypes, manufacturing process optimization, series tests certification, technological performance, maintenance and operation analysis, demonstration project management and environmental analysis, as well as demand and supply of HFBC technology. Associated research, not funded by GEF sources, will focus on research into costs and benefits of non-polluting transport in megacities, the politics and economics of bus replacement, diagnostic and solution alternatives, health, and the economics of mass hydrogen production for transport .</p>	<p>Plan for Public Awareness component and Research Program prepared.</p>	<p>Project Staff, TOR 01, SETRAVI, STE and UNDP</p>

**IMPLEMENTATION PART II: YEARS 2002 - 2006**

Output 2: A fleet of 10 HFCBs (initial 3 followed by an additional 7) operated over a period of 5 years to obtain reliable information on its environmental performance.

ACTIVITIES AND SUBACTIVITIES	DESCRIPTION	INPUT
<p>8. Place an additional 7 HFCB in service, and operate the entire 10 HFCB fleet for 5 years, operating under different regimes in a Mexico City commercial route. Initially, 3 HFCB will be purchased and start operation in 2001/2 for strong prototype monitoring and inspection, and also due to manufacturing constraints. The remaining 7 will start operation in year 2002/3.</p> <p>8.1 Implement operation of initial set of 3 HFCBs.                      8.2 Implement operation of second set of 7 HFCBs.                      8.3 Initiate monitoring, evaluation and research.</p>	<p>Initial fleet of 3 HFCBs starting operation in 2001 and 7 HFCBs starting operation in 2002, in revenue service under realistic operating conditions and initiation of monitoring, evaluation and research.</p>	<p>STE, vendor, subcontractors and Project Staff, TORs 01, 04, 05, 16, 17, 18, 19.</p>

Output 3: A significant demonstration of technological, manufacturing capacities and operational viability of fuel cell drives in urban buses and their refueling infrastructure under Mexican conditions.

ACTIVITIES- SUBACTIVITIES	DESCRIPTION	INPUT
<p>9. Formulate the guidelines for the monitoring and evaluation plan (as in paragraph 9 below) for the complete Demonstration Project.</p>	<p>Protocol for issuing quarterly reports on the technological performance of the HFCBs fleet (e.g., in-service reliability, failure modes, energy consumption, etc.), and on the technological performance of the hydrogen supply subsystem.</p>	<p>Project Staff, TORs 01, 04, 05, 17, 18, 19, vendor and subcontractors</p>
<p>10. Collect operating data, that includes the collection, analysis and evaluation of the operating, performance data and monitoring information of the whole HFCBs fleet and their associated system for hydrogen supply.</p>	<p>Reports on operating data, analysis and evaluation of the operating, performance data and monitoring information of the whole HFCBs fleet and their associated system for hydrogen supply.</p>	<p>Project Staff, TORs 01, 04, 05, 14, 17, 18, 19</p>

Output 4: A cadre of bus operators and staff trained in the operation, maintenance and management of fuel cell buses and their associated system for hydrogen supply.

ACTIVITIES- SUBACTIVITIES	DESCRIPTION	INPUT
<p>11. Train operating and maintenance personal for both the HFCEBs technology and the associated system for hydrogen supply by means of on-the-job training seminars for drivers, maintenance staff, engineers and managerial staff. A sufficient number of trained personnel has to be achieved to ensure the successful execution of phases 1 and the preparation for phase 2.</p> <p>11.1 On-the-job training seminars for drivers, maintenance staff, engineers and managerial staff, for this Demonstration Project and for the initiation of the commercialization period.</p>	<p>A sufficient number of trained personnel has to be achieved to ensure the successful execution of this Demonstration Project. The number of trained personnel shall also include the requirements of the commercialization period.</p>	<p>Vendor, Project Staff, TORs 01, 05, 06, 16</p>

Output 5: A substantial body of knowledge accumulated on reliability, failure modes and opportunities permits to undertake an awareness campaign directed at creating an enabling environment for the future FCB market in Mexico.

ACTIVITIES- SUBACTIVITIES	DESCRIPTION	INPUT
<p>12. Carry out the research studies associated to HFCEB technology in Mexico. The project team will engage in systematic research related to HFCEB technology in Mexico such as HFCEB Mexican manufacturing, HFCEB reception tests certification, HFCEB technological performance, HFCEB operation analysis, and HFCEB maintenance analysis. This research will form part of the evaluation of the whole demonstration project. At least one final report of each topic will be issued.</p>	<p>Partial and final research reports on: HFCEB Mexican manufacturing, HFCEB reception tests certification, HFCEB technological performance, HFCEB operation analysis, and HFCEB maintenance analysis, will be issued as part of this Demonstration Project.</p>	<p>Project Staff, TORs 01, 02, 03, 04, 05, 06 and vendor. Also, TORs 16, 17, 18, 19</p>
<p>13. Carry out the research studies associated to Government transport policies and economics. The project team will engage in systematic research related to Government transport policies and economics such as: Demonstration project management, Technology supply and demand, Zero emissions transport costs and benefits, economics and politics of Bus replacement, and economics of hydrogen production for urban transport. This research will serve both as project evaluation instruments as well as evidences to raise political and social awareness to engage in phase 2.</p>	<p>Partial and final research reports on: HFCEBs Technology supply and demand, Zero emissions transport costs and benefits, Economics and politics of Bus replacement, Economics of hydrogen production for urban transport, will be issued as part of this Demonstration Project</p>	<p>Project Staff, TORs 08, 09, 10, 13 and vendor. Also, TORs 16, 17, 18, 19</p>

ACTIVITIES- SUBACTIVITIES	DESCRIPTION	INPUT
<p>14. Carry out the research studies associated to Environment and Health in Mexico. The project team will engage in systematic research related to environment and health such as comparative project environmental analysis, zero emissions transport costs and benefits in megacities, Mexico City air pollution alternative solutions, and Mexico City air pollution and health. This research will also serve both as project evaluation instruments as well as evidences to rise political and social awareness to engage in phase 2. Carry out the research studies associated to Environment and Health in Mexico. The project team will engage in systematic research related to environment and health such as omparative project environmental analysis, zero emissions transport costs and benefits in megacities, Mexico City air pollution alternative solutions, and Mexico City air pollution and health. This research will also serve both as project evaluation instruments as well as evidences to raise political and social awareness to engage in phase 2.</p>	<p>Partial and final research reports on:</p> <p>Comparative environmental analysis, Zero emissions transport costs and benefits in megacities,</p> <p>Mexico City air pollution alternative solutions, and Mexico City air pollution and health, will be issued as part of this Demonstration Project</p>	<p>Project Staff, TORs 07, 09, 11, 12. Also, TORs 16, 17, 18, 19</p>
<p>15. Carry out the research projects in preparation for future FCB market development in Mexico.</p>		
<p>16. Disseminate results and adaptive management. It includes the feeding of the obtained data and analysis, back to the vendors, and into the preparation for future FCB market development. It makes public diffusion of these results, and it initiates activities related to the Mexican mass manufacturing of hydrogen fuel cell buses.</p>	<p>Results dissemination and technology production improvement</p>	<p>Project Staff, TORs 01, 02, 03, 04, 05, 06. Also, TORs 14, 15, 16, 17, 18, 19 and vendor</p>
<p>17. Organize and take part in National and International meetings on HFCB manufacturing technology, operation, maintenance, and management. It includes the organization and participation in National and International meetings on hydrogen fuel cell technology for development and joint entrepreneurial purposes, and for widespread dissemination of results.</p>	<p>Organization and participation in National and International meetings on HFCB technology, operation, maintenance, and management.</p>	<p>STE, SETRAVI, Project Staff, TORs 01, 16, and vendor</p>
<p>18. Both the communications and research initiatives begun during Part I will be continued throughout Part II. The FCB Private Sector Advisory Group will continue to be consulted on a regular basis regarding project results. International meetings on hydrogen fuel cell technology will be attended for development and joint entrepreneurial purposes, and for widespread dissemination of research results. The research results will be shared with the other GEF FCB projects through meetings and other communications (e.g., FCB Website) coordinated by the UNDP-GEF.</p>		

**D.2 TIME FRAME: PROJECT ACTIVITIES GENERAL PROGRAMME**

**IMPLEMENTATION PART I: YEARS 2001 – 2002**

Output 1: Procurement of initial 3 FCBs and associated refueling infrastructure.

ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity 1: Design the detailed layout and work plan of the project.																				
Activity 2: Prepare the protocol for the technical and performance specifications of the complete fuel cell electric buses and associated fueling system. Conduct a stakeholders meeting, inviting representatives from the fuel cell and urban transit community, and soliciting comments on the draft technical and cost specifications for the tendering. Finalize technical and cost specifications for procurement bundle.																				
Activity 3: Issue the international call for tenders. Includes the publication of the technical specification protocol and the invitation to qualified vendors to bid. Tenders from different combinations of fuel cell engines, International and/or Mexican bus chassis/body manufacturers, will be sought and encouraged.																				
Activity 4: Select vendor(s). The selection of vendors will be based on the lowest costs on the complete project (HFCBs and associated system for hydrogen supply). It will take into account the vendors fulfilling of technical and performance requirements, and the extent to which cost-reduction objectives of the project will be achieved.																				
Activity 5: The selected vendor installs, tests, operates and maintains the associated system for hydrogen supply, consisting of the natural gas based hydrogen reformer, and the equipment for storage and fueling the HFCBs with hydrogen. Its installation and operational tests will precede the arrival of the initial set of 3 HFCBs.																				



Output 1: Procurement of initial 3 FCBs and associated refueling infrastructure.

ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity 6: The selected vendor initiates the manufacturing of the first 3 HFCEs and prepares conditions for the remaining 7 units.																				
Activity 7: Establish a plan for public awareness efforts, including developing a marketing strategy and communications plan. The communications plan will include outreach efforts that will encompass the larger private sector community as a target for the project results and will facilitate engagement of the FCB Private Sector Advisory Group, as outlined in the UNDP-GEF FCB Strategy Note. In addition, a research program will be established during Part I, including analysis on (a) performance of natural gas reforming technology with carbon sequestration process for hydrogen production; (b) the net avoided emissions in hydrogen reformer when examined “well to wheel” (including carbon sequestration process); (c) reorganization of Mexico City urban transport and its environmental, political and economical impact; (d) technical studies on the HFCE Mexican prototypes, manufacturing process optimization, series tests certification, technological performance, maintenance and operation analysis, demonstration project management and environmental analysis, as well as demand and supply of HFCE technology. Associated research, not funded by GEF sources, will focus on research into costs and benefits of non-polluting transport in megacities, the politics and economics of bus replacement, diagnostic and solution alternatives, health, and the economics of mass hydrogen production for transport.																				

**IMPLEMENTATION PART II: YEARS 2002 - 2006**

Output 2: A fleet of 10 HFCBs (initial 3 followed by an additional 7) operated over a period of 5 years to obtain reliable information on its environmental performance.

ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity 8: Place an additional 7 HFCB in service, and operate the entire 10 HFCB fleet for 5 years, operating under different regimes in a Mexico City commercial route. Initially, 3 HFCB will be purchased and start operation in 2001/2 for strong prototype monitoring and inspection, and also due to manufacturing constraints. The remaining 7 will start operation in year 2002/3.																				

Output 3: A significant demonstration of technological, manufacturing capacities and operational viability of fuel cell drives in urban buses and their refueling infrastructure under Mexican conditions.

ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity 9: Formulate the guidelines for the monitoring and evaluation plan (as in paragraph 9 below) for the complete Demonstration Project.																				
Activity 10: Collect operating data, that includes the collection, analysis and evaluation of the operating, performance data and monitoring information of the whole HFCBs fleet and their associated system for hydrogen supply.																				

Output 4: A cadre of bus operators and staff trained in the operation, maintenance and management of fuel cell buses and their associated system for hydrogen supply.

ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity 11: Train operating and maintenance personal for both the HFCBs technology and the associated system for hydrogen supply by means of on-the-job training seminars for drivers, maintenance staff, engineers and managerial staff. A sufficient number of trained personnel has to be achieved to ensure the successful execution of phases 1 and the preparation for phase 2.																				

Output 5: A substantial body of knowledge accumulated on reliability, failure modes and opportunities permits to undertake an awareness campaign directed at creating an enabling environment for the future FCB market in Mexico.

ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity 12: Carry out the research studies associated to HFCB technology in Mexico. The project team will engage in systematic research related to HFCB Technology in Mexico such as HFCB Mexican manufacturing, HFCB reception tests certification, HFCB technological performance, HFCB operation analysis, and HFCB maintenance analysis. This research will form part of the evaluation of the whole demonstration project. At least one final report of each topic will be issued.																				
Activity 13: Carry out the research studies associated to Government transport policies and economics. The project team will engage in systematic research related to Government transport policies and economics such as Demonstration project management, Technology supply and demand, Zero emissions transport costs and benefits, economics and politics of Bus replacement, and economics of hydrogen production for urban transport. This research will serve both as project evaluation instruments as well as evidences to rise political and social awareness to engage in phase 2.																				

Output 5: A substantial body of knowledge accumulated on reliability, failure modes and opportunities permits to undertake an awareness campaign directed at creating an enabling environment for the future FCB market in Mexico.

ACTIVITIES	YEAR 1				YEAR 2				YEAR 3				YEAR 4				YEAR 5			
	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Activity 14: Carry out the research studies associated to Environment and Health in Mexico. The project team will engage in systematic research related to environment and health such as comparative project environmental analysis, zero emissions transport costs and benefits in megacities, Mexico City air pollution alternative solutions, and Mexico City air pollution and health. This research will also serve both as project evaluation instruments as well as evidences to rise political and social awareness to engage in phase 2.																				
Activity 15: Carry out the research projects in preparation for future FCB market development in Mexico.																				
Activity 16: Disseminate results and adaptive management. It includes the feeding of the obtained data and analysis, back to the vendors, and into the preparation for future FCB market development. It makes public diffusion of these results, and it initiates activities related to the Mexican mass manufacturing of hydrogen fuel cell buses.																				
Activity 17: Organize and take part in National and International meetings on HFCB manufacturing technology, operation, maintenance, and management. It includes the organization and participation in National and International meetings on hydrogen fuel cell technology for development and joint entrepreneurial purposes, and for widespread dissemination of results.																				
Activity 18: Both the communications and research initiatives begun during Part I will be continued throughout Part II. The FCB Private Sector Advisory Group will continue to be consulted on a regular basis regarding project results. International meetings on hydrogen fuel cell technology will be attended for development and joint entrepreneurial purposes, and for widespread dissemination of research results. The research results will be shared with the other GEF FCB projects through meetings and other communications (e.g., FCB Website) coordinated by the UNDP-GEF.																				

## **ANNEX E: TERMS OF REFERENCE FOR PROJECT PERSONNEL AND ORGANIGRAM**

### **POSITION: PROJECT MANAGER**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.01

Responsibilities and Duties:

A. The Project Manager shall be accountable for the:

- 1) Overall management to meet the Project objectives and outputs.
- 2) Overall management of the financial, material and human resources of the Project.

B. The Project Manager shall be responsible for:

- 1) Convening the meetings of the Project Steering Committee, chaired by the Secretary of Transport and co-chaired by the UNDP Representative and/or the Project Manager, that will meet on a quarterly basis with the role of overseeing Project planning, implementation and performance.
- 2) Convening the meetings of the National Coordinating Agency, chaired by the Secretary of Transport and co-chaired by the UNDP Representative and/or the Project Manager, that will meet as required with the role of informing and discussing Project specific issues, for decision making.
- 3) Convening the meetings of the National Executing Agency, chaired by the STE Director General and co-chaired by the UNDP Representative and/or the Project Manager that will meet as required with the role of informing and discussing STE involvement, for decision making.
- 4) Chairing or Co-Chairing the Project meetings that will supervise the Project state of progress.
- 5) Ensuring achievement of the Project objectives in compliance with the Project planning.
- 6) Ensuring achievement of Project programming, procurement preparations, project design of policies and strategies, project monitoring, and financial management.

- 7) Constituting and forming part of a Board of government members, bus manufacturers, bus operators, bus associations, HFCEB technology developers and vendors, financing agencies and banks, and UNDP members, to outlook and support the development, manufacture and large-scale commercialisation of hydrogen-fuel cell buses in Mexico City and replication in other major Mexican urban areas (Guadalajara, Mexico State and Monterrey).
- 8) Constituting and forming part of the Project Staff composed by the coordinators consultants, advisors, and officers, under UNDP subcontracts, responsible of carrying out the different activities and research associated to the project.
- 9) Producing and revising TORs with STE and UNDP Project Staff members.
- 10) Ensuring financial sustainability of the Project, with the support of SETRAVI, STE and the UNDP Office in Mexico.
- 11) Reviewing with UNDP the annual and quarterly work plans and technical and financial reports, according to UNDP Manual for Nationally Executed Projects.
- 12) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 13) Supervising the implementation of the Project annual and quarterly work plans.
- 14) Ensuring synergy among the Project activities of all the technical, administrative and financial areas
- 15) Submitting Project data to the STE annual operation programme (POA), so that, the Mexico City Government Project co-financing resources are included timely
- 16) Constituting and forming part of the Project Monitoring and Evaluation missions, composed by:
  - The consultants/researchers, under UNDP subcontract, responsible for the monitoring and evaluation research lines,
  - The selected SETRAVI and STE personnel to carry out the Project monitoring and evaluation process,
  - The responsible people named by the HFCEB technology developers and selected subcontract vendors to carry out the Project monitoring and evaluation process,
  - The UNDP representatives ascribed to the Project.
- 17) Defining the publication and archives criteria for all material and documents produced by the Project.

18) Submitting to the donors, government authorities, GEF and UNDP the Project technical reports.

C. The Project Manager, following UNDP guidelines and procedures, shall perform the following duties:

- 1) Coordinate and supervise the work of the Project Staff, and facilitate UNDP's monitoring and evaluation by preparing quarterly progress reports and by organising project steering committee, tripartite meetings, and monitoring and evaluation missions.
- 2) Carry out in close coordination with the SETRAVI, STE and UNDP Project representatives the supervision and follow-up of the Project planning.
- 3) Participate in the UNDP contracts committee to select the coordinators, consultant/researchers, advisors and officers and the subcontracts.

Selection Criteria:

Project Manager				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in electrical, mechanical, chemical, energy, environmental, transport engineering, in physics, or in economics.</p> <p>Preferably with 10 years experience of successful leadership in the design and execution of international projects related to the fields of transport, energy, environment or equivalent.</p>	<ul style="list-style-type: none"> <li>• Financial, material and human resources management</li> <li>• International projects management</li> <li>• Transport projects management</li> <li>• Relations with actors of international transport / environmental projects, such as governmental and political agencies, private and state owned enterprises, local and international experts, national and international lending and financing agencies, bus manufacturers and providers of HFCB technology, and hydrogen producers</li> <li>• UNDP and GEF organization, structure, and operational strategy</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open leadership</li> <li>• High initiative</li> <li>• Management by objectives</li> <li>• Establishment, execution and follow-up of long, short and medium term goals</li> <li>• Negotiation and conflict resolution</li> <li>• Strategic planning and follow-up of work plans</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making</li> <li>• Personnel management</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• Full time availability</li> <li>• His/her activities will be executed within the UNDP, SETRAVI, STE premises, and/or the HFCBs or fueling infrastructure manufacturers premises, and/or his own place of work</li> <li>• UNDP, SETRAVI or STE will devote a specific furnished-and-with-computer-equipment place, so that, he/she can comply with his/her responsibilities and duties</li> <li>• Availability to continuously travel inside Mexico and abroad</li> <li>• Selection through UNDP contracts committee</li> </ul>



**POSITION: CONSULTANT/RESEARCHER ON HFCB MEXICAN MANUFACTURING PROCESS OPTIMIZATION**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget line: 017.06

**Responsibilities and Duties:**

A. Under the supervision of the Project Manager, the consultant/researcher on HFCB Mexican manufacturing process optimization, is responsible for:

- 1) Carrying out the research activities to optimize the Mexican manufacturing processes towards the creation of a national HFCB manufacturing capability.
- 2) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers to design the optimized manufacturing process of a Mexican version of an HFC bus.
- 3) Creating the necessary relations among Mexican bus operators, public transport governmental and political associations, lending and financing agencies, and bus manufacturers in order to study the conditions under which HFCB full deployment and commercialization is feasible. This includes the replication feasibility in the major Mexican urban areas of Monterrey, Guadalajara and the State of Mexico.
- 4) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers, as demanded by his/her line of research.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with his/her line of research, the state of progress HFCB Mexican manufacturing process optimization subproject, as well as, the partial and final reports and their conclusions.
- 6) Preparing the needed technical reports of his/her area, to be submitted to the Project Steering Committee, National Coordinating Agency, National Executing Agency, or any other Agency related with his/her line of research.
- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.

- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to his/her associated research, and/or other activities of the project.
- 10) Meeting regularly with the personnel in his/her area to monitor and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on HFCB Mexican manufacturing process optimization shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group in charge of the activities on HFCB Mexican manufacturing process optimization.
- 2) Supervise and follow up the state of progress of his/her research in order to comply with the UNDP annual and quarterly work plans.
- 3) Carry out, in close coordination with the SETRAVI, STE and UNDP Project representatives, the supervision and follow up of the project planning in those aspects related to his/her research.

Selection Criteria:

Consultant/Researcher on: HFCB Mexican manufacturing process optimization				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in manufacturing systems, optimization systems, industrial, electrical, electronics, mechanical, transport or systems engineering, in economics or in business administration.</p> <p>Preferably with 10 years experience of successful leadership in the design and execution of research related to manufacturing process optimization in the fields of transport, energy, environment or equivalent.</p>	<ul style="list-style-type: none"> <li>• HFCB technology and fueling infrastructure</li> <li>• Research on manufacturing process optimization as leader and executer</li> <li>• Relations with representatives of bus manufacturers and HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on HFCB manufacturing</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open research leadership</li> <li>• High initiative</li> <li>• Organization of research projects and programmes</li> <li>• Establishment, execution and follow-up of long, short and medium term research goals</li> <li>• Negotiation and conflict resolution within research actors and actions</li> <li>• Research planning, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on research topics</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her half time activities will be executed within the UNDP, SETRAVI, STE premises, and/or the bus manufacturers, the HFCBs manufacturers premises, and/or his own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Availability to occasionally travel inside Mexico and abroad</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON HFCB PROTOTYPES AND SERIES TEST CERTIFICATION.**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.07

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the consultant/researcher on HFCB Prototypes and Series Tests Certification (Energy Conversion, Mechanical, Electrical and Control), is responsible for:

- 1) Carrying out the research and/or technological activities to certify the HFCB prototype and series tests activities, in compliance with the HFCB manufacturers, and/or STE tests standards and protocols.
- 2) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers to design the certification process for the energy conversion, mechanical, electrical and control systems of the HFC buses.
- 3) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution, the HFCB bus manufacturers and hydrogen producers, in order to plan the procedures to certify the HFCB prototype and series tests.
- 4) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers, as demanded by his/her area of activities.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with the certification of HFCB prototype and series tests, the state of progress of his/her activities on that issue.
- 6) Preparing the needed technical reports on the HFCBs tests certification process, to be submitted to the Project Steering Committee, National Coordinating Agency, National Executing Agency, or any other Agency related with his/her activities.
- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.

- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the HFCBs tests certification process.
- 10) Meeting regularly with the personnel in his/her area to monitor and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on HFCB Prototypes and Series Tests Certification (Energy Conversion, Mechanical, Electrical and Control) shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group in charge of the energy conversion, mechanical, electrical and control HFCBs certification tests process.
- 2) Supervise and follow up the state of progress in each one of the subsystems (energy conversion, mechanical, electrical and control) of the HFCBs certification tests process in order to comply with the UNDP annual and quarterly work plans.
- 3) Carry out, in close coordination with the SETRAVI, STE and UNDP Project representatives, the supervision and follow up of the project planning in those aspects related to the HFCBs certification tests.

Selection Criteria:

Consultant/Researcher on: HFCB Prototypes and Series Tests Certification (Energy Conversion, Mechanical, Electrical and Control)				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in manufacturing or quality control systems, industrial, electrical, electronics, mechanical, transport or systems engineering, or in physics.</p> <p>Preferably with years of experience in the leadership planning, programming and executing the technological activities related to the HFCBs or any other transport system or technology tests certification process.</p>	<ul style="list-style-type: none"> <li>• HFCB technology and fueling infrastructure</li> <li>• Prototype and Series tests certification processes, as leader and executer</li> <li>• Relations with representatives of bus manufacturers and HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on HFCB manufacturing</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership in the tests certification process area</li> <li>• High initiative</li> <li>• Organization of tests certification groups and programmes</li> <li>• Establishment, execution and follow-up of the stages of the certification tests process</li> <li>• Negotiation and conflict resolution within the certification tests process actors and actions</li> <li>• Certification tests planning, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on tests certification processes</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• Full time devoted to the tests certification process during the time of these tests, and part time after finishing them</li> <li>• His/her activities will be executed within the UNDP, SETRAVI, STE premises, and/or the HFCBs or fueling infrastructure manufacturers premises, and/or his own place of work</li> <li>• Availability to take part in the project meetings as required</li> <li>• Availability to occasionally travel inside Mexico and abroad</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON HFCB TECHNOLOGICAL PERFORMANCE**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.03

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the consultant/researcher on HFCB Technological Performance, is responsible for:

- 1) Carrying out the research and/or technological activities in order to define and take part in the HFCB and fueling infrastructure technological performance testing criteria, in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE technological performance standards and protocols.
- 2) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers to design and execute the tests and analysis of the HFCB and fueling infrastructure technological performance.
- 3) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution, the HFCB bus manufacturers and hydrogen producers, in order to plan the procedures to execute the tests and analysis of the HFCB and fueling infrastructure technological performance.
- 4) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers. These meetings will have the role of informing, discussing and decision making specific issues on tests and analysis of the HFCB and fueling infrastructure technological performance.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with the tests and analysis of the HFCB and fueling infrastructure technological performance, the state of progress of his/her activities on that issue.
- 6) Preparing the needed technical reports on the tests and analysis of the HFCB and fueling infrastructure technological performance, to be submitted to the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with his/her activities.

- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the tests and analysis of the HFCB and fueling infrastructure technological performance.
- 10) Meeting regularly with the personnel in his/her area to monitor and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on HFCB Technological Performance shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of testing and analyzing the HFCB and fueling infrastructure technological performance. These activities have to be made in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE technological performance standards and protocols.
- 2) Supervise and follow up the state of progress of testing and analyzing processes on HFCB and fueling infrastructure technological performance, in order to comply with the UNDP annual and quarterly work plans.
- 3) Carry out, in close coordination with the SETRAVI, STE and UNDP Project representatives, the supervision and follow up of the project planning in those aspects related to the testing and analyzing of the HFCB and fueling infrastructure technological performance.



Selection Criteria:

Consultant/Researcher on: HFCB Technological Performance				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in manufacturing or quality control systems, industrial, electrical, electronics, mechanical, transport or systems engineering, or in physics.</p> <p>Preferably with years of experience in the leadership planning, programming and executing the technological activities related to the testing criteria to analyze the HFCBs and fueling infrastructure technological performance. Or equivalent experience to analyze any other transport and/or fueling system technological performance.</p>	<ul style="list-style-type: none"> <li>• HFCB technology and fueling infrastructure</li> <li>• Testing criteria for technological performance of transport or any other kind of equipment, as leader and executer</li> <li>• Relations with representatives of bus manufacturers, HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on HFCB and fueling infrastructure manufacturing</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership in technological performance tests and analysis</li> <li>• High initiative</li> <li>• Organization of tests and analysis technological performance specialized groups and programmes</li> <li>• Establishment, execution and follow-up of the stages of the technological performance tests and analysis</li> <li>• Negotiation and conflict resolution within the actors and actions on technological performance tests and analysis</li> <li>• Technological performance tests and analysis planning, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on technological performance tests and analysis</li> </ul> <p>Excellent use of language to communicate and to write reports in both English and Spanish</p>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her half time activities will be executed within the UNDP, SETRAVI, STE premises, and/or the bus manufacturers, the HFCBs manufacturers premises, and/or his own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Availability to occasionally travel inside Mexico and abroad</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON HFCB OPERATION ANALYSIS**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.04

Responsibilities and Duties:

A. Under the supervision of the Project Manager , the consultant/researcher on HFCB Operation Analysis, is responsible for:

- 1) Carrying out the research and/or technological activities in order to define the evaluation criteria and monitoring actions towards the determination of the HFCB Operation Analysis. These activities are to be made in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE operation standards and protocols. Such aspect as initial operating costs, steady demonstration operating costs, reliability, running bus performance, availability and other operation variables have to be included in the HFCBs and fueling infrastructure Operation Analysis
- 2) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers to design the procedures to better execute the HFCB and fueling infrastructure Operation Analysis.
- 3) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution, the HFCB bus manufacturers and hydrogen producers, in order to plan the procedures to execute the HFCB and fueling infrastructure Operation Analysis.
- 4) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers. These meetings will have the role of informing, discussing and decision making specific issues on the HFCB and fueling infrastructure Operation Analysis.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with the HFCB and fueling infrastructure Operation Analysis, the state of progress of his/her activities on that issue.
- 6) Preparing the needed technical reports on the HFCB and fueling infrastructure Operation Analysis, to be submitted to the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with his/her activities.

- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the HFCB and fueling infrastructure Operation Analysis.
- 10) Meeting regularly with the personnel in his/her area to monitor and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on HFCB Operation Analysis shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of HFCB and fueling infrastructure Operation Analysis. These activities have to be made in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE operation standards and protocols.
- 2) Supervise and follow up the state of progress of the HFCB and fueling infrastructure Operation Analysis, in order to comply with the UNDP annual and quarterly work plans.
- 3) Carry out, in close coordination with the SETRAVI, STE and UNDP Project representatives, the supervision and follow up of the project planning in those aspects related to the HFCB and fueling infrastructure Operation Analysis.

Selection Criteria:

Consultant/Researcher on: HFCB Operation Analysis				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in industrial, systems, , electrical, electronics, mechanical, transport engineering, or in economics.</p> <p>Preferably with years of experience in the leadership of planning, programming and executing the technological activities related to the HFCB and fueling infrastructure Operation Analysis. Or equivalent experience to analyze any other transport and/or fueling system operational performance.</p>	<ul style="list-style-type: none"> <li>• HFCB technology and fueling infrastructure operation</li> <li>• Transport operation analysis, as leader and executer</li> <li>• Relations with representatives of bus manufacturers, HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on HFCB and fueling infrastructure manufacturing</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership in transport operation analysis</li> <li>• High initiative</li> <li>• Organization of monitoring and evaluation of the transport operation groups and programmes</li> <li>• Establishment, execution and follow-up of the stages of the transport operation analysis</li> <li>• Negotiation and conflict resolution within the actors and actions on transport operation analysis</li> <li>• Transport operation analysis planning, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on transport operation analysis</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her part time activities will be executed within the UNDP, SETRAVI, STE premises (bus corridors and garages), and/or the bus manufacturers, the HFCBs manufacturers premises, and/or his own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Availability to occasionally travel inside Mexico and abroad</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON HFCB MAINTENANCE ANALYSIS**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.05

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the consultant/researcher on HFCB Maintenance Analysis, is responsible for:

- 1) Carrying out the research and/or technological activities in order to define the evaluation criteria and monitoring actions towards the determination of the HFCB and fueling infrastructure maintenance analysis. These activities are to be made in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE maintenance standards and protocols. Such aspect as detailed maintenance programme, demonstration maintenance costs, time between failures, maintenance reliability, running bus maintenance performance, and other maintenance variables have to be included in the HFCBs and fueling infrastructure maintenance analysis
- 2) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers to design the procedures to better execute the HFCB and fueling infrastructure maintenance analysis.
- 3) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution, the HFCB bus manufacturers and hydrogen producers, in order to plan the procedures to execute the HFCB and fueling infrastructure maintenance analysis.
- 4) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers. These meetings will have the role of informing, discussing and decision making specific issues on the HFCB and fueling infrastructure maintenance analysis.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with the HFCB and fueling infrastructure maintenance analysis, the state of progress of his/her activities on that issue.

- 6) Preparing the needed technical reports on the HFCB and fueling infrastructure maintenance analysis, to be submitted to the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with his/her activities.
- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the HFCB and fueling infrastructure maintenance analysis.
- 10) Meeting regularly with the personnel in his/her area to monitor and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on HFCB Maintenance Analysis shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of the HFCB and fueling infrastructure demonstration maintenance programme and analysis. These activities have to be made in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE maintenance standards and protocols.
- 2) Supervise and follow up the state of progress of the HFCB and fueling infrastructure maintenance programme and analysis, in order to comply with the UNDP annual and quarterly work plans.
- 3) Carry out, in close coordination with the SETRAVI, STE and UNDP Project representatives, the supervision and follow up of the project planning in those aspects related to the HFCB and fueling infrastructure maintenance analysis.

Selection Criteria:

Consultant/Researcher on: HFCB Maintenance Analysis				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in industrial, systems, electrical, electronics, mechanical, transport engineering.</p> <p>Preferably with years of experience in the leadership of planning, programming and executing the technological activities related to the HFCB and fueling infrastructure maintenance analysis. Or equivalent experience to analyze any other transport and/or fueling system maintenance performance.</p>	<ul style="list-style-type: none"> <li>• HFCB technology and fueling infrastructure maintenance</li> <li>• Transport maintenance analysis, as leader and executer</li> <li>• Relations with representatives of bus manufacturers, HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on HFCB and fueling infrastructure maintenance</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership in transport maintenance analysis</li> <li>• High initiative</li> <li>• Organization of monitoring and evaluation of the transport maintenance programme and analysis</li> <li>• Establishment, execution and follow-up of the stages of the transport maintenance programme and analysis</li> <li>• Negotiation and conflict resolution within the actors and actions on transport maintenance programme and analysis</li> <li>• Transport maintenance planning, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on transport maintenance programme and analysis</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her half time activities will be executed within the UNDP, SETRAVI, STE premises (bus corridors and garages), and/or the bus manufacturers, the HFCBs manufacturers premises, and/or his own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Availability to occasionally travel inside Mexico and abroad</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON DEMONSTRATION PROJECT ENVIRONMENTAL ANALYSIS**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.08

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the consultant/researcher on Demonstration Project Environmental Analysis, is responsible for:

- 1) Carrying out the research and/or technological activities in order to define the evaluation criteria and monitoring actions towards the determination of the Demonstration Project Environmental Analysis. These activities are to be made in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE maintenance standards and protocols. Such aspects as a review of public buses pollutant's load, both toxic compounds and greenhouse effect gases, detailed environmental evaluation and monitoring programme for the demonstration project, environmental evaluation and monitoring programme costs, and other environmental variables have to be included in the demonstration project environmental analysis.
- 2) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers to design the procedures to better execute the demonstration project environmental analysis.
- 3) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution, the HFCB bus manufacturers and hydrogen producers, in order to plan the procedures to execute the demonstration project environmental analysis.
- 4) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers. These meetings will have the role of informing, discussing and decision making specific issues on the demonstration project environmental analysis.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with the demonstration project environmental analysis, the state of progress of his/her activities on that issue.
- 6) Preparing the needed technical reports on the demonstration project environmental analysis, to be submitted to the Project Steering Committee, National Coordinating



Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with his/her activities.

- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the demonstration project environmental analysis.
- 10) Meeting regularly with the personnel in his/her area to monitor and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on Demonstration Project Environmental Analysis shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of the demonstration project environmental analysis. These activities have to be made in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE environmental standards and protocols.
- 2) Supervise and follow up the state of progress of the demonstration project environmental analysis, in order to comply with the UNDP annual and quarterly work plans.
- 3) Carry out, in close coordination with the SETRAVI, STE and UNDP Project representatives, the supervision and follow up of the project planning in those aspects related to the demonstration project environmental analysis.

Selection Criteria:

Consultant/Researcher on: Demonstration Project Environmental Analysis				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in environmental, chemical, or transport engineering, or in physics or environmental economics.</p> <p>Preferably with years of experience in the leadership of planning, programming and executing environmental projects.</p>	<ul style="list-style-type: none"> <li>• HFCB technology and fueling infrastructure</li> <li>• Environmental projects</li> <li>• Transport environmental analysis, as leader and executer</li> <li>• Relations with representatives of bus manufacturers, HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on environmental analysis</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership in transport environmental analysis</li> <li>• High initiative</li> <li>• Organization of monitoring and evaluation of the transport environmental programme and analysis</li> <li>• Establishment, execution and follow-up of the stages of the transport environmental programme and analysis</li> <li>• Negotiation and conflict resolution within the actors and actions on transport environmental programme and analysis</li> <li>• Transport environmental project planning, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on transport environmental programme and analysis</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her part time activities will be executed within the UNDP, SETRAVI, Environmental Secretary, STE premises, environmental monitoring centers and/or the bus manufacturers, the HFCBs manufacturers premises, and/or his own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON DEMAND AND SUPPLY OF HFCB TECHNOLOGY**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.09

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the consultant/researcher on Demand and Supply of HFCB Technology, is responsible for:

- 1) Carrying out the marketing research on demand and supply of HFCB technology. These activities are to be made, preferentially, supported by the HFCB manufacturers, fueling infrastructure manufacturers, transit authorities that operate HFCBs. Prospective costs, analysis on HFCB technology, HFCBs life-cycle costs, HFCBs fuel cells replacements costs, hydrogen consumption costs and others are issues to be included in the research.
- 2) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers in order to determine the demand and supply of HFCB technology.
- 3) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution of Mexico City, Guadalajara, Monterrey and Mexico State, the HFCB bus manufacturers and hydrogen producers, in order to determine the prospective demand and supply of HFCB technology.
- 4) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers. These meetings will have the role of informing, discussing issues related on the demand and supply of HFCB technology.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with the demand and supply of HFCB technology, the state of progress of his/her activities on that issue.
- 6) Preparing the needed technical reports on the demand and supply of HFCB technology, to be submitted to the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with his/her activities.
- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.

- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the demand and supply of HFCB technology.
- 10) Meeting regularly with the personnel in his/her area to follow up and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on Demand and Supply of HFCB Technology shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of the research on the demand and supply of HFCB technology.
- 2) Organize his/her research activities, preferably, supported by the HFCB manufacturers, fueling infrastructure manufacturers, national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers, hydrogen producers, Mexico City, Guadalajara, Monterrey and Mexico State bus operators and transport governmental institutions, representatives of HFCB international transport/projects, private and state owned enterprises, and other institutions and enterprises related to the demand and supply of HFCB technology.
- 3) Supervise and follow up the state of progress of the research on demand and supply of HFCB technology, in order to comply with the UNDP annual and quarterly work plans.
- 4) Carry out, in close coordination with the SETRAVI, STE and UNDP Project representatives, the supervision and follow up of the project planning in those aspects related to the research on demand and supply of HFCB technology.

Selection Criteria:

Consultant/Researcher on: Demand and Supply of HFCB Technology				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in economics business administration, or international commerce, industrial or systems engineering.</p> <p>Preferably with years of experience in the leadership of planning, programming and executing projects related to technology demand and supply.</p>	<ul style="list-style-type: none"> <li>• HFCB technology and fueling infrastructure demand and supply</li> <li>• Projects on technology demand and supply</li> <li>• Transport demand and supply analysis, as leader and executer</li> <li>• Relations with representatives of bus manufacturers, HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on environmental analysis</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership on transport technology demand and supply analysis</li> <li>• High initiative</li> <li>• Organization of programmes on transport technology demand and supply analysis</li> <li>• Establishment, execution and follow-up of the stages of the research on demand and supply of transport technology</li> <li>• Transport technology demand and supply projects, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on transport technology demand and supply projects</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her half time activities will be executed within the UNDP, SETRAVI, STE premises, and/or the bus manufacturers, the HFCBs manufacturers premises, and/or his/her own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON COSTS AND BENEFITS OF NON-POLLUTING TRANSPORT IN MEGACITIES - THE CASE OF MEXICO CITY.**

Project : Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.10

Responsibilities and Duties:

- 1) A. Under the supervision of the Project Manager, the consultant/researcher on Costs and Benefits of non-polluting transport in Megacities. The case of Mexico City, is Carrying out the research and/or technological activities in order to define and take part in the HFCB and fueling infrastructure technological performance testing criteria, in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE technological performance standards and protocols.
- 2) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers to design and execute the tests and analysis of the HFCB and fueling infrastructure technological performance.
- 3) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution, the HFCB bus manufacturers and hydrogen producers, in order to plan the procedures to execute the tests and analysis of the HFCB and fueling infrastructure technological performance.
- 4) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers. These meetings will have the role of informing, discussing and decision making specific issues on tests and analysis of the HFCB and fueling infrastructure technological performance.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with the tests and analysis of the HFCB and fueling infrastructure technological performance, the state of progress of his/her activities on that issue.
- 6) Preparing the needed technical reports on the tests and analysis of the HFCB and fueling infrastructure technological performance, to be submitted to the Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related with his/her activities.
- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.

- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the tests and analysis of the HFCB and fueling infrastructure technological performance.
- 10) Meeting regularly with the personnel in his/her area to monitor and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on Costs and Benefits of non-polluting transport in Megacities. The case of Mexico City, shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of testing and analyzing the HFCB and fueling infrastructure technological performance. These activities have to be made in compliance with the HFCB manufacturers, fueling infrastructure manufacturers, and/or STE technological performance standards and protocols.
- 2) Supervise and follow up the state of progress of testing and analyzing processes on HFCB and fueling infrastructure technological performance, in order to comply with the UNDP annual and quarterly work plans.
- 3) Carry out, in close coordination with the SETRAVI, STE and UNDP Project representatives, the supervision and follow up of the project planning in those aspects related to the testing and analyzing of the HFCB and fueling infrastructure technological performance.

Selection Criteria:

Consultant/Researcher on: Costs and Benefits of non-polluting transport in Megacities. The case of Mexico City.				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in manufacturing or quality control systems, industrial, electrical, electronics, mechanical, transport or systems engineering, or in physics.</p> <p>Preferably with years of experience in the leadership planning, programming and executing the technological activities related to the HFCBs or any other transport system or technology tests certification process.</p>	<ul style="list-style-type: none"> <li>• HFCB technology</li> <li>• Prototype and Series tests certification processes, as leader and executer</li> <li>• Relations with representatives of bus manufacturers and HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on HFCB manufacturing</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership in the tests certification process area</li> <li>• High initiative</li> <li>• Organization of tests certification groups and programmes</li> <li>• Establishment, execution and follow-up of the stages of the certification tests process</li> <li>• Negotiation and conflict resolution within the certification tests process actors and actions</li> <li>• Certification tests planning, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on tests certification processes</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in Mexico City or in the surrounding area</li> <li>• Full time devoted to the tests certification process</li> <li>• Availability to take part in the project meetings as required</li> <li>• Availability to occasionally travel inside Mexico and abroad</li> <li>• His/her main work will be either executed within the HFC bus manufacturers, hydrogen providers or STE testing areas, or in his/her working place, with mobility capacities as required</li> <li>• Selection through UNDP contracts committee</li> </ul>



**POSITION: CONSULTANT/RESEARCHER ON THE POLITICS AND ECONOMICS OF BUS REPLACEMENT**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.11

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the consultant/researcher on The Politics and Economics of Bus Replacement, is responsible for:

- 1) Carrying out the research on the politics and economics of bus replacement. The activities of this research are to be made with the support of the transit and environmental authorities of the Mexico City government, SETRAVI, Environment Secretary, and STE.
- 2) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution of Mexico City, and the Mexican bus and bus body assemblers and manufacturers, the National lending agencies and banks, and the private owners and buses associations of gasoline fueled micro and minibuses, and diesel buses, in order to establish the basis of negotiation for reaching political and economical agreements on the issue of bus replacement in Mexico City.
- 4) Participating in meetings with the above institution, associations and individuals that will meet with the role of informing, discussing, and decision making on issues related to the establishment of a feasible policy and economy of bus replacement in Mexico City.
- 5) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency or any other governmental institution or political bus association, the state of progress of the research on the politics and economics of bus replacement.
- 6) Preparing the needed technical reports on the research on the politics and economics of bus replacement, to be submitted to the Mexico City Government transport and political institutions.
- 7) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 8) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the research on the politics and economics of bus replacement.

10) Meeting regularly with the personnel in his/her area to follow up and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on The Politics and Economics of Bus Replacement shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of the research on the politics and economics of bus replacement.
- 2) Organize, the research on the politics and economics of bus replacement, with the support of the transit and environmental authorities of the Mexico City government, the Mexican bus and bus body assemblers and manufacturers, the National lending agencies and banks, and the private owners and buses associations of gasoline fueled micro and minibuses, and diesel buses.
- 3) Supervise and follow up the state of progress of the research on the politics and economics of bus replacement, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Consultant/Researcher on: The Politics and Economics of Bus Replacement				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in political science, economics, or law, business administration, international commerce, or systems engineering.</p> <p>Preferably with years of experience in the leadership of planning, programming and executing projects related to the management of political and economical conflicts, or with years of experience and knowledge of the basis of bus replacement political and economical conflicts.</p>	<ul style="list-style-type: none"> <li>• The Mexico City transport law</li> <li>• Projects on social and political conflict management</li> <li>• Mexico City urban transport political and economical conflicts and negotiations</li> <li>• Relations with the transit and environmental authorities of the Mexico City government, the Mexican bus and bus body assemblers and manufacturers, the National lending agencies and banks, and the private owners and buses associations of gasoline fueled micro and minibuses, and diesel buses</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on bus replacement in large cities</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership on political and economical conflicts in bus replacement</li> <li>• High initiative</li> <li>• Organization of programmes to carry out the research on politics and economics of bus replacement</li> <li>• Establishment, execution and follow-up of the stages of the research on politics and economics of bus replacement</li> <li>• Research on politics and economics of bus replacement, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• Negotiation and conflict resolution</li> <li>• High ability for needs detection and decision making on the research politics and economics of bus replacement</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her half or full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her research, including his/her own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON DIAGNOSTIC AND SOLUTION ALTERNATIVES TO MEXICO CITY AIR POLLUTION**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.12

Responsibilities and Duties:

A Under the supervision of the Project Manager, the consultant/researcher on Diagnostic and Solution Alternatives to Mexico City Air Pollution, is responsible for:

- 1) Carrying out the research on the diagnostic and solution alternatives to Mexico City air pollution. The activities of this research are to be made with the support of the transit and environmental authorities of the Mexico City government, SETRAVI, Environment Secretary, and STE.
- 2) Creating the necessary relations among STE, the bus operator enterprise, SETRAVI, the public transport governmental institution of Mexico City, and the Environment Secretary, in order to develop an appropriate diagnostic and solution alternatives to Mexico City air pollution.
- 3) Participating in meetings with the above institutions, environment associations and individuals that will meet with the role of informing and discussing on issues related to the diagnostic and solution alternatives to Mexico City air pollution.
- 4) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency or any other governmental environment institution or environment association, the state of progress of the research on diagnostic and solution alternatives to Mexico City air pollution.
- 5) Preparing the needed technical reports on the research on the diagnostic and solution alternatives to Mexico City air pollution, to be submitted to the Mexico City Government transport, environment and political institutions.
- 6) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 7) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 8) Participating in meetings of the Project Staff, in order to discuss the different activities related to the research on the diagnostic and solution alternatives to Mexico City air pollution.

- 9) Meeting regularly with the personnel in his/her area to follow up and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on Diagnostic and Solution Alternatives to Mexico City Air Pollution, shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of the research on the diagnostic and solution alternatives to Mexico City air pollution.
- 2) Organize, the research on the diagnostic and solution alternatives to Mexico City air pollution, with the support of the transit and environmental authorities of the Mexico City government, environment associations, the Global Environmental Facilities, and the Mexican bus and bus body assemblers and manufacturers.
- 3) Supervise and follow up the state of progress of the research on the diagnostic and solution alternatives to Mexico City air pollution, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Consultant/Researcher on: Diagnostic and Solution Alternatives to Mexico City Air Pollution				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in chemical, environment, systems engineering or environmental or economics or physics.</p> <p>Preferably with years of experience in the leadership of planning, programming and executing projects related to the diagnostic and solution alternatives to air pollution, or general pollution or with years of experience and knowledge of the basis of environmental pollution.</p>	<ul style="list-style-type: none"> <li>• The Mexico City pollution regulations</li> <li>• Mexico City urban transport political and economical conflicts and negotiations</li> <li>• Relations with the transit and environmental authorities of the Mexico City government, the Mexican bus and bus body assemblers and manufacturers, the fuel producers</li> <li>• Relations with representatives of international environmental projects, environmental, governmental and political agencies, private and state technological enterprises related to the solutions of air pollution, local and international experts on environment</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership on diagnosis and solution alternative to the air pollutions</li> <li>• High initiative</li> <li>• Organization of programmes to carry out the research on diagnostic and solution alternatives to Mexico City air pollution</li> <li>• Establishment, execution and follow-up of the stages of the research on the diagnostic and solution alternatives to Mexico City air pollution</li> <li>• Research on the diagnostic and solution alternatives to Mexico City air pollution</li> <li>• High ability to relate with people of any level and representation</li> <li>• Negotiation and conflict resolution</li> <li>• High ability for needs detection and decision making on the research diagnostic and solution alternatives to Mexico City air pollution</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her half or full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the environmental authorities of the Mexico City government, and within any other premises related to his/her research, including his/her own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON AIR POLLUTION AND HEALTH IN MEXICO CITY**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.13

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the consultant/researcher on Air Pollution and Health in Mexico City, is responsible for:

- 1) Carrying out the research of air pollution and health in Mexico City. The activities of this research are to be made with the support of the environmental and health authorities of the Mexico City government, SETRAVI, Environment Secretary, Health Secretary and STE.
- 2) Participating in meetings with the above institution, associations and individuals that will meet with the role of informing, discussing, and decision making on issues related to the establishment of a short and long term programme to perform the air pollution and health policies for Mexico City.
- 3) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency or any other health and environment institution or association, the state of progress of the research of air pollution and health in Mexico City.
- 4) Preparing the needed technical reports on the research of air pollution and health in Mexico City, to be submitted to the Mexico City Government environment and health institutions.
- 5) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 6) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 7) Participating in meetings of the Project Staff, in order to discuss the different activities related to the research of air pollution and health in Mexico City.
- 8) Meeting regularly with the personnel in his/her area to follow up and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on Air Pollution and Health in Mexico City, shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of the research of air pollution and health in Mexico City.
- 2) Organize, the research of air pollution and health in Mexico City, with the support of the health and environmental authorities of the Mexico City government, the Global Environmental Facilities, World Health Associations.
- 3) Supervise and follow up the state of progress of the research of air pollution and health in Mexico City, in order to comply with the UNDP annual and quarterly work plans.



Selection Criteria:

Consultant/Researcher on: Air Pollution and Health in Mexico City				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in physics, chemical, environmental or systems engineering, or in medicine or environmental, economics.</p> <p>Preferably with years of experience in the leadership of planning, programming and executing projects related to the analysis of air pollution and health, or with years of experience and knowledge of the basis of pollution and health diagnosis.</p>	<ul style="list-style-type: none"> <li>• The environment and health laws</li> <li>• Projects on health and pollution</li> <li>• Mexico City health and pollution status and conflicts</li> <li>• Relations with the health and environmental authorities of the Mexico City government</li> <li>• Relations with representatives of international health and pollution projects, governmental and political agencies, private and state owned supporting or related with pollution and health enterprises, local and international experts health and pollution in large cities</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership on analyzed the air pollution and health</li> <li>• High initiative</li> <li>• Organization of programmes to carry out the research of air pollution and health in Mexico City</li> <li>• Establishment, execution and follow-up of the stages of the research of air pollution and health in Mexico City</li> <li>• Research of air pollution and health in Mexico City, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• Negotiation and conflict resolution</li> <li>• High ability for needs detection and decision making on the research of air pollution and health in Mexico City</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her half or full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her research, including his/her own place of work</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: CONSULTANT/RESEARCHER ON ECONOMICS OF MASS HYDROGEN PRODUCTION FOR TRANSPORT**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.14

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the consultant/researcher on Economics of Mass Hydrogen Production for Transport, is responsible for:

- 1) Carrying out the research on Economics of Mass Hydrogen Production for Transport. The activities of this research are to be made with the support of the National hydrogen producers authorities, PEMEX and private firms, environmental authorities of the Federal District and Mexico government, SEMARNAT and SMA.
- 2) Creating the necessary relations among Federal Government authorities, SETRAVI, environment secretary, the hydrogen producers, PEMEX, the public transport governmental institution of Mexico City, and the Mexican bus and bus body assemblers and manufacturers, the National lending agencies and banks, in order to determine the Economics of Mass Hydrogen Production for Transport in Mexico.
- 3) Participating in meetings with the above institutions, associations and individuals that will meet with the role of informing, discussing, and decision making on issues related to the Economics of Mass Hydrogen Production for Transport in Mexico.
- 4) Presenting before the Project Steering Committee, National Coordinating Agency, National Executing Agency or any other governmental institution or political bus association, the state of progress of the research on Economics of Mass Hydrogen Production for Transport in Mexico.
- 5) Preparing the needed technical reports on the research on Economics of Mass Hydrogen Production for Transport in Mexico, to be submitted to the Federal Government transport and political institutions.
- 6) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 7) Developing the necessary tools in the field to ensure all activities are financially sustainable.
- 8) Participating in meetings of the Project Staff, in order to discuss the different activities related to the research on Economics of Mass Hydrogen Production for Transport in Mexico.

- 9) Meeting regularly with the personnel in his/her area to follow up and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the consultant/researcher on Economics of Mass Hydrogen Production for Transport, shall perform the following duties:

- 1) Organize under his/her leadership the establishment of a research group to take part in the designing and execution of the research on Economics of Mass Hydrogen Production for Transport in Mexico.
- 2) Organize, the research on Economics of Mass Hydrogen Production for Transport in Mexico, with the support of the Federal Government authorities, SETRAVI, environment secretary, the hydrogen producers, PEMEX, the public transport governmental institution of Mexico City, and the Mexican bus and bus body assemblers and manufacturers, the National lending agencies and banks.
- 3) Supervise and follow up the state of progress of the research on Economics of Mass Hydrogen Production for Transport in Mexico, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Consultant/Researcher on: Economics of Mass Hydrogen Production for Transport				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in political science, economics, or law, business administration, international commerce, or chemics, environment or systems engineering.</p> <p>Preferably with years of experience in the leadership of planning, programming and executing projects related to economics for mass hydrogen production, or with years of experience and knowledge of the basis of mass fuel production.</p>	<ul style="list-style-type: none"> <li>Hydrogen production status</li> <li>Projects on hydrogen production</li> <li>Mexico City urban transport fuel and hydrogen production</li> <li>Relations with the transit and environmental authorities of the Mexico City government, the Mexican bus and bus body assemblers and manufacturers, the National lending agencies and banks, and the private owners and buses associations of gasoline fueled micro and minibuses, and diesel buses</li> <li>Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on bus replacement in large cities</li> <li>Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>Positive and open and executive leadership on economics of mass hydrogen production for transport</li> <li>High initiative</li> <li>Organization of programmes to carry out the research on economics of mass hydrogen production for transport</li> <li>Establishment, execution and follow-up of the stages of the research on economics of mass hydrogen production for transport</li> <li>Research on economics of mass hydrogen production for transport, follow up and reports making</li> <li>High ability to relate with people of any level and representation</li> <li>Negotiation and conflict resolution</li> <li>High ability for needs detection and decision making on the research economics of mass hydrogen production for transport</li> <li>Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>Fully committed</li> <li>Honest, great thrust and initiative</li> <li>Charismatic</li> <li>Convincing, congruent</li> <li>Adaptable</li> <li>Empathic</li> <li>Highly responsible</li> <li>Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>Live in or near Mexico City</li> <li>His/her half or full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her research, including his/her own place of work</li> <li>High mobility capacities are required</li> <li>Availability to take part in the project meetings as required</li> <li>Selection through UNDP contracts committee</li> </ul>

**POSITION: TECHNICAL OFFICER 1 DATA COLLECTION**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.21

Responsibilities and Duties:

A .Under the supervision of the Project Manager, and in close contact with the consultant on HFCB Prototypes and Series Tests Certification (Energy Conversion, Mechanical, Electrical and Control) the Technical Officer 1 on Data Collection, is responsible for:

- 1) Carrying out the data collection emanated from the prototypes and series tests and technical specifications of HFCBs and hydrogen supply subsystem. The activities of this position are to be made with the support of the Project Manager, the consultant on HFCB prototypes and series tests certification the Project Staff, other consultants, STE, and vendors.
- 2) Preparing the guidelines for reporting the prototypes and series tests, the checking of the delivered buses and hydrogen supply subsystem according to specifications of the procurement process. These activities are to be executed with the support of the consultant on the prototypes and series tests certification, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Participating in meetings with the consultant on the prototypes and series tests certification, other consultants, STE and the HFCBs and fuel supply system technology providers that will meet with the role of informing, discussing, and decision making on issues related to the data collection process.
- 4) Presenting before the Project Manager, Project Staff or any other institution when necessary, the state of progress of the data collection.
- 5) Preparing the needed technical reports from the collected data, to be submitted to the authorities or institutions when necessary.
- 6) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.

B .Under the supervision of the Project Manager, the Technical Officer 1 on Data Collection, shall perform the following duties:

- 1) Organize the designing and execution of the activities related to of data collection.
- 2) Organize, the data collection procedures, with the support of the Manager, the consultant on the prototypes and series tests certification, STE, UNDP, other consultants and vendors.
- 3) Follow up the state of progress of the data collection activities, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Technical Officer 1 on Data Collection				
Professional Background:	Desired experience and knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
First degree, Master of Science and/or Major degrees in electronics chemical, industrial, computer, mechanical or systems engineering.	<p>Preferably with years of experience in the follow up of prototype and series tests and in the recognition of technical specifications of new technology such as HFCBs and hydrogen supply systems</p> <ul style="list-style-type: none"> <li>English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>High initiative</li> <li>Organization of procedures to carry out the data collection</li> <li>Establishment, execution and follow-up of the stages of the data collection</li> <li>follow up and reports making from collected data</li> <li>High ability to relate with people of any level and representation</li> <li>High ability for needs detection and decision making to evaluate the collected data</li> <li>Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>Fully committed</li> <li>Honest, great thrust and initiative</li> <li>Charismatic</li> <li>Convincing, congruent</li> <li>Adaptable</li> <li>Empathic</li> <li>Highly responsible</li> <li>Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>Live in or near Mexico City</li> <li>His/her full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her activities</li> <li>High mobility capacities are required</li> <li>Availability to take part in the project meetings as required</li> <li>Selection through UNDP contracts committee</li> </ul>

**POSITION: TECHNICAL OFFICER 2 ON ANALYSIS AND REPORT PREPARATION**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.22

Responsibilities and Duties:

A. Under the supervision of the Project Manager, and in close contact with the consultant on HFCB Technological Performance the Technical Officer 2 on Analysis and Report Preparation, is responsible for:

- 1) Carrying out the analysis and report preparation of the HFCB technological performance. The activities of this position are to be made with the support of the Project Manager, the consultant on HFCB technological performance the Project Staff, other consultants, STE, and vendors.
- 2) Preparing the guidelines for quarterly reporting on mean time between failures and failure mode analysis, on the availability of vehicles and on fuel consumption, on hours and kilometers of operation by individual buses and the fleet as a whole, and on proposed engineering modifications, if it is concluded that they are needed, and the communication of these to vendors, plus confirmation of actions taken. These activities are to be made with the support of consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Participating in meetings with the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers that will meet with the role of informing, discussing, and decision making on issues related to the analysis and report preparation.
- 4) Presenting before the Project Manager, Project Staff or any other institution when necessary, the state of progress of the analysis and report preparation.
- 5) Making the analysis and report preparation, to be submitted to the authorities or institutions when necessary.
- 6) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 7) Participating in meetings of the Project Staff, in order to discuss the different activities related to the analysis and report preparation.



B .Under the supervision of the Project Manager, the Technical Officer 2 on Analysis and Report Preparation, shall perform the following duties:

- 1) Organize the designing and execution of the activities related to analysis and report preparation.
- 2) Organize, the analysis and report preparation procedure, with the support of the Project Manager, consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Follow up the state of progress of the analysis and report preparation activities, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Technical Officer 2 on Analysis and Report Preparation				
Professional Background:	Desired experience and knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
First degree, Master of Science and/or Major degrees in electronics chemical, industrial, computer, mechanical or systems engineering.	<ul style="list-style-type: none"> <li>• Preferably with years of experience in the follow up of urban transport performance and operation</li> <li>• English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership</li> <li>• High initiative</li> <li>• Organization of procedures to carry out the analysis and report preparation</li> <li>• Establishment, execution and follow-up of the stages of the analysis and report preparation</li> <li>• follow up the analysis and report preparation</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making to evaluate the analysis and report preparation</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her activities</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> </ul> <p>Selection through UNDP contracts committee</p>

## **POSITION: TECHNICAL OFFICER 3 ON PROJECT ADMINISTRATION**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.23

Responsibilities and Duties:

A. Under the supervision of the Project Manager, the Technical Officer 3 on Project Administration, is responsible for:

- 1) Carrying out the Project Administration. The activities of this position are to be made with the support of the Project Manager, UNDP, the Project Staff, STE, SETRAVI, and vendors.
- 2) Preparing the Demonstration Project documentation to adjust it to the UNDP project administration software. This activity is to be executed with the support of the Project Manager, the UNDP and STE personnel, the consultants and the Project Staff.
- 3) Follow up the timely production of quarterly and annual project reports, , to be submitted to the authorities or institutions when necessary.
- 4) Creating the Demonstration Project archives both in hard and electronic versions.
- 5) Participating in the organization of the National and International workshops for dissemination of Demonstration Project results and acquisition of other experiences.
- 6) Preparing the communications required by the project to UNDP, STE, vendors, and consultants and other technical officer.
- 7) Preparing the annual records of communication activities and participation in international meetings.
- 8) Participating in meetings with the above institutions, associations and individuals that will meet with the role of informing, discussing, and decision making on issues related to the project administration.
- 9) Presenting before the Project Manager, UNDP, Project Staff or any other institution when necessary, the state of project administration.
- 10) Preparing the needed project administration reports, to be submitted to the authorities or institutions when necessary.
- 11) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.

- 12) Participating in meetings of the Project Staff, in order to discuss the different activities related to the project administration.
- 13) Meeting regularly with the personnel of UNDP, STE, SETRAVI in his/her area to follow up and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the Technical Officer 1 on Project Administration, shall perform the following duties:

- 1) Organize under his/her responsibility the execution of the project administration activities.
- 2) Organize, the project administration procedures, with the support of the Project Manager, STE, UNDP, consultants and vendors.
- 3) Supervise and follow up the state of progress of the project administration, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Technical Officer 3 on Project Administration				
Professional Background:	Desired experience and knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Major degrees in business administration, economics, electronics, industrial or systems engineering.</p>	<ul style="list-style-type: none"> <li>• Preferably with years of experience in the administration of technological projects.</li> <li>• Knowledge of UNDP procedures of project administration follow up</li> <li>• Knowledge of software oriented to project administration and to creation and maintaining of project archives</li> <li>• Relations with personnel and institutions involved in Demonstration Project</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• High initiative</li> <li>• Organization of procedures to carry out the project administration</li> <li>• Establishment, execution and follow-up of the stages of the project administration</li> <li>• follow up and reports making on the project administration</li> <li>• High ability to relate with people of any level and representation</li> <li>• Negotiation and conflict resolution</li> <li>• High ability for needs detection and decision making on project administration</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her activities</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: TECHNICAL OFFICER 4 ON MONITORING AND EVALUATION**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.24

Responsibilities and Duties:

A. Under the supervision of the Project Manager, and in close contact with the consultant on HFCB Operation analysis, the Technical Officer 4 on Monitoring and Evaluation, is responsible for:

- 1) Carrying out the analysis and report preparation of the HFCB operational performance. The activities of this position are to be made with the support of the Project Manager, the consultant on HFCB operation analysis, the Project Staff, other consultants, STE, and vendors.
- 2) All the activities listed below will be made by the Technical Officer on Monitoring and Evaluation with the support of the Director General, the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Developing of a detailed monitoring and evaluation plan showing the milestones and benchmarks of the HFCB and hydrogen production, storage and supply technology.
- 4) Making a proposal for timely execution of specifications setting, solicitation and procurement activities for the entire Demonstration Project.
- 5) Developing a detailed work plan for the delivery of HFC buses fleet and fuel cell facilities (hydrogen production, storage and supply technology), and of the operation of these equipments during the Demonstration Project.
- 6) Developing a detailed work plan for the manufacturers data certification of HFC buses fleet and fuel cell facilities (hydrogen production, storage and supply technology) prior to operation.
- 7) Preparation of a detailed work plan for commissioning buses, fueling system, spare inventories, software, etc.
- 8) Preparing the guidelines for quarterly reporting on mean time between failures and failure mode analysis, on the availability of vehicles and on fuel consumption, on hours and kilometers of operation by individual buses and the fleet as a whole, and on proposed engineering modifications, if it is concluded that they are needed, and the communication of these to vendors, plus confirmation of actions taken.

- 9) Participating in meetings with the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers that will meet with the role of informing, discussing, and decision making on issues related to the monitoring and evaluation.
- 10) Presenting before the Project Manager, Project Staff or any other institution when necessary, the state of progress of the monitoring and evaluation.
- 11) Making the analysis and report preparation, to be submitted to the authorities or institutions when necessary.
- 12) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 13) Participating in meetings of the Project Staff, in order to discuss the different activities related to the monitoring and evaluation.

B. Under the supervision of the Project Manager, the Technical Officer 4 on Monitoring and Evaluation, shall perform the following duties:

- 1) Organize the designing and execution of the activities related to monitoring and evaluation.
- 2) Organize the reports and procedures for monitoring and evaluation, with the support of the Project Manager, consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Follow up the state of progress of the monitoring and evaluation procedures, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Technical Officer 4 on Monitoring and Evaluation				
Professional Background:	Desired experience and knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
First degree, Master of Science and/or Major degrees in electronics, chemical, industrial, computer, mechanical or systems engineering.	<ul style="list-style-type: none"> <li>• Preferably with years of experience in the follow up of urban transport performance and operation tests, certification, monitoring and evaluation</li> <li>• English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership</li> <li>• High initiative</li> <li>• Organization of procedures to carry out the monitoring and evaluation</li> <li>• Establishment, execution and follow-up of the stages of the monitoring and evaluation</li> <li>• Follow up the monitoring and evaluation process</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making for the monitoring and evaluation process</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her activities</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>



**POSITION: TECHNICAL OFFICER 5 ON MONITORING AND EVALUATION**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.25

Responsibilities and Duties:

A Under the supervision of the Project Manager, and in close contact with the consultant on HFCB Operation and Maintenance Analysis, the Technical Officer 5 on Monitoring and Evaluation, is responsible for:

- 1) Carrying out the analysis and report preparation of the HFCB operation and maintenance performance. The activities of this position are to be made with the support of the Project Manager, the consultants on HFCB operation and maintenance performance analysis, the Project Staff, other consultants, STE, and vendors.
- 2) All the activities listed below will be made by the Technical Officer on Monitoring and Evaluation with the support of the Project Manager, the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Preparation of a detailed work plan for commissioning buses, fueling system, spare inventories, software, etc.
- 4) Developing of a work plan for preventive and predictive maintenance of the bus fleet
- 5) Developing of a work plan for preventive and predictive maintenance of the fuel cell supply subsystem (hydrogen production, storage and supply technology).
- 6) Preparing the guidelines for quarterly reporting on executive, preventive and maintenance for the bus fleet and the supply subsystem (hydrogen production, storage and supply technology).
- 7) Preparing the guidelines for quarterly reporting on mean time between failures and failure mode analysis, on the availability of vehicles and on fuel consumption, on hours and kilometers of operation by individual buses and the fleet as a whole, and on proposed engineering modifications, if it is concluded that they are needed, and the communication of these to vendors, plus confirmation of actions taken.
- 8) Participating in meetings with the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers that will meet with the role of informing, discussing, and decision making on issues related to the monitoring and evaluation.

- 9) Presenting before the Project Manager, Project Staff or any other institution when necessary, the state of progress of the analysis and report preparation.
- 10) Making the monitoring and evaluation report, to be submitted to the authorities or institutions when necessary.
- 11) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 12) Participating in meetings of the Project Staff, in order to discuss the different activities related to the monitoring and evaluation.

B. Under the supervision of the Project Manager, the Technical Officer 4 on Monitoring and Evaluation, shall perform the following duties:

- 1) Organize the designing and execution of the activities related to monitoring and evaluation.
- 2) Organize the reports and procedures for monitoring and evaluation, with the support of the Project Manager, consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Follow up the state of progress of the monitoring and evaluation procedures, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Technical Officer 5 on Monitoring and Evaluation				
Professional Background:	Desired experience and knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
First degree, Master of Science and/or Major degrees in electronics, chemical, industrial, computer, mechanical or systems engineering.	<ul style="list-style-type: none"> <li>• Preferably with years of experience in the follow up of urban transport performance and operation tests, certification, monitoring and evaluation</li> <li>• English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership</li> <li>• High initiative</li> <li>• Organization of procedures to carry out the monitoring and evaluation</li> <li>• Establishment, execution and follow-up of the stages of the monitoring and evaluation</li> <li>• Follow up the monitoring and evaluation process</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making for the monitoring and evaluation process</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her activities</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

**POSITION: TECHNICAL OFFICER 6 ON MONITORING AND EVALUATION**

Project : Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.26

Responsibilities and Duties:

A. Under the supervision of the Project Manager, and in close contact with the consultants on HFCB technological performance and operation analysis, the Technical Officer 6 on Monitoring and Evaluation, is responsible for:

- 1) Carrying out the analysis and report preparation of the HFCB technological and operational performances. The activities of this position are to be made with the support of the Project Manager, the consultant on HFCB operation analysis, the Project Staff, other consultants, STE, and vendors.
- 2) All the activities listed below will be made by the Technical Officer on Monitoring and Evaluation with the support of the Project Manager, the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Developing of a detailed monitoring and evaluation plan showing the milestones and benchmarks of the HFCB and hydrogen production, storage and supply technology.
- 4) Making a proposal for timely execution of specifications setting, solicitation and procurement activities for the entire Demonstration Project.
- 5) Developing a detailed work plan for the delivery of HFC buses fleet and fuel cell facilities (hydrogen production, storage and supply technology), and of the operation of these equipments during the Demonstration Project.
- 6) Developing a detailed work plan for the manufacturers data certification of HFC buses fleet and fuel cell facilities (hydrogen production, storage and supply technology) prior to operation.
- 7) Preparation of a detailed work plan for commissioning buses, fueling system, spare inventories, software, etc.

- 8) Preparing the guidelines for quarterly reporting on mean time between failures and failure mode analysis, on the availability of vehicles and on fuel consumption, on hours and kilometers of operation by individual buses and the fleet as a whole, and on proposed engineering modifications, if it is concluded that they are needed, and the communication of these to vendors, plus confirmation of actions taken.
- 9) Preparing the guidelines for quarterly reporting on operator and maintenance staff training and achievement.
- 10) Preparing a work plan for a comparative analysis of DBs versus HFCBs technological operational and maintenance performances.
- 11) Preparing the procedures for the annual review of progress towards fuel cell cost reduction, reliability improvement and increased durability.
- 12) Participating in meetings with the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers that will meet with the role of informing, discussing, and decision making on issues related to the analysis and report preparation.
- 13) Presenting before the Project Manager, Project Staff or any other institution when necessary, the state of progress of the monitoring and evaluation.
- 14) Making the monitoring and evaluation report, to be submitted to the authorities or institutions when necessary.
- 15) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 16) Participating in meetings of the Project Staff, in order to discuss the different activities related to the monitoring and evaluation.

**B. Under the supervision of the Project Manager, the Technical Officer 4 on Monitoring and Evaluation, shall perform the following duties:**

- 1) Organize the designing and execution of the activities related to monitoring and evaluation.
- 2) Organize the reports and procedures for monitoring and evaluation, with the support of the Project Manager, consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Follow up the state of progress of the monitoring and evaluation procedures, in order to comply with the UNDP annual and quarterly work plans.

Selection Criteria:

Technical Officer 6 on Monitoring and Evaluation				
Professional Background:	Desired experience and knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
First degree, Master of Science and/or Major degrees in electronics, chemical, industrial, computer, mechanical or systems engineering.	<ul style="list-style-type: none"> <li>• Preferably with years of experience in the follow up of urban transport performance and operation tests, certification, monitoring and evaluation</li> <li>• English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership</li> <li>• High initiative</li> <li>• Organization of procedures to carry out the monitoring and evaluation</li> <li>• Establishment, execution and follow-up of the stages of the monitoring and evaluation</li> <li>• Follow up the monitoring and evaluation process</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making for the monitoring and evaluation process</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her activities</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

## **POSITION: SUPERVISOR OF GARAGE MODIFICATIONS**

Project : Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.15

Responsibilities and Duties:

A. Under the supervision of the Project Manager, and in close contact with the consultants on HFCB technological performance, operation and maintenance analysis, the Supervisor of Garage Modifications, is responsible for:

- 1) Carrying out the supervision of the garage modifications and of the installation, tests and initial operation of the fuel supply subsystem (hydrogen production, storage and supply technology). The activities of this position are to be made with the support of the Project Manager, the consultants on HFCB technological performance, operation and maintenance analysis, the Project Staff, other consultants, STE, and vendors.
- 2) All the activities listed below will be made by the Supervisor of garage modification with the support of the Project Manager, the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Developing of a detailed work plan for the installation, testing and initial operation of the fuel supply subsystem (hydrogen production, storage and supply technology).
- 4) Making a proposal for timely execution of specifications setting, solicitation and procurement activities for the garage modifications.
- 5) Developing a detailed work plan for the delivery of the fuel supply subsystem facilities (hydrogen production, storage and supply technology), and other required garage modification, including the initial operation and testing procedures of these equipments.
- 6) Preparation of a detailed work plan for commissioning the fueling supply system.

- 7) Participating in meetings with the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers that will meet with the role of informing, discussing, and decision making on issues related to the garage modifications.
- 8) Presenting before the Project Manager, Project Staff or any other institution when necessary, the state of progress of the garage modifications.
- 9) Making the report on garage modifications, to be submitted to the authorities or institutions when necessary.
- 10) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 11) Participating in meetings of the Project Staff, in order to discuss the different activities related to the garage modifications.

**B. Under the supervision of the Project Manager, the Supervisor of Garage Modifications, shall perform the following duties:**

- 1) Organize the designing and execution of the activities related to garage modifications.
- 2) Organize the reports and procedures for the garage modifications, with the support of the Project Manager, consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Follow up the state of progress of the garage modifications procedures, in order to comply with the Demonstration Project work plan.



Selection Criteria:

Supervisor of Garage Modification				
Professional Background:	Desired experience and knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
First degree, Master of Science and/or Major degrees in civil, electronics chemical, industrial, computer, mechanical or systems engineering	<ul style="list-style-type: none"> <li>• Preferably with years of experience supervising the construction or reconstruction of plant installations and/or of urban transport garages</li> <li>• English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership</li> <li>• High initiative</li> <li>• Organization of procedures to carry out the garage modifications</li> <li>• Establishment, execution and follow-up of the stages of the garage modifications</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making for the garage modifications</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her activities during the period that the garage modification lasts.</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

## **POSITION: CONSULTANT ON GARAGE MODIFICATIONS**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 021.01

### Responsibilities and Duties:

A Under the supervision of the Project Manager, STE personnel, the Supervisor on Garage Modifications, the fuel supply subsystem (hydrogen production, storage and supply technology) providers, the Consultant on Garage Modifications, is responsible for:

- 1) Carrying out the garage modifications and setting up the required spaces for the installation, tests and initial operation of the fuel supply subsystem (hydrogen production, storage and supply technology). The activities of this position are to be made with the support of the Project Manager, the consultants on HFCB technological performance, operation and maintenance analysis, the Project Staff, other consultants, STE, and vendors.
- 2) Developing of a detailed work plan for the garage modifications.
- 3) Making a proposal for timely execution of specifications setting, solicitation and procurement activities for the garage modifications.
- 4) Preparation of a detailed work plan for commissioning the fueling supply system.
- 5) Participating in meetings with the consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers that will meet with the role of informing, discussing, and decision making on issues related to the garage modifications.
- 6) Presenting before the Project Manager, Project Staff or any other institution when necessary, the state of progress of the garage modifications.
- 7) Making the report on garage modifications, to be submitted to the authorities or institutions when necessary.
- 8) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 9) Participating in meetings of the Project Staff, in order to discuss the different activities related to the garage modifications.

B Under the supervision of the Project Manager and the Supervisor of garage modifications, the Consultant on Garage Modifications, shall perform the following duties:

- 1) Organize the designing and execution of the activities related to garage modifications.
- 2) Organize the reports and procedures for the garage modifications, with the support of the Project Manager, consultants on HFCB technological performance, operation and maintenance, other consultants, STE and the HFCBs and fuel supply system technology providers.
- 3) Follow up the state of progress of the garage modifications procedures, in order to comply with the Demonstration Project work plan.

Selection Criteria:

Consultant on Garage Modification				
Professional Background:	Desired experience and knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Major degrees in civil, electronics chemical, industrial, computer, mechanical or systems engineering</p> <p>This consultancy work can also be given to a specialized firm on construction or reconstruction of plant installations and/or of urban transport garages</p>	<ul style="list-style-type: none"> <li>• Preferably with years of experience on the construction or reconstruction of plant installations and/or of urban transport garages</li> <li>• English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open and executive leadership</li> <li>• High initiative</li> <li>• Organization of procedures to carry out the garage modifications</li> <li>• Establishment, execution and follow-up of the stages of the garage modifications</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making for the garage modifications</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her full time activities will be executed within the premises of UNDP, SETRAVI, STE and/or in the premises of the transit and environmental authorities of the Mexico City government, and within any other premises related to his/her activities during the period that the garage modification lasts.</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Selection through UNDP contracts committee</li> </ul>

## **POSITION: RESEARCH DIRECTOR**

Project: Demonstration Project of Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City

Budget Line: 017.02

### Responsibilities and Duties:

A. Under the supervision of the Project Manager, the Research Director, is responsible for:

- 11) Coordinating all consultant/researchers and technical officers in charge of the associated research, data collection, analysis and report preparation and monitoring and evaluation of the Demonstration Project.
- 12) Creating the necessary relations among national and international bus manufacturers, HFCB technology providers, bus electrical traction/control manufacturers and hydrogen producers, consultants and technical officers to keep close contact in the subprojects development.
- 13) Creating the necessary relations among Mexican bus operators, public transport governmental and political associations, lending and financing agencies, and bus manufacturers in order to obtain information required by the consultant/researchers and technical officers.
- 14) Participating in meetings with representatives of international transport / environmental projects, governmental and political agencies, private and state owned enterprises, local and international experts, national and international bus manufacturers, HFC bus developers, hydrogen producers, as demanded by his/her responsibilities.
- 15) Presenting before the Project Manager, Project Steering Committee, National Coordinating Agency, National Executing Agency, Monitoring and Evaluation missions or any other Agency related to the associated research, the state of progress of the complete associated research, as well as, the partial and final reports and their conclusions, in GEF format required by the UNDP.
- 16) Preparing the needed technical reports in GEF format of all the associated research, to be submitted to the Project Steering Committee, National Coordinating Agency, National Executing Agency, or any other Agency related with his/her activities.
- 17) Applying UNDP policies and procedures, within the framework of the National Execution modality, to all actions under his/her responsibility.
- 18) Developing the necessary tools in the field to ensure all activities are financially sustainable.

- 19) Participating in meetings of the Project Staff, in order to discuss the different activities related to his/her direction, and/or other activities of the project.
- 20) Meeting regularly with the personnel in his/her area to monitor and assess all the activities to be carried out to ensure compliance with their plans of action and contribution to the achievement of the Project outputs.

B. Under the supervision of the Project Manager, the Research Director shall perform the following duties:

- 4) Coordinate under his/her leadership the research group formed by consultant/researchers, technical officers or any other entity or personnel related to associated research.
- 5) Supervise and follow up the state of progress of all the associated research in order to comply with the UNDP annual and quarterly work plans.
- 6) Carry out, in close coordination with the Project Manager, SETRAVI, STE and UNDP Project responsible the supervision and follow up of the associated research projects planning following GEF procedures.

Selection Criteria:

Consultant/Researcher on: HFCB Mexican manufacturing process optimization				
Professional Background:	Proven and successful experience and broad knowledge in:	Abilities and/or skills in the following areas:	Personal qualities:	Hiring conditions:
<p>First degree, Master of Science and/or Ph.D. degrees in manufacturing systems, optimization systems, industrial, electrical, electronics, mechanical, transport or systems engineering, in economics or in business administration.</p> <p>Preferably with 10 years experience of successful leadership in the coordinating projects.</p>	<ul style="list-style-type: none"> <li>• Coordinate projects</li> <li>• Relations with consultants, representatives of bus manufacturers and HFCB technology providers, and hydrogen producers.</li> <li>• Relations with representatives of international transport projects, governmental and political agencies, private and state owned transport enterprises, local and international experts on HFCB manufacturing</li> <li>• Excellent English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Positive and open research leadership</li> <li>• High initiative</li> <li>• Organization of research projects and programs</li> <li>• Establishment, execution and follow-up of long, short and medium term research goals</li> <li>• Negotiation and conflict resolution within research actors and actions</li> <li>• Research planning, follow up and reports making</li> <li>• High ability to relate with people of any level and representation</li> <li>• High ability for needs detection and decision making on research topics</li> <li>• Excellent use of language to communicate and to write reports in both English and Spanish</li> </ul>	<ul style="list-style-type: none"> <li>• Fully committed</li> <li>• Honest, great thrust and initiative</li> <li>• Charismatic</li> <li>• Convincing, congruent</li> <li>• Adaptable</li> <li>• Empathic</li> <li>• Highly responsible</li> <li>• Hard worker</li> </ul>	<ul style="list-style-type: none"> <li>• Live in or near Mexico City</li> <li>• His/her full time activities will be executed within the UNDP, SETRAVI, STE premises, and/or the bus manufacturers, the HFCBs manufacturers premises,</li> <li>• High mobility capacities are required</li> <li>• Availability to take part in the project meetings as required</li> <li>• Availability to occasionally travel inside Mexico and abroad</li> <li>• Selection through UNDP contracts committee</li> </ul>

### **Project Steering Committee**

- The Secretary of Transport of the Mexico City Government (SETRAVI),
- The Director General of the Electric Transport Service of the Mexico City Government (STE),
- The UNDP Programme Officer
- The Project Manager,
- The Representative of the Technology Developers,
- The Representative of the Project Contract,
- The Research Director,
- Invited Members.

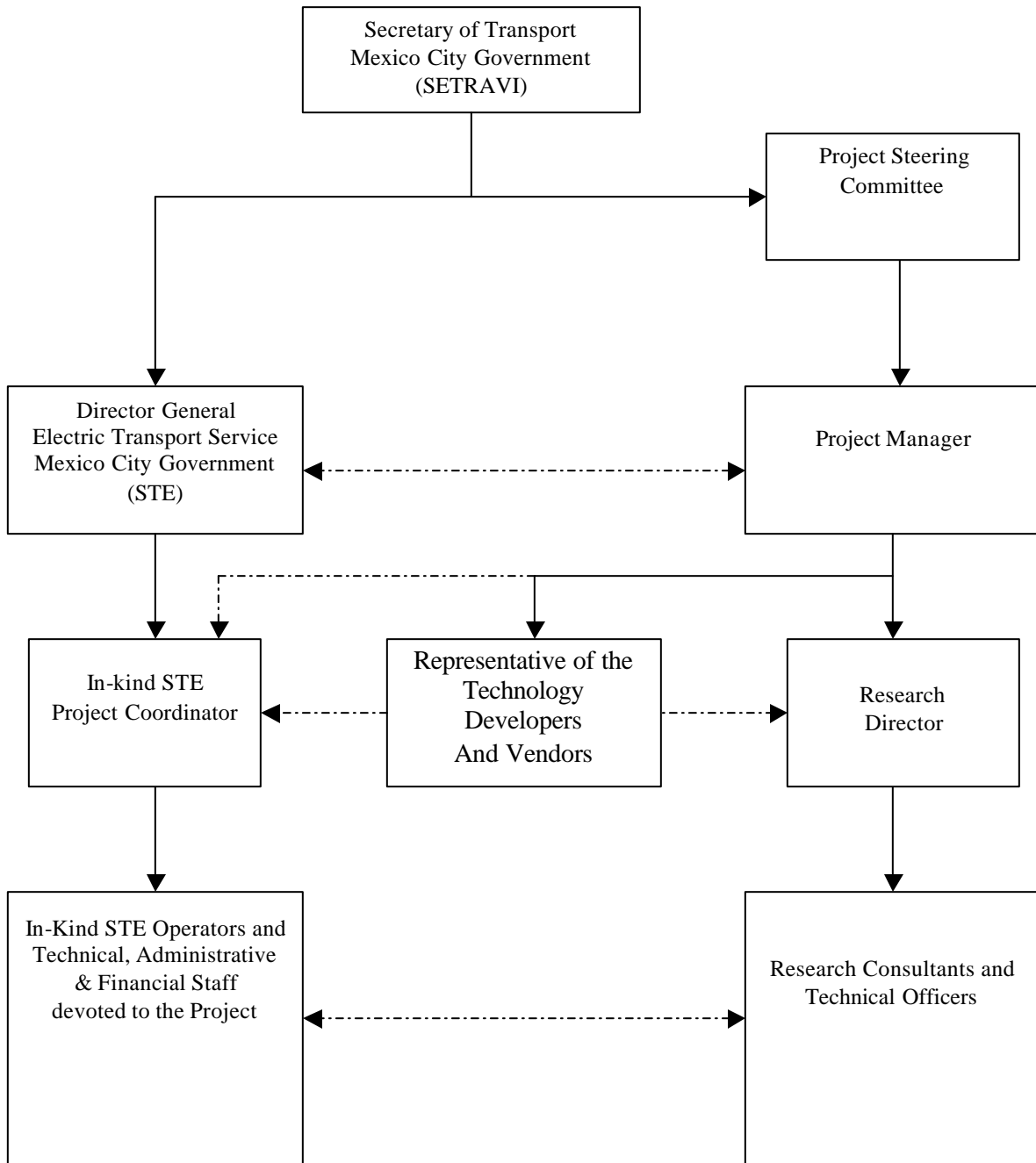


### **Project Staff**

- The Project Manager under UNDP subcontract
- Research Director, Consultants, Technical Officers, under UNDP subcontracts
- The in-kind SETRAVI and STE personnel devoted to the project
- The project HFCB technology developers
- The vendors representatives



**Project Staff Organisation Chart**



## **ANNEX F: TECHNICAL SPECIFICATIONS**

### **DRAFT TECHNICAL SPECIFICATIONS FOR THE ACQUISITION OF 10 ELECTRIC HYDROGEN FUEL CELL BUSES AND TECHNICAL SPECIFICATIONS FOR THE ACQUISITION OF A SYSTEM FOR HYDROGEN SUPPLY**

#### **BASIC SPECIFICATIONS FOR POTENTIAL SUPPLIERS**

##### **1 – INTRODUCTION**

This report deals with a Demonstration Project of Electric Hydrogen Fuel Cell Buses and an Associated System for Hydrogen Supply in Mexico City. Under this Project, 10 Electric Hydrogen Fuel Cell Buses (HFCBs for short) will be acquired and tested in their operational, maintenance and technological performance, when running in a commercial corridor during 5 years. The associated system for hydrogen supply will also be subjected, to operational tests under the applicable safety regulations.

This Demonstration Project is in agreement with the actions of the Mexico City Government to introduce the environmentally cleanest buses in the streets of Mexico City, as part of a long-term policy for airborne pollution control in the greater Mexico City Metropolitan Area.

The HFCBs Demonstration Project is funded by GEF - Global Environmental Facilities, through the UNDP – United Nations Development Program according to the approved Project Brief, Reference MEX/98/G42. The Electric Transport Service of the Mexico City Government (STE), and the private sector, mainly the potential suppliers of the 10 HFCBs and of the hydrogen supply system are also co-financing this Demonstration Project as they are deeply interested in the technological development and future commercialization of electric buses powered by hydrogen fuel cell stacks.

Regarding the 10 HFCBs, these will be purchased in 2 lots, through a two-part bidding process. The acquisition and operation will start with 3 HFC buses in 2001/2. Based on the successful production and acquisition of the first three buses, the bidding process will then be conducted for the remaining 7 buses in the year 2002/3. All 10 HFCBs will be acquired from a single vendor. However, a consortium may be formed, so that a combination of specialized companies may be subcontracted, for as long as those companies and their products are included in the acquisition offer and appraised in the bidding process, under the exclusive responsibility of a sole bidder. In that sense, International and/or Mexican bus chassis/body manufacturers established in Mexico or elsewhere are highly encouraged to participate as tenders. It should be clear that, with this bidding procedure we want to warranty full responsibility of the HFCBs suppliers in relation to the buses costs and quality. For that reason the HFCBs supplies will be mandatorily performed by one sole bidder or consortium as it was explained above.

On the other hand, the hydrogen supply system based on natural gas reformer to produce the hydrogen, as well as the equipment for storage and fueling the vehicles with hydrogen will be in principle negotiated under a different bidding process. The basis of this negotiation together with the basic technical specification for the hydrogen supply system are presented under chapter 7.

At the end of the 5-years Demonstration Project, and provided that the HFCB technology proves to be competitive in commercial and performance terms, STE and RTP (acronym in Spanish for Red de Transporte Público) both under the Authority of the Secretary of Transport of the Mexico City Government (SETRAVI by its name in Spanish) would initiate the acquisition of 100 HFCBs/annum starting in 2006.

The purpose of these two Invitations to Bid is the immediate purchase of a complete system composed by a set of electric hydrogen fuel cell powered buses and its associated hydrogen supply, comprising the following subsystems:

**HFCBs bid**

- 10 electric hydrogen fuel cell buses;

**Hydrogen supply system bid**

- natural gas based reformer and required peripheral equipment for the production of hydrogen; and
- equipment for storage and fueling the HFCBs with hydrogen.

These 2 Invitations to Bid shall identify qualified suppliers, whose appraisal will be performed by means of technical criteria and by the assessment of their ability to ensure the technical support required to conduct the project.

Along the implementation of the 2 bidding processes, the explanations that may be required by the bidders shall be requested to the Demonstration Project Director General, the STE Project Coordination, or the UNDP Office in Mexico.

With these bidding processes, we intend to disclose the Demonstration Project purposes, the supplier's knowledge of the HFCB technology and their degree of qualification to supply both the HFCBs, and the associated hydrogen supply system required for the described Demonstration Project.

Taking by granted a common interest among the different actors involved in the development of HFCB technology, this Demonstration Project will seek that, besides the technological development of Mexico in this area, the suppliers will follow and participate in the demonstration project activities, which will be public. In that sense, the technological results, and experiences emanated from the tests, replaced parts, and performance measurements of both the HFCB buses and the associated hydrogen supply system, will be used by the suppliers -in agreement with the purchasers- in the benefit of

their own products' development. For that reason, the bidders shall propose an interest of between 20% to 33% of the project's costs.

In all cases, any evaluation that may be performed during or after the tests must be followed by STE personnel, consultants and other participants of the Project Staff (PS), and the results may be freely utilized by STE and the UNDP.

With that purpose, the UNDP and STE intend to develop the following stages:

- a) Identification of companies and/or consortia which are able to supply HFC buses or their subassemblies separately (chassis, body, hydrogen fuel cell system, electrical traction system, digital electronic control, auxiliary equipment); and HFCB maintenance facilities provided with the safety equipment required.
- b) Identification of companies which are able to supply hydrogen production subsystems (natural gas based hydrogen reformer), gas storage and fueling subsystems and the associated maintenance facilities provided with the safety equipment required.
- c) Development of the 2 bid processes among the qualified companies or consortia, in order to purchase 10 HFCBs and the associated hydrogen supply system required for this Demonstration Project.
- d) Acquisition of a complete system, that is, 10 HFCBs, as it is described in item 5 – Basic Technical Specifications of the HFCBs.
- e) Negotiation of a complete hydrogen supply system that includes, the natural gas based hydrogen reformer, the subsystem for hydrogen storage and the subsystem for fueling the vehicles with hydrogen; as it is described in items 6 – basic technical specifications for the hydrogen supply, 7 – basic technical specifications of the hydrogen production subsystem, and 8 – basic technical specifications of the hydrogen storage and supply subsystem.
- f) A technical and economical follow-up of the HFCBs performance, aiming to the evaluation of the HFCBs and related subsystems, and of the Mexican technological capabilities that may be achieved.

## **2 – TECHNICAL DOCUMENTATION FOR THE BID**

The companies interested in these bids shall provide technical specifications and documentation for themselves, for the manufacturers, suppliers and sub-suppliers of the HFCBs and related subsystems, equipment, components and materials, comprising at least the following topics:

- A handbook with the fitting procedures and requirements, where applicable.

- A handbook with the operation procedures.
- A Maintenance Handbook and preventive maintenance program (HFCB, equipment and components of the HFCB and of the related subsystems).
- A Parts and Tools Handbook (including the special ones).
- Handbook/Warranty Term (HFCB, components, materials, equipment and related subsystems).
- A Training Program for STE personnel (operators, technicians and engineers).
- Technical Designs (HFCBs and related subsystems, combined, interior lay-out and painting).
- Methodology and results of the tests performed on the different parts of the HFCBs (chassis, body, hydrogen fuel cell system, electrical traction system, digital electronic control and HFCB maintenance facilities).
- A list containing the description and minimum quantities of spare parts (in CD), being mandatory the delivery of at least a full set of extra supply fuel cell stacks.
- In the case of fuel cells and their catalysts, the manufacturers shall specify the hydrogen minimum quality requirements needed to achieve a good operation and durability of the components.
- Methodology and results of the tests performed on the different parts of the hydrogen supply system (hydrogen production subsystems - natural gas based hydrogen reformer - gas storage and fueling subsystems and hydrogen supply system maintenance facilities).
- The subcontracted suppliers that do not take part in consortia for the supply of the whole system requested in these Invitations to Bid shall declare explicitly that they accept the specifications of the related subsystems, assemblies, subassemblies and materials that take part in these Invitations to Bid, and that the performance of their products will not be impaired if the specifications are complied with, in case STE opts later for the supply of the various subsystems by independent suppliers.

Before the manufacture of the subsystems, subassemblies, equipment or materials, STE shall conduct the analysis of the designs, specifications and compatibilities with the full system, such as the basic plan of the HFCB (dimensions, inner distribution of the passengers compartment, doors location, inner and outer visual communication, among others); the compatibility of subassemblies provided by different suppliers, the installation plan of the fixed equipment and other requisites and requirements of the

system and their implementation. In case of incompatibilities, the supplier(s) shall change its (their) specifications as required and according to the establishment of new criteria from STE, or the company shall be able to choose another supplier for the items at issue.

Once it is approved, a “Compliance Term” shall be issued for each design, which will cause it to be a “standard model” to be followed for the compliance with the specifications from the Project Staff.

The bidders disagreeing with the specifications contained in this Invitation to Bid shall inform STE on the fact, along with their justifications and suggestions, within 30 days after their publication, so that STE shall be able to analyze and eventually revise the specifications, at its exclusive discretion.

### **Costs**

The suppliers of HFCBs and of the associated hydrogen supply system shall present realistic cost estimates for each stage of the project (with specific amounts for the purchase of 3 HFCBs in the years 2001/2 and 7 additional HFCBs in the years 2002/3), taking into account the introduction of the fuel cells technology, and that the development of such products as a result of the project will comprise new future business opportunities, and they shall propose separately their interest percentages in those costs, as companies interested in the access to the results of the project.

As to the costs of the imported materials or items, they must indicate separately the total amounts to be paid, FOB, freight and incurring taxes. The costs shall also be indicated for each subsystem, as defined and specified in this Invitation to Bid.

### **Supply Terms**

The minimum terms for the supply of the 10 HFCBs and equipment for the demonstration project shall be presented, followed by the respective implementation schedules.

### **Characterization of the bidder or supplier**

The companies and consortia interested in the supplies that are object of these Invitations to Bid shall describe the characteristics qualifying them as suppliers and the items (assemblies, subassemblies or even special components) that they intend to supply or to purchase from other companies subcontracted by them.

Those descriptions shall be clear and detailed, defining the limits of the supply intended and the way of integration of their product in the full system of hydrogen fuel cell-powered buses and/or the complementary subsystems of production and storage of the fuel.

The following items shall take part in the characterization and qualification of the supplier:

- a) total practice time in the manufacture and supply of buses in Mexico;
- b) total practice time in the development and supply of the items offered, considering their participation in similar applications in Mexico;
- c) total of investments made in the technological development of the items offered;
- d) built area and number of people involved in the technological development and production of the items offered;
- e) characterization and quantification of similar supplies and applications already performed, indicating the durability of the items offered and of the items in operation.

### **3 – TECHNICAL RULING**

All the Resolutions, Technical Guidelines and Legislation specific to the manufacture industry must be complied with, in addition to those mentioned below, starting from their inclusion in this document, taking into account, however, that in case of doubt or disagreement, the original text description of such technical ruling shall prevail.

#### **3.1 – OF INTERNATIONAL NATURE**

3.1.1 All technical guidelines applicable to the design, manufacturing and testing of the HFCBs and of the hydrogen supply subsystem shall be based on the norms of the following International Associations:

AFNOR	-	Association Francaise de Normalisation
ASME	-	American Society of Mechanical Engineers
ASTM	-	American Society of Testing Materials
DIN	-	German Institute of Norms
FMVSS	-	Federal Motor Vehicle Safety Standards
ICEA	-	Insulated Cable Engineers Association, Inc.
IEEE	-	Institute of Electrical and Electronics Engineers
IEC	-	International Electrotechnical Commission
ISO	-	International Organization for Standarization
JIS	-	Japanese Industrial Standard
NEMA	-	National Electrical Manufacturers Association
SAE	-	Society of Automotive Engineer
UIC	-	Union Internationale des Chemins de Fer
UL	-	Underwriters Laboratories, Inc.

3.1.2. All technical guidelines applicable to the hydrogen production, storage and handling, pressurized chambers, pressure reductive equipment and its accessories shall be proposed by the vendors.

### **3.2 – MEXICAN NORMS**

The applicable Mexican Norms for the design, manufacturing and testing of the HFCBs and of the hydrogen supply subsystem are the following:

NOM	-	Norma Oficial Mexicana
NTIE	-	Normas Técnicas de Instalaciones Eléctricas
STV	-	Secretaría de Transportes y Vialidad del Distrito Federal
DDF	-	Gaceta Oficial del Distrito Federal

### **3.3 – STANDARDS PERTAINING SETRAVI**

All physical and dimensional characteristics of the HFCBs shall comply with the “Technical Guidelines for Vehicles of the Public Service Transport in the Federal District of Mexico” issued by SETRAVI (this document will form part of the International Bid).

### **3.4 – ENVIRONMENTAL CONDITIONS OF OPERATION**

The HFCBs and the hydrogen supply system will operate under the following most severe environmental conditions:

- Heavy raining season	4 months a year
- Average pluvial precipitation	816.2 mm/year
- Ambient temperature	0 to 40°C
- Relative humidity	90% maximum
- Mexico City altitude	2240 m above sea level
- External agents	Acid raining, volcanic ashes raining, seismic zone, grease, oil, solvents, and occasional graffiti on the HFCB body

## **4 – DEVELOPMENT AND USE OF NEW TECHNOLOGIES**

New technologies must be applied to the HFCB project as a whole or to its subassemblies, as well as to the natural gas based hydrogen reformer, storage and fueling subsystems, in addition to the elements mentioned in this document, targeting the



comfort, safety, performance, durability and optimization of the material and human resources, mainly concerning the decrease of sensitiveness of the catalyzers utilized in the fuel cells to the carbon monoxide and sulfur compounds, as well as of the electronic systems on board, enabling the self-management of the main subassemblies taking part in the HFCB, such as suspension, steering wheel, motor, brakes, H<sub>2</sub> inventory in the HFCB, monitoring and control of the parameters related to the performance of the power generating subassembly (hydrogen fuel cells system) and of the electric motor.

Since technologies that are new to Mexico are involved, such as that of the hydrogen fuel cells, the purchase of complete HFCBs will be necessary, as long as their subsystems are suitable to the local conditions by means of an engineering development with the highest Nationalization rate possible, and as long as they are assembled in Mexico by bus manufacturers installed in Mexico or consortia with their participation. The new technologies introduced in the project shall be submitted to the PS previous approval.

## **5 - BASIC TECHNICAL SPECIFICATIONS OF THE HFCB**

This document presents the basic specifications desired, which shall be followed by the manufacturer/supplier of the HFCBs, equipment, subassemblies and materials, but the manufacturer/supplier shall be free to propose the most convenient alternatives for his company, as long as they are proved and justified, which must be approved by the PS before their adoption.

The items that are usually utilized in the HFCBs, such as side mirrors, windshield wipers, kinds of tires, etc., are not specified here in order to provide freedom to the suppliers to utilize their usual production components and, that way, to avoid raising the prices of the final products.

However, each supplier shall list and specify the components or subassemblies utilized, in a clear and objective way, indicating the characteristics defining the product, and prove compliance with the Mexican legislation (SETRAVI guidelines) where applicable. The bidder shall show his level of interest in producing in Mexico, or in joining Mexican companies to supply his products in Mexico. He shall show also the existence and the rate of his interest in co-financing the development, together with the project funds. According to maximum private involvement scenario, the private sector will finance between 20% to 33% of the project.

### **5.1 – STRUCTURE OF THE HFCB**

The HFCB structure -preferently of the low-floor type, whose specifications will be described by the manufacturer- shall be designed in order to meet the performance features described in this specification and may be one of the three following types:

- Monoblock.

- Structural chassis and body.
- Integrated body and platform.
- The (local and globalized) rigidity shall be enough to prevent noises and vibrations impairing the comfort of the passengers.

### **Minimum capacities**

The manufacturer shall describe in detail the technical specifications regarding passengers seats and area for standing passengers for a low-floor type HFCB.

The integrity of the system shall be ensured under all the operation conditions in urban traffic, meeting with safety the usual requests and those resulting from overloads due to the HFCB operation, including an unusual occupation of 10 standing passengers per square meter of functional area, being able to support the dynamic load deriving from the usual operation conditions.

### **HFCBs Life**

The transportation system by means of hydrogen fuel cell-powered HFCBs was conceived for an average 20-year effective life of the buses, so that the main subassemblies shall have a higher durability than that, while other components may be less durable and their replacement and exchanges periodicity shall be previewed in the preventive maintenance plan. In principle, the following minimum values for the effective life of the main subassemblies are expected:

Chassis and body 20 years

Electric and traction subassemblies 30 years or 3,000,000 km

Hydrogen fuel cells:

First prototypes 3 years or 250,000 km

Project target 7 years or 700,000 km

The manufacturer shall present a development schedule ensuring, at least, the target intended.

## **5.2 - ENVIRONMENTAL PROTECTION AND COMFORT**

### **5.2.1 - Exterior Noise Emission**

The manufacturer shall present technical specifications on this issue.

### **5.2.2 – Interior Noise Level**

The maximum noise levels allowed, with doors and windows closed, are:

77 dBA: HFCB with a maximum acceleration from rest up to the maximum speed on good quality pavement.

60 dBA: Ventilation system of the HFCB at full charge.

72 dBA: HFCB parked with all the auxiliary equipment running.

60 dBA: Each equipment installed under the HFCB, running under the usual conditions, except for the propulsion system.

### **5.2.3 - Electromagnetic Noise Emission**

The supplier shall ensure the protection required to prevent any interference whatsoever on the equipment in the surroundings, such as pacemakers, airbags, ABS, etc., besides describing and specifying the protection devices used with that purpose.

In the electromagnetic equipment, sensitive to the generation of electromagnetic noise that may impair the radio-reception, there must be a provision of filters suited to suppress such noise.

The levels of radio-interference (electromagnetic noise) generated by the HFCB are subject to approval by the buyer.

The elimination of electromagnetic noise shall comply with the standards proposed by the manufacturer and are subject to approval by the buyer.

## **5.3 – RELIABILITY, WARRANTY AND PREVENTIVE MAINTENANCE**

As a target of the Demonstration Project, in the project of each subassembly, the quantity of failures that may occur, implying repairs out of the maintenance interval, shall be foreseen. The HFCB shall not present failures interrupting its operation in frequency higher than once in every 50,000 km driven. The manufacturer shall indicate the reliability predicted for its project, which will be the object of scoring.

In addition, the fueling subsystem shall not present failures compromising or interrupting, even momentarily, the operation of the bus transportation system.

A Preventive Maintenance Plan shall be prepared for each subsystem, within the standards required, which shall ensure to the assembly the reliability level specified above. Therefore, for all the assemblies, subassemblies and components, there must be a specification of the replacement terms before such failures occur.

The supplier must be able to provide a 5 (five)-year warranty on the operation and be responsible for the preventive maintenance plan, including the replacement of vital parts, which ensures the subsystem operation with the reliability desired, as well as specify the terms for the replacement of components before such failures occur.

## **5.4 – CHASSIS**

### **5.4.1 – Steering**

The steering system shall be integral hydraulic or pneumatic.

The mechanic and geometric features of the system shall be optimized so as to allow accuracy of control and response, high steering stability and the adequate return to the position corresponding to the rectilinear course once the steering effort ceases.

The steering mechanism shall be designed so as the moves due to the suspension action do not introduce directional effects disturbing the HFCBs course.

The tangential effort applied by the driver, in case of a total loss of hydraulic assistance in any maneuver, shall not be higher than 500 N.

The hydraulic or pneumatic pump shall be vane type, activated by an electric motor and electrically insulated from the HFCB structure.

In case of failure in the electric power supply, the system shall not suffer an immediate reduction of the hydraulic assistance, which shall be maintained in the proper levels for at least 20 seconds, in order to ensure safety in the pulling over maneuver of the HFCB.

#### **5.4.2 - Suspension**

The suspension shall be fully pneumatic or pneumatic-spring combination (air and springs) , with a preference for a height variation system .

The suspension shall, in all the operation conditions of the HFCB:

- a) Lessen the shocks and vibrations of the body, originated by defects on the paved surface.
- b) Ensure stability to the HFCB.
- c) Keep constant the height from the ground in relation to the shafts, so as to ensure the comfort of the passengers.

The elastic elements shall be provided with stroke limitation devices capable of, in case of total loss of pressure or rupture of the springs, allowing the continuity of the operation without compromising the safety of the passengers and the HFCB.

#### **5.4.3 - Brakes**

The brake system comprises the following subsystems:

- a) Brake: is made up by the friction brake acting on all wheels and by the electric brake.
- b) Parking brake: acts on the rear shaft, keeps the HFCB motionless and acts automatically as an emergency brake.

The friction brake system shall be drum or wheel with fully pneumatic action and made up by two independent circuits, one for the front shaft and the other for the back shaft, capable to cause a  $5,0\text{M/S}^2$  deceleration with the HFCB in the total gross weight situation.

The electric brake of the HFCB shall be activated automatically by means of the brake pedal.

The parking brake, fed by a third independent circuit, shall comprise energy accumulator cylinders acting by means of springs, integrated to the activation servomechanism of the back shaft brake.

The HFCB shall remain directionally stable, in any braking operation and under any load conditions whatsoever.

The system shall comply with the legal safety requirements applicable in the date of production.

#### **5.4.4 - Shafts**

The system shall endure the vertical strains due to the HFCB weight and inertia, the horizontal strains resulting from accelerations, decelerations and pavement defects, as well as the transverse ones.

The system integrity shall be ensured in all the operation conditions of the urban traffic, meeting with safety the usual demands and those arisen from overloads, due to the operation of the HFCB, including an unusual occupation rate of 10 standing passengers per square meter of area available, being able to support the dynamic load originated from the usual operation conditions.

The supplier shall present the loads transmitted to the ground, for each shaft, in the total gross weight situation.

The transmission system shall be suited to the performance specified, and perfectly compatible with the traction system.

#### **5.4.5 – Subassemblies for Propulsion, Energy Generation and Feeding of the Hydrogen Fuel Cells Description**

a) Electric traction subassembly :

The electric traction equipment of the HFCB shall be designed so as to meet the performance requirements.

The propulsion subassembly shall utilize, in principle, a high-revolution AC electric motor, water, air or oil cooled, with a speed reducer acting on the HFCB back wheels. Alternatives may be considered, as long as they are duly substantiated.

b) Cooling subassembly:

The operation temperature of the hydrogen fuel cells shall be specified and recommended by the manufacturer, and it must be maintained in those levels by a thermostatically controlled system, such as a radiator(s) with electronically controlled fan(s). If that system utilizes water as the cooling fluid, the water may also be used to moisten the air and the fuel gas flow before its entrance in the hydrogen fuel cells stacks, in case it is necessary. In that case, some device (such as a ion exchange filter, for instance) shall be proposed to keep the water pure, in order to prevent it from turning into an electricity conductor.

An auxiliary cooling system shall be provided to cool the high power electric and electronic components and the exhaust vapors condenser, according to the manufacturers' specifications for those components.

c) Control subassembly:

The mechanical, processing and electric source subassemblies shall be coordinated and controlled by means of a device integrated with modules for the dosage of fuel and air, cooling, traction force, indicators and operation modes (ignition, warming, use and switching off). The control device utilizes the information from the interior instruments and provides responses to several components, such as motor controllers, valves and indicators, utilizing a digital signal processor (DSP) or any other digital processor proposed by the manufacturer.

The acceleration control shall respond to the position of the acceleration pedal without interruptions in the intensity of the traction thrust.

d) Electric subassembly:

The electric subassembly is made up of the interfaces for the power transfer from the hydrogen fuel cells system to the electric equipment, the motor and the HFCB. The power for the main motor shall be provided with nominal values of 600 V and 400 amperes or any other nominal values proposed by the manufacturers. Current switches for the protection of circuits and controllers managing the HFCB traction and the auxiliary systems shall preferably be centralized in the same place. CC to AC converters shall provide power in the different voltages required to the operation of the motor and of the other pieces of equipment in the HFCB. The high power electric components may be cooled by a liquid in order to reduce size and weight. Alternatives may be considered, as long as they are justified.

e) Hydrogen fuel feeding subassembly:

The fueling must be performed under a pressure limited to 3 (three) bar or the pressure recommended by the manufacturer, by means of two-stage regulators. In order to ensure a uniform distribution and the full use of the fuel, as well as the moistening of the gases inside the cells, a device or a fuel cells-fed hydrogen re-circulation system shall be provided.

f) Air supply subassembly:

The discharge and pressure parameters for the air supply shall be specified for the optimization of the fuel cells operation and control of the power produced, and to ensure the proper removal of the water produced by the electrochemical reaction on the electrodes.

The filtering, pressurization and control of the air flow subassemblies shall be specified and provided by the hydrogen fuel cells manufacturer, integrated to the system.

g) Hydrogen fuel cells subassembly:

The hydrogen fuel cells shall preferentially be of the “Proton Exchange Membrane” type or any other type of hydrogen fuel cells proposed by the manufacturer. The number and size of the stacks of interconnected hydrogen cells, which make up the cells subassembly, shall be specified in order to ensure the supply of the power required to all the electric systems and subsystems of the HFCB, including for the momentary surges required at the start of the motor and in short accelerations.

Labyrinths and inner galleries shall distribute the flows of fuel, air and cooling liquid, as well as collect the water produced by the fuel cells operations and assist in the removal of the heat generated in the electrodes, maintaining the cells in the proper operation temperature.

h) Hydrogen containers in the HFCB:

The compressed hydrogen shall be stored in pressurized cylinders, preferentially installed on top of the HFCB, so as to ensure the proper ventilation of the containers and preserve the largest interior space in the HFCB.

The supplier shall specify the Safety Guidelines utilized and demonstrate the compliance of its product with those guidelines, indicating the types of the sensors utilized and their location, as well as the conception of the monitoring and safety system concerning leakages. The Supplier must operate the fuel supply system.

i) Dynamic braking

The HFCB propulsion subassembly shall have characteristics allowing for the dynamic braking.

## **Hydrogen consumption targets**

The hydrogen consumption targets shall be specified by the HFCB manufacturer so that the fuel supply system full fills this requirement.

## **Performance requirements**

The manufacturer shall indicate in detail the indexes and parameters characterizing the HFCB performance, taking into account all the items required and mentioned in this document, especially the acceleration curves and the traction capacity with relation to the speed, fuel consumption, time to reach the working conditions in cold and hot starts and other requirements considered important to characterize the subsystems and the HFCB regarded as a whole.

## **Accessories**

The following items are considered components required to the HFCB operation:

- air supply subassembly;
- cooling devices;
- devices for the H<sub>2</sub> flow control;
- safety mechanisms.

### **5.4.6 – Traction Control Equipment**

The manufacturer shall describe in detail the technical specifications and guidelines utilized in the HFCB and in each subassembly, according to the following list:

#### **General Features**

- DC/AC Converter Control type
- Insulation
- Ventilation
- Equipment protection
- Test points for control parameters monitoring
- The parameters monitored
- Insulation trials
- Printed circuit cards and modular units
- Cables and connectors
- Protection against external radio-interference and protection of the circuits themselves.



## Operational and Manufacturing Features

The DC/AC converter control for the traction control shall use in principle intelligent IGBT 's (Insulated Gate Bipolar Transistor) or IPM's technology. Any other alternative proposed by the manufacturer shall be consider if fully justified.

The acceleration control shall act so as to meet the requirements mentioned, satisfying the performance requisites in the Total Gross Weight condition:

- the traction acceleration control shall allow for the command corresponding to the accelerator pedal position, conferring continuous characteristics, without interruption in the intensity of the traction effort. The acceleration position sensor shall be redundant.
- starting from the rest position on a horizontal pavement and in an environment with a temperature between 15°C and 25°C, the HFCB shall reach 50km/h at most in 18 seconds.
- the HFCB shall be able to reach the following accelerations on acclivities:

### Acclivity (%) at ( $m/s^2$ )

00 1.30

05 1.20

10 0.70

15 0.30 (at the moment of start)

Other values of acceleration on acclivities can be proposed by the manufacturer and subject to PS and STE approval.

- the HFCB acceleration shall be limited, in whatever situation, to a maximum value of 1.3  $m/s^2$ . The acceleration variation rate shall be limited to a maximum value of 1.5 $m/s^3$  , either in the moment of start of the motor or during the reapplication of the traction effort.
- the HFCB shall be started with an automatically controlled acceleration, regardless of its load and the slope, preventing the backward movement of the HFCB, allowing the motor to be exerted in the limit conditions, without detrimental surges.
- when the HFCB exceeds 55 km/h, a sound signal shall be activated. The system shall limit the maximum speed of the HFCB to 60 km/h, and a 3-digit counter shall record the number of times that speed was reached.
- for the model garage implementation stage, the PS may change the specifications above, in consequence of the technologic development and the results of the test stage.

The electrical braking control shall act so as the following requirements are met, in the situation of Nominal Gross Weight, on a flat, horizontal and dry pavement, save where there are different indications:

- deceleration rate regardless of the HFCB load and the slope, as long as it is not overloaded;
- the control equipment shall promote a maximum deceleration (as a component of the electric braking) between  $1.0\text{m/s}^2$  and  $1.3\text{m/s}^2$ , adjustable according to the brake pedal stroke, in the Total Gross Weight condition, starting from any speed whatsoever up to 10km/h;
- the deceleration variation rate (jolt) shall be limited to the maximum value of  $1.5\text{m/s}^3$ , either in application or in the reapplication of the electric braking;
- the electric brake shall be activated immediately after the idle course of the brake pedal, besides having continuous characteristics, with no steps, and the maximum effect of the electric braking shall be reached at the beginning of the performance of the air braking;
- for the dynamic electric braking, the bidder shall specify the systems it intends to offer.

The whole equipment shall be designed modularly in order to ease the maintenance.

The supplier shall describe the control equipment or digital control logic, which shall be designed with the purpose of interpreting and processing the signals produced by means of the accelerator and brake pedals, monitoring and activating the maneuver equipment, controlling the current in the traction motor and the air and hydrogen flows and pressures on the cells, controlling their auxiliary equipment and performing the protection functions.

It is desirable that the control device have diagnostic indicators of defects, hydrogen leakages and other safety items and that there are integrated control and supervision circuits.

The traction equipment shall not allow for a backward movement of the HFCB when it departs on a slope.

#### **5.4.7 - Low Voltage Electric Equipment**

The low voltage electric subassembly shall operate at a 24 Vcc nominal voltage (or other voltage proposed and justified by the manufacturer), supplying the power required to meet the HFCB interior lighting level, as well as the other equipment and accessories.

That subassembly shall be fed by two sets of sealed batteries, both 24 V (alternatives proposed and justified by the manufacturer can be considered). The first one will supply power to the conventional equipment of the HFCB, and the second one will feed the electronic systems of the clippers. Each set of batteries will have its own static charger, fed from the inverters.

The equipment shall be fitted with an overall checking system that will be able to provide an optical indication on the Dashboard, in the case of critical failures.

#### **5.4.8 – Auxiliary Electric Subassembly**

The Auxiliary Electric Subassembly shall provide power to activate the following systems and subsystems:

- hydraulic or pneumatic steering pump;
- ventilation/exhaustion of the passengers compartment;
- air conditioning;
- compressor(s) to activate the suspension, brakes, doors, etc.;
- the ventilation motor of the semiconductors box;
- batteries charger (24Vcc);
- the motor for induced cooling ventilation of the traction motor, hydrogen cells and other equipment, where applicable.

There shall be an optical indicator on the Dashboard to indicate whatever failure in the subassembly.

The access for checking and maintenance of all parts and components shall be easy.

The supplier shall specify in detail its conception of the auxiliary electric subassembly.

#### **5.4.9 - Lubrication**

The lubrication subassembly will be centralized and automatic for all the lubricated parts of the chassis/platform, ensuring a specified dosage at regular intervals, keeping a renewed grease, regardless of the type of work, preventing the early wear of the parts caused by a lack of the proper lubrication. The manufacturer shall determine the grease substitution/addition periodicity for lubrication.

### **5.5 - BODY**

All specification under this paragraph shall comply with the SETRAVI technical guidelines for urban transport service in Mexico City. However, considering that a low-floor type of HFCB is preferably requested, the manufacturer shall feel free to present the whole specifications of their HFCBs.

## **Dimensioning**

The design of the preferably low-floor HFCB shall provide the smallest weight possible and its dimensioning shall be performed based on a static load equal to the HFCB full of passengers, utilizing an occupation rate of standing passengers per square meter defined by the manufacturer.

### **Dimensions of the steps, the floor and doors:**

Dimensions of the steps, the floor and doors shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

### **HFCB floor:**

All the unprotected structural parts below the floor, including the inner part of the body valance of the body, if they are built with materials subjected to corrosion, shall be adequately protected with the use of compounds and sealants, besides the conventional anti-noise treatment.

The floor shall be covered with a rubber blanket or other antiskid material ensuring the electric insulation, with no indentations, waterproof and with no metallic bands on the coating.

All corners must be round and protected by rubber or plastic bands, with no rough edges or projections that could harm the passengers. The rubber blanket shall be fixed with the suitable glue, and the use of nails, rivets or other perforating means is not allowed.

The floor shall be watertight when submitted to washing operations. The equipment on it shall not, in any way, be affected during those operations.

### **Service Doors**

a) The HFCB shall be provided with 2 (two) disembark doors and 1 (one) embark door. Configurations with doors on the right side and/or on the left side of the HFCB may be required.

b) The doors shall be operated exclusively by the driver.

c) The activation shall be electro-pneumatic, with compressed air valves near each door, fitted with mufflers. Alternatively, the electric activation of the doors may be proposed.

d) Near each door there shall be a device allowing for the valves pressure easing, to be manually activated in case of emergency, with an easy access and safe from accidental activation by the passengers.

e) The system shall allow for the opening and closing of the doors between 2 and 5 seconds.

- f) The entrance door shall be located as near the HFCB front as possible.
- g) All doors shall have a 2,000 mm minimum free height.
- h) The doors shall have 2 (two) blades, opening in such a way that their inner side is turned to the passengers and, when open, they shall not protrude more than 20 mm outside the body of the HFCB. Alternatively, a one-blade door shall be proposed, sliding outside the HFCB.
- i) The steps shall have the smallest trimmings possible, so that they will not present any risk to the passengers.
- j) The edges of the blades that are side-by-side when the doors close shall be provided with a soft material stripe ensuring their sealing and with a minimum 50 mm width.
- k) The entrance door shall be fitted with glass so that, with the door closed, the driver is able to see a point at the height of 200 mm from the ground and 400 mm from the HFCB side. The other doors shall have at least 2 (two) upper halves fitted with glass covering the widest area possible on the panels.
- l) The glass fitting on the doors shall be made with safety glasses or other proposed by the manufacturer.
- m) The HFCB shall have an electric interlocking between the control circuits of the doors and traction, so that, in regular conditions, it will not be able to move with the doors open.
- n) A key shall be fitted in the outer side of the HFCB to open the front door, so that the driver is able to get into it.
- o) A bypass switch shall be fitted near the doors mechanism, on the front door, which will allow for the regular moving of the HFCB in the case of defect of the interlocking with the traction.
- p) The compressed air feeding system for the doors cylinders shall have a properly dimensioned container, in order to keep the system uniform, and it shall have a pressure reduction valve at its entrance.

### **Steps**

- a) The structure of the steps shall be designed taking into account the cyclic loading effect, from the embarking and disembarking of the passengers and which may cause possible fatigue problems.

- b) The steps and their connection with the rest of the structure shall support six people, weighing 640 N each (alternatives proposed and justified by the manufacturer can be considered).
- c) All parts of the steps that may be touched by the passengers, being in contact with the ground, shall be electrically insulated from the rest of the HFCB.
- d) There shall be 2 (two) steps, at most, between the HFCB and the ground (alternatives proposed and justified by the manufacturer can be considered).
- e) The inner corners of the steps shall be rounded to prevent the accumulation of dirt, and the edges shall not have clasps in order to prevent the passengers from stumbling
- f) The steps shall be coated with antiskid material.

### **Windows, windshields and rear windshields**

Specifications of the windows, windshields and rear windshields shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

- a) All glasses utilized in the windows and fixed must be tempered, except for the front and rear windshields, which shall be laminated, with a 70% minimum transparency.
- b) All windows, windshields and fixed glasses must be protected from water dripping from the roof in the case of rain.
- c) The frames of the movable part of the window shall allow for a smooth sliding with an effort lower than 20N, and that characteristic shall not suffer any change due to the constant use.

They shall be coated with a fabric in similar material so as to reduce the vibration and noise levels.

- d) The height of the front windshield shall allow for a visual angle higher than 20° (twenty degrees) for drivers within the anthropometrics range specified in the guideline and its complement.
- e) The back windshield must be ample, with its bottom immediately above the back of the rear seat and its top part following the same height as the side glasses, and it shall not cause interior reflecting.
- f) It shall have emergency windows located on both sides of the HFCB and their operation shall be easy, with clear and distinct instructions on their handling, located according with the following description:

- 2 (two) windows located on the left side of the usual HFCB, non-adjacent and distributed equally.

g) The windows shall have a 900 mm minimum height and a 1,400 mm minimum length. Their bottom shall be located at 900 mm above the floor, at most, while their top shall be located 1.750 mm above the floor, at least.

h) In case the HFCB is not air-conditioned, the side windows shall be divided in two equal parts in their height, with sliding panes on top and fixed panes at the bottom, except for the windows behind the back doors.

i) A sun visor shall be provided to be used by the driver.

### **Passengers' seats**

Specifications of the Passengers' seats shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

a) The seats shall be upholstered and provided with a head protection.

b) The upholstery shall be anatomically shaped for a perfect pressure uniformity.

c) All passengers' seats shall be installed forward-oriented, except for those installed on the wheel boxes, which may be back-to-back with other seats or laterally located.

d) The seat and its back shall be independent.

e) The seats installed on the wheel boxes shall be provided with armrests in the aisle side.

f) All seats shall be provided with handles installed on top of the seat back.

g) The back seat shall comprise individual or double seats, instead of a continuous seat.

h) The whole metallic frame of the seats shall be built with an anti-corrosion material or with a material protected against corrosion by means of the proper treatment.

i) All seats shall be at least 30 mm far from the interior sides of the HFCB body.

(alternatives proposed and justified by the manufacturer can be considered)

### **Posts, balusters, handrails and supports**

Specifications of the posts, balusters, handrails and supports shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

- a) The HFCB shall have support rails for the passengers, in adequate quantities, in the shape of posts, balusters, handrails and supports, and their distribution shall be done in such a way that the passenger, when moving along a crowded HFCB, may always have a support within his/her reach.
- b) Balusters, handrails and posts, as well as their connections with the HFCB frame, shall endure the pressures of the everyday utilization without presenting permanent deflections.
- c) The handrail height shall remain constant along the HFCB.
- d) The posts, balusters and handrails located near the doors shall be electrically insulated from the rest of the HFCB body.
- e) The top handrails, located above the single seats shall be installed with their axis at 1,850 mm above the floor.
- f) The top handrails aligned with the sides of the seats, as well as their extensions in the regions where the aisle is wider, shall be located approximately 1,900 mm above the floor.
- g) All the variations in height and direction of the top handrails shall be slightly curved.
- h) All the top handrails and balusters shall end in a curve fastened on the ceiling and the side of the HFCB, respectively.
- i) The handrails of the steps shall have a support on the first and second steps and on the ceiling, at a height between 860 mm and 960 mm from the natural inclination of the stair.
- j) The posts, the top handrails, and the stair handrails shall be made with a round tube with a 30 or 40 mm exterior diameter, made in stainless steel or aluminum tubes with a surface treatment.

### **Panels-screens**

Specifications of the panels-screens shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

- a) All panels shall have round corners and edges, as well as a 40 to 60 mm distance from the floor and the ceiling, in the case of the driver's sun visor.
- b) The HFCB shall be provided with panels-screens in front of each seat turned to the stairs and behind the driver's seat.
- c) The panels-screens located in front of the seats that are turned to the stairs shall be as wide as the corresponding seats.



- d) The panels shall be manufactured in non-corrosion and opaque material.
- e) The finishing material shall be the same one utilized in the coating.

### **Driver's seat**

Specifications of the driver's seat shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

- a) The driver's seat (and the ticket-collector's, if applicable) shall be provided with a safety belt, a head protection and an anatomic shape, molded in the upholstering material so as to ensure good comfort levels to an operator within the anthropometrics range specified in ABNT NBR 6056/80 guideline and the complementary guidelines.
- b) The steering-wheel shall be coated.
- c) The blinker lever shall be fitted on the left side of the steering column and be provided with an automatic return.
- d) The horn shall be blown by means of a button located preferably on the steering-wheel.

### **Speedometer/odometer**

Specifications of the speedometer/odometer shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The speed indication system and at least one non-settable accumulator of the distance traveled shall be installed in a sole instrument and the unit of measure for distance shall be the kilometer (km). The speedometer shall indicate the 80 km/h speed with a 2% accuracy and be graduated with 10 km/h sections, with 5 km/h subsections just with a broken line marking.

The kilometrical accumulator shall be provided with six digits, reaching its maximum capacity at 999.999 km.

### **Tachograph/computer aided graphic recorder manometer**

The manometer shall measure the pressures in the air chambers of the front and back brakes independently, by means of two pointers and its scale graded from 0 to 10 bar, partitioned every 2 bar.

### **Lighted indicators**

Specifications of the lighted indicators shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The dashboard shall have the following lighted indicators:

traction;  
air brake;  
insulation of the 600 V circuit;  
motor ventilation/temperature;  
stop requested;  
reverse gear selection;  
on speed;  
high beam;  
blinker;  
parking brake applied.

### **Ventilation and air-conditioning**

Specifications of the ventilation and air-conditioning shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The HFCB shall be provided with 2 (two) forced ventilation systems:

- ventilation/windshield defogger;
- ventilation or air-conditioning of the passengers compartment.

The supplier shall specify and quote an air-conditioning system as an option.

### **Interior communication system**

Specifications of the interior communication system shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The communication between passengers and the driver shall be performed by means of the stop sign operated by means of buttons installed respectively on the posts and along the whole paid area in the HFCB.

When the stop sign is pressed for the first time, a short sound sign shall ring near the driver and lighted signs shall switch on, and that sound shall not ring another time, even if the stop sign is pressed again.

The system shall be reset when the doors are closed, after leaving the bus-stop, or by means of the reset button on the dashboard.

The lighted stop signs shall remain lighted until the doors are opened.

The lighted signs shall be amber, so that they are seen at daylight, and located on the following places:

- near the driver's seat;
- on the dashboard;
- near the mechanisms protecting boxes of the disembarking doors.

### **Interior lighting system**

Specifications of the interior lighting system shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

### **Exterior lighting system and signaling**

Specifications of the exterior lighting system and signaling shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The HFCB shall have:

Headlights, body demarcating lamps, brake lights, blinkers, backing lights, license plate light, equipment boxes lights.

The intensities of the whole lighting shall follow the specific ABNT guidelines and the traffic legislation.

### **Painting**

The exterior painting, interior visual communication and exterior visual communication of the HFCB shall be those determined by the PS in accordance with specifications of the SETRAVI technical guidelines painting or with the low-floor type HFCB specifications provided by the manufacturer. The definition of the painting will take place up to three months before the date previous to the delivery of the HFCBs.

### **Accessories**

Specifications of the accessories shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The HFCB shall be supplied with all the accessories allowing for the adequate safety conditions required by the legislation in effect.

The HFCB shall have a fire extinguisher loaded with 6 kg chemical powder, and shall be installed within the driver's reach.

Safety triangle.

Package compartment to be used by the driver.

### **Towing devices**

Specifications on towing devices shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The HFCB shall be provided with towing devices in both ends, so as they do not interfere in the operation and in the bumpers action.

The device shall be such that the tow bar will work with no interference with the bumper.

The HFCB shall have on its front end a connector to receive signs of the towing HFCB to switch on the backlights, brake lights and blinkers.

Near the bumpers there shall be a fast air connector for the brakes and another one for the wet chamber, when the HFCB is towed.

### **Ticket collection system**

Specifications of the ticket collection system shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The ticket collection system provides for the use of a ratchet wheel with electronic locks near the (front) embarking door of the HFCB.

### **Destination Electronic Panel (PED)**

Specifications of the destination electronic panel (ped) shall comply with the SETRAVI technical guidelines or with the low-floor type HFCB specifications provided by the manufacturer.

The HFC buses shall be provided with Destination Electronic Panels (DEP) in the front and side ends, being perfectly visible even under natural or artificial lights.

The messages on the panels shall be legible, with no interference impairing the free view of the route by users located at least 50 meters from the HFCB, at the extremity of 65 degrees to both sides of the perpendicular line of the center of the main plan of the messages area.

Panels with minimum 1,000 x 200 mm dimensions shall be utilized. The height of the alphanumeric characters shall not be less than 160 mm, except for extraordinary cases duly justified.

The Electronic Panel shall present the Flip Dot concept, configuring the messages by means of software-controlled lines and columns.

The DEP box shall be impervious to water, dust, dirt and insects during the usual operation or washing. In the front DEP, the glass shall be tilted 7 degrees frontward to prevent sunlight or public lights reflections, allowing for their reading under any exterior lighting condition.

The interior lighting of the panel shall be done so as to reduce reflection during the nightly use.

The feeding of the panels shall be compatible with the capacity and electric offer of the HFCB.

In order to certify reliability, the equipment shall be tested for at least 12 continuous hours of operation in a 70° Celsius temperature. It shall also be qualified to operate between -5° and 70° C.

## **6 – BASIC TECHNICAL SPECIFICATIONS FOR THE HYDROGEN SUPPLY**

### **6.1 – HYDROGEN QUALITY REQUIREMENTS**

The hydrogen fuel cells system is still a recent technology, where the prototypes are extremely expensive, and the catalyzer applied on the cell membrane is sensitive to some elements and chemical compounds, especially to the carbon monoxide (CO) and sulphur compounds, which may cause poisoning or passivation of the catalyzers and a decrease in the efficiency of the cell, damages to the membrane and the resulting loss of the cell or of the hydrogen cells battery.

Bearing in mind these considerations, the quality standards of the hydrogen fuel must be presented by the manufacturer. The data described in the following table must be strictly respected unless the manufacturer proposes an improvement on that data.

On the other hand, in order to increase the cell efficiency, some water must be introduced by means of the hydrogen humidification to keep the control on the conductivity of the membrane and of the electrode. A small oxygen concentration (<5000 ppm) in the fuel is also accepted to help the beginning of the oxidation.

That way, the minimum quality requirements required for the hydrogen supplied to the HFCB are:

- total purity at the HFCB storage level >99,95%
- maximum CO concentration (in case it is free from sulphur) <10 ppm
- maximum S concentration (measured as H<sub>2</sub>S or SO<sub>2</sub>) Free (<1ppm)
- maximum S + CO concentration <10 ppm
- maximum N<sub>2</sub> concentration <400 ppm
- maximum HC concentration (measured as methane) <10 ppm
- maximum KOH concentration Free (<1ppm)
- oxygen addition <5.000 ppm

water addition Saturated gas in the maximum pressure

These specifications, or specifications of an increased hydrogen level of quality recommended by the suppliers shall be necessarily followed in all the stages of hydrogen production storage and final supply to the HFCBs, so the supplier shall specify in detail the procedures that it recommends in the case of hydrogen production by means of a natural gas based hydrogen reformer.

## **6.2 – NATURAL GAS BASED HYDROGEN REFORMER**

The hydrogen to be supplied to the HFCBs shall be obtained from a natural gas based hydrogen reformer, or any other hydrogen production system that the supplier recommends as more convenient for this Demonstration Project. In case of a hydrogen reformer based on natural gas, or in any other case, the hydrogen shall be supplied every night in the garage where the HFCBs overnight, or at any other daytime in case that for any reason (as for maintenance needs), the HFCBs initiate their service late during the day. The objective is to ensure the continuous operation of the HFCBs. That supply, estimated as a minimum nominal hydrogen volume of 250 kg/day (2000Nm<sup>3</sup>/day), or a larger amount of hydrogen volume per day if recommended by the bidders, according to their estimations of daily HFCBs hydrogen consumption shall be requisitioned by STE whenever it is necessary and at its exclusive discretion.

### **6.2.1 – SUPPLY MODE**

The bidder shall detail thoroughly the procedures, requisites and specifications of the equipments required to the hydrogen production, hydrogen storage and subsystem of hydrogen to fuel the HFCBs, as well as the International guidelines required in the operations. The storage conditions and HFCBs hydrogen fueling subsystem shall comply with what is provided for in the Chapter 8 of these Invitations to Bid.

## **6.3 – INSTALLATION**

If the supply of hydrogen by a natural gas based hydrogen reformer proves to be the most convenient method for this Demonstration Project, allowing for the concentration of all financial efforts in the development of the HFCBs as described in Chapter 7 below, the garages shall be equipped with just the hydrogen reformer, the hydrogen storage subsystem and the fuel equipment for the HFCBs, complying with the requirements of Chapter 8 of these Invitations to Bid. STE, with the assistance of the UNDP/GEF and the PS, will be in charge of taking that decision, in case the convenience exists. Also, the natural gas reforming plant shall incorporate a vacuum-swing absorption or any other method for CO<sub>2</sub> recovery, and if necessary, the process efficiency will be obtained through increased hydrogen production.

The CO<sub>2</sub> sequestration process is intended to achieve that the “well to wheel” hydrogen reformer based on natural gas is effectively zeroed. Consequently, the bidder shall also

specify the method and instrumentation to monitor closely the reformer plant performance during the demonstration project implementation.

## **7 – BASIC TECHNICAL SPECIFICATIONS OF THE HYDROGEN PRODUCTION SUBSYSTEM**

Economically speaking, one of the most promising options for the production of hydrogen is setting the subsystems in the area of the garage itself, by for instance, the proposed natural gas based hydrogen reformer. This method will prevent additional transportation and storage costs and gas contamination problems during the transfer from one container to another.

In that case, the hydrogen production equipment shall be preferably modular, so as to be prepared for future investments that may be progressive, according to the size of the fleet and the fuel demand.

The production, storage and fueling facilities in the garage shall be provided with a sensor to detect hydrogen leakages, associated to alarm devices, fans and exhausters. The areas intended to such facilities shall be isolated from the other facilities and buildings.

The suppliers of all infrastructure equipment for hydrogen production, storage and fueling shall be responsible for their assembly, installation, maintenance and operation during the whole period of 5 years that lasts the Demonstration Project and the development tests.

As for the assembly, installation, maintenance and operation of the whole reformer plant with hydrogen storage and fueling subsystems, the following financial contribution in exchange for business making is open to the bidders that will supply the natural gas based hydrogen reformer system and required subsystems:

Land in Mexico City is very expensive so, the bidder is encouraged and therefore may feel free to make a proposal to rent a piece of land within the STE premises to assemble, install, maintain and operate the natural gas based hydrogen production plant, the hydrogen storage, the natural gas fueling subsystems for the hydrogen reformer plant, and the hydrogen fueling subsystem for delivering hydrogen to the HFCBs.

This natural gas based hydrogen production plant may have a hydrogen production which can be much higher than the hydrogen consumption required by the 10 HFCBs fleet of this Demonstration Project. If that is the case, the remaining hydrogen production may be commercialized by the firm which produces it, in exchange for supplying at any time of the night or day, the required volume of hydrogen for the HFCBs during the whole period of 5 years of the Demonstration Project.

This will be done at no cost for STE, the Demonstration Project Executing Agency; neither for UNDP, the Demonstration Project Implementing Agency. That means, that the cost-free supply of hydrogen during the HFCBs 5 years Demonstration Project is made in exchange for the concession given to the firm to commercialize the hydrogen production surplus, which is independent of the cost of the land rent that the hydrogen production firm must pay to STE. Also, all the utilities and inputs required for the whole amount of produced hydrogen will be paid by the hydrogen production firm.

If this arrangement proves to be beneficial for all the participants, an agreement shall be signed among the involved actors, with the details of their involvement and responsibilities. This agreement shall also include the degree of involvement and responsibilities of the participants at the end of the 5 years of the Demonstration Project.

## **7.1 – REQUIREMENTS OF THE HYDROGEN PRODUCTION TECHNOLOGY**

As indicated above, the hydrogen to be supplied may be obtained from natural gas, with a CO<sub>2</sub> sequestration process included as it was mentioned in Chapter 6.3. Also, the employed method for hydrogen production must not generate contaminating elements, that may poison the cell catalyzers. The hydrogen produced by any chosen method, including that of natural gas based hydrogen reformer, has to be of 99.95% purity.

## **7.2 – BASIC TECHNICAL SPECIFICATIONS FOR THE HYDROGEN PRODUCTION AND COMPRESSION SUBSYSTEM**

The equipment required to the production and compression of hydrogen shall be described as detailedly and as thoroughly as possible, indicating the following items:

- the area required to settle the hydrogen production and compression equipment;
- basic layout of the facilities, with approximate measures;
- energy consumption per kg of hydrogen produced and installed power of the equipment;
- natural gas consumption per kg of hydrogen produced;
- procedures for the equipment operation, the reliability degree of the system, safeguards against occasional failures, mainly concerning the issue of gas leakage, possible risks of accidents and protection against environmental damages;
- description of the leakage monitoring system and safety alarms;
- estimate of the cost of the hydrogen placed in the containers of the garage and of the HFCB.

The equipment used in the hydrogen production subsystem by natural gas and their compressors shall be designed to meet the following technical requirements:

### **7.2.1 - Efficiency**

The overall efficiency of the conversion of electric power into hydrogen inner energy shall be specified by the manufacturer and will be subjected to PS approval, and the



bidder must provide the specifications of the electrodes and their main performance features (potential difference, electrode performance curves, etc.).

### **7.2.2 – Durability and Reliability**

As a project target of the Demonstration Project, in the design of each subassembly, the quantity of failures that may occur implying repairs out of the maintenance intervals shall be provided. The equipment shall not present failures interrupting their operation longer than 5 consecutive days and in intervals lower than 30 days.

The durability previewed for the equipment shall be 15 (fifteen) years or 5,000 accumulated hours of use or other durability specified by the manufacturer and subjected to PS approval. The supplier shall provide a 5 (five)-year warranty on the operation and be responsible for a preventive maintenance plan, including the replacement of vital parts, ensuring the supply of the subsystem with the reliability desired, and specify the terms for the replacement of components before the occurrence of failures.

### **7.2.3 – Noise emission**

The hydrogen production facilities shall comply with the legal requirements issued by the Ecology Secretary of the Mexico City Government for industrial facilities. They shall not emit noise exceeding the 55 dB (A) level in the boundaries of the grounds where they are fitted or other noise emission specified by the manufacturer and subjected to PS approval.

### **7.2.4 – Electromagnetic noise emission**

The supplier shall ensure the protection required to prevent interferences on the equipment in the surroundings, such as pacemakers, airbags, ABS brakes, etc., besides describing and specifying the protection devices utilized with that purpose.

In the electro-electronic equipment, sensitive to the generation of electromagnetic noise impairing radio-reception, the proper filters to suppress that noise shall be provided.

The radio-interference (electromagnetic noise) levels generated by the HFCB will be subjected to the buyer's approval.

### **7.2.5 – Pressure of the hydrogen supplied to the HFCBs**

The nominal pressure of the hydrogen supplied to the HFCBs shall be defined by the manufacturer. The hydrogen production equipment shall meet the specifications ensuring the resistance, the imperviousness and its perfect operation under those pressures, and supply the gas in such a way that the pressure will be maintained during the whole fueling period of the HFCBs, without creating conditions likely to impair the operation.

### **7.2.6 – The area occupied by the facilities**

The area occupied by the facilities shall be defined by the manufacturer and approved by the buyers.

### **7.2.7 – Safety Guidelines**

The supplier shall specify the Safety Guidelines utilized and manifest the compliance of his product with those guidelines, indicating the types of sensors utilized and their location, as well as the conception of the monitoring and safety system concerning leakages.

It is advisable that the subsystem control devices have diagnostic indicators of defects, hydrogen leakages and other safety items, and that there are integrated control and supervision devices.

### **7.2.8 – Painting**

The exterior painting of the facilities will be determined by the STE and PS, whose definition will be made up to 3 months before the date previous to the subsystem delivery.

## **7.3 – REQUIREMENTS OF THE HYDROGEN PRODUCTION AND COMPRESSION SUBSYSTEM**

The supplier shall specify all the requirements of its product that will demand changes in the garage fittings, such as electric and hydraulic fittings, the need of heat exchangers, etc.

Those specifications shall be previously approved by STE and all changes shall be conducted by the transportation operator, with project allowances provided with that purpose, supervised by STE.

## **7.4 – OPTIONS FOR THE HYDROGEN PRODUCTION TECHNOLOGY**

Equipment based on other commercially proved processes may be proposed for evaluation and shall necessarily respect the specifications mentioned previously, concerning the quality of the hydrogen produced and the minimum standards of contaminating elements and compounds.

## **8 – BASIC TECHNICAL SPECIFICATIONS OF THE HYDROGEN STORAGE AND SUPPLY SUBSYSTEM**

The hydrogen storage shall be performed as a gas, under bar pressure proposed by the manufacturer. One must take into account that the HFCBs fueling will be made during

the night period. The fuel shall be stored in a quantity ensuring the HFCBs fueling for 10 (ten) consecutive days so as to prevent interruption in the HFCBs operation.

The suppliers shall present the procedures required to the hydrogen storage subsystem operation and HFCBs fueling, including the supply frequency and the minimum stock of the fuel.

The suppliers of all infrastructure equipment shall be responsible for their assemblies, fittings, maintenance and operation for the whole period comprised by the Demonstration period (5 years).

Those fittings shall be provided with sensors to detect hydrogen leakages, connected to alarm devices, fans and exhausters. The areas previewed for such fittings shall be isolated from the other facilities and buildings.

## **8.1 – THE REQUIRED EQUIPMENT**

The equipment required to the hydrogen storage and its transfer to the HFCBs shall be described as detailed and thoroughly as possible, indicating the following items:

- the area required to install the equipment for hydrogen storage and transfer to the HFCBs containers;
- basic layout of the facilities, with approximate measures;
- energy consumption per hydrogen kg transferred to the HFCBs (in case there is an additional pumping) and the installed power of the equipment, if it is applicable;
- the procedures for the equipment operations, the degree of reliability of the system, safety in case of occasional failures, mainly concerning the gas leakage issue, possible accident risks and protection against environmental damages;
- description of the leakage monitoring and safety alarms systems;
- estimate of the cost of the hydrogen placed in the HFCB container .

The consumption capacity forecasted is 70 to 250 kg/day, in the Demonstration Project with 3 to 10 buses, respectively, this consumption estimation can be corrected by the manufacturer according to the HFC bus design.

The equipment shall be designed to meet the following requirements:

### **8.1.1 – Durability and reliability**

As a project target of the Demonstration Project, in the design of each subassembly, the occurrence of failures causing an interruption in the fueling operation implying repairs out of the maintenance intervals shall be prevented.

The durability previewed for the equipment shall be 15 (fifteen) years of use or any other justified durability presented by the manufacturer subjected to the buyers approval. The supplier shall provide a 5 (five)-year warranty on the operation and be responsible for a preventive maintenance plan, including the replacement of vital parts, ensuring the supply of the subsystem with the reliability desired, and specify the terms for components replacement before the occurrence of failures.

#### **8.1.2 – Noise emission**

The hydrogen fueling operation shall not produce noise exceeding the 55 dB(A) level in the boundaries of the grounds where it is fitted.

#### **8.1.3 – Resistance to pressure and imperviousness**

The hydrogen storage and HFCBs fueling system shall meet the specifications ensuring the resistance and imperviousness for a bar nominal pressure presented by the manufacturer.

#### **8.1.4 – The area occupied by the facilities**

The area occupied by the hydrogen storage facilities and transfer to the HFCBs shall be proposed by the manufacturer and approved by the PS, and must be suitably designed so as to ease the access and moving of the HFCBs to be fueled.

#### **8.1.5 – Safety Guidelines**

The supplier shall specify the Safety Guidelines utilized and manifest the compliance of his product with those guidelines, indicating the types of sensors utilized and their location, as well as the conception of the monitoring and safety system concerning leakages.

It is advisable that the subsystem control devices have diagnostic indicators of defects, hydrogen leakages and other safety items, and that there are integrated control and supervision devices.

#### **8.1.6 – Painting**

The exterior painting of the facilities will be determined by the STE and PS, whose definition will be made up to 3 months before de date previous to the subsystem delivery.

#### **8.1.7 – Emergency supply**

In order to ensure the ongoing buses operation during a period of occasional failure in the hydrogen production, the garage storage subsystem shall allow for the gas supply by third parties. That is the sole emergency instance in which the supply of hydrogen that has not been produced in the STE premises shall be accepted.

## **8.2 – OPERATIONS PROCEDURE FOR THE HFCBs FUELING**

Handbooks shall be provided containing the operations procedure for the HFCBs fueling, the measures required to prevent gas contamination, accident prevention and procedures in case of accidents, as well as training courses for the fueling subsystem operation and explanations concerning the risks of the hydrogen and/or equipment handling.

The supplier shall indicate in detail the rates and parameters characterizing the performance in the HFCBs fueling, mainly concerning the storage volume, number of HFCBs that may be sequentially fueled, fueling time for each HFCB, considering the first and the last HFCB fueled in the sequence.

The bidder shall also provide an estimate of the number of employees and the qualification required from those who will operate the fueling subsystem. All cost and personnel estimates shall take into account the assumption of work for 3, 10, 100 and 200 HFCBs.

## **9. COMPLEMENTARY CONDITIONS**

### **9.1 – TRAINING**

Technical and operations handbooks for all the equipment fitted shall be provided, besides a specific training concerning the systems operation. In addition, the specific safety guidelines shall be described for the equipment installed and procedures in case of accidents.

Training courses for the personnel belonging to the Operator Company, indicated by the STE and PS, shall be scheduled, on the technologic concepts of the systems acquired and on the operation and maintenance procedures of the equipment and HFCBs, with an annual updating and with a frequency to be established in agreement with the STE and PS, during the whole trial period.

### **9.2 – MAINTENANCE**

The suppliers or supplier consortium of the main systems and subassemblies shall offer to the STE and PS the maintenance procedures, the training programs and permanent technical support with a residing engineer, placed at the STE and PS disposal.

The fittings in the garages for the maintenance of the HFCBs shall be provided with sensors to detect hydrogen leakages inside the garage, connected to alarm devices, fans

and exhausters. The area previewed for the maintenance of the hydrogen buses shall be isolated from the areas where the other buses circulate.

For each subsystem a detailed Preventive Maintenance Plan of the equipment and components installed shall be presented, in which the terms for the replacement of parts and equipment before the occurrence of failures shall be specified.

As to the fixed fueling systems, those shall not present severe failures resulting in hydrogen leakage, with the risk of severe accidents. Other failures whatsoever that may occur out of the maintenance interval shall be forecasted, specified, duly quantified and the corrective procedures shall be clearly established. The occurrence of such failures shall not, under any circumstance, compromise the bus transportation operation system.

The average effective life of the production, storage and fueling subsystems shall be at least 15 years. Taking into account that the small pieces of equipment and components may be replaced more frequently, the main equipment subassemblies shall last longer than that.

The manufacturer shall indicate the reliability predicted in its project, which will be an object of scoring.

### **9.3 – SPARE PARTS**

The suppliers shall propose plans for the replacement of parts, both for preventive maintenance and in the case of failures, so as to ensure the full operation of all pieces of the equipment and, in the case of failures, brevity in the repairs that may be required, preventing occasional detriments to the bus transportation system.

### **9.4 – SAFETY PROCEDURES**

The suppliers of all subsystems, mainly those associated with the hydrogen, shall provide the safety procedures and recommendations required to their operation, as well as the overall safety of the full garage facilities. The recommendations shall include those related to the recommended distances from other pieces of equipment.

## ANNEX G: NOTES ON PROJECT COSTS

- (a) Purchase of 10 HFC buses at the price of US\$ 1.425 millions each for the first three, and US\$ 1.300 for each one of the remaining 7.
- (b) Quoted purchased cost for a reformer plant installed in Mexico City, based on communication with reformer manufacturing plant producers. The quotation includes all the facilities for H<sub>2</sub> production, like high-pressure compressor, steam boiler, water treatment system, emergency power generator and the reformer plant itself.
- (c) Quoted purchased costs of H<sub>2</sub> storage
- (d) Garage modifications, based on Mexican building experience and necessities communicated by STE and reformer producers.
- (e) Baseline diesel storage provided by STE.
- (f) Cost of electrical equipment to handle additional power supply to the existing garage facilities.
- (g) Estimated from actual experience on managing the trolleybus fleet by STE and talks with HFCB manufacturers.
- (h) Estimated costs of monitoring and measurement equipment.
- (i) This item is considered within the baseline, it estimates cost furniture facilities.
- (j) Land rental is considered an in-kind contribution of STE for natural gas reforming and refueling facilities sites.
- (k) Estimated cost of the diesel fuel for 10 buses, for the 5 years period of the baseline, based on STE experience on managing a bus fleet.
- (l) Estimated cost for the 5 years period of the demonstration project based on communication with reformer manufacturing plants producers, cost of natural gas needed to be fed to the reformer plant; this natural gas is to be supplied by PEMEX from an existing pipe, located nearby the garage facilities.
- (m) Estimated cost for the 5 years period of the demonstration project based on communication with reformer plant producers, water for cracking and cooling is to be supplied from public services in Mexico City.
- (n) Average electricity price estimated at \$0.026 kWh. It considers only the power necessities to operate the reformer plant equipment.
- (o) Item considered within baseline and transferred to the cost of the project.

- (p) Project management cost estimation for the demonstration period.
- (q) Operating and administrative personal based on STE experience, HFCB manufacturers and the FCS replacement strategy.
- (r) The monitoring and evaluation plan of the project has been estimated taking as a basis similar activities that are usually carried out on STE. Additionally, a special department is going to be created with the objective to follow up closely the HFCB fleet performance.
- (s) A provision has been made within the baseline for training activities. It is expected that this provision will be sufficient for the necessities of the fuel cell buses.
- (t) Vehicle maintenance parts as considered within the base line. This item has been transferred to the cost of the project as it is considered to be sufficient for the HFCBs project.
- (u) Facilities maintenance as considered within the base line. This item has been transferred to the cost of the project as it is considered to be sufficient for the HFCBs project.
- (v) A provision has been made for insurance payments.
- (w) A provision has been made for route maintenance.
- (x) Fuel cell stack replacement with costs estimated by stack providers.
- (y) Estimated costs for studies and research to be made during the demonstration project.  
The costs in USD of the research projects are depicted below:

HFBC Mexican manufacturing process optimization. (2 years).	\$50,000 per year, 2 years = \$100,000
HFBC Prototypes and Series tests certification. (3 years). Energy Conversion, Mechanical, Electrical, and Control	\$50,000 per year, 3 years = \$150,000
HFBC Technological Performance. (3 years).	\$50,000 per year, 3 years = \$150,000
HFBC Operation Analysis. (2 years).	\$50,000 per year, 2 years = \$100,000
HFBC Maintenance Analysis. (2 years)	\$50,000 per year, 2 years = \$100,000
HFBC Demonstration Project Management. (2 years)	\$50,000 per year, 2 years = \$100,000
Demonstration Project Environmental Analysis. (3	\$50,000 per year, 3 years =



years)	\$150,000
Demand and Supply of HFCB Technology (2 years).	\$50,000 per year, 2 years = \$100,000
Costs and Benefits of non-polluting transport in Megacities. The case of Mexico City. (2 years)	\$50,000 per year, 2 years = \$100,000
The Politics and Economics of Bus Replacement. (3 years)	\$50,000 per year, 3 years = \$150,000
Diagnostic and Solution Alternatives to Mexico City Air Pollution. (2 years)	\$50,000 per year, 2 years = \$100,000
Air Pollution and Health in Mexico City. (2 years)	\$50,000 per year, 2 years = \$100,000
Economics of Mass Hydrogen Production for Transport (2 years)	\$50,000 per year, 2 years = \$100,000
	Total = \$1,500,000

(z) Participation in three seminars per year (each 3 days long) in 3 different years of the demonstration period. Attendance by 10 persons, which means 270 person-days, equivalent to 9 person-months, the estimated salary being US\$3,000/month leads to US\$27,000. On top of that, seminar registration is estimated to be US\$750/person, that is  $90 \times 750 = \text{US\$}67,500$ .

(aa) Participation in three seminars per year in 3 different years of the demonstration period, each attended by two persons. One week time commitment, with a salary of \$5,000/month:  $3 \times 3 \times 2 \times 5000 / 4.3 = \text{US\$}20,930$ . Air tickets plus per-diem US\$4,000/person trip. Total travel expenses = US\$72,000 seminar registration US\$2,000/person per seminar = US\$36,000.

(bb) Assuming 5 person trips (1 week each) per year in 3 different years of the demonstration period; \$4,000/person trip for air ticket and expenses gives US\$60,000. Salary is  $\text{US\$}5,000 \times 15 / 4.3$  for a total of US\$17441.86

(cc) Workshops organized and held at STE to share project information with national and international organizations and individuals. One workshop per year in 3 different years of the demonstration period at US\$25,000.

(dd) Contingencies are assumed to be 10% of total project cost.

## ANNEX H: ENDORSEMENT LETTER

08/28/00 08:42 FAX 2550095  
08-25-00 19:17

UNDP MEXICO

002 002

AGO-25-00 19:15 SHOP DIR PROCD LEG CRED

TEL: 2221699

P: 02

G.H.1



SECRETARIA  
DE  
HACIENDA Y CRÉDITO PÚBLICO

DIRECCIÓN GENERAL DE CRÉDITO PÚBLICO  
DIRECCIÓN DE ORGANISMOS FINANCIEROS  
INTERNACIONALES  
Subdirección de Proyectos Especiales

Oficio No. 305. VI. 6.- 207

México, D.F., a 25 de agosto de 2000.

**SR. BRUNO GUANDALINI**  
Representante Residente en México del  
Programa de las Naciones Unidas para el Desarrollo  
Presidente Masaryk 29, Piso 2  
Col. Polanco  
C i u d a d

Hago referencia al Proyecto "Demostración de autobuses Impulsados con celdas combustibles (hidrógeno) y un sistema asociado para el suministro de combustible de la Ciudad de México".

Sobre el particular, a través del presente me permito comunicar a usted que en virtud de que el proyecto de referencia cuenta con el apoyo técnico de la Secretaría del Medio Ambiente, Recursos Naturales y Pesca (SEMARNAP), esta Secretaría de Hacienda y Crédito Público está de acuerdo en que dicha propuesta se someta a consideración del Secretariado del GEF en Washington, a través del PNUD como Agencia Instrumentadora del GEF en México. Lo anterior, en virtud de que su financiamiento contribuirá al cumplimiento de metas sectoriales de desarrollo.

Mucho le agradeceré nos mantenga informados del trámite que guarden estas gestiones, y sin otro particular por el momento, aprovecho la ocasión para reiterar a usted las seguridades de mi más atenta y distinguida consideración.

Atentamente,  
SUFRAGIO EFECTIVO, NO REELECCION.  
El Director de Organismos Financieros  
Internacionales

  
Ricardo Ochoa

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