Demonstration for Fuel-Cell Bus Commercialization in China (Phase II)

(Project ID: PIMS 2933)

Final-Term Review Report

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Acronyms

AFC	Alkaline Fuel Cell
APR	Annual Project Report
BP	British Petroleum
BSTC	Beijing Science and Technology Commission
CDR	Combined Delivery Report (financial report)
CDIAC	Carbon Dioxide Information Analysis Center (US DOE)
CICETE	China International Center for Economic and Technical Exchanges
cm2	square centimeter (area)
CNG	Compressed Natural Gas
CO	Carbon Monoxide
CTA	Chief Technical Advisor
CUTE	Clean Urban Transport for Europe
CUTPP	China Urban Transport Partnership Program
DMFC	Direct Methanol Fuel Cell
DOE	Department of Energy (US)
ECTOS	Ecological City Transport System (Reykjavik, Iceland)
EA	Executing Agency (MoST)
EOP	end-of-project
EU	European Union
EV	Electric Vehicle
DC	Daimler Chrysler Company Limited, Germany
FCB	Fuel Cell Bus
FCV	Fuel Cell Vehicle

FCEV	Fuel Cell Electric Vehicle
FCHV	Fuel Cell Hybrid Vehicle
FTR	Final-Term Review
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
GoC	Government of China
HEV	Hydrogen Electric Vehicles
HRS	Hydrogen Refueling Stations
H2	Hydrogen
IPHE	International Partnership for the Hydrogen Economy
kg	kilogram (1,000 grams)
km	kilometer (1,000 meters)
kW	kilowatt (1,000 watts)
LNG	Liquefied Natural Gas
m	meter (1 meter = 100 centimeters)
M	Million (population)
MCFC	Molten Carbonate Fuel Cell
MEP	Ministry of Environmental Protection
mg	milligram
MNES	Ministry of Non-Conventional Energy Sources (India)
MOEF	Ministry of Environment and Forests (India)
MoST	Ministry of Science and Technology
MoC	Ministry of Commerce
MoF	Ministry of Finance

Mtoe	Million tons of oil equivalent (1 ton = 1,000 kg)
MTR	Mid-Term Review
MW	Megawatt (1 MW = 1,000 kW)
NABI	North American Bus Industries
NDRC	National Development Reform Commission
NEPC	National Environmental Protection Center
NFCBTI	National Fuel Cell Bus Technology Initiative
Nm3	normal cubic meter (volume)
NOx	Nitrogen Oxides (NO, NO2)
NPC	National Project Coordinator
NPD	National Project Director
NRDR	National Development and Reform Commission
NREL	National Renewable Energy Laboratory (US)
NRW	North-Rhine-Westphalia
O2	Oxygen
PAFC	Phosphoric Acid Fuel Cell
PEM	Polymer Electrolyte Membrane (also PEMFC)
PEMFC	Proton Exchange Membrane Fuel Cell (also PEM fuel cell)
PIF	Project Information Form
PIR	Project Implementation Report
PMO	Project Management Office
ProDoc	Project Document
QOR	Quarterly Operation Report
RCB	Regional Central Bureau
RTA	Regional Technical Adviser

SAIC	Shanghai Automobile Industry Corporation
SCTC	Shanghai Science and Technology Commission
SEPA	State Environmental Protection Agency
SOFC	Solid Oxide Fuel Cell
SO2	Sulfur Dioxide
STEP	Sustainable Transport Energy (Perth, Australia)
ToR	Terms of Reference
TPR	Tripartite review
UHC	Unburnt Hydro Carbon
UNDAF	United Nations Development Assistance Framework
UNDP	United Nations Development Programme
UNDP CO	UNDP Country Office
UNFCCC	United Nations Framework Convention on Climate Change
US	United States (of America)
W	Watt (1 Watt = 1 Joule/second)

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Executive Summary

Final-Term Evaluation Purpose and Approach

This report documents the Final-Term Review (FTR) (December 5 - 26, 2011) of the UNDP-GEF *Demonstration for Fuel-Cell Bus Commercialization in China (Phase II)* Project (referred to as FCB Phase II Project), following the monitoring and evaluation system of UNDP-GEF to promote accountability in the achievement of GEF objectives. The FTR team is composed of independent consultants Engr. Marcial T. Ocampo (International Consultant and Team Head) and Prof. Tian Guangyu, Ph.D. (National Consultant and Team Member).

The purpose of the FTR is to evaluate the project implementation and management performance. It will determine whether the project is on track to achieve the project objectives and therefore just needs to be sustained. The project evaluation will also determine and report on the experiences and lessons learnt during the project implementation so as to provide guidance in determining the targets and strategies for the planned next Phase III Expanded Demonstration of FCB that will hopefully result in Phase IV Full Commercialization of FCB. In this regard, the findings and recommendations of the evaluation will contribute to identify best possible ways to advance the modern public transportation technology by commercializing FCBs in the cities.

Through the review of pertinent documents related to the project such as project document, quarterly and annual project progress reports, sub-contract reports; conduct of structured interview with knowledgeable parties (e.g. PMO, GoC personnel, Beijing and Shanghai government officials, Sub-Contracting Parties/Entities, National Consultants, UNDP Country Office Counterparts, members of the Project Steering/Advisory Committee/s, Project Beneficiaries or grantees, etc.); and field visits to various pilot project sites, the evaluation mission will carry out the tasks (1) to (8) as enumerated in "Specific Tasks for the Evaluation" found in Annex K - Terms of Reference (ToR).

The scope of the FTR covers the entire UNDP/GEF-funded FCB Phase II Project and its components as well as the co-financed activities in each component of the project. The FTR will assess the FCB Phase II Project implementation taking into account the status of the project activities and outputs and the resource disbursements made up the final evaluation review date. The FTR team conducted the interviews and site visit in Beijing and Shanghai from Dec 14 - 20, 2011. The evaluation will involve analysis at two levels: component level and project level.

The final evaluation also provided recommendations for FCB Phase II demonstration and FCB Phase III expanded demonstration as well as summary of findings and achievements, conclusions, best practice and lessons learned.

Brief on the FCB Phase I

The Phase I project document was signed in November 2002, and the project officially began operation on 27 March 2003 after a few months of preparation. In late 2003, China International Center for Economic and Technical Exchanges (CICETE), which was entrusted by the project executing agency to lead the procurement activities, launched the international procurement process for the project. Bids were evaluated by a committee in March 2004, and DaimlerChrysler was announced as the winner. In May 2004, intense negotiations were conducted with DaimlerChrysler and a supply contract for FCBs was signed on 26 May 2004. Three Citaro fuel cell buses were delivered to Beijing in September 2005.

In addition, a memorandum has been signed with British Petroleum (BP) for the construction of a hydrogen refueling station in Beijing on 9 May 2004. Beijing SinoHytec Limited, BP and Beijing Tongfang Co. Ltd signed agreement on cooperative construction of hydrogen refueling station in Beijing in

May 2005. The quality and quantity of hydrogen supplied by this station fully met the FCB demonstration requirement in Beijing. The initial source of hydrogen was through water electrolysis, with hydrogen generated off-site and transported with tube trailers.

Brief on FCB Phase II

The China FCB demonstration program is jointly funded by UNDP and GEF and is aimed at catalyzing the cost-reduction of fuel-cell buses (FCBs) for public transit applications in Chinese cities by supporting significant parallel demonstrations of FCBs and their refueling infrastructures in Beijing and Shanghai. The knowledge and experience gained through this project will enable the FCB technology suppliers to identify cost reduction opportunities and the host public transit operators to gain valuable experience needed to adopt larger fleets of FCBs in the future.

The project helps build capacity relating to FCBs, including strengthening policy and planning capabilities of the public transit companies and line government institutes; enhancing scientific, technical, and industrial capacity for commercializing FCBs; and increasing the understanding of FCBs to climate change among government, investment, media, and other key actors. This project focuses on defining a detailed strategy for large-scale FCB commercialization in China.

China is the first developing country that has successfully started official demonstration among the 5 global FCB demonstration projects co-funded by UNDP and GEF.

Long-Term Plan for FCEV in China

The long-term plan for fuel cell bus, electric and hybrid vehicles (FCB, FCEV, FCHV) in China spans many phases in order to innovate on the fuel cell hybrid and electric vehicle technologies to ensure safety, reduce capital and operating costs, raise fuel utilization efficiency in transportation sector, encourage its use as mode of transport in order to reduce pollution (particulates, NOx , SO2, CO and UHC) and GHG emissions (CO2) from transport sector, and diversify fuel supplies and sources of hydrogen used in transport.

- Phase I – "*Demonstration for Fuel Cell Bus Commercialization in China Part I*" - year 1 of the project involving the preparation and procurement of the first set of FCBs and hydrogen refueling stations
- Phase II – "*Demonstration for the Fuel Cell Bus Commercialization in China (Phase II)*" - years 2 to 5 principally involving demonstration activities of the FCBs and refueling stations constructed in Phase I, then a second procurement of FCBs, and preparation of the Phase III demonstration project.
- Phase III – "*Expanded Demonstration of Fuel Cell Bus in China (Phase III)*" - intends to increase the demonstration scale of FCVs operating in several cities in China under different driving modes (high speed City Cluster and heavy traffic stop and go Urban City)
- Phase IV – *"Market Penetration of Cost-Competitive FCBs in China (Phase IV)*" – mass production of FCBs and diversification of hydrogen sources to reduce CO2 emissions on larger scale

Background on FCB Phase II

The Project Document (ProDoc) for Phase II of the project was signed on 14 May 2007, launched in 15 November 2007 and the first disbursement was made on 29 December 2007. This Phase II is co-funded by the Government of China (GoC) and other private sector companies in China, GEF and UNDP. It is co-organized by the Ministry of Science and Technology (MoST), Beijing and Shanghai municipal governments.

In Phase II of the FCB Demonstration project, the Shanghai hydrogen refueling plant will obtain hydrogen as by-product from a steel plant and chemical plant while the one in Beijing will get its hydrogen supply from onsite water electrolysis and natural gas reforming facilities. In phase II, a study will be carried out on the assessment of hydrogen production routes for China and will examine other options and their feasibility over the longer term.

Components of the FCB Phase II

The components of FCB Phase II were designed in such a way that the project will:

- Catalyze cost reduction of FCB for public transport in Chinese cities by supporting significant parallel demonstrations of FCB and HRS in Beijing and Shanghai
- Enhance scientific, technical and industrial capacity for commercializing FCB to strengthen policy and planning capabilities of government institutes and public transport companies (H2 production route, FCEV technology)
- Increase understanding of FCB technology's contribution to mitigation of climate change among government, investors, financial institutions, media and the people which will lead to a detailed strategy for large-scale FCB commercialization in China

Once the activities under each component are successfully implemented, the following end results will be achieved:

- **Outcome 1** - Clearer understanding of the operational viability of FCBs and their refueling infrastructure
- **Outcome 2** - Availability of adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems
- **Outcome 3** - Improved awareness and conducive enabling environment for FCB applications and support for the commercialization of FCBs in China
- **Objective** - Demonstration of the operational viability of FCBs and their refueling infrastructure under Chinese conditions
- **Goal** - Reduction of GHG emissions and air pollution in urban areas of China.

The cost of the FCB Phase II project is US$18.625 million, consisting of US$5.963 million from GEF/UNDP with co-financing from the Government of China (GoC) amounting to US$3.519 million from Ministry of Science & Technology (MoST) (not including waived duties), local government units of US$3.536 from Municipal government of Beijing and US$4.384 million from Municipal government of Shanghai, and US$1.223 million from private sector.

UNDP-China's contribution of $196,000 is for supporting policy-related activities. Bulk of the $5.767 million provided by GEF covers the cost of purchasing the FCBs, since their high incremental cost (relative to conventional diesel buses) represents the greatest barrier to the dissemination of the new technology today. Phase II involves the procurement of 3 to 6 FCBs. The refueling stations will be financed by the Shanghai and Beijing municipal governments as indicated in the total budget and work plan.

The FCB II project involves the participation of technology suppliers as stakeholders through the flexible procurement process, including Beijing Bus Corporation Ltd., Shanghai Bus Corporation Ltd., Shanghai Automobile Industry Corporation, Qinghua University, Tongji University, Foton, and Shanghai World Expo Bureau.

Other stakeholders in the FCB project include:

- Ministry of Science and Technology (MoST)
- National Development and Reform Commission (NDRC)
- Ministry of Finance (MoF)
- Beijing Science and Technology Commission (BSTC)
- Shanghai Science and Technology Commission (SCTC)

As in Phase I, MoST is the head of the Project Advisory Committee that provides overall advice and guidance to the project at the national level, review the project work plan, attend the semi-annual meetings and receive all project reports. The Advisory Committee consists of representatives from the United Nations Development Programme (UNDP), the Ministry of Science and Technology (MoST), the National Development and Reform Commission (NRDR), the Ministry of Finance (MoF), and the Ministry of Environmental Protection (MEP).

Most of the project activities are implemented through sub-contract and consultancy services which are administered, managed and monitored by the PMO. The international, national CTA and consultants provide technical support to PMO while the NDRC provides institutional support for policy coordination and establishing relationships with other government agencies and local government units.

At the project level, the standard UNDP/GEF monitoring and evaluation procedures are applied which include: Annual Project Report/Project Implementation Review (APR/PIR), quarterly progress reports, quarterly operational reports, periodic thematic reports and independent evaluations.

To implement the FCB Phase II Project, the PMO issued the following twelve (12) sub-contracts (see Annex C for details on status of the reports). As of 13 Dec 2011, all sub-contracts submitted their final reports.

No.	Title
1	001-Status Quo and Development Mode Research of China's Fuel Cell Vehicle Industry
2	002-Research on the Development of Innovation System of Fuel Cell Automobile Industry in China
3	003-Fiscal and Taxation Policy in Promoting the Development of Fuel Cell Vehicle Industry in China
4	004-A Study on Roadmap for Development of Fuel Cell Buses in China
5	005-Vehicle Optimization and Integration Design Plan of Fuel Cell Bus for China City Demonstration
6	006-Techno-economic analysis of Domestic Hydrogen Fuel Cell Vehicles and Relevant Industrial Chains
7	007-Research on Energy Efficiency and Emission of FCV Vehicle Cycle under Mass Production Situation
8	008-Life-cycle Energy Efficiency Analysis and Technology Industry Chain Research for the Fuel Pathway of Hydrogen Fuel Cell Vehicles (HFCV)
9	009-Summary Report on FCB Demonstration Operation Programs in China and Abroad
10	010-Analysis Summary Report of Hydrogen Infrastructure Operation

11	011-Legal Research on Improvement of Industrialization of Fuel Cell Bus (FCB)
12	012-Policy Study on the Development and Application of Fuel Cell Bus (FCB)
13	013-Analysis Report on the Vehicle Operation of Beijing FCB Demonstration Program
14	014-Report on Production, Storage and Transportation of Hydrogen
15	015-Analysis of China Fuel Cell Bus Demonstration Operation and Optimized Design Research Report
16	016-Hydrogen Energy Infrastructure Policies Tracking and Research Report
17	017-Research Report on current Status of Hydrogen Resources and its Utilization
18	018-Analysis Report on Technology of Preparation and Application and Storage of Hydrogen & Industrial Development of Hydrogen

Key findings

1. All the reports of the sub-contractors (18 reports) were prepared and submitted. According to the PMO, all the sub-contract reports had been reviewed and accepted by the national expert panel and all the reports have been posted on the project homepage website and can be downloaded by everyone. These reports were circulated among all the relevant stakeholders and team members. Some reports have been submitted to UNDP for dissemination. In addition, some of the sub-contract results will be used as basis for the FCB Phase III preparation.
2. The targets for 16 activity indicators were met while those of 8 indicators were exceeded. Targets of 2 activity indicators were completed in advance of the expected time frame, while those of 12 indicators will be completed at EOP. Those of 6 activity indicators are expected to be realized 5 years after EOP.

Strategy	not meets target	meets target	exceeds target	advanced completion	at EOP completion	5 years after EOP	Total indicators
Goal	0	0	1	0	0	1	2
Objective	0	2	1	0	1	0	4
Component 1	0	3	6	1	5	3	18
Component 2	0	5	0	1	1	0	7
Component 3	0	6	0	0	5	2	13
TOTAL	**0**	**16**	**8**	**2**	**12**	**6**	**44**

3. The attainment of the project's goal and objective is rated "***Satisfactory (S)***" while the attainment of Outcomes 1, 2 and 3 is also rated "***Satisfactory***". Therefore, the FTR team rated the overall progress towards achievement of results for the FCB Phase II project to be "***Satisfactory (S)***".
4. The following table summarizes the accomplishments of the project (e.g. CO2 emission reduction, distance traveled, H2 consumption, fuel economy, passengers carried, personnel trained, newsletter, reviews, study tour reports, exhibitions/road shows, conferences, workshops, seminars) vs. target:

Goal, Objective, Outcome and Activities	Accomplishments	Target at EOP
Goal	**Satisfactory**	
1 - Annual CO2 emissions reduction in the transport sector in Beijing & Shanghai during project	Beijing = 65,460 km = 81 tons CO2; Shanghai = 183,558 km = 198 tons CO2; total CO2 = 279	198 tons of CO2 or 54 tons C for 6 buses over two years (exceeds target)
2 - CO2 emissions reduction in the Chinese transport sector five years after the end-of-project (EOP)		198 tons of CO2 or 54 tons C (5 years at EOP)
Objective	**Satisfactory**	
1 - Number of FCBs in commercial operation in Beijing and Shanghai (B&S) during the project	6 in Shanghai 3 in Beijing	6 in Shanghai; 3 in Beijing funded by in-kind finance (national 863 projects) (meets target)
2 - Number of additional FCBs in commercial operation in China by EOP	0	12 (at EOP)
3 - Number of H2 refueling stations installed and in operation during the project	2 in Shanghai	1 in Shanghai (exceeds target)
4 - Number of additional H2 refueling stations installed and in operation at EOP	1	1 (meets target)
Outcome 1 / Component 1	**Satisfactory**	
1 - Completed FCB and H2 refilling station operational guidelines	1 set of guidelines for Beijing; 1 set of guidelines for Shanghai	1 set of guidelines for Shanghai (advanced completion)
2 - Number of demo FCBs that are operational by EOP	6 FCBs procured in Shanghai 3 FCBs in Beijing funded by in-kind finance (national 863 projects)	6 in Shanghai 3 in Beijing (meets target)
3 - Number of trained and practicing FCB drivers in B&S by EOP	Beijing: 3 drivers Shanghai: 18 drivers	In Shanghai: 3 drivers for each FCB, target 18 drivers (meets target)
4 - Cumulative number of trained and practicing FCB mechanics trained in B&S by EOP	Beijing: 1 mechanic Shanghai: 16 mechanics	7 (exceeds target)
5 - Number of demo H2 refilling stations installed and operational by EOP	1 in Beijing 2 in Shanghai	1 in Shanghai (exceeds target)
6 - Number of operators H2 refilling station operators in B&S by EOP	Beijing: 3 operators Shanghai: 17 operators for a total of 20 operators	17 (exceeds target)
7 - Number of trained and practicing: * FCB drivers * FCB mechanics * H2 refilling station operators in China five years after	3 in Beijing; 18 in Shanghai	18 drivers 6 mechanics 16 operators (5 years after EOP)

EOP		
8 - Frequency of receipt of acceptable demo FCB performance reports	Quarterly reports submitted	Quarterly (meets target)
9 - Average annual passengers of a FCB in B&S	Beijing: 75,460 km and 39,995 passengers; 15,262 km test runs Shanghai: 183,558 km and 106,040 passengers, to reach 200,000 km by end Dec 2011	80,000 passengers in Shanghai 38,000 passengers in Beijing (exceeds target)
10 - Average annual energy consumption of a FCB in B&S	Beijing: 9.56 kg/100km Shanghai: 11.60 kg/100km	12 kg/100km (exceeds target)
11 - Annual volume of supply of H2 to H2 refilling stations (tons) in B&S	Beijing: 5,753 kg (Aug 2008-Jul 2009) Shanghai: 18,395 kg (Dec 13, 2011) to reach 23,192 kg by end Dec 2011	21,600 kg in Shanghai 5,000 kg in Beijing (exceeds target)
12 - Overall annual revenues from the commercial operations of FCBs in B&S		80,000 RMB (at EOP)
13 - Overall level of satisfaction of FCB service in B&S		90% (at EOP
14 - Overall level of comfort and safety of FCB operation in B&S		80% (at EOP
15 - Overall level of satisfaction of H2 refilling station service in B&S		95% (at EOP
16 - Overall level of safety of H2 refilling station operation in B&S		100% (at EOP
17 - Number of new FCBs deployed by transport companies in other Chinese cities five years after EOP		12 (5 years after EOP)
18 - Number of new H2 refilling stations established in Chinese cities five years after EOP		1 (5 years after EOP)
Outcome 2 / Component 2	**Satisfactory**	
1 - Number of "FCB value chain" research reports prepared and submitted to MoST by Year 4	Study completed as of Nov 2011	3 (meets target)
2 - Established FCB Certification program by Year 3	FCB certification program established	1 (meets target)
3 - Number of proposed implementing rules and regulations on FCB certification by Year 4	Implementing rules and regulations on FCB certification established	1 (advanced completion)
4 - The total number of technical materials made available for the public on FCB and FCB systems by the end of EOP: * Newsletters * Technical reports * Study trip reports	15 newsletter issues 7 annual reviews 9 study tour report	12 newsletters (yes) 6 technical reports (no) 8 study trip reports (no) (meets target)

5 - Overall level of satisfaction and/or acceptance by the public and project stakeholders of the technical materials by the end of EOP		90% (at EOP)
6 - Completed "Well-to-Wheel" Analysis of the FCB system in B&S and FCB fuel supply options	Study completed as of Dec 2011	Completed report by Year 3 (meets target)
7 - Completed study on the improvement of local FCB design	Study completed as of Dec 2011	Completed report by Year 4 (meets target)
Outcome 3 / Component 3		
1 - Number of policy studies on the development and promotion of FCB applications carried out by EOP	Completed report as of Dec 2011	1 (meets target)
2 - Number of policies and regulations proposed in cities supporting the utilization of FCBs for urban transport by EOP	Completed report as of Dec 2011	1 (meets target)
3 - Number of policies and regulations proposed in cities supporting the implementation of "FCB value chain" projects in cities by EOP	Completed report as of Dec 2011	1 (meets target)
4 - Number of completed techno-economic feasibility studies of FCB and "FCB value chain" applications in other Chinese cities by EOP	Completed report as of Dec 2011	1 (meets target)
5 - Number of cities interested in implementing FCB and "FCB value chain" projects by EOP		at least 3 (at EOP)
6 - Level of satisfaction of stakeholders about the FCB information exchange system service		90-95% (at EOP)
7 - Established project website by Year 2	1 keep updating	1 keep updating (meets target)
8 - Level of satisfaction of stakeholders about the FCB website service		90-95% (at EOP)
9 - Number of promotional campaigns: * Exhibitions/ road shows * Conferences * Workshops * Seminars on FCBs implemented annually starting Year 2	10 exhibitions and/or road shows 3 conferences 6 workshops 15 seminars	10 exhibitions and/or road shows (no) 2 conferences (exceeds) 6 workshops (yes) 15 seminars (no) (meets target)
10 - FCB Roadmap completed and approved by Year 4		Completed report by Year 4 (at EOP)
11 - Number of cities that are interested in deploying FCBs in their transport sector five years after EOP		at least 3 (5 years after EOP)
12 - Number of approved "FCB value chain" businesses in China five years after EOP		3 (5 years after EOP)
13 - Completed FCB III project strategy and proposal	in progress (long process)	Completed report by Year 4 (at EOP)

5. The rating for conceptual design of the project is ***"Satisfactory (S)***" considering the success indicators and targets used in the revised project monitoring system continue to be specific, measurable, achievable, reasonable, and time-bounded to achieve the desired project outcomes. For instance, the

target of CO2 emission reduction, kg H2 consumed and 100 km traveled as well as fuel economy at specific time frame during the 4-year project provided clear guidance for the project team to achieve.

6. The rating for project performance, timeliness, quality and cost-effectiveness of the project is ***"Satisfactory (S)"*** considering the deployment of manpower, material and financial resources to come up with innovative fuel cell hybrid bus design such as regenerative braking and use of ultra-high capacitors to augment battery storage capacity and ensure fast response and discharge of recovered energy to drive the motors.
7. The rating of impact of the project is ***"Satisfactory (S)"*** considering the great strides obtained to date that resulted in cheaper domestically-manufactured fuel cell bus which now enjoys declining costs, higher energy utilization efficiency (lower H2 consumption per 100 km), reliability and safety. The following vehicle improvements were achieved per High Tech Plan of MoST as a result of the FCB demonstration project, starting with the 2nd generation FCBs costing 5.0 million RMB with 80 kW and lifetime of fuel cell stack of less than 2,000 hours to 3rd generation FCBs now cheaper at 2.6 million RMB with 50 kW and longer lifetime of fuel cell stack of more than 4,000 hours. The use of energy recovery thru regenerative braking and ultra capacitors has resulted in smaller power requirement:

2nd generation Hybrid FC BUS:

- FC: 80kW, Battery: 80Ah * 360V
- Cost: 5.0 million RMB
- Lifetime of FC stack < 2000 h

3rd generation Hybrid FC BUS:

- FC: 50kW, Battery: 120Ah * 336V + Ultra Capacitor
- Cost: 2.6 million RMB
- Lifetime of FC stack > 4000 h

8. Based on the compilation of good practices and lessons learnt prepared, the rating is ***"Satisfactory***
9. Based on the compilation of recommendations prepared, the rating is ***"Satisfactory (S)".***
10. Based on the compilation of response on effectiveness of project implementation at the component level, the rating is ***"Satisfactory (S)".***
11. Based on the compilation of response on effectiveness of project implementation at the project level, the rating is ***"Satisfactory (S)".***
12. Financial delivery of the project in support of the various outcomes and activities was 99.78% utilization of GEF-UNDP funds. In the case of government and private sector co-financing, financial data are not yet available during the conduct of the final-term review. However, latest data shows 100% utilization of the GoC co-financing at US$12,662,000.
13. Presently, there are two major integrated urban and transport planning initiatives in Chinese cities that will also have great impact on reducing GHG emission and pollution arising from inter-city and intra-city travel by complementing the FCB III project thru wider use of the "clean energy" and energy efficient transport technologies developed in the FCB program (Phase I, II and III) into public transport systems designed for City Clusters Transport and within the City Urban transport: (1) Eco-Transport in City Clusters Program which aims to develop strategy and policies that will encourage shift from private to public transport systems that are more energy efficient and have lower carbon footprint such as optimized use of transport resources, efficient interchange and connecting nodes, use of cleaner vehicles and fuels, higher percentage of public transport and inland waterways; and (2) Urban Transport Program which aims to achieve a paradigm shift in China's urban transport policies and investments toward the promotion of public and non-motorized transport modes such as Bus Rapid Transit (BRT) which are less energy intensive and polluting than those fostered by current urban land-use planning and transport systems in China. Conflicts and duplication among the two

integrated transport mode optimization projects with the FCB technology commercialization project can be avoided by clearly understanding each project (strategy and policy development to encourage paradigm shift from private vehicle use to the more energy efficient and low carbon public transport modes and optimized transport systems vs. FCB technology development and commercialization).

14. From the low 15 demonstration projects reported in the earlier ProDoc of FCB Phase II project, latest data from US NREL show results of the implementation of 26 FCB projects involving 44 buses in the US alone. Worldwide including the US, the number is much larger as 29 FCB projects were completed involving 147 buses. On-going FCB projects aggregate 35 involving 108 buses while there are new 25 planned FCB projects in the pipeline with 45 buses. In all these FCB projects, the main FC technology used is PEM in hybrid mode while the majority of the bus units were manufactured by Ballard, followed by Hydrogenics and UTC Power. There seems to be a mad rush among the FC technology suppliers to innovate and demonstrate their own technologies to capture future market share in this evolving international market for FCBs.

Conclusions

The most important conclusions arising from this final-term evaluation includes:

- The rapid economic development of China has catapulted the country from being 2nd in global CO2 emission in 2003 to being the largest emitter of CO2 in 2010, having overtaken the US as largest emitter in 2009. As such, it needs valuable UNDP and GEF assistance in addressing the great responsibility arising from this recent global development. This development has provided great impetus to the Chinese Government to address the need to reduce China's CO2 and overall GHG emissions in the various sectors of Chinese economy, especially the transport sector.
- The FCB Project (Phases I and II) is very important to the Chinese Government. The development and commercialization of FCBs responds to sustainable "clean fuel" and "clean vehicle" policies and has obtained support from the Chinese Government, both central and municipal. The Phase I procured 3 FCBs while the Phase II purchased 6 FCBs of which 3 were funded by the project budget and the other 3 by the Shanghai municipal government.
- The partnership that developed among the various stakeholders (government agencies and ministries, central and municipal government units, academic institutes and private sector firms), has led to significant achievements. Significant design innovations (hybrid design, regenerative braking, ultra capacitors, Li-ion battery), system integration and use of GPRS and internet communications have resulted in reduction of power requirement, higher energy efficiency, durability and reliability, safety and lower FCB unit cost. Also, the maintenance and operation of the FCB fleet and the hydrogen refueling system were tested leading to accumulation of valuable operating data. Fuel economy has significantly improved from Phase I Daimler FCBs of 20 kg/100 km (baseline Beijing) to 12 kg/100 km (target Shanghai) with Phase II domestic FCBs (3 Foton and 6 SAIC) at 11.60 (2009-2011) for both running and maintenance operation.
- Improving alone the energy efficiency of private and public transport systems may not be enough alone in reducing CO2 emission. Government policies must also direct and encourage the paradigm shift from inefficient private transport to highly integrated, optimized and energy efficient public transport modes such as buses, inland waterways and railways powered by low-carbon and low-pollution emitting vehicle technologies. This is where the Eco-Transport in City Clusters Program and the Urban Transport Program could complement the efforts of the FCB project in achieving CO2 emission reduction for transport sector in China.
- The use of fuel cell hybrid technology is the leading global innovation to raise energy efficiency and lower the CO2 emission of public transit buses worldwide. The global interest among suppliers to be the leader in FCB, FCEV and FCHV technologies as manifested by the rise in the numerous demonstration projects worldwide makes it imperative for China to actively participate in fuel cell and electric vehicle R&D to remain updated with recent global developments and to focus on its built-in

advantage (fuel cell stack, controls, Li-ion battery, ultra-capacitors, regenerative braking, enormous supply of platinum catalyst, large scale bus chassis manufacture, largest domestic bus market in the world and widespread public acceptance of FCB).

- It is in China as well as the world's interest that China expands its FCB demonstration to other cities or cluster of cities in a sustainable manner so it may encourage shift from inefficient and high-carbon footprint private motoring and diesel-fed bus systems with advanced transport systems to reduce its CO2 and GHG emission using a proven FCB technology that is nearing commercialization with minimal or nil subsidy. China needs to expand the demonstration to other City Clusters and Cities in order to optimize the technology mix of its public transit system (e.g. 70% diesel-hybrid bus, 20% CNG-hybrid bus, 10% FC hybrid bus from Shanghai interview). By improving both the current diesel and CNG bus system hand-in-hand with the FC hybrid bus, the overall cost of the bus system is kept low since the diesel and CNG bus will be able to cross-subsidize the fare of the more expensive FC hybrid bus.
- Because of China's satisfactory completion of the FCB Phase II project, and together with non-GEF initiatives in "clean energy" vehicles and continuing implementation of integrated and optimized transport modes for both City Clusters (e.g. inland waterways) and Urban Transport (e.g. bus rapid transit or BRT), China is a good candidate for "*Expanded Demonstration of Fuel Cell Bus in China (Phase III)*". Stopping the project at Phase II and not proceeding to Phase III Expanded Demonstration will result in lost momentum in terms of partnerships cemented by the FCB project, forgone R&D innovations that are in the pipeline such as utilization of more advanced FCB units from the world's leading suppliers and innovators of FC technology, and inability to raise existing diesel-fed and CNG-fed bus efficiencies that will provide cross-subsidy to the more expensive FC bus (due to higher capital cost and cheaper fossil fuels compared to hydrogen) at this point in time. The Phase III must focus on the newer FC technologies available compared to when Phase I and Phase II were implemented, test the various newer FC technologies and compare performance and economics with current diesel-fed and CNG-fed buses that also needs performance improvements (such as hybrid and regenerative braking), so that overall, the Chinese commuter will benefit from the positive results of Phase III which includes overall reduction in bus fares of diesel and CNG hybrid buses, require minimal subsidy for the newer FC hybrid bus, and sustainable reduction of CO2 and GHG emissions which would not be possible unless the entire public transit system is made modern and energy efficient also.

With respect to evaluation of performance at the component level, the following could be concluded from the response to the excel survey that was carried out by the FTR Team. These survey results were concurred by the FTR Team:

- There is effective relationship and communications between team members so that data, information, lessons learned, best practices and outputs are shared efficiently, including cross-cutting issues (Yes in B & S)
- The performance measurement (success) indicators and targets used in the project monitoring system are specific, measurable, achievable, reasonable and time-bounded to gauge the achievement of the desired project outcomes (Yes in B & S)
- The use of consultants has been successful in guiding the Chinese experts and research institutions in implementing the various activities of the FCB Phase II project (Yes in B & S)

With respect to performance at the project level, the following conclusions were deduced from the response to the excel survey form, which was also concurred by the FTR team:

(a) Progress towards achievement of results (internal and within the project's control):

- The project is making satisfactory progress in achieving project outputs vis-à-vis the targets and delivery of inputs and activities at the end of project *(the project has resulted in cheaper FCB compared to high-end imported FCB, more efficient FCB as shown by declining hydrogen* *consumption per km traveled, and safe and reliable operation as shown by operating and maintenance reports)* (Yes in B & S)

- The direct partners and project consultants were able to provide necessary inputs and results (Yes in B & S)
- The project is likely to achieve its purpose/objective *(operational viability of FCB and HRS)* and contribute to the attainment of its goal *(reduction of GHG emissions and air pollution in urban areas of China)* (Yes in B & S)

(b) Factors affecting successful implementation and achievement of results (beyond the Project's immediate control or project-design factors that influence outcomes and results):

- The project implementation and achievement of results are proceeding well and according to plan, and there are no outstanding issues, obstacles, bottlenecks, etc. from various stakeholders (national and local government, research institutes, sub-contractors, private sector) *(The SHANGHAI EXPO have special permit so there was no purchase tax on the demonstration FCBs. However, after EXPO, there was no budget for purchase tax once municipal permit is secured.; hence, need for a new exemption policy for FCB once permit is secured. (Without a service permit, the Shanghai team used dummy weights as passengers in order to continue testing the FCBs after the EXPO and collect data needed to achieve the targets.)* (Yes in B & S)
- The broader policy environment remain conducive to achieving expected project results, including existing and planned legislations, rules, regulations, policy guidelines and government priorities.. *(In China, the policy on environment is supportive of FCV. There is plan to have 1,000 cars in the next 5 years by SAIC. The FCB II demonstration project promoted this plan. (The main reason for non-issuance of service permit to the Shanghai FCBs after the EXPO is to avoid an accident involving real passengers for the purpose of obtaining real-time test data which would have a significant negative public news impact as to the safety of FCBs. Using weight dummies to simulate passengers and obtain real-time data would be a better alternative according to the Shanghai team.)* (Yes in B & S)
- The project's logical framework and design remain relevant in the light of the implementation experience to date. *(The minor modifications were largely in the performance indicators for the goal, objectives and outcomes. In particular, the revised project planning matrix (PPM) renamed the outcomes as components A, B and C, and their title were revised accordingly. Outcome A was expanded from 11 to 18 success indicators; Outcome B as is at 7 success indicators; and Outcome C from 11 to 13 success indicators. Annual targets were also provided to guide the team in implementing the 4-year project. The effect of the revision is providing more clarify in the expected outputs, what activities to pursue in order to attain the success indicators at the specified time frame.)* (Yes in B & S)
- There are no new critical assumptions / risks that need to be raised on top of what were previously validated by the project team. *(There was a risk that the 200,000 kms target for the 6 FCBs would not be met by end-of-project because of the delay in obtaining a service permit from the Shanghai municipal government. This was mitigated, however, by conducting test runs using weight dummies instead of live passengers, and tests were then accelerated.)* (Yes in B & S)
- The project is well-placed and integrated within the national government development strategies such as community development, poverty reduction, etc. and aligned to global development programs. *(The FCB project is important not only to the Chinese Government but also aligned to global development program since addressing CO2 and GHG emissions and mitigating climate change has positive impact on community development and power reduction since the first and significant victims of climate change disturbances are the poor communities and urban centers who suffer from sea level rise, severe flooding and loss of live, severe drought and reduced food production, and higher incidence of respiratory illness arising from polluted environment and warmer temperatures.)* (Yes in B & S)

- The project's institutional and implementation arrangements are still relevant and helpful in achieving its goal, objective and outcomes; there are no institutional concerns that hinder its implementation and progress towards completion (Yes in B & S)

(c) Project management (adaptive management framework):

- The project management arrangements remain adequate and appropriate as evidenced by the progress reports (PIR, APR, Beijing and Shanghai presentation and site visits to SAIC fuel cell bus factory and Anting hydrogen refueling station facility) and is observed to be results-based and innovative (Yes in B & S)
- The project is well managed at all levels as per excel survey (Yes in B & S)
- The project management systems (progress reporting, administrative, financial systems, monitoring and evaluation systems) are effective and provide sufficient basis for evaluating performance and facilitating decision making (Yes in B & S)
- Technical assistance and support from project partners and stakeholders were found to be appropriate, adequate and timely (Yes in B & S)
- The risks originally identified in the revised Project Document and currently in the APRs/PIRs are indeed the most critical and the assessments and risk ratings placed are still reasonable for which the FTR team also concurs (Yes in B & S)
- During the interview, there are no additional risks, except for the risk of non-completion of the Shanghai demos due to non-issuance of municipal service permits, identified as the risk of not procuring the required number of FCBs with the funding budget available and permits by local government were identified in advance. (*Without the permits, the Shanghai team decided to conduct the test runs using weight dummies to gather real-time operating data to reach the target of 200,000 kms at end-of-project.)* (No in B & S)
- The use of project's logical framework and work plans as management tools and in meeting with UNDP-GEF requirements in planning and reporting is deemed effective and the FTR team itself found it useful in organizing and analyzing the final-term evaluation results (Yes in B & S)
- The effective use of electronic information and communication technologies in the implementation and management of the project has greatly automated, simplified, expedited and made more accurate the gathering of data, reports, calculations and results (Yes in B & S)
- The financial management of the project is effective and none noted any irregularities (Yes in B & S)
- The APR/PIR process has helped in monitoring and evaluating the project implementation and achievement of results as it tracks the extent and time of delivery of the project outputs (Yes in B & S)

(d) Strategic partnerships (project positioning and leveraging):

- The sub-contractors responded that project partners are strategically and optimally positioned and effectively leveraged to achieve maximum effect of the sustainable Transport and Energy Efficiency program objectives for the country. *(The project partners such as the municipal governments of Beijing and Shanghai, universities, bus operators and bus manufacturers have effectively contributed their unique expertise to the greater pool of technical excellence needed to perfect the FC hybrid bus and to do innovative work in their respective areas.)* (Yes in B & S)
- The project partners, stakeholders and co-financing institutions are involved in some aspects of the project's adaptive management framework since they provide us comments and suggestion during the projects. *(The municipal government of Shanghai suggested instead the use weight dummies instead of live passengers when conducting the test runs for accumulating 200,000 kms of bus operating experience.)* (Yes in B & S)
- There are opportunities for stronger collaboration and substantive partnerships identified to enhance the project's achievement of results and outcomes (Yes in B & S)

- The project information and progress of activities are disseminated to project partners and stakeholders (Yes in B & S)

Recommendations

Status of MTR Recommendations for Phase II

"For the Shanghai FCBs, it is recommended that the testing program be accelerated in order to attain the planned 200,000 km by securing as soon as possible permits for city bus operation. It is recommended that the Shanghai PMO secure the municipal service permits for the 6 FCBs purchased in this Phase II project considering that EOP is fast approaching." Testing with sand-bag dummies were carried out in the absence of permit. It was more prudent to use weight dummies for conducting the test runs instead of live passengers to avoid negative publicity arising from any accident or equipment failure during testing if passengers are used to simulate bus load capacity.

"In the case of Beijing FCBs which has attained so far 60,198 km traveled in its one year planned operation. It is recommended that the 3 Beijing FCBs be preserved in good running condition before they are distributed to the final recipients for museum display and training purposes." The 3 Phase I FCBs are preserved. Present status is one FCB is preserved in museum, one FCB with a university for student and faculty research and one FCB on stand-by demonstration for Beijing to continue its mission for public awareness on the benefits of "clean fuel" FCB. The 6 Phase II FCBs are in good running condition and continuing their test runs to attain the planned 200,000 km target by end-of-project. These Shanghai FCBs could also be retrofitted with latest FC vehicle technology enhancements to enlarge the fleet for the FCB Phase III expanded demonstration in City Cluster and Urban City driving modes.

"The numerous studies completed and in the possession of the PMO can be combined into a technical volume that could be accessed readily by interested researchers throughout the world, and possibly be used as reference for future policy development and fuel cell hybrid technology improvements…" The reports have been posted on-line at the UNDP-China FCB Phase II project website for appropriate viewing and downloading by the public.

"China appears to have successfully carried out the procurement, testing and demonstration of this hydrogen fuel cell technology. It is highly recommended that this enabling experience be shared throughout the world to highlight its successful efforts..." This has been done and available at the website.

Status of MTR Recommendations for Phase III

"The development of FC vehicle technologies is rapidly evolving. Thus, it is recommended that in the preparation of the Phase III proposal, the project team shall endeavor to evaluate which FC hybrid technology/manufacturer to commercialize in China…" This will be reflected in the PIF for Phase III as it conduct further tests on the newer FC hybrid buses that entered the market very recently to ensure that the best FC hybrid technology is adopted for the expanded demonstration in several Chinese cities.

"In the design of the FCB III project proposal, there is now an earnest need to conduct scientific parallel tests between the baseline diesel engine bus and the alternative hydrogen fuel cell hybrid bus. This means procuring the same identical bus chassis of same length, height, weight, passenger capacity…" This will also be reflected in the PIF for Phase III which will evaluate the comparative economics of the newer FC hybrid buses vs. the conventional diesel-fed and CNG-fed buses fitted preferably with hybrid technology also in order to optimize the bus fleet mix that will enable sustainable CO2 and GHG emission reduction in the Chinese transport sector for City Cluster and Urban City driving conditions. Existing information for determining comparative economics under current conditions is not recommended due to significant rise in conventional fossil fuel costs and FCB price and performance improvements (lower price, higher efficiency, longer fuel cell lifetime).

Recommendations for Phase II

"For the Shanghai FCBs, it is recommended that the testing program be accelerated in order to attain the planned 200,000 km." Without the municipal service permit, the 6 Shanghai FCBs continued their test runs by using weight dummies instead of live passengers in order to avoid accidents with passengers on board. This has led to attainment of 183,558 km and transport of 106,040 dummy passengers as of 13 Dec 2011.

"In the case of Beijing FCBs which has attained so far 75,460 km (no requirement in the project document), it is recommended that the 3 Beijing FCBs be preserved in good condition." The 3 FCBs were purchased under Phase I for the Beijing demonstration. One FCB is preserved in a museum, another one is preserved in a university for continuing research by students and faculty and the last one is kept on running condition to continue its role as Beijing's clean vehicle demonstration to continue public interest and awareness of hydrogen FC bus as a cleaner alternative vehicle for densely populated Chinese cities, and thus contribute to the commercialization of FCB in China.

"The Beijing PMO has already secured municipal service permit for its 3 existing FCBs as a result of diligent follow-ups and it is recommended that the Shanghai PMO do the same expeditiously for the 6 FCBs purchased in this Phase II project considering that EOP is fast approaching." While this is now water under the bridge since the 6 Shanghai FCBs continued their test runs without live passengers by using instead weight dummies to simulate passenger service, it would be a prudent move for the Shanghai Government to initiate an independent evaluation on the reliability and safety of the said FCBs so that after the 200,000 km test, the said FCBs may be granted the necessary permit for test runs under the expanded demonstration under Phase III and its technical and economic performance be compared with the current conventional bus fleet in Shanghai. In this way, the FCBs and the conventional buses could run in a sustainable manner by means of cross-subsidy mechanism within the bus mix without the need for external budget support from either the municipal or central government of China.

Recommended FCB II exit plan if there will be no FCB III

- What is the plan for the 6 FCBs in Shanghai? Will these be placed in operations as regular bus transport vehicles? Who will own and operate these FCBs?

  The FTR team recommends that it secure the needed municipal service permits after it has been fully authorized as a regular bus fit for public transit service. The ownership of the bus will remain with the entity that purchased them (Shanghai municipal government and FCB project), but will be operated as a regular bus by the local bus company operating the regular bus fleet. Its fuel costs, operating costs and other maintenance costs shall be monitored by the bus fleet operator using the FCB project staff who will continue to get paid by the FCB project using funds from the entity that owns the bus with additional funding to be provided by the Chinese central government.

- How will the CO2 emission reductions from the use of the 6 FCBs be monitored?

  The operating parameters (km traveled, H2 consumption for revenue run and maintenance, kg H2 per 100 km revenue run, passengers carried, CO2 emission reduction) should be monitored specially up to the next 5 years. After 10 years of operation of each FCB unit, it is deemed to have reached its economic life and shall be kept in preservation mode, preferably in a public museum, university campus for student/faculty research or instructional purposes, as may be practicable.

- How will these be reported and to which entity will these be reported?

The operating parameters monitored, stored and analyzed shall be reported to the PMO, UNDP, GEF and central GHG emission monitoring body of the China central government in charge for GHG emission inventory (as agreed or identified in the SNC Project).

Recommendations for Phase III

The development of FC vehicle technologies is rapidly evolving. Thus, it is recommended that in the preparation of the Phase III proposal, the project team shall endeavor to evaluate which FC hybrid technology/manufacturer to commercialize in China in order to adopt the most optimal and economical FC hybrid technology for commercialization in China's cluster cities and urban areas.

In this manner, as China endeavors to reduce its CO2 and GHG emission from the transport sector, it will be done in a sustainable manner as the FC hybrid technology chosen shall be the cheapest in terms of long run marginal cost (LRMC, expressed as RMB per passenger-km) that considers the initial capital cost of the FCB unit, its capacity factor and passengers carried, fuel cost and energy efficiency, operating and maintenance costs, and fuel cell stack overhaul and replacement cost during the expected 10-15 years economic life of the FCB unit and driving cycle mode for city cluster (long distance intra city travel) and urban city (short distance heavy traffic stop and go).

In the design of the FCB III project proposal, there is now an earnest need to conduct scientific parallel tests between the baseline diesel-fed and CNG-fed bus and its hybrid variants and the alternative hydrogen fuel cell hybrid bus that will be procured in FCB III. This means procuring the same identical bus chassis of same length, height, weight, passenger capacity. In this manner, the current conventional bus fleet for City Cluster and Urban City applications are also optimized and made energy efficient and cost effective. Such improvement of existing conventional bus fleet will result in cheaper bus fares whose cost savings may be applied to cross-subsidize the more expensive FC hybrid buses.

Only by having an optimal mix of energy-efficient bus technologies will China be able to address long-term and in a sustainable manner the need to reduce pollution (NOx, SO2, CO, UHC, particulates) from bus transit fleet, lower commuter transport fare and reduce CO2 and GHG emissions.

Thus having together an optimal vehicle mix and policy initiatives that promotes a paradigm shift from inefficient private motoring to optimized, integrated and "clean fuel" and "clean vehicle" technology applicable to both driving modes from City Cluster (long distance high speed) and Urban City (short distance heavy traffic stop and go) will enable China to address in a sustainable way its global responsibility of significantly contributing to CO2 and GHG emission reduction.

In a way, the FCB Phase III would be essentially an expanded demonstration to remove the barriers that prevent its commercialization in China's city clusters and urban cities. Of course, among the main barriers to commercialization are: higher cost of the FCB unit relative to conventional fossil-fed engine buses; higher fuel cost of hydrogen compared to diesel, gasoline or CNG; need for higher efficiency to over come higher fuel cost; shorter fuel cell stack lifetime and frequent replacement; durability and reliability issues; and safety concerns as it carries compressed hydrogen – all of which conspire to form a barrier to commercialization of FC hybrid technology.

The PMO is now drafting the Project Information Form (PIF) of the next Phase III expanded demonstration of the latest FC hybrid bus technology and of conventional diesel-fed and CNG-fed buses preferably with hybrid technology to improve energy efficiency and reduce cost of commuting using public bus fleet in City Clusters and Urban Cities in China and thus remove the main barriers identified above; hence, it should pursue its development into a full-pledged Project Document for approval by the GEF/MoF so it may commence by 2012 after the project ends by Dec 2011.

Components of Phase III – Expanded Demonstration

The goal of Phase III is to expand and optimize the reduction of GHG emissions and air pollution in city clusters and urban cities of China using both the latest FC hybrid bus and updated conventional diesel-fed and CNG-fed bus preferably with hybrid technology. The objective of Phase III is to verify the operational viability and economic performance of newer FC hybrid bus and that of conventional diesel-fed and CNG-fed bus preferably with hybrid technology. Lastly, the recommended components or outcomes for Phase III are as follows:

- Expand commercial demonstration in several cities (city clusters and urban city) with differing driving modes (long distance intra-city vs. short distance heavy traffic stop and go) and types of vehicles (newer FC hybrid bus, diesel-fed and CNG-fed buses preferably in hybrid mode)

- Conduct parallel tests on pure diesel, gasoline/diesel electric hybrid, pure electric vehicle and fuel cell hybrid vehicle as well as policy reviews (taxation, permits, emissions, safety) in order to determine the comparative economics of various transport vehicles driving under different driving modes (city cluster vs. urban city). In this way, the optimal mix for diesel, CNG and hydrogen fueled vehicles are determined for each type of driving mode so that overall economics and cheaper commuter fare is possible (conventional diesel and CNG buses cross-subsidizing fuel cell buses)
- Study further hydrogen fuel source route (electrolysis, natural gas reforming, biomass, steel and chemical plant by-product). The previous studies need to be updated considering that crude oil prices have risen from previous levels of about US$38 per barrel to over US$100 as of today (end 2011).
- Study further fuel cell technology to use. Since FCB Phase II, numerous developments have been introduced to FC hybrid bus so the Phase III needs to evaluate and test which one is to be adopted.
- Expand demonstration fleet - buses, taxi fleet, hotel car fleet, car rental fleet, government and post office fleet, fixed-route delivery truck fleet. Aside from buses, Phase III needs to test and demonstrate other fleet types. Involving the government and post office fleet, for instance, will provide a steady market for fuel cell stack and accessories that it will reduce R&D and mass production costs for FC vehicles in China.
- Expand hydrogen refueling station infrastructure
- Expand fuel cell hybrid bus manufacturing capacity
- Review and expand government regulatory, permitting and taxation policies for FCB, FCEV, FCHV and other "clean energy" vehicles for both private and public transport in China

Best Practices

- The exceptional effort of the MoST in convincing and lobbying the Shanghai municipal government to purchase 2 FCBs out of the required 6 FCBs when it was clear that the allocated budget for FCB purchase can accommodate only 4 FCBs.

- The strong stakeholder support and good working relationship among all project participants is needed at all times. The close cooperation between the UNDP-China FCB demonstration project team and other national electric vehicle (EV) project teams under the National 863 Program is essential in avoiding potential problems along the way such as in Beijing which obtained city bus operating permit from municipal authorities to allow continued testing and demonstration of the FOTON FCB buses even after the end of the Beijing Olympics and Paralympics.

- Having strong technical support from the universities and industry associations is a key to a successful project implementation as it contributed to assisting the fuel cell and hybrid bus fabricators and systems integrators by way of innovative research and technical support.

- The show casing of the Fuel Cell Hybrid technology in the 2008 Olympic Games and 2010 World Expo that were attended by the top management of GEF, UNDP, ADB, WB and Government of China ministries is highly commendable as it provided the opportunity to observe the enthusiasm of the recipients of the new technology.

- By implementing the demonstration in time for the Beijing Olympics and Paralympics for the 3 FCBs procured under the National 863 Program as well as the Shanghai World Expo for the 6 FCBs procured under the FCB Phase II project, a wider audience from both local and foreign guests were able to observe the clean, noise-free and comfortable experience in riding the fuel cell hybrid buses.

Lessons Learned

- Had the local municipal government service permits for city bus operation been issued prior to the ending of the 2010 Shanghai Expo, the demonstration and evaluation of the Shanghai FCBs would have proceeded at a faster pace so that the target 200,000 km would have been attained sooner. As a corrective measure, however, the central PMO and local PMO found another way to continue testing by utilizing sand-bag dummies as passengers. In this manner, the safety concern raised by the Shanghai municipal government of conducting the test runs with live passengers have been addressed by substituting weight dummies as passengers. Operational and safety data were thus obtained and collected continuously until the target 200,000 km run would be attained. It was felt that any accident or equipment failure with live passengers on board would have been a publicity debacle if accidents and equipment failure would occur during actual runs.

  On the other hand, the Beijing FCBs continued their testing program without major interruption after the ending of the 2008 Beijing Olympic and Paralympics through the active lobbying and follow-up of the project team and cooperation of the local government. The positive response of the Beijing municipal government to allowing testing with live passengers as opposed to the negative response of the Shanghai municipal government of not allowing testing with live passengers on board shows the variability in government perception on safety issues regarding hydrogen-powered vehicles as well as its pragmatic approach to tests. The Shanghai government thought it would be most prudent to conduct tests using weight dummies instead rather than live passengers since an accident may impact negatively on the FCB demonstration project.

- Greater effort in estimating the future cost of a fuel cell hybrid bus is needed in order to ensure that adequate project funding is secured from the potential sources of funding and investors. This could have avoided the need for Shanghai municipal government to provide funding for 2 FCBs since the budget was sufficient only for the purchase of 4 FCBs. However, this initial funding problem became a blessing in disguise for the project as it provided a unique opportunity for the Shanghai municipal government to participate intimately by providing its own funds for 2 FCBs and claim significant ownership and participation in this project of great importance to the Chinese government.

1.0 Introduction

This Final-Term Review (FTR) Report is part of the monitoring and evaluation requirement in the implementation of the UNDP-GEF project *Demonstration for Fuel-Cell Bus Commercialization in China (Phase II)*. This is a continuation to the *Demonstration for Fuel-Cell Bus Commercialization in China Part I (CPR/01/G31)* project which weas completed and evaluated in November 2004. A proposal is in the Project Information Form (PIF) stage preparation for *Expanded Demonstration (Phase III)* project which intends to increase the demonstration scale of FCVs operating in several cities in China. Once the PIF is approved, a Project Document (ProDoc) will be prepared for approval to ensure continuity towards *Full Commercialization (Phase IV)* project in China.

The long-term plan for fuel cell bus, electric and hybrid vehicles (FCB, FCEV, FCHV) in China spans many phases in order to innovate on the fuel cell hybrid and electric vehicle technologies to ensure safety, reduce capital and operating costs, raise fuel utilization efficiency in transportation sector, encourage its use as mode of transport in order to reduce pollution (particulates, NOx, SO2, CO and UHC) and GHG emissions (CO2) from transport sector, and diversify fuel supplies and sources of hydrogen used in transport.

- Phase I – "*Demonstration for Fuel Cell Bus Commercialization in China Part I*" - year 1 of the project involving the preparation and procurement of the first set of FCBs and hydrogen refueling stations
- Phase II – "*Demonstration for the Fuel Cell Bus Commercialization in China (Phase II)*" - years 2 to 5 principally involving demonstration activities of the FCBs and refueling stations constructed in Phase I, then a second procurement of FCBs, and preparation of the Phase III demonstration project.
- Phase III – "*Expanded Demonstration of Fuel Cell Bus in China (Phase III)*" - intends to increase the demonstration scale of the newer FCVs operating in several cities in China under different driving modes (high speed City Cluster and heavy traffic stop and go Urban City)
- Phase IV – *"Market Penetration of Cost-Competitive FCBs in China (Phase IV)*" – mass production of FCBs and diversification of hydrogen sources to reduce CO2 emissions on larger scale

1.1 *Brief Description of the Project*

The China FCB demonstration program is jointly funded by UNDP and GEF and aimed at catalyzing the cost-reduction of fuel-cell buses (FCBs) for public transit applications in Chinese cities by supporting significant parallel demonstrations of FCBs and their refueling infrastructures in Beijing and Shanghai. The knowledge and experience gained through this project will enable the FCB technology suppliers to identify cost reduction opportunities and the host public transit operators to gain valuable experience needed to adopt larger fleets of FCBs in the future. The project will help build capacity relating to FCBs, including strengthening policy and planning capabilities of the public transit companies and line government institutes; enhancing scientific, technical, and industrial capacity for commercializing FCBs; and increasing the understanding of FCBs to climate change among government, investment, media, and other key actors. This project focuses on defining a detailed strategy for large-scale FCB commercialization in China.

On 18 October 2005, the Project Identification Form (PIF) was approved, followed by approval of GEF CEO Endorsement Request on 7 July 2006. The Project Document (ProDoc) was signed on 14 May 2007, launched in 15 November 2007 and the first disbursement was made on 29 December 2007. This Phase II is co-funded by the Government of China (GoC) and other private sector companies in China, GEF and UNDP. It is co-organized by the Ministry of Science and Technology (MoST), Beijing and Shanghai municipal governments.

The cost of the FCB Phase II project is US$18.625 million, consisting of US$5.963 million from GEF/UNDP with co-financing from the Government of China (GoC) amounting to US$3.519 million from

Ministry of Science & Technology (MoST) (not including waived duties), local government units of US$3.536 from Municipal government of Beijing and US$4.384 million from Municipal government of Shanghai, and US$1.223 million from private sector.

UNDP-China's contribution of $196,000 is for supporting policy-related activities. Bulk of the $5.767 million provided by GEF covers the cost of purchasing the FCBs, since their high incremental cost (relative to conventional diesel buses) represents the greatest barrier to the dissemination of the new technology today. Phase II involves the procurement of 3 to 6 FCBs. The refueling stations will be financed by the Shanghai and Beijing municipal governments as indicated in the total budget and work plan.

In Phase II Project, Shanghai will obtain hydrogen from a plentiful by-product from a steel plant and chemical plant while Beijing will obtain hydrogen from onsite facilities such as electrolysis of water and reforming of natural gas. The Project Team anticipates that by the time the FCBs are in commercial use, a substantial portion of electricity mix in China will be from renewable energies. The study that will be carried out on the assessment of hydrogen production routes for China will examine other options and their feasibility over the longer term.

Broadly, the project activities are of 4 kinds:

- ***Catalyze cost reduction*** of FCB for public transport in Chinese cities by supporting significant parallel demonstrations of FCB and HRS in Beijing and Shanghai
- ***Enable FCB technology suppliers*** to identify cost reduction opportunities while host public transit operators gain valuable experience needed to adopt larger fleets of FCB
- ***Enhance scientific, technical and industrial capacity*** for commercializing FCB to strengthen policy and planning capabilities of government institutes and public transport companies (H2 production route, FCEV technology)
- ***Increase understanding of the contributions of FCB to mitigating climate change*** among government, investors, financial institutions, media and the people which will lead to a detailed strategy for large-scale FCB commercialization in China

1.2 *Purpose of the Evaluation*

This Final-Term Review (FTR) Report is part of the monitoring and evaluation requirement in the implementation of the project entitled *Demonstration for Fuel-Cell Bus Commercialization in China (Phase II).* This project which started disbursing on 29 December 2007 (Dec 2007 - Dec 2008 as Year 1) and has now reached final-term stage as of Dec 2011 (Dec 2010 - Dec 2011 as Year 4) in terms of physical and financial delivery and therefore, a final-term evaluation is being conducted now. The Terms of Reference (ToR) may be referred to in Annex K.

The purpose of the FTR is to evaluate the project implementation and management performances. It will determine whether the project is on track to achieve the project objective and therefore just need to be sustained as it approaches end of project (EOP) this end of December 2011.

The project evaluation will also determine and report on the experiences and lessons learnt during the project implementation so as to provide guidance in determining the targets and strategies for the planned *Expanded Demonstration of Fuel Cell Bus in China (Phase III)*. In this regard, the findings and recommendations of this evaluation will contribute to identifying best possible ways to advance the modern public transportation technology by commercializing FCBs in the cities.

1.3 *Key Issues Addressed and Scope of the Evaluation*

The scope of the FTR (Section 3.1 of the ToR) covered the entire UNDP/GEF-funded FCB Phase II project and its components as well as the co-financed activities in each component of the project. The FTR will assess the FCB Phase II project implementation taking into account the status of the project activities and outputs and the resource disbursements made up to the final evaluation review date. The evaluation involved analysis at two levels: component level and project level.

The FTR also included such aspects as appropriateness and relevance of work plan, compliance with the work and financial plan with budget allocation, timeliness of disbursements, procurement, coordination among project team members and committees, and the UNDP country office support. Any issue or factor that has impeded or accelerated the implementation of the project or any of its components, including actions taken and resolutions, made were highlighted.

1.4 *Methodology of the Final-Term Review (FTR)*

A Final-Term Review Team comprising Engr. Marcial T. Ocampo (International Consultant and Team Head) and Prof. Tian Guangyu, Ph.D. (National Consultant and Team Member) was formed by the UNDP. They conducted the FTR from Dec 5-26, 2011 taking into account the status of project activities, outputs and resource disbursements made up to Dec 13, 2011. The itinerary is shown in Annex A1- FTR Schedule of Meetings and Site Visits.

Largely, the methodology consisted of:

- Review of key documents such as the evaluator's Terms of Reference (ToR), final evaluation report of the *Demonstration for Fuel Cell Bus Commercialization in China Part I*, Project Document (ProDoc) and Project Logical Framework (Log Frame)**,** Annual Project Review (APR) and Project Implementation Report (PIR), Quarterly Operation Report (QOR), Combined Delivery Report (see Annex C1- List of Documents Reviewed) and Mid-Term Review (MTR) Report of the *Demonstration for Fuel-Cell Bus Commercialization in China (Phase II)*
- Interviews of PMO, key sub-contracting personnel, and UNDP Country Office Counterparts (see Annex B - List of Persons and Their Affiliations)
- Site visits to fuel cell bus manufacturer and hydrogen refueling station (see Annex A1- FTR Schedule of Meetings and Site Visits)
- Review of public awareness and education activities (see Annex A2 - List of Exhibitions, Conferences, Workshops and Seminars
- Review of sub-contract reports (see Annex C2 - Status of the Different Sub-Contracts as of Dec 2011)
- Review of other UNDP-GEF projects on government policies in development of FCBs for Chinese cities, e.g. China - Eco-Transport in City Clusters: Model Development & Pilots and China - GEF-World Bank-China Urban Transport Partnership Program (CUTPP).

After the review of documents, interview of personnel, appreciation of power point presentation materials and FCB manufacturing plant and hydrogen refueling station visits, the FTR Team analyzed and synthesized the information to deliver the following outputs of this final evaluation:

- Report presenting the final-term evaluation results of the project, recommendations for the implementation of any remaining activities, and suggestions for implementation of the Third National Communication. The report would be submitted to UNDP CO in electronic format.

- Presentation of findings in a debriefing meeting at the UNDP CO. The findings of the evaluation will be used by the project team in preparing the PIF and the ProDoc for the next Phase III on expanded demonstration of FCB in several cities in China.

The FTR followed the rating chart as per GEF guidelines in rating the progress and performance of a project. The details of the rating system are given in the table below:

Table 1-1: Chart for rating the project

Highly Satisfactory (HS)	Project is expected to achieve or exceed **all** its major global environmental objectives, and yield substantial global environmental benefits, without major shortcomings. The project can be presented as "good practice".
Satisfactory (S)	Project is expected to achieve **most** of its major global environmental objectives, and yield satisfactory global environmental benefits, with only minor shortcomings.
Marginally Satisfactory (MS)	Project is expected to achieve **most** of its major relevant objectives **but** with either significant shortcomings or modest overall relevance. Project is expected not to achieve some of its major global environmental objectives or yield some of the expected global environment benefits.
Marginally Unsatisfactory (MU)	Project is expected to achieve its major global environmental objectives with **major shortcomings** or is expected to achieve only some of its major global environmental objectives.
Unsatisfactory (U)	Project is expected **not** to achieve most of its major global environment objectives or to yield any satisfactory global environmental benefits.
Highly Unsatisfactory (HU)	The project has **failed** to achieve, and is not expected to achieve, any of its major global environment objectives with no worthwhile benefits.

1.5 *Specific Tasks for the FTR*

The specific tasks for the FTR (Section 3.2 of the ToR) covered the review pertinent documents related to the project such as project document, quarterly and annual progress reports, other activity/component specific deliverables, reports and evaluation, if there are any, etc; conduct of structured interview with knowledgeable parties (e.g., PMO, GOC personnel, Beijing & Shanghai government officials, Sub-Contracting Parties/Entities, National Consultants, UNDP CO Counterparts, members of the Project Steering/Advisory Committee/s, Project Beneficiaries or grantees, etc.); and visit various pilot project sites. The evaluation mission will carry out the following tasks:

1) Review of the project design, and planning to find out whether: (a) the project approaches and strategy are sound; (b) the immediate objectives and outputs are properly stated and verifiable in the project logical framework; (c) the timeframe of the project is feasible and practicable; and, (d) others.
2) Review of project performance: timeliness and quality of inputs; timeliness and cost-effectiveness of activities undertaken; quality and quantity of outputs produced; achievement of outcomes; and a financial review against the project budget.
3) Review the project impact: determine the extent to which the project objectives are expected to be achieved and what are the short-term and long-term impact of the project, including efficiency of the project, cost-effectiveness of the project;
4) Study the government policies in development of FCBs for the Chinese cities and assess the relevance of the project against the national development priorities and objectives;
5) Analyze the current FCB projects in other countries, and the domestic and international market developments in supply and demand of the technology to find out and advise potentials for possible project expansion;

6) Analyze and report on the good practices and lessons learnt in partnership building of the project with companies and agencies in introducing the FCBs and designing and building the refuelling station in expanded demonstration cities in China
7) Provide recommendations on the improvement or sustenance of the implementation; potential aspects of FCB commercialization that can be covered in a planned Phase III of the project; and actions to be taken to support the sustainable development of FC vehicle technologies and applications in China.
8) Revisit the MTR Report to see if the key recommendations have been put into practice in the process of project implementation.

1.6 *Limitation of the FTR*

The FTR team was provided by the UNDO CO and PMO with the required documents prior to the actual mission to facilitate understanding of the scope of the evaluation, project document, progress implementation report, financial report and power point presentation of selected sectors. To supplement these information, the FTR team provided the PMO with an excel survey form to be filled up during the site visits to Beijing and Shanghai.

The FTR report is based and limited to information obtained from the following:

- Final evaluation report on project *Demonstration for Fuel Cell Bus Commercialization in China Part I* (FCB I China Evaluation report.pdf)
- Project Document (ProDoc) which contain the description of outcomes / components and success indicators, outputs, activities, baseline and annual targets (China FCBII ProDoc.pdf)
- Final Mid-Term Review (MTR) Report FCB II_Dec 10, 2010.doc
- Logical Framework (Revised FCB Log Frame 210208 final.xls)
- Annual Targets (FCB II Annual Targets 270709.xls)
- Reporting of physical progress: Annual Project Review (APR) and Project Implementation Report (PIR) for 2010 (PIMS 2933 CPR FCB II PIR 2010 Report - Final.xls) and 2011 (PIMS 2933 CPR FCB II PIR 2011 - Revised by Noel final.xls)
- Quarterly Operating Reports (QOR) - 2008, 2009, 2010, 2011
- Combined Delivery Reports (CDR) – 2007, 2008, 2009, 2010, 2011
- Final reports of sub-projects (Annex C1 - List of Documents Reviewed)
- Electronic file of presentation materials provided by the Beijing team (GEF UNDP BEIJING FCBUS Report 20111215_Ver03.ppt) and Shanghai team (Progress of Shanghai Project.ppt)
- The World's Largest Economies 2011(Richest People)
- BP Statistical Review of World Energy June 2011
- List of Countries by 2010 Emissions Estimate (CDIAC, US DOE)
- Fuel Cell Technologies - Performance, Status and Cost (US NREL)
- List of Fuel Cell Bus Projects in US (US NREL)
- List of Worldwide Fuel Cell Bus Projects Completed, On-Going and Planned (US NREL)
- China: Eco-Transport in City Clusters: Model Development & Pilots
- GEF-World Bank-China Urban Transport Partnership Program (CUTPP)

2.0 Project and Its Development Context

As of Oct 31, 2011, world population is estimated at 7.0 billion people with a global economy valued at US$61.96 trillion worth of gross domestic product (GDP). According to Richest People (The World's Largest Economies 2011), the top 10 largest economies in the world by nominal GDP (in Trillion US$) are United States ($14.6), China ($10.0), Japan ($4.3), India ($4.0), Germany ($2.9), Russia ($2.2), Brazil ($2.1), United Kingdom ($2.0), France ($2.0) and Italy ($1.7) while the top 10 countries in terms of population (in Million) are United States (312 M), China (1,340 M), Japan (128 M), India (1,210 M), Germany (82 M), Russia (143 M), Brazil (192 M), United Kingdom (62 M), France (66 M) and Italy (61 M).

China as of 2009, however, has overtaken the United States as the largest energy user. As of 2010, the top 10 countries according to British Petroleum (BP Statistical Review of World Energy, June 2011) in terms of primary energy consumption (in million tons of oil equivalent or Mtoe) are China (2,432), United States (2,286), Russia (691), India (524), Japan (501), Germany (320), Canada (317), South Korea (255), Brazil (254) and France (252).

The Carbon Dioxide Information Analysis Center (CDIAC) is the primary climate-change data and information analysis center of the U.S. Department of Energy (DOE). CDIAC released preliminary 2010 estimates for limited number of countries. Out of the total 33,509 million tons of CO_2 emitted by the world, the top 20 emitters of CO_2 emissions are China (8,241), United States (5,492), India (2,070), Russia (1,689), Japan (1,138), Germany (763), Iran (575), South Korea (563), Canada (518), Saudi Arabia (494), United Kingdom (493), Indonesia (477), Mexico (466), South Africa (452), Brazil (420), Australia (366), France (363) and Poland (310).

Table 2-2: World Statistics on Population, GDP, Primary Energy and CO2 Emissions (2010)

GDP Rank	Country	Population Million	GDP Trillion US$	Primary Energy (BP) Mtoe	Share of Energy % of Total	CO2 Emission (CDIAC) Million tons	Share of CO2 % of Total
	World Total	**7,000.000**		**12,002.4**	**100.0**	**33,508.9**	**100.0**
1	United States	312.222	14.660	2,285.7	19.0	5,492.2	16.4
2	China	1,339.725	10.090	2,432.2	20.3	8,241.0	24.6
3	Japan	127.960	4.310	500.9	4.2	1,138.4	3.4
4	India	1,210.193	4.060	524.2	4.4	2,069.7	6.2
5	Germany	81.800	2.940	319.5	2.7	762.5	2.3
6	Russia	142.905	2.223	690.9	5.8	1,688.7	5.0
7	United Kingdom	62.262	2.173	209.1	1.7	493.2	1.5
8	Brazil	192.376	2.172	253.9	2.1	419.5	1.3
9	France	65.722	2.145	252.4	2.1	362.6	1.1
10	Italy	60.682	1.774	172.0	1.4	407.9	1.2

China's primary energy rose from 1,178.3 Mtoe in 2003 or 12.0% of world's total and establishing China as the second largest consumer of energy in the world behind United States at 23.6%. By 2009, its breath-taking GDP growth of over 7% p.a. as the world's manufacturing center has resulted in primary energy growth of 6% p.a. leading to China's overtaking the United States as the largest user of energy. China in 2010 consumed 2,432.2 Mtoe or 20.3% of world primary energy, eclipsing the United States which dropped to second place at 2,285.7 Mtoe or 19.0% of world energy use.

In a similar manner, China was also the second largest emitter of CO2 in the world in 2003, and as its energy consumption rose to support its rapid industrialization and rise in per capita income, China became the largest emitter by 2010 at 8,241.0 million tons CO2 or 24.6%, overtaking the United States which dropped to second place at 5,492.2 million tons of CO2 or 16.4% of world emission.

A measure of relative economic development is the per capita income. China's per capita income is a low 7,531 US$ per person per year compared to the highly affluent United States' per capita income of 46,954 US$ per person per year.

Similarly, per capita energy use in China is 1.82 Mtoe per person per year compared to 7.32 Mtoe per person per year in the United States.

In terms of per capita CO2 emission, China's 6.15 tons per person per year is still a far cry from the most affluent emitters in the United States at 17.59 tons per person per year.

Table 2-3: Per Capita GDP, Energy and CO2 Emission (2010)

GDP Rank	Country	Per Capita GDP	Per Capita Energy	Per Capita CO2
	World Total		**1.71**	**4.79**
1	United States	46,954	7.32	17.59
2	China	7,531	1.82	6.15
3	Japan	33,682	3.91	8.90
4	India	3,355	0.43	1.71
5	Germany	35,941	3.91	9.32
6	Russia	15,556	4.83	11.82
7	United Kingdom	34,901	3.36	7.92
8	Brazil	11,290	1.32	2.18
9	France	32,637	3.84	5.52
10	Italy	29,234	2.83	6.72

In 2003, China's primary energy consumption consisted of 68.7% coal and 23.4% oil aggregating to 91.2% of the total primary energy consumption and providing a major source of air pollution and green house gas (GHG) emission in the country. By 2010, the share of coal further increased to 70.5% while oil decreased to 17.6% for a lower total of 88.1% as cleaner natural gas increased to 4.0%. The ProDoc predicts that dependency on imported oil will reach 40% - 60% by 2010 and 2020, respectively.

The advanced economies of United States, Japan and United Kingdom show uniform dependency on oil at 33% - 40%, natural gas at 17% - 40% and coal at 15% - 25%.

Nuclear energy is predominant only in Japan (13%) and France (38%).

Hydro is the major source of energy for Brazil (35%).

Leaders in renewable energy development are Germany (5.8%), Italy (3.3%), Brazil (3.1%), United Kingdom (2.3%), United States (1.7%) and France (1.3%).

The other minor users of renewable energy include Japan and India at 1.0% and China at 0.5%.

China (70.5%) and India (53.0%) are highly dependent on coal as shown in the table below:

Table 2-4: Primary Energy Consumption by Type of Energy Source (2010)

GDP Rank	As of 2010 Country	Oil %	Natural Gas %	Coal %	Nuclear %	Hydro %	Renewable %
	World Total						
1	United States	37.2	27.2	23.0	8.4	2.6	1.7
2	China	17.6	4.0	70.5	0.7	6.7	0.5
3	Japan	40.2	17.0	24.7	13.2	3.9	1.0
4	India	29.7	10.6	53.0	1.0	4.8	1.0
5	Germany	36.0	22.9	23.9	10.0	1.3	5.8
6	Russia	21.4	54.0	13.6	5.6	5.5	0.0
7	United Kingdom	35.2	40.4	14.9	6.7	0.4	2.3
8	Brazil	46.0	9.4	4.9	1.3	35.3	3.1
9	France	33.1	16.7	4.8	38.4	5.7	1.3
10	Italy	42.5	39.8	8.0	0.0	6.5	3.3

According to the ProDoc, around two-thirds of the 343 cities in China under air quality monitoring failed to achieve "2nd Class" of National Air Quality Standard that is acceptable for outdoor activities. The population residing below this "2nd Class" cities accounted for approximately 75% of the total population of the monitored cities.

The "2nd Class" air quality standard are as follows: inhaled particulates (0.100 mg/Nm3), suspended particulates (0.200), SO2 (0.060), NOx (0.080) and CO (not available). Major pollutants in these cities were inhaled particulates (0.141 mg/Nm3), suspended particulates (0.252), SO2 (0.061), NOx (0.072) and CO (2.4). Exceeded were inhaled particulates, suspended particulates and SO2.

Around 70% of the pollutants in urban areas came from vehicle emissions. In the case of Beijing and Shanghai, one of the major contributors to air pollution are the public buses due to their large fleets, high engine power, large fuel consumption, long daily running distance and operation in heavily populated areas.

The ProDoc also provided estimates of motor vehicle population in China. In 2003, the annual vehicle production was 4.44 million units while total number of vehicles in operation stood at 24.21 million. Based on annual production of 8 million units by 2010 and 15 million units by 2020, the total vehicle population will reach 120 - 150 million units by 2020.

With a population of 1.3 billion in 2003, there were 18.6 vehicles per 1000 persons while global vehicles in operation were 850 million units or 127 vehicles per 1000 persons. In developed economies, the typical vehicle ownership is around 500 - 700 vehicles per 1000 persons.

The National Environmental Protection Center (NEPC) predicts that by 2010, pollutant emissions from big cities will represent 64% of total emissions from all cities in China. So far, only 10% of total CO2 emissions come from automotive sources. But if no action is taken to reduce emissions and save energy, it is predicted that 30% of CO2 emissions will come from automotive sources.

The ProDoc has identified key linkages with the recently approved United Nations Development Assistance Framework (UNDAF) for China (2006-2010) that supports more efficient management of national resources, with a special focus on energy, to ensure environmental sustainability. This project is consistent with the recently approved UNDP China Country Programming Document (CPD) (2006 - 2010) which supports continued assistance to China in application of new and renewable energy technologies and in refueling its obligations under multilateral environmental agreements.

2.1 *Project Start and Key Dates*

The PIR provides the project chronology and milestones of this 4-year project as shown below:

Table 2-1: Project Chronology	
Project Timeline (June 2010 APR/PIR)	
Pipeline entry or Project Information Form (PIF) approval	18-Oct-05
GEF CEO Endorsement / approval date	7-Jul-06
Project Document (ProDoc) signature date	14-May-07
Launching of Project	15-Nov-07
Date of first disbursement	29-Dec-07
Original planned closing date	13-May-11
Revised Planned closing date	31-Dec-11
Date project manager hired	14-May-07
Date of project steering committee meeting during the period	8-Feb-10
Planned date of Mid-Term Evaluation (actual start date is Nov 9-18, 2010 plus 5 days at home base)	1-Sep-10
Project Timeline (June 2011 APR/PIR)	
The GEF Honor Day. The Senior Management of UNDP China and programme manager in charge of the project attended the event at the World Expo, along with the GEF CEO and other senior governmental officials, representatives from the World Bank and Asian Development Bank. A ride on a FCB was arranged during the visit to the Expo.	20-Jul-10
Review draft PIR 2010 was conducted by UNDP CO (Zhang Weidong and Zhang Yu)and RTA (Manuel Soriano), along with PMO staff (Wang Ju and Yu Dan)	July 7-28, 2010
Kick-off meeting of Mid-Term Evaluation (Nov. 8 – 19, 2010) at the PMO Office.	9-Nov-10
The Project Review Meeting was held to mainly review the implementation of the project in 2010 and the Annual Work Plan for 2011.	19-Jan-11
Discussions with Shanghai PMO and Shanghai municipal government on the issuance of transport license to the 6 fuel cell buses in order to re-start the FCB demonstrations. Site visit to H2 refilling station and local FC vehicle manufacturer.	May 27-29, 2011
Final-Term Evaluation (Dec 14-20, 2011 mission to Beijing and Shanghai) 16 days total	Dec 5-26, 2011

The Project Identification Form was approved on 18 October 2005 and endorsed to the GEF CEO on 7 July 2006. The Project Document signed on 14 May 2007. The project was launched on 15 November 2007 and made its first disbursement in 29 Dec 2007. On its 4th year, the FCB Phase II project is due for final-term review by its revised closing date of 31 December 2011.

2.2 *Roles and Responsibilities*

The UNDP-GEF Regional Technical Advisor (based in Bangkok, Thailand) who oversees the UNDP-GEF FCB Phase II project assisted the UNDP CO and the FTR team in preparing for the Final-Term Review of the project. The FTR Team reported to the UNDP CO and MoST. The project's executing agency (MoST) coordinated all relevant national and the international agencies and companies and provided in advance copies of the necessary documents needed by the evaluation expert/s.

Likewise, the Executing Agency (MoST) arranged and finalized the itinerary / schedule for the FTR team in consultation with all parties concerned. The project's Chief Technical Advisor (CTA) provided insights of the global FCB market to the FTR Team and discussed with them in detail the technology selection for future FCB development. The EA and UNDP CO coordinated the logistical arrangements for the evaluation.

2.3 *Problems that the Project Seeks to Address*

Air pollution problems and public transport needs in developing countries are among the problems that the GEF, UNDP and GoC would like to address. Such solutions to the two problems, however, need to be implemented in a cost-effective and energy-efficient manner and should be flexible to address varying situations such as that existing in Beijing and Shanghai which have different geography, climate, road infrastructure, traffic conditions and severity, as well as social and market conditions. Both cities, however, face common fast growing needs to upgrade its public transit and address critical challenge of air pollution, security and diversity of future energy supplies for transport and the need to reduce CO2 and other GHG emissions in order to ensure sustainable development by mitigating global warming and climate change in China's transport sector.

Climate change means dramatic change of average conditions of global climate or a comparatively long-lasting change in climate. It may be caused by internal or external forces, or result of continuing human-induced change in land use and composition of the atmosphere due to continued combustion of carbon and hydrogen in transport fossil fuels leading to elevated concentrations of CO2 and H2O.

By developing fuel cell vehicles, electric vehicles and hybrid vehicles (fuel cell, electric, regenerative braking), the use of fossil fuels (oil, coal, natural gas) is made efficient and thus conserved. Such vehicles will encourage the optimal use of conventional energy resources (hydro, geothermal, nuclear) and renewable energy resources (solar, wind, biomass, biogas, mini-hydro, ocean thermal, ocean wave, and tidal current) by generating off-peak electricity to store surplus energy in hydrogen form through electrolysis of water.

Considering that the world has just passed the peak oil regime in 2011 (after which oil reserves begin to decline while consumption continue to rise), it is anticipated that crude oil and its by-product natural gas will be depleted within 50 - 70 years during our lifetime. Although natural gas may be supplemented by newly discovered LNG fields in the Middle East and from tar sands in North America, thus extending the lifetime of natural gas, there are concerns, however, as to its environmental impacts since current extraction technologies are principally "dirty" and will lead to greater emission of GHG gases during its mining, processing and its utilization.

While natural gas may be considered cleaner than coal, the continued mining and combustion of coal for power generation and chemical processes will likewise lead to its depletion in over 250 years (ratio of proven coal reserves to annual extraction rate).

In a similar manner, current fissile uranium reserves are believed to last another 250 - 500 years using existing fission nuclear reaction technologies. By using breeder reactor technology which produces more energy than it consumes, however, nuclear experts believe that the economic lifetime of the world's finite uranium reserves will be extended by another 1,000 years.

With severe climatic changes occurring worldwide, with cycles of "El Nino" and "La Nina" more frequently occurring in cycles of 4 - 6 years, the operation of large hydro power, mini-hydro power and geothermal resources will also be severely constrained during severe droughts as "El Nino" events become more pronounced and dry, leading to minimal hydro power production. Geothermal energy production may also be restrained as it also requires adequate re-injection of water to heat the geothermal rocks to produce sustainable steam pressures for economical power generation in steam turbines.

In this context, China moves forward with greater focus and dedication to innovate on existing fuel cell hybrid technologies currently in the world market, make use of local Chinese talent and manufacturing skills and its abundant rare-earth materials (catalysts) used in fuel cells. As it begin to penetrate the public transport and private automobile sectors in growing fleets, it will contribute to a cleaner environment since fuel cells produce only water upon conversion of hydrogen to electricity.

With the various energy resources that could be tapped to produce hydrogen and stored in highly compressed form, it can provide the needed diversity and security of a mobile fuel supply for the transportation sector of the Chinese economy, and hopefully, share the same experience with the other developing and highly developed countries of the world. In addition to transport use, hydrogen-fed fuel cells can also be used in providing embedded stationary electric power supply in highly concentrated urban housing developments and provide by-product hot water for domestic use (cooking, washing, bathing) as well as drinking water (potable water supply).

2.4 *Immediate and Development Objectives of the Project*

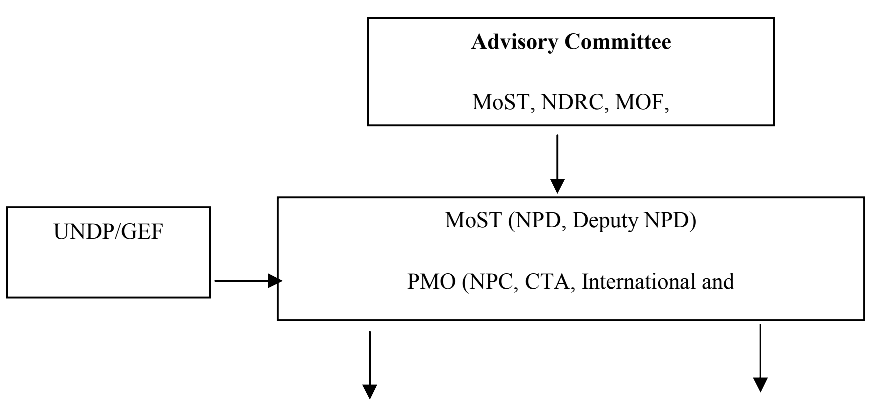
The ***goal*** of the project is Reduction of GHG emissions and air pollution in urban areas of China.

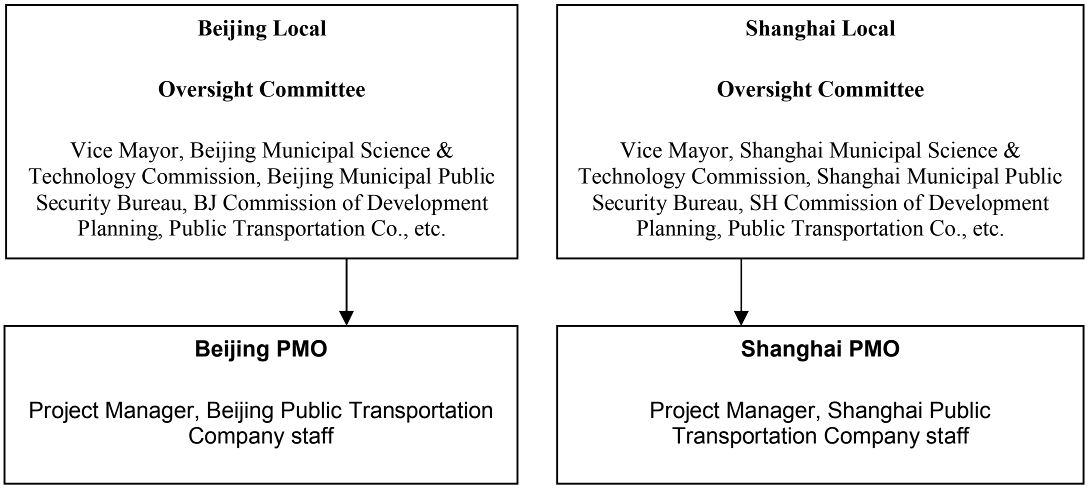
The ***objective*** of the project is the demonstration of the operational viability of FCBs and their hydrogen refueling infrastructure under Chinese operating conditions in mega cities such as Beijing and Shanghai.

The ***expected outcomes*** of the project are: (1) obtain clearer understanding of the operational viability of FCBs and their hydrogen refueling stations, (2) make available adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems, and (3) improve awareness and conducive enabling environment for FCB applications and support for the commercialization of FCBs in China.

2.5 *Main Stakeholders and Institutional Arrangements*

Overall guidance at the national level is provided by an Advisory Committee consisting of representatives from the Ministry of Science and Technology (which heads the national committee), the National Development & Reform Commission, the Ministry of Finance, the Ministry of Public Security, and the Ministry of Commerce. This committee seeks advice from outside experts, as needed. The present FCB Phase II implementation structure is shown below:





The project is nationally executed. The GEF funded project activities are implemented by MoST, and the project activities funded by the UNDP TRAC resources are implemented by the China International Centre for Economic and Technical Exchanges (CICETE). The National Project Director (NPD) appointed by MoST takes overall responsibility for ensuring that all national inputs are mobilized in a timely and effective manner, and is responsible to the Government of China and UNDP/GEF for achieving project objectives.

The day-to-day implementation of the project is conducted by the national project management office (PMO) to be recruited by MoST. CICETE provides implementation support services for the GEF input at the request of the NPD in securing deliverables (personnel, training, equipment, etc.) and facilitating the preparation of financial and administrative reports.

A local project advisory committee was formed in each of the two host municipalities, Beijing and Shanghai. Each committee is headed by a Vice Mayor of the municipality and included representatives from the following municipal level organizations: the Science and Technology Commission, the Economic and Trade Commission, the Development Planning Commission, and the Public Transportation Company. The municipal advisory committees seek advice from outside experts, as needed. The advisory committee meets quarterly.

The day-to-day implementation of the project in each city is under the local project management office (LPMO) and FCB operation is under the responsibility of the Beijing Public Transportation General Company and the Shanghai Bus Electric Limited Company and exchanges experiences and lessons at the annual review meeting. Regular communication between these committees is through the annual meeting, official documents, and project implementation reports and newsletters, and study tour reports.

The institutional arrangement consists of the following entities participating in various capacities as follows:

- ***Global Environment Facility (GEF)* –** is the sponsoring group that promotes global initiatives to address climate change issues, develop mitigation measures and encourage adaptation action plans.
- ***Advisory Committee* –** provides overall guidance at the national level and consists of representatives from the Ministry of Science and Technology, the National Development & Reform Commission, the Ministry of Finance, the Ministry of Public Security, and the Ministry of Commerce. This national guidance committee will seek advice from outside experts, as needed.

- ***National Project Director (NPD)* –** is a senior official appointed by MoST and will take overall responsibility for ensuring that all national inputs are mobilized in a timely and effective manner, and will be responsible to the Government of China and UNDP/GEF for achieving project objectives.
- ***Project Management Office (PMO)* –** is recruited by MoST and will conduct the day-to-day implementation of the project.
- ***Implementing Agency* –** is the United Nations Development Program (UNDP). The UNDP-China Country Office and the UNDP-GEF Asia-Pacific Regional Coordination Unit will supervise this project on behalf of the GEF. UNDP will manage the disbursement of the GEF funds in a timely manner, ensuring that the required reporting of expenditures and audit of project funds comply with national laws and regulations as well as UNDP rules and procedures.
- ***Support Services* –** CICETE will provide implementation support services for the GEF input at the request of the NPD in securing deliverables (personnel, training, equipment, etc.) and facilitate the preparation of financial and administrative reports.

2.6 *Results Expected and Actual Accomplishments*

During the FCB Phase II implementation, there were some minor modifications from what were contained in the original agreement embodied in the ProDoc. The minor modifications were largely in the performance indicators for the goal, objectives and outcomes. In particular, the revised project planning matrix (PPM) renamed the outcomes as components A, B and C, and their title were revised accordingly. Outcome A was expanded from 11 to 18 success indicators; Outcome B as is at 7 success indicators; and Outcome C from 11 to 13 success indicators.

Annual targets were also provided to guide the team in implementing the 4-year project. The effect of the revision is providing more clarify in the expected outputs, what activities to pursue in order to attain the success indicators at the specified time frame. However, the APR/PIR was not revised to reflect the modifications.

The project's logical frame work (Log Frame) clearly indicates the expected results or targets at the end of this four year project.

Table 2-2: Results Expected from the Project

Strategy	Details	Expected Results at end of project (Target)
Goal	Reduction of GHG emissions and air pollution in urban areas of China	1 - Annual CO_2 emissions reduction in the transport sector in Beijing & Shanghai during project 2 - CO_2 emissions reduction in the Chinese transport sector five years after the end-of-project (EOP)
Objective	Demonstration of the operational viability of FCBs and their refueling infrastructure under Chinese conditions	1 - Number of FCBs in commercial operation in Beijing and Shanghai (B&S) during the project 2 - Number of additional FCBs in commercial operation in China by EOP 3 - Number of H_2 refueling stations installed and in operation during the project 4 - Number of additional H_2 refueling stations installed and in operation at EOP
Outcome 1	Clearer understanding of the operational viability of FCBs and their refueling infrastructure	1 - Completed FCB and H_2 refilling station operational guidelines 2 - Number of demo FCBs that are operational by EOP 3 - Number of trained and practicing FCB drivers in B&S by EOP 4 - Cumulative number of trained and practicing FCB mechanics trained in B&S by EOP 5 - Number of demo H_2 refilling stations installed and

		operational by EOP 6 - Number of operators H2 refilling station operators in B&S by EOP 7 - Number of trained and practicing: * FCB drivers * FCB mechanics * H2 refilling station operators in China five years after EOP 8 - Frequency of receipt of acceptable demo FCB performance reports 9 - Average annual passengers of a FCB in B&S 10 - Average annual energy consumption of a FCB in B&S 11 - Annual volume of supply of H2 to H2 refilling stations (tons) in B&S 12 - Overall annual revenues from the commercial operations of FCBs in B&S 13 - Overall level of satisfaction of FCB service in B&S 14 - Overall level of comfort and safety of FCB operation in B&S 15 - Overall level of satisfaction of H2 refilling station service in B&S 16 - Overall level of safety of H2 refilling station operation in B&S 17 - Number of new FCBs deployed by transport companies in other Chinese cities five years after EOP 18 - Number of new H2 refilling stations established in Chinese cities five years after EOP
Outcome 2	Availability of adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems	1 - Number of "FCB value chain" research reports prepared and submitted to MoST by Year 4 2 - Established FCB Certification program by Year 3 3 - Number of proposed implementing rules and regulations on FCB certification by Year 4 4 - The total number of technical materials made available for the public on FCB and FCB systems by the end of EOP: * Newsletters * Technical reports * Study trip reports 5 - Overall level of satisfaction and/or acceptance by the public and project stakeholders of the technical materials by the end of EOP 6 - Completed "Well-to-Wheel" Analysis of the FCB system in B&S and FCB fuel supply options 7 - Completed study on the improvement of local FCB design
Outcome 3	Improved awareness and conducive enabling environment for FCB applications and support for the commercialization of FCBs in China	1 - Number of policy studies on the development and promotion of FCB applications carried out by EOP 2 - Number of policies and regulations proposed in cities supporting the utilization of FCBs for urban transport by EOP 3 - Number of policies and regulations proposed in cities supporting the implementation of "FCB value chain" projects in cities by EOP 4 - Number of completed techno-economic feasibility studies of FCB and "FCB value chain" applications in other Chinese cities by EOP 5 - Number of cities interested in implementing FCB and

		"FCB value chain" projects by EOP 6 - Level of satisfaction of stakeholders about the FCB information exchange system service 7 - Established project website by Year 2 8 - Level of satisfaction of stakeholders about the FCB website service 9 - Number of promotional campaigns: * Exhibitions/ road shows * Conferences * Workshops * Seminars on FCBs implemented annually starting Year 2 10 - FCB Roadmap completed and approved by Year 4 11 - Number of cities that are interested in deploying FCBs in their transport sector five years after EOP 12 - Number of approved "FCB value chain" businesses in China five years after EOP 13 - Completed FCB III project strategy and proposal

The actual accomplishments vs. the targets at final-term of implementation are reported in the APR/PIR 2011 report (1 July 2010 to 30 June 2011).

All the reports of the sub-contractors (18 reports) were prepared and submitted. According to the PMO, all the sub-contract reports had been reviewed and accepted by the national expert panel and all the reports have been posted on the project homepage website and can be downloaded by everyone.

These reports were circulated among all the relevant stakeholders and team members. Some reports have been submitted to UNDP for dissemination. In addition, some of the sub-contract results will be used as basis for the FCB Phase III preparation.

There is no activity indicator that did not meet its target as shown in Table 2-3 while tabulation shows the summary of the evaluation. A total of 16 activity indicators met their targets while 8 exceeded target completion requirement. Around 2 activity indicators were completed in advance while 12 will be completed at EOP and another 6 activity indicators is predicted to be completed 5 years after EOP.

Strategy	**not meets target**	**meets target**	**exceeds target**	**advanced completion**	**at EOP completion**	**5 years after EOP**	**Total indicators**
Goal	0	0	1	0	0	1	2
Objective	0	2	1	0	1	0	4
Component 1	0	3	6	1	5	3	18
Component 2	0	5	0	1	1	0	7
Component 3	0	6	0	0	5	2	13
TOTAL	**0**	**16**	**8**	**2**	**12**	**6**	**44**

The following table summarizes the accomplishments of the project (e.g. CO2 emission reduction, distance traveled, H2 consumption, fuel economy, passengers carried, personnel trained, newsletter, reviews, study tour reports, exhibitions/road shows, conferences, workshops, seminars) vs. target at EOP:

Table 2-3: Actual Accomplishments vs. Targets	Dec 2011 APR/PIR 4th Quarter 2011	4th Year Target (End-of-Project)
Goal, Objective, Outcome and Activities	**Accomplishments**	**From Log Frame**
Goal	**Satisfactory**	
1 - Annual CO2 emissions reduction in the transport sector in Beijing & Shanghai during project	Beijing = 65,460 km = 81 tons CO2; Shanghai = 183,558 km = 198 tons CO2; total CO2 = 279	198 tons of CO2 or 54 tons C for 6 buses over two years (exceeds target)
2 - CO2 emissions reduction in the Chinese transport sector five years after the end-of-project (EOP)		198 tons of CO2 or 54 tons C (5 years at EOP)
Objective	**Satisfactory**	
1 - Number of FCBs in commercial operation in Beijing and Shanghai (B&S) during the project	6 in Shanghai 3 in Beijing	6 in Shanghai; 3 in Beijing funded by in-kind finance (national 863 projects) (meets target)
2 - Number of additional FCBs in commercial operation in China by EOP	0	12 (at EOP)
3 - Number of H2 refueling stations installed and in operation during the project	2 in Shanghai	1 in Shanghai (exceeds target)
4 - Number of additional H2 refueling stations installed and in operation at EOP	1	1 (meets target)
Outcome 1 / Component 1	**Satisfactory**	
1 - Completed FCB and H2 refilling station operational guidelines	1 set of guidelines for Beijing; 1 set of guidelines for Shanghai	1 set of guidelines for Shanghai (advanced completion)
2 - Number of demo FCBs that are operational by EOP	6 FCBs procured in Shanghai 3 FCBs in Beijing funded by in-kind finance (national 863 projects)	6 in Shanghai 3 in Beijing (meets target)
3 - Number of trained and practicing FCB drivers in B&S by EOP	Beijing: 3 drivers Shanghai: 18 drivers	In Shanghai: 3 drivers for each FCB, target 18 drivers (meets target)
4 - Cumulative number of trained and practicing FCB mechanics trained in B&S by EOP	Beijing: 1 mechanic Shanghai: 16 mechanics	7 (exceeds target)
5 - Number of demo H2 refilling stations installed and operational by EOP	1 in Beijing 2 in Shanghai	1 in Shanghai (exceeds target)
6 - Number of operators H2 refilling station operators in B&S by EOP	Beijing: 3 operators Shanghai: 17 operators for a total of 20 operators	17 (exceeds target)
7 - Number of trained and practicing: * FCB drivers * FCB mechanics * H2 refilling station operators in China five years after	3 in Beijing; 18 in Shanghai	18 drivers 6 mechanics 16 operators (5 years after EOP)

EOP		
8 - Frequency of receipt of acceptable demo FCB performance reports	Quarterly reports submitted	Quarterly (meets target)
9 - Average annual passengers of a FCB in B&S	Beijing: 75,460 km and 39,995 passengers; 15,262 km test runs Shanghai: 183,558 km and 106,040 passengers, to reach 200,000 km by end Dec 2011	80,000 passengers in Shanghai 38,000 passengers in Beijing (exceeds target)
10 - Average annual energy consumption of a FCB in B&S	Beijing: 9.56 kg/100km Shanghai: 11.60 kg/100km	12 kg/100km (exceeds target)
11 - Annual volume of supply of H2 to H2 refilling stations (tons) in B&S	Beijing: 5,753 kg (Aug 2008-Jul 2009) Shanghai: 18,395 kg (Dec 13, 2011) to reach 23,192 kg by end Dec 2011	21,600 kg in Shanghai 5,000 kg in Beijing (exceeds target)
12 - Overall annual revenues from the commercial operations of FCBs in B&S		80,000 RMB (at EOP)
13 - Overall level of satisfaction of FCB service in B&S		90% (at EOP
14 - Overall level of comfort and safety of FCB operation in B&S		80% (at EOP
15 - Overall level of satisfaction of H2 refilling station service in B&S		95% (at EOP
16 - Overall level of safety of H2 refilling station operation in B&S		100% (at EOP
17 - Number of new FCBs deployed by transport companies in other Chinese cities five years after EOP		12 (5 years after EOP)
18 - Number of new H2 refilling stations established in Chinese cities five years after EOP		1 (5 years after EOP)
Outcome 2 / Component 2	**Satisfactory**	
1 - Number of "FCB value chain" research reports prepared and submitted to MoST by Year 4	Study completed as of Nov 2011	3 (meets target)
2 - Established FCB Certification program by Year 3	FCB certification program established	1 (meets target)
3 - Number of proposed implementing rules and regulations on FCB certification by Year 4	Implementing rules and regulations on FCB certification established	1 (advanced completion)
4 - The total number of technical materials made available for the public on FCB and FCB systems by the end of EOP: * Newsletters * Technical reports * Study trip reports	15 newsletter issues 7 annual reviews 9 study tour report	12 newsletters (yes) 6 technical reports (no) 8 study trip reports (no) (meets target)

5 - Overall level of satisfaction and/or acceptance by the public and project stakeholders of the technical materials by the end of EOP		90% (at EOP)
6 - Completed "Well-to-Wheel" Analysis of the FCB system in B&S and FCB fuel supply options	Study completed as of Dec 2011	Completed report by Year 3 (meets target)
7 - Completed study on the improvement of local FCB design	Study completed as of Dec 2011	Completed report by Year 4 (meets target)
Outcome 3 / Component 3		
1 - Number of policy studies on the development and promotion of FCB applications carried out by EOP	Completed report as of Dec 2011	1 (meets target)
2 - Number of policies and regulations proposed in cities supporting the utilization of FCBs for urban transport by EOP	Completed report as of Dec 2011	1 (meets target)
3 - Number of policies and regulations proposed in cities supporting the implementation of "FCB value chain" projects in cities by EOP	Completed report as of Dec 2011	1 (meets target)
4 - Number of completed techno-economic feasibility studies of FCB and "FCB value chain" applications in other Chinese cities by EOP	Completed report as of Dec 2011	1 (meets target)
5 - Number of cities interested in implementing FCB and "FCB value chain" projects by EOP		at least 3 (at EOP)
6 - Level of satisfaction of stakeholders about the FCB information exchange system service		90-95% (at EOP)
7 - Established project website by Year 2	1 keep updating	1 keep updating (meets target)
8 - Level of satisfaction of stakeholders about the FCB website service		90-95% (at EOP)
9 - Number of promotional campaigns: * Exhibitions/ road shows * Conferences * Workshops * Seminars on FCBs implemented annually starting Year 2	10 exhibitions and/or road shows 3 conferences 6 workshops 15 seminars	10 exhibitions and/or road shows (no) 2 conferences (exceeds) 6 workshops (yes) 15 seminars (no) (meets target)
10 - FCB Roadmap completed and approved by Year 4		Completed report by Year 4 (at EOP)
11 - Number of cities that are interested in deploying FCBs in their transport sector five years after EOP		at least 3 (5 years after EOP)
12 - Number of approved "FCB value chain" businesses in China five years after EOP		3 (5 years after EOP)
13 - Completed FCB III project strategy and proposal	in progress (long process)	Completed report by Year 4 (at EOP)

3.0 Findings and Conclusions

The FTR team rated the overall progress towards achievement of results for the FCB Phase II project to be "***Satisfactory (S)***".

The project is expected to ***achieve its major global environmental objectives*** (to enable China to reduce GHG emission via the introduction of hydrogen fuel cell FCBs for urban public transport).

Further, the project is expected to ***achieve its major relevant objectives*** (to demonstrate the operational viability of FCBs and their hydrogen refueling infrastructure under Chinese operating conditions in mega cities such as Beijing and Shanghai; to obtain clearer understanding of the operational viability of FCBs and their hydrogen refueling stations; to make available adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems; and improve awareness and conducive enabling environment for FCB applications and support for the commercialization of FCBs in China).

Assessment of each objective and outcome is presented by stating the objective, outcome, targets at end of project, physical and financial achievements as of date, assessment of its contribution to the objective / outcome and finally a rating of the progress. The detailed assessment is presented in the sections that follow.

3.1 *Assessment of progress towards Development Objective*

With only 2 activity indicators not meeting its end-of-project minor targets and the rest meeting (14 indicators) or exceeding (8 indicators) their targets and advanced completion (2 indicators), the FCB Phase II project is well on its way in attaining its Development Objective.

In terms of financial delivery of the project in support of the various outcomes, the PMO provided the following information (from ProDoc and CDR) that shows 99.78% utilization of GEF-UNDP funds.

Table 3-1: Actual Expenditure vs. Budget			
Component / Activity	**As of Dec 2011**		
Planned Activities	**As per ProDoc**	**Actual (CDR) Expenditure**	**% of Project Budget**
Outcome 1			
Clearer understanding of the operational viability of FCBs and their refueling infrastructure	4,365,000	5,304,841	**121.53**
Outcome 2			
Availability of adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems	796,000	146,732	**18.43**
Outcome 3			
Improved awareness and conducive enabling environment for FCB applications and support for the commercialization of FCBs in China	606,000	305,023	**50.33**
TOTAL GEF Contribution	**5,767,000**	**5,756,596**	**99.82**
UNDP Contribution	196,000	193,303	**98.62**
Total GEF and UNDP Contribution	**9,532,000**	**5,949,899**	**99.78**

In the case of co-financing contributions by the GoC through MoST and the municipal governments of Beijing and Shanghai as well as private sector, financial data is not yet available during the conduct of the final-term review.

The total cost of Phase II (GoC, private sector, GEF and UNDP) is US$18,625,000 of which US$15,271,866 or 82.00% were spent as of 31 October 2010. However, latest data shows nearly100% utilization of the GoC co-financing fund of US$12,662,000.

If the PMO could provide the updated GoC co-financing report, then the table below could be updated together with its breakdown.

Detailed Co-Financing	Confirmed As per ProDoc		Actual As of 31 Oct 2010		Actual As of Dec 2011	
	US$	**% of Total**	**US$**	**% of Budget**	**US$**	**% of Budget**
MoST	3,519,000	18.89%	3,167,100	90.00%		
Beijing	3,536,000	18.99%	3,536,000	100.00%		
Shanghai	4,384,000	23.54%	2,805,760	64.00%		
Private Sector	1,223,000	6.57%	1,223,000	100.00%		
Sub-total Co-Financing	**12,662,000**	**67.98%**	**10,731,860**	**84.76%**	**12,662,000**	**100.0%**
GEF/UNDP Contribution	5,963,000	32.02%	5,779,392	96.92%		
Total Cost of Phase II	**18,625,000**	**100.00%**	**16,511,252**	**88.65%**		

GoC	11,439,000	61.42%	9,508,860	83.13%		
Private Sector	1,223,000	6.57%	1,223,000	100.00%		
GEF	5,767,000	30.96%	4,416,746	76.59%		
UNDP	196,000	1.05%	123,260	62.89%		
Total Cost of Phase II	**18,625,000**	**100.00%**	**15,271,866**	**82.00%**		

Overall Assessment of Progress & Rating

The overall assessment of the FCB Phase II project is ***"Satisfactory (S)"*** since all reports of the sub-contracts (18 reports) have prepared and submitted and only 2 output indicators did not meet targets out of the total 44 output indicators, and financial delivery is 99.78% of total UNDP-GEF funds while co-financing from government and private sectors is almost 100% as of end December 2010.

Overall, the project is expected to attain its development objective at end-of-project.

3.2 *Assessment of Outcomes*

The FTR team's assessment of outcomes is not anymore necessary since most of the information and assessment done, including financial delivery, has already been discussed previously (Section 2.6 and Section 3.1).

The attainment of the project's goal and objective is rated "***Satisfactory (S)***" while the attainment of Outcomes 1, 2 and 3 is also rated "***Satisfactory***". Therefore, the FTR team rated the overall progress towards achievement of results for the FCB Phase II project to be "***Satisfactory (S)***".

The detailed output and activity-wise assessment is presented in Annex I while the annual targets are presented in Annex J as to how the project team was guided over the 4-year project duration.

3.3 *Project Formulation Review*

This section focuses on the FTR team's specific tasks of reviewing the FCB Phase II project's formulation: (1) design and work plan, (2) project performance, (3) project impact, (4) government policies in the development of FCBs for Chinese cities, (5) current FCB projects in other countries including international market developments in supply and demand of the technology to find out and advise potentials for possible project expansion, (6) good practices and lessons learnt in partnership building of the project with companies and agencies in introducing the FCBs and designing and building the refueling station in expanded demonstration cities in China, (7) recommendations on the improvement or sustenance of the implementation, potential aspects of FCB commercialization that can be covered in the planned FCB Phase III project, and (8) revisit the MTR Report to see if the key recommendations have been put into practice in the process of project implementation.

3.3.1 **Conceptualization / Project Design and Work Plan**

A review of the conceptual design and work plan was conducted to determine whether: (a) the project approaches and strategy are sound; (b) the immediate objectives and outputs are properly stated and verifiable in the project's logical framework; (c) the time frame of the project is feasible and practicable; and (c) others.

During the course of the initial implementation, minor revisions were made on the Project Document in order to refine the performance measurement (success) indicators, baseline, target at end-of-project, sources of verification, and risks and assumptions (see Section 2.6).

Overall, the project design and work plan remain valid and consistent with the project strategy (goal, objectives and outcomes).

The success indicators and targets used in the revised project monitoring system continue to be specific, measurable, achievable, reasonable, and time-bounded to achieve the desired project outcomes.

For instance, the target of CO2 emission reduction, kg H2 consumed and 100 km traveled as well as fuel economy at specific time frame during the 4-year project provided clear guidance for the project team to achieve.

Therefore, the rating for conceptual design of the project is ***"Satisfactory (S)".***

The project has three well-thought out components, namely:

Outcome 1 - Clearer understanding of the operational viability of FCBs and their refueling infrastructure

Output 1- A commercially-relevant demonstration of the technical feasibility of FCBs and their refueling infrastructure and staff training related to their operation in Beijing and in Shanghai

Activity 1.1: Purchase the FCBs.

Activity 1.2: Install, operate and maintain the fueling infrastructure.

Activity 1.3: Working together with the suppliers, hold training for drivers, maintenance and refueling station staff

Activity 1.4: Place the buses in operation.

Output 2 - Performance analyzed including reliability and failure modes, supporting improvement the design and reducing the cost of FCBs in China

Activity 2.1: Collect, analyze, and evaluate operating data on efficiencies, reliability, failures, and potential improvements.

Activity 2.2: Develop operation guideline for FCB and HRS operation and maintenance.

Activity 2.3: Social and environment research

Outcome 2 - Availability of adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems

Output 3 - Set up the FCB knowledge base, and analyze the technical issues related to FCB value chain

Activity 3.1: Learn the international experience related to FCBs value chain

Activity 3.2: Research on the technical development related to FCBs value chain

Output 4 - Promote the FCB related technology development

Activity 4.1 Promote the future certification development for FCB and refilling station in China

Activity 4.2: Provide the suggestions for future FCB design that might better meet Chinese operational conditions

Activity 4.3: FCB related life cycle analysis.

Outcome 3 - Improved awareness and conducive enabling environment for FCB applications and support for the commercialization of FCBs in China

Output 5 - Policy and market studies on FCB related value chain

Activity 5.1: Policy and market study to promote the FCB commercialization

Output 6 - Set up the platform to strengthen the cooperation between national and international stakeholders including policy makers, investors, industries and the general public

Activity 6.1: Partnership building

Activity 6.2: Set up the project website to provide technical, policy and market information.

Activity 6.3 Organize the national and international conference/workshop to promote the cooperation among stakeholders

Activity 6.4 Public awareness and education

Output 7 - Support and engage in the FCB development roadmap design including expanded demonstration feasibility study

Activity 7.1: Carry out technical, institutional, and financing feasibility studies for future expanded demonstration cities

Activity 7.2: Support the FCB development roadmap in China.

3.3.2 Project Performance / Timeliness, Quality and Cost-Effectiveness

A review of project performance was conducted to determine: (a) timeliness, quality of inputs and cost-effectiveness of activities undertaken; (b) quality and quantity of outputs produced; (c) achievement of outcomes; and (d) financial review against the project budget (see Section 3.2 - Assessment of Outcomes).

Based on the reviewed APR/PIR, list of reports completed and sample progress report power point presentation (Beijing and Shanghai project teams), all the required inputs, outputs and reports as of 30 June 2011 and 4th Quarter Operating Reports were obtained and prepared in a timely manner, of desired quality per reports, and within the financial resources provided for in the project budget.

Therefore, the rating for project performance, timeliness, quality and cost-effectiveness of the project is ***"Satisfactory (S)"*** considering the deployment of manpower, material and financial resources to come of with innovated fuel cell hybrid bus design such as regenerative braking and use of ultra-high capacitors to augment battery storage capacity and ensure fast response and discharge of recovered energy to drive the motors.

3.3.3 Project Impact

A review of the project impact was made to determine: (a) extent to which project objectives are expected to be achieved; and (b) what are the short-term and long-term impact of the project, including the efficiency and cost-effectiveness of the project.

The project goal of "reducing GHG emissions via the introduction of hydrogen FCBs for urban public transport" is indeed within reach at the end of this FCB Phase II project as evidenced by the report of the UNDP Regional Technical Adviser (RTA) who reported in the DORating tab of the 2011 PIR the following:

"The project which was started in 2002 is in line with the Government of China (GoC)'s objective of addressing the increasingly serious air pollution problems in the country's major urban centers, particularly from the transport sector. Because of the significant public health and economic impacts of transport-related air pollution, reducing urban air pollution has become a high priority. Since the gaseous emission s (particularly CO2) from the transport vehicles are also greenhouse gas (GHG) emissions, actions taken to reduce transport air pollution are also in line with the GoC's objective of mitigating climate change, which it views as a major threat to its ability to achieve sustainable development.

As part of its efforts to mitigate climate change and reduce energy consumption and the associated GHG emissions, this project on fuel cell bus application in China was designed and developed to facilitate the widespread commercial application of fuel cell buses in urban areas of China. The long term target is for the cost of FCB technology to be brought down to levels that will enable their widespread cost-competitive use in many cities in the country. Fuel cell technology has been considered as having significant potential for both domestic and export applications. Since the early 1990s, a variety of scientific and technological *institutes in China have been involved in research and development relating to fuel cells and their applications.*

For this project, it is expected that the widespread use of FCBs in China can reduce both urban air pollution and GHG emissions. Based on scientific and engineering analyses that were made during the project design, the magnitude of potential reductions in carbon dioxide emissions achievable by widespread introduction of FCBs in China was about 9.1 million tons per year. The current project is in its second phase of implementation, showcasing the application and operation of locally-manufactured FCBs in Shanghai. The first phase involved the demonstration of the application and operation of FCBs that were imported from abroad. The future Phase III, the commercialization phase, is the final phase of potential GEF involvement and is intended to increase China's demand for, and production of, FCBs to the point where the costs become competitive with that of conventional buses. It is anticipated that, between 2010 and 2015, FCBs will be mass produced and are cost-competitive to be widely introduced on a commercial basis in Chinese cities.

Despite the very good potentials, there are several barriers to commercialization of FCBs that have to contend with. The removal (or at least the reduction) of such barriers is deemed very important because of the significant private and public sector funding of fuel cell technology development. These barriers include technical issues, such as the need for further development of fuel cell design and manufacturing technology; inadequate hydrogen supply infrastructure, high initial costs; and the need for better storage technology. Other barriers are market issues, including the under-valuation of environmental and other societal benefits; continued availability of cheap fossil energy; limited global demand for clean technologies for transport; inability to achieve manufacturing economies at current levels of production; inadequate regulatory framework; and poor public perception.

With China's relatively strong research and development activities in fuel cell science and technology relevant to fuel cell buses, the project addresses the abovementioned barriers through: (1) Field demonstration of the operation of FCBs in Beijing & Shanghai, including the design, construction and operation of hydrogen refilling stations (one each in Beijing and Shanghai); (2) Institutional capacity building relating to commercial operation, maintenance, or manufacturing of FCBs in China; and, (3) Capacity building on FCB technology and FCB technology applications among key stakeholders actors, including policy makers and potential investors, and among the general public, including technical assistance on capacity building on public transport policy and planning.

The main activities, which are the demonstration of the operation of the FCBs in Shanghai, are currently ongoing, as well as that of the operation of the hydrogen refilling station. The project's 6 FCBs were also fielded along with other fuel cell vehicles to serve as transport for visitors/guests in and around the World Expo 2010 in Shanghai. The project partner, Shanghai Municipal Government fielded 90 fuel cell cars and 100 fuel cell powered tourist shuttles, along with the project's 6 FCBs – as part of the fuel cell vehicle technology demonstrations of the World 2010 Expo (May – October 2010). So far, the overall impact of the project can be gleaned from the reported cumulative energy savings and associated cumulative CO2 emission reductions in the transport sector in Shanghai.

Thus far, the project has contributed to the boosting of the development and demonstration of "energy-efficient and new energy vehicle" in China. There are now 20 Chinese cities (inclusive of Beijing and Shanghai) that have become pilot cities for these demonstrations. The Government of China has introduced fiscal incentives to support energy-efficient and new energy vehicle pilot projects in 13 cities in the country. Part of that incentive scheme is the provision of a subsidy of 600,000 RMB per FCB. The Ministry of Industry and Information has already released the "Market entry rules on clean energy automotive enterprises and products", in conjunction with the establishment of the FCB demonstration program, and which facilitates the development of clean energy vehicle including fuel cell vehicles.

With the momentum built regarding the promotion of energy efficient transport, in general, and fuel cell vehicle technology, in particular, it is expected that the project will help influence the commercialization of the FCB technology in the country. Consequently, that would lead to improve energy utilization efficiency in the transport sector with the associated carbon savings and contribution to the realization of China's committed GHG emission reduction targets.

The Mid-term review of the project was completed in Dec 2010. The overall assessment of the project performance was Satisfactory, with the project achieving the planned outputs vis-à-vis the targets and delivery of inputs and activities as targeted in the work plan. Based on the MTR, the Project has been a centerpiece of technological innovation for China for having been among the two remaining countries (China and Brazil) with ongoing fuel cell bus demonstration projects funded by seed money from UNDP-GEF. The Project is an example of best practice achievements that naturally resulted from an overall exemplary project execution by a developing country. Along with the need to reduce GHG emissions and other air pollutants such as CO, SO2, NOx and THC, the project has promoted zero emission and highly technologically advanced concepts that will provide China the leading edge in fuel cell, advanced battery and hybrid vehicle design, manufacturing and operation. As of mid-term review, the GHG emissions reduction attributable to the FCBs in Beijing is 83.2 tons CO2 after running 75,460 km (60,198 km passenger + 15,262 km testing). In Shanghai, the FCBs emission reduction contribution is 29.2 tons CO2 after running a shorter 26,261 km due to shorter route of the Shanghai World Expo 2010 venue compared to the Beijing Olympics venue. In May 2010, the Shanghai has stepped up the demonstration activities with the issuance of the temporary license plates for the FCBs that would enable these buses to continuously operate along the designated demonstration routes and collectively cover the target 200,000 kilometers."

Likewise, it is clear from the reports that public awareness on the use of fuel cell bus for public transport is growing and with continued innovative research, cost reduction and efficiency initiatives will soon bear fruit leading to cost-effective utilization and environmentally-benign use of fuel cells.

Therefore, the rating of project impact of the project is ***"Satisfactory (S)"*** considering the great strides obtained to date that resulted in cheaper domestically-manufactured fuel cells bus which now enjoys declining costs, higher energy utilization efficiency (lower H2 consumption per 100 km), reliability and safety. The following vehicle improvements were achieved per High Tech Plan of MoST as a result of the FCB demonstration project, starting with the 2nd generation FCBs costing 5.0 million RMB with 80 kW and lifetime of fuel cell stack of less than 2,000 hours to 3rd generation FCBs now cheaper at 2.6 million RMB with 50 kW and longer lifetime of fuel cell stack of more than 4,000 hours. The use of energy recovery thru regenerative braking and ultra capacitors has resulted in smaller power requirement:

2nd generation Hybrid FCBUS:

- FC: 80kW, Battery: 80Ah * 360V
- Cost: 5.0 million RMB
- Lifetime of FC stack < 2000 h

3rd generation Hybrid FCBUS:

- FC: 50kW, Battery: 120Ah * 336V + Ultra Capacitor
- Cost: 2.6 million RMB
- Lifetime of FC stack > 4000 h

3.3.4 Government Policies and Relevance

This section will study government policies in the development of FCBs for Chinese cities and assess the relevance of the project against the national development priorities and objectives.

The ProDoc documented the first initiative towards developing sustainable government policies in China as emanating from the 10th National People's Congress on 5 March 2005 when Premier Jiabao delivered the government's report and he pointed out "New energy and renewable energy will be explored, as important elements for a cyclic economy… The friendly-environmental and energy-saving vehicles will be encouraged. Energy-saving production and consumption manners will be advocated with great effort, to accelerate construction of a society featured with resources saving."

Hydrogen and fuel cell technology research was reflected in the national scientific and technical development plan for 2005-2020. Vehicles fueled by hydrogen, especially FCVs, will be the primary component of urban public transport systems in the future. The Chinese government thus implemented more stringent vehicle emission and fuel consumption standards such as stopping the production and sale of leaded gasoline, adoption of Euro I, Euro II and Euro III fuel and vehicle emission standards and adopted Limits of Fuel Consumption for Passenger Car.

Starting in 1999, the Chinese government also carried out "clean vehicle activity" program which demonstrated alternative fuel vehicles in 12 cities and then in 16 cities. By end of 2003, the volume of CNG and LPG vehicles reached to 190,000 units in 16 cities with 560 refueling stations established. In 2003, around 2,000 CNG buses were deployed in Beijing. The government also encouraged the use of renewable fuel from biological sources such as ethanol and bio-diesel with some provinces requiring all gasoline blends to include 10% ethanol. Additionally, bio-diesel and methanol gasoline are being tried in demonstrations. A Shenhua project in the Inner Mongolia Autonomous Region also makes oil directly from coal with a capacity of 9.7 million tons of coal producing 500,000 tons of gasoline, 2.15 million tons of diesel and 310,000 tons of LPG annually.

R&D was conducted on electric vehicle and related batteries, electric motor, management systems during electric vehicle research and trials beginning 1992. Significant progress has been made on the development of the NiMH-battery, Li-ion-battery and AC synchronous an asynchronous motors and controllers. Battery-driven electric sedan, wagon and bus prototypes have been in pilot operation.

In 1998, a National Electric Vehicle test and demonstration Zone was established in Shantou City of Guangdong province. Twenty electric vehicles and ten China-made sends, wagons and mini-buses were under testing. China has also become the largest producing country of electric bicycles of over 6 million units in 2004.

Presently, there are two major integrated urban and transport planning initiatives in Chinese cities that will also have great impact on reducing GHG emission and pollution arising from inter-city and intra-city travel:

1) Eco-Transport in City Clusters: Model Development & Pilots

This UNDP-GEF in its PIF indicated implementation start of 1 Jan 2012 and project closing date by 31 Dec 2016 to be executed by the Ministry of Transport.

With rapid urbanization, city clusters (two or more geographically adjacent cities linked by commuting corridors with increasing social and economic interdependence) are emerging and developing fast in China. The transport characteristics of city clusters are different from either intra-city transport or inter-city transport at the national and regional scale. However, there are no clear strategic directions and implementation models for city cluster transport. This project aims to develop strategy and policies that will encourage shift from private to public transport systems that are more energy efficient and have lower carbon footprint.

Developing sustainable transport between cities within a city cluster to meet the rapidly growing travel demand is a new and urgent challenge. This project aims to develop and implement a strategy for city-cluster based sustainable urban transport systems (SUTS), with a pilot demonstration in the city cluster of Changsha-Zhuzhou-Xiangtan (CZX), located in Hunan Province in central China. It has an overall goal of increasing the efficiency of resource use, reducing transport energy consumption and GHG emissions while meeting the need for transport accessibility and mobility in city clusters.

SUTS aims to improve accessibility, higher transport service quality and efficiency and lower energy and carbon intensities to be achieved thru optimized use of transport resources, efficient interchange and connecting nodes, use of cleaner vehicles and fuels, higher percentage of public transport and inland waterways. The project will focus on integrated planning, policy and institutional innovation, incentive mechanisms, capacity building and public participation as strategic solutions and taking the CZX city cluster as a pilot to explore, assess and test these solutions which could be applied to other city clusters to achieve broader positive changes at the national level.

The project has four components dealing with national strategy formulation, testing of strategy, capacity building to enable institutions and individuals for SUTS implementation, and project management.

The CZX city cluster is located in Hunan Province in central China whose economic development is at moderate level and increasingly constrained by resource and environmental factors. The cluster has a population of 13 million covering an area of 28,000 square km with inland waterway for transport which is a region-specific and unique transport resource with sizable transport capacity, lower energy consumption, lighter pollution and lower requirements for land. The purpose is to explore a feasible pathway of urbanization toward a greater sustainability with lower carbon intensity which is feasible in China as it promotes similar reforms nationwide.

Very clearly, this Eco-Transport in City Clusters Program is very relevant and supportive of national development priorities and objectives for a low carbon development and sustainability.

2) GEF-World Bank-China Urban Transport Partnership Program (CUTPP)

This project is under the project umbrella of "World Bank Urban Transport Program in China". The UNDP-GEF CEO Endorsement indicated implementation start of June 2008 and project closing date of December 2012.

This project aims to achieve a paradigm shift in China's urban transport policies and investments toward the promotion of public and non-motorized transport modes that are less energy intensive and polluting than those fostered by current urban land-use planning and transport systems in China. Concurrent Global Environment Objective is to slow the forecast growth of urban transport GHG emissions in China's cities.

The project has two components. One component for encouraging urban transport policy-makers in central government to effectively promote (with policies, guidelines, and other technical and financial assistance) investments and strategies promoting public transport and non-motorized transport; and another on the demonstration in at least 10 demonstration cities of the implementation of investments and transport policies that promote public and non-motorized transport.

At least 8 cities will implement transport development programs that include: (1) BRT development; and (2) integration of public and non-motorized transport facilities. (2B) At least 1 city introduces automobile demand management. (2C) At least 1 city implements a transit-oriented land use development plan.

Bus rapid transit (BRT) is a term applied to a variety of public transportation systems using buses to provide faster, more efficient service than an ordinary bus line. Often this is achieved by making improvements to existing infrastructure (by making dedicated busways), vehicles and scheduling. The goal of these systems is to approach the service quality of rail transit while still enjoying the cost savings and flexibility of bus transit. The expression BRT is mainly used in North America; however in Europe and Australia, it is often called a busway.

In South Korea, for instance, a smart debit card may be used by a passenger to ride and transfer seamlessly from home inter-city public bus to intra-city railway station to destination inter-city public bus, as well as inter-city and intra-city bus transfers and railway transfers. The use of the smart debit card enables fast collection of fares and faster loading and unloading of passengers as well as providing real-time data on commuter travel routes to guide highly optimized and timely dispatch of transport vehicles to meet real-time passenger demand.

Again, it is clearly visible that this Urban Transport Program is very relevant and supportive of national development priorities and objectives for a low carbon development and sustainability.

Next Steps for Government Policies

Ensuring a safe and economical FCB system that requires minimal cross-subsidy from current cheaper diesel-fed, gasoline-fed and compress natural gas-fed engines for public and private transport is the key to having sustainable and cleaner public transport system in densely populated Chinese cities. It is anticipated, however, that as the world price of crude oil, diesel and gasoline go beyond 100-200 US$/bbl and with it the rise also of natural gas, LNG and coal prices in response to rising oil prices, there will be a point at which fuel cell and electric vehicles powered from cheaper hydrogen and electricity supplies from off-peak renewable energy and nuclear energy will be become economical compared to present diesel-fed, gasoline-fed and natural gas-fed engines.

However, improving alone the energy efficiency of private and public transport systems may not be enough. Government policies must also direct and encourage the shift from inefficient private transport to highly integrated, optimized and energy efficient public transport modes such as buses and railways powered by low-carbon and low-pollution emitting vehicle technologies such as fuel-cell powered vehicles, electric vehicles, hybrid vehicles and railway systems.

Hence, relevant policies, safety and performance standards relating to "clean energy" vehicles and integrated mode of transport (inland waterways, railways and dedicated busways) need to be updated to world standards so as to ensure the overall welfare of the inhabitants of the Chinese cities that will be the future market of this Chinese-made FCB transport system and beneficiary of integrated and optimized mode of transport.

3.3.5 Current FCB Projects of Other Countries

This section will analyze the current FCB projects in other countries, and the domestic and international market developments in supply and demand of the technology to find out and advise potentials for possible project expansion.

Fuel Cell

The Fuel Cell (FC) is an electrochemical device, closely related to the battery. It generates electricity from hydrogen, which in turn can be extracted from natural gas or other hydrocarbon gases through a chemical process called reforming. Hydrogen can also be produced through electrolysis of water using electricity produced preferably from surplus and off-peak renewable and nuclear energy. The by-product of the fuel cell is clean water, unlike fossil fuels which produce CO_2 as the by-product of power generation aside from other pollutants such as NO_x, SO_2, CO, UHC and particulates.

Types of Fuel Cell

The US NREL reports the latest developments in fuel cell stack developments. The most common and commercialized fuel cell technologies are as follows: Polymer Electrolyte Membrane or Proton Exchange Membrane Fuel Cell (PEM or PEMFC), Direct Methanol Fuel Cell (DMFC), Alkaline Fuel Cell (AFC), Phosphoric Acid Fuel Cell (PAFC), Molten Carbonate Fuel Cell (MCFC), and Solid Oxide Fuel Cell (SOFC). (See comparison of Fuel Cell Technologies from US NREL in next table.)

The following table shows a PEM fuel cell stack can produce up to 1-100 kW at 60% energy conversion efficiency in transport mode (35% if stationary) at a typical low temperature of 80 ^{o}C. However, it uses expensive catalyst and is sensitive to fuel impurities. The nearest competitor for transport use of PEM fuel cell is the PAFC which has a higher power output (100-400 kW), lower efficiency (40%) and higher operating temperature (150-200 ^{o}C). Typical all-in capital cost is 500-1,000 US$/kW for PEM and 3,000 US$/kW for PAFC.

The other types of fuel cell are mainly for other specialty applications such as portable and backup power, military and space applications, auxiliary power, electric utility, distributed generation and co-generation of power and heat.

Comparison of Fuel Cell Technologies

Fuel Cell Type	Common Electrolyte	Operating Temperature	Typical Stack Size	Efficiency	Applications	Advantages	Disadvantages
Polymer Electrolyte Membrane (PEM)	Perfluoro sulfonic acid	50-100°C 122-212° typically 80°C	< 1kW–100kW	60% transportation 35% stationary	• Backup power • Portable power • Distributed generation • Transporation • Specialty vehicles	• Solid electrolyte reduces corrosion & electrolyte management problems • Low temperature • Quick start-up	• Expensive catalysts • Sensitive to fuel impurities • Low temperature waste heat
Alkaline (AFC)	Aqueous solution of potassium hydroxide soaked in a matrix	90-100°C 194-212°F	10–100 kW	60%	• Military • Space	• Cathode reaction faster in alkaline electrolyte, leads to high performance • Low cost components	• Sensitive to CO_2 in fuel and air • Electrolyte management
Phosphoric Acid (PAFC)	Phosphoric acid soaked in a matrix	150-200°C 302-392°F	400 kW 100 kW module	40%	• Distributed generation	• Higher temperature enables CHP • Increased tolerance to fuel impurities	• Pt catalyst • Long start up time • Low current and power
Molten Carbonate (MCFC)	Solution of lithium, sodium, and/or potassium carbonates, soaked in a matrix	600-700°C 1112-1292°F	300 kW-3 MW 300 kW module	45-50%	• Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Can use a variety of catalysts • Suitable for CHP	• High temperature corrosion and breakdown of cell components • Long start up time • Low power density
Solid Oxide (SOFC)	Yttria stabilized zirconia	700-1000°C 1202-1832°F	1 kW–2 MW	60%	• Auxiliary power • Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Can use a variety of catalysts • Solid electrolyte • Suitable for CHP & CHHP • Hybrid/GT cycle	• High temperature corrosion and breakdown of cell components • High temperature operation requires long start up time and limits

Significant Progress on Fuel Cell and Fuel Cell Vehicle Technology

Fuel cells must satisfy competing requirements such as energy efficiency, stack power output, operating temperature, type of electrolyte, cost of fuel cell stack, noble metal catalyst (platinum) consumption, volume and weight power density, durability and reliability, environmental adaptability, dynamic performance, safety protection and cold starting performance; hence, the most common fuel cell technology for transport use is the PEM or PEMC.

Developed by General Electric, the early PEM fuel cells were used in the Gemini space program and had limited life. Ballard Power Systems of Canada is the commercial leader in PEM. It has high energy density and is attractive to automotive industry (Daimler Benz). Ballard Generating Systems developed a 250-kW power generating prototype in 1997 with efficiency of 40% and costs less than $1,000/kW.

According to the ProDoc, the 2010 US DOE FreedomCAR Program target for volume and weight power density are 309 watt/liter and 309 watt/kg, respectively, which is now almost met by recent models from Ballard.

Significant reduction in noble metal usage has dropped from the 1990 level of 5 mg/cm2 to lower than 0.5 mg/cm2 today.

In a FC car (NECAR4) test done by DaimlerChrysler using Ballard FC system, the energy conversion efficiency of the FC stack reached 62%; however, deducting accessory loss (16.4%) and motor drive loss (8.1%), the fuel tank-to-wheel energy source efficiency is 37.7% which is much higher than typical gasoline engine vehicle (16-18%) and diesel engine vehicle (20-24%).

In May 2002, a DaimlerChrysler FC car (NECAR5) traveled from San Francisco to Washington, DC covering 5,220 km with an average speed of 112 km/h with only one failure (cooling hose). Another test in mid 2004 by General Motors (GM) completed a trip across Europe covering 9,696 km without any failure. However, much work needs to be done to improve fuel cell vehicle (FCV) reliability and durability, since lifespan of current fuel cell stack is only 2,000 hours.

The current commercial price of FC system is estimated at an average of 3,000-5,000 US$/kW. However, users require suppliers to provide 2 years or 4,000 hours of durability warranty and free maintenance which make suppliers to quote a relatively unaffordable price of 10,000 US$/kW.

The US DOE forecasts a drop in cost from 45 US$/kW by 2010 to 30 US$/kW by 2015 which is the current gasoline engine price. Ballard is investigating significant improvements in the FC stack and announced in April 2005 that FC stack costs will be reduced further to 60 US$/kW by 2007 and 30 US$/kW by 2010 while improving durability from 3,200 hours by 2007 to 5,000 hours by 2010.

Other significant improvements by Ballard, for instance, concerns projected start-up time to 50% maximum power in 100 seconds at -20 ^{o}C in 2005 to 25 seconds at -30 ^{o}C by 2010.

Electric Vehicle Research and Improvements

Apart from producing electricity from fuel cells or sourcing power from the grid, electric vehicles need to store power in storage batteries to increase operating distance between charging thus leading to development of NiMH-Battery, Li-ion-Battery and AC synchronous and asynchronous motors, ultra capacitors and controllers, and regenerative braking systems to capture waste energy from deceleration and braking. Thus, improvements made on electric vehicles are also being applied to fuel cell hybrid bus systems to further raise its overall fuel tank-to-wheel energy source efficiency.

Fuel Cell Bus Programs in Other Countries

According to the ProDoc, FCB research & development (R&D) and demonstrations have received greater attention from many countries due to the FCB having been recognized as one of the FCV's with the highest potential for early commercialization because the bus has ample internal space and load capacity to carry the low weight power density, achieves low emissions and noise when traversing densely populated urban cities, mets urban driving cycles by using current FC technology, operates on specified route and timing suitable for centralized hydrogen refueling stations, easily obtains financial support from government, serves many people to widen awareness and public acceptance.

By end 2003, a total of 65 FCBs around the world have been developed since 1993 when the first PEM FCB was developed by Ballard Power Systems, of which 70% were developed by DaimlerChrysler-Ballard.

There are more than 15 FCB demonstration projects globally covering 12 countries in four continents as reported in the ProDoc:

1) 1998-2000 Chicago-Vancouver Project - provided 3 buses in each city traveling 118,000 km in 10,559 hours with 205,000 passengers but with low availability of 56% and 55%, respectively.

2) 2000-2001 California Project - conducted a one year test on a FCB supplied by Ballard to Sunline Transit Agency in Los Angeles with a FC system volume reduced by 50%, vehicle mass reduced by 1,550 kg and maintenance cost reduced by 90%. A second FCB with hybrid configuration was added in 2002-2003 with 70% availability. By 2004-2005, a total of 7 FCBs were demonstrated by AC Transit, Sunline and Santa Clara Transit.

3) 2001-2002 Tokyo FCB Project - developed 1st and 2nd generation hybrid FCBs and carried out demonstration drive in Tokyo that indicated better acceleration performance of hybrid FCB than a diesel engine bus aside from being 66% more energy efficient than the diesel engine bus which includes 17.6% improvement from regenerative braking and 5% from optimizing engine control strategy. The Toyota-Hino also provided 8 FCBs during the 2005 World Expo in Ai-chi City.

4) US Georgetown University Demonstration Project - has a 10-year R&D history in FCB technology and demonstrated FCBs on its campus and within Washington, D.C.

5) FCB Demonstration Project - is supported by the European Union (EU) and 10 European countries and implemented in 8 European cities (Stuttgart, Hamburg, London, Madrid, Barcelona, Amsterdam, Porto, Stockholm and Iceland). Since May 2003, demonstration drives have been performed successively with a duration of 2 years on 30 FCBs provided by DaimlerChrysler (3 units per city). By 2005, bus fleets have driven a total of 750,000 km in 55,000 hours with availability reaching 75%.

6) Demonstration Projects in Perth, Toronto and Berlin.

7) Demonstration Projects listed by NREL - show a dramatic rise from the 15 FCB demonstration programs reported earlier in the ProDoc in 2003. Recent data from NREL shows that majority of US and worldwide FCB projects completed, on-going and planned are of the PEM fuel cell type in hybrid configuration and provided mainly by Ballard. There are 26 US fuel cell bus projects to-date. Heavy-duty fuel cell and hydrogen vehicle projects worldwide consist of 29 completed projects, 35 on-going projects and 25 planned projects. There is indeed a mad rush to demonstrate the numerous innovations made by the various FC manufacturers and it will be in the great interest of China to remain a top contender in FC technology.

Please refer to Annex M to Annex P for recent updates from the NREL as of 20 April 2011:

Annex M - U.S. Fuel Cell Bus Projects (26 projects, 44 buses)

Annex N - Heavy-Duty Fuel Cell and Hydrogen Vehicle Projects (completed 29, 147 buses)

Annex O - Heavy-Duty Fuel Cell and Hydrogen Vehicle Projects (on-going 35, 108 buses)

Annex P - Heavy-Duty Fuel Cell and Hydrogen Vehicle Projects (planned 25, 45 buses)

UNDP-GEF Fuel-Cell Bus Programme: Update

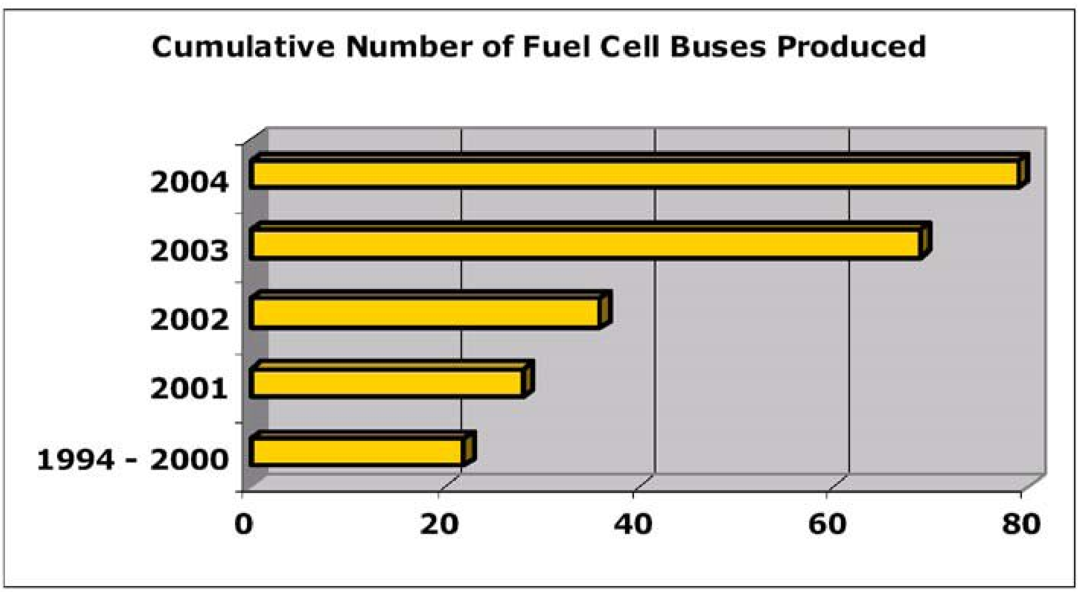
To help catalyze the commercialization of FCB technology for urban areas of developing countries, the GEF and UNDP launched a program to prepare the stage for large-scale commercial deployment of FCBs and associated refueling systems in the largest bus markets in the developing world: Beijing, Mexico City, New Delhi, Sao Paulo and Shanghai. The development objective is to reduce long-term greenhouse gas (GHG) emissions from the transport sector in GEF program countries. For the five city projects, the total GEF commitment approved by the GEF council was US$36 million.

FCBs using hydrogen offers reduced GHG emissions over conventional diesel buses. Although fuel cells are technically proven, they are not yet economically competitive in commercial applications. Around 5 to 7 years involving the production of between 2,000 to 5,000 buses is needed to attain this economic goal.

The UNDP-GEF strategy for FCB commercialization involves building partnership between GEF, private industry and local/national governments in GEF Program Countries. It will fund incremental costs of FCB projects, facilitate the process of FCB commercialization by convening various parties to discuss, collaborate in and finance the commercialization program, and enabling information exchange within and between program countries, industry and other FCB demonstrations in both donor and recipient countries.

To meet the development objective of this programmatic initiative, the UNDP-GEF strategy involves three distinct phases of support: (I) Preparatory Phase, (II) Demonstration Phase, and (III) Commercialization Phase. GEF is now funding the Demonstration Phase II. Whether GEF support will continue to be warranted in Phase III will depend largely on the nature of GEF's continuing role in climate change, the degree to which the developing country demonstrations have been successful, and the continued investment and interest in the technology within donor countries. At present, the GEF has not recommended to commit to one specific program of support for Phase III projects. Rather, the GEF will make an informed decision most likely in the next 3 to 8 years after 2005.

Cumulatively, the total number of buses that have operated on roadways up to 2004 was about 80 buses (Figure 1. Source: K. Adamson, "Fuel Cell Market Survey: Buses", *Fuel Cell Today*).



A summary of fuel cell bus projects up to 2004 is shown below.

MAN "Bavaria 1"	Regular service in Erlangen and Nurernberg, Germany. 50% funded by Bavarian State	40 ft. low-floor city bus NL 263 "Bavaria I"	2000	Fuel cell/ battery hybrid	120kW/ PEMFC	Siemens	155mi 250km	50mph 80km/h	1548 L Compress. Hydrogen	
MAN	Will be used for EU's THERMIE program: Berlin, Copenhagen, Lisbon	40 ft. MAN N L223 low floor	Not Compl	Fuel cell/ Super capacitator hybrid	5 x 30kW/ PEMFC	Nuvera	N/a	N/a	700 L Liquid Hydrogen @ -253° C	
MAN	Will deliver one fuel cell bus to be operated as part of the hydrogen project at Munich Airport	40 ft. MAN low floor	Not Compl	Fuel cell/ battery hybrid	PEMFC	Ballard	N/a	N/a	H2 tanks on the roof at 5,000 psi	N/a
Neoplan	2 years fee-paying service in public traffic in the German spa resort Oberstdorf. Funded by Bavarian State	Midi bus N 8008 FC	1999	Fuel cell/ battery hybrid	40kW/ PEMFC	Nuvera	373mi 600km	30mph 50km/h	Compress. Hydrogen	
Neoplan	Available for Sales	N8012 - 33-seat bus	2000	Fuel cell/ 100kW flywheel hybrid	80kW/ PEMFC	Proton Motor Fuel Cell GmbH	155mi 250km	50mph 80km/h	Compress. Hydrogen	
New Flyer Industries	Demo. service of 3 buses in Chicago (1997) and Vancouver (1998) for 2 years	**P3**: H40LF models	1998	Fuel cell/ battery hybrid	205kW/ PEMFC	Ballard	N/a	N/a	Compress. Hydrogen	
New Flyer Industries	Natural Resources Canada (US$1.9 million) and Hydrogenics for demo in Winnipeg, Manitoba, Canada *Will incorp. Vehicle-To-Grid technology	40 ft.	March 2005	Distributed array of 25kW modules w/ ultra-capacitors	180kW/ PEMFC	Hydrogenics	N/a	N/a	Compress. Hydrogen	N/a
NovaBus Corporation (a subsidiary of Volvo)	Demonstrated in NY, NV, and DC. Received FTA funding to continue program.	Standard 40-foot transit bus	1999	Zinc-Air fuel cells with batteries	Zinc-Air	Arotech	N/a	65mph 105km/h	Zinc	
NovaBus Corporation (a subsidiary of Volvo)	Plans for RTC (Nevada Transit Agency) to use 2 – 5 buses	Standard 40-foot transit bus	2001	Zinc-Air fuel cells with ultra-capacitors	Zinc-Air	Arotech	N/a	N/a	Zinc	
Thor Industries (ThuderPower LLC)	Will be tested by SunLine Transit in 2002 for 6 months (started public service at Sunline Nov. 6, 2002)	30 ft. Low Floor El Dorado National E-Z Rider	2001	Fuel cell/ battery hybrid	75kW/ PEMFC Ambient-pressure	UTC Fuel Cells	200mi 322km	55mph 90km/h	Compress. Hydrogen	
Van Hool	3 will be used in regular service at AC Transit	40 foot	2005 goal	Fuel cell/ battery hybrid	PEMFC Ambient-pressure	UTC Fuel Cells	250mi 400km	65mph 105km/h	5,000 psi Compress. Hydrogen	
Van Hool	No Demonstration (Project EUREKA)	18 meter City Bus	1995	Fuel cell/ battery hybrid	78kW/ PAFC	Elenco	186mi 300km	N/a	700 Liters Liquid Hydrogen	
NABI	1 will be used in regular service at SunLine Transit	45 foot	Not Compl	Fuel cell/ battery hybrid	PEMFC Ambient-pressure	UTC Fuel Cells	N/a	N/a	Compress. Hydrogen	N/a
Macchi-Ansaldo (EC project EQHHPP)	Company Testing only; part of the EC project EQHHPP	Full size regular floor city bus	1997	Fuel cell/ battery hybrid	45kW/ PEMFC	Nuvera	250mi 400km	N/a	600 Liters Liquid Hydrogen	
Hino Motors Ltd. (Toyota subsidiary)	Toyota in-house testing	Low-floor city bus: **FCHV-BUS1**	2001	Fuel cell/ battery hybrid	160kW/ PEMFC	Toyota	186mi 300km	50mph 80km/h	Compress. Hydrogen @ 5,000 psi	
Hino Motors Ltd. (Toyota subsidiary)	Tokyo metro. gov. began using this bus during summer 2003 on waterfront route – Japan's nat'l debut of public fuel cell buses	60 pass. Low fl., diesel model: **FCHV-BUS2**	2002	Fuel cell/ battery hybrid	180kW/ PEMFC [2 x 90kW]	Toyota	186mi 300km	50mph 80km/h	Compress. Hydrogen @ 5,000 psi	
NovaBus Corporation (a subsidiary of Volvo)	BVG - Berlin's public transportation body - to buy 2 prototypes	15.3 meter long Double-Decker	Not Compl	N/a	N/a	Proton Motor Fuel Cell GmbH	N/a	N/a	Hydrogen	

1) DaimlerChrysler Ballard FCB Demonstration Program - Within the CUTE/ECTOS/STEP program, three full-size (12 meter) Citaro buses have been successfully operating in revenue service in each of 9 cities in Europe and in Reykjavik, Iceland and in Perth, Australia. The stated objectives of this 33 FCB effort over a two-year period are: to demonstrate FCB operation in inner city areas under a wide variety of operating conditions, inform the public about fuel cell technology, design, build and successfully operate the necessary infrastructure for hydrogen production and refueling, and exchange experiences including bus operation under differing conditions among the participating countries. In June 2004, a Task Force for Security and Safety was established to facilitate incident-reporting, improve communication and contribute to safety improvements across the program. As of end 2004, the 33 Citaro buses had collectively logged 500,000 km of revenue service and 50,000 bus-hours of operation by April 2005. The completion of the full 33-bus Citaro program is slated for April 2006. Detailed information regarding bus performance is

available to members of the "Fuel Cell Bus Club". Ballard has provided all of the fuel cell engines for the 33 Citaro buses. Ballard is also providing fuel cells for 3 Gillig buses which recently entered revenue service at the Santa Clara Valley Transit Authority as well as for a MAN bus demonstration at Munich Airport that began in 2004 and for the initial three buses (Evobus Citaro) in the UNDP/GEF China FCB demonstration project. Ballard is aiming to offer a commercially-viable fuel cell engine by 2010 and has announced three major technology milestones in a 10-cell stack: (1) repeated freeze-start at -20 ^{o}C (50 cycles) without performance degradation or stack damage, (2) stack lifetime greater than 2,000 hours with a 5% performance reduction with no damage to the proton exchange membrane after 2,200 hours, and (3) 30% reduction in platinum loading from 1.0 mg/cm2 to 0.7 mg/cm2 without performance compromise resulting in cheaper stack costs. The lifetime of Ballard fuel cell stack is projected to grow from 1,000 hours in 2003 to 2,000 by 2005 to 3,000 by 2006 to 4,000 by 2008 and 5,000 by 2010. Ballard fuel stack cost is also projected to drop from 150 US$/kW in 2002 to 154 by 2003 to 103 by 2004 to 80 by 2005 to 60 by 2007 and to 30 by 2010 (US DOE target).

2) California Fuel-Cell Partnership FCB Demonstrations – California continues to lead US-based FCB demonstration efforts. In 2004, three 40-ft Gillig buses with 205 kW Ballard fuel cell engines with regenerative braking were delivered to the Santa Clara Valley Transportation Authority. A two-year revenue service began in March 2005. In September 2005, three 40-ft van Hool buses with United Technologies fuel cell engines with regenerative braking (PC40 120 kW PEM + 100 kW nickel-sodium chloride battery) integrated by ISE were delivered to AC transit in Oakland. Sunline Transit in Thousand Palms also took delivery in 2005 of a unit similar to that of AC Transit, but with composite body made by NABI. This revenue-service bus logged 7,600 miles, 556 hours and over 1,500 hours of stack operating time (higher than design life of 1,000 hours) with 83% availability and fuel economy of 7.6 mpg. A similar AC Transit diesel bus had 93% availability and 3.8 mpg.

3) Toyota FCB Program – Toyota, in collaboration with bus manufacturer Hino, and with the support of the Japanese government has developed the FCHV-BUS2 model that uses the energy management system used in the Prius hybrid-electric automobile to optimize energy utilization. Four FCHV-BUS2 buses have been on Tokyo roads since 2002 primarily in non-revenue service, while one of the buses were operated in revenue service from August 2003 to December 2004. In 2005, Toyota delivered 8 units of this model for a 6-month run at the World Exposition in Aichi, Japan. This puts Toyota second only to Ballard in terms of number of fuel cell engines put into passenger revenue-service.

Additional FCB Demonstration Activities (non-UNDP/GEF)

1) China (separate from UNDP/GEF) – In addition to UNDP/GEF efforts, China has continued its independent development efforts on fuel cell vehicles thru the "863 Program" (named for the date it was originally created, March 1986) of the MoST with state funding of US$106 million for hybrid-electric and fuel cell vehicle development work from 2001-2005 and private company investment of around US$200-300 million during this period. The emphasis of the "863 Program" is on demonstration, commercialization and support of the Chinese vehicle industry. Most of the US$106 million are programmed for buses (rather than cars) as well as on hydrogen production and storage technology. The immediate goal is to develop two full-size 150 kW FCBs by 2005 and three prototype 50 kW FC cars. The 2008 Olympics in Beijing and the 2010 World Expo in Shanghai provided opportunities to showcase Chinese FCB development efforts. Around 60 organizations are currently involved in fuel cell research, development and demonstration in China, the most prominent of which are Shanghai's Shen-Li High Tech and Dalian's Sunrise Power. Both of these are developing FC engines for buses while system integration works are being done by Tsinghua University and Shanghai Fuel Cell Vehicle Powertrain Company.

2) Hydrogenics (Canadian company) - The company was engaged in 3 FCB projects:

- With support from Natural Resources Canada and New Flyer Bus Company, Hydrogenics has developed a 40-foot FCB (180 kW PEM + regenerative braking + ultra-capacitors) for demonstration and testing in Winnipeg in April 2005. Partners in this 3-year project include Dynetek Industries, ISE Research and Maxwell Technologies. The Canadian government is targeting larger fleet demonstrations (15-25 buses per demo) in 2008-2009.

- Hydrogenics also signed a contract in November 2004 with the German state of North-Rhine-Westphalia (NRW) to demonstrate a fully-operational "mid" bus, a 17-foot bus that will use Hydrogenics "HyPM" power module technology (a 10-kW module that can be combined in parallel or series) at a total cost of US$1.5 million.
- In February 2004, the US Air Force took delivery of a 30-foot hybrid FCB with a 20 kW Hydrogenics FC engine at its Hickam, Hawaii base. One year of demonstration and testing was planned, to be followed by routine service use of the bus.

3) Proton Motor (German company) – The Proton Motor Fuel Cell GmbH continues to exhibit some activity around FCBs with confirmed construction plans completed for a double-decker FCBs with fuel cell engines to be provided by Proton Motor. Currently, Berlin buses can only hold an average of 95 passengers, but the new buses will be able to pack 120-130 passengers by increasing bus length by 1.8 meters from current 13.5 meters.

4) Other Activities - Other 4 minor activities are listed below by the UNDP-GEF update report:

- National Fuel Cell Bus Technology Initiative (NFCBTI) is an effort in the US spearheaded by Westart/Calstart supported by component suppliers (Ballard), vehicle manufacturers (Volvo, GM, Caterpillar) and vehicle users (Sunline, AC Transit, FedEx). The goal of the NFCBTI is to accelerate development of commercially viable fuel cell and hydrogen buses in the US, with focus on reducing bus costs and increasing durability and reliability. In March 2005, the US House of Representatives passed HR3, "The Transportation Equity Act: A Legacy for Users", a 6-year US$284 billion federal highway, transit and highway safety program which includes US$65 million for R&D to make hydrogen FCBs commercially viable. The R&D must be 50% cost shared by partners. If funding is secured for the NFCBTI, this US program may begin to rival that of Europe's CUTE program.
- In 2002, the European Union provided Euro 7.84 million (US$9.6 million) to a consortium involving Air Liquide, Axane Fuel Cell Systems (France), Nuvera, Irisbus and Johnson Matthey to develop a standardized 100 kW PEMFC system for buses, heavy-duty vehicles and stationary power with the aim to mass-produce and reduce cost to 300 Euro/kW for the fuel cell and hydrogen storage components.
- The European Citycell Project was designed to operate four different hybrid fuel cell buses in Berline, Madrid, Paris and Turin. However, the delivery of the buses to Paris and Turin was stopped, and the Madrid bus (Irisbus with UTC fuel cell engine in May 2003) has been taken off the road, while the fate of the Berlin bus is unknown.
- Georgetown University has long maintained demonstration efforts with methanol fuel cell buses (using on-board reforming of methanol) in hybrid configuration with batteries and is supported primarily by the US government. There is a plan to demonstrate "third generation" bus that will use methanol, but without battery hybridization.

UNDP-GEF FCB Programme Implementation Update

The UNDP-GEF FCB Programme intended to support commercial demonstrations of FCB and associated hydrogen refueling systems in the mega cities of Beijing, Mexico City, New Delhi, Sao Paulo and Shanghai. Following is the status of each city implementation from UNDP-GEF update:

- **Sao Paulo -** The Brazilian FCB project has negotiated with the FCB Consortium responsible for designing, developing and producing the hydrogen FCBs, supply equipment, storage and refueling systems. The consortium has also presented the technical and commercial proposal to UNDP for the FCB and the terms of the procurement contract are currently being finalized for approval. There is agreement that a FCB prototype will run first in Sao Paulo, to be followed by a proposal from the consortium to produce up to 8 FCBs. After completion of official testing, the consortium will present a proposal for the production of the full FCB fleet. However, an official Tripartite Review (TPR) was not held as the project waited for the official establishment of the consortium; however, a meeting was held to discuss the annual project revision.

- **Mexico City** – In December 2004, the Secretary of Environment and Natural Resources of Mexico, thru the Operational Focal Point, determined that the will pursue official cancellation of the UNDP-GEF FCB project due to substantial changes in conditions originally foreseen for the project, in particular, the financial and institutional aspects of the project. While awaiting official cancellation, potential reformulation of the FCB project into a non-technology focused Sustainable Transport Project was undertaken, and the project is now implementing a revised work plan that focused on developing technical and operational capacity related to FCBs thru collaboration with Mexican institutions familiar with fuel cells and transportation technologies.
- **China** – In late 2003, the China International Center for Economic and Technical Exchanges (CICETE) launched the international procurement process for the project and in March 2004, the committee declared DaimlerChyrsler as winning bidder. A contract was signed in May 2004 and three Citaro buses were delivered to Beijing later in September 2005. The Beijing hydrogen refueling systems was built by BP and Chinese counterparts (Beijing SinoHytec Limited, Beijing Tongfang Co. Ltd.). The hydrogen source will initially be compressed hydrogen, followed by hydrogen produced on-site using electrolysis of water, and finally hydrogen from reformed natural gas and/or by-product from industrial waste gas. After the purchase of the first set of 3 buses under Tranche I, this triggered implantation of Tranche II which is already in the GEF pipeline and subject to GEF Council approval when submitted as part of a work programme. The Tranche I project has been completed and subject to a final-term review in November 2004. The evaluation mission suggested that Shanghai procure the newer generation FCB in Tranche II since the active state of FC development in China and abroad will likely produce a new generation of FCBs within two years with likely improved durability and reliability as well as lower costs. The project was found to have effectively built capacity within various Chinese academic, government agencies and private sector manufacturing and fabrication of fuel cell stack and components. Considering that China is the world's largest public transport sector and rapidly becoming the world's largest energy consumer of fossil fuels, the overall impact of a successful FCB demonstration in China will have extremely significant contribution in reducing GHG emissions and sustainability. A mid-term evaluation was conducted on the Tranche II (Phase II FCB Demonstration) last November 2010 and a final-term evaluation was conducted this December 2011 (this report).
- **Egypt** – With the progress of Brazil and China FCB projects and other FCB demonstrations around the world thru competitive procurement process of FCB units, the UNDP-GEF provided support to FCB projects in both India and Egypt. However, the FCB project was closed by the Egyptian government in 2004/2005 as co-financing from the government and other sources were not finalized and implementation arrangements were not negotiated. Egypt has since then revised its priorities for transport and a new GEF project is being officially proposed
- **New Delhi** – In May 2004, the Indian Ministry of Environment and Forests (MOEF) conveyed to the Ministry of Non-Conventional Energy Sources (MNES) that the FCB project be cleared by the GEF for implementation within six months (November 2004) or be cancelled. The India FCB project implementation arrangement was submitted in May 2001 to the GEF Council. Ultimately, it appeared that the national counterparts and the government had accepted the need to cancel the FCB project. India is now pursuing a Cleaner Mobility project and entered the GEF pipeline in January 2005.

The FCB Programme has witnessed major achievements realized by the Brazil and China projects which have now both procured FCBs and conducted trials and demonstration runs. Major losses have also been felt within the FCB Programme with the cancellation of the Mexico, Egypt and India projects which have been terminated by their respective countries.

The cancellation of the three of the original five projects participating in the FCB Programme has provided valuable lessons, namely:

- The FCB projects initially formulated all seemed viable, only two projects have proceeded to full project operational status; therefore, picking individual "winners" at the outset is risky, and spreading the risk requires pursuing several promising initiatives.
- For GEF projects involving a technology that is proven yet not-commercial, it is difficult to predict timing; such that, in the case of Brazil, it has kept the project moving forward thru frequent discussions among stakeholders, yearly reviews and continuous attention to its budgets.
- The corrective action applied to the FCB Programme has been proven cost effective and prudent since the transaction costs associated with pursuing the three cancelled GEF projects at this point have been absorbed internally, mainly thru preparatory funds and IA costs

Thus at this stage, future communications approaches will focus on increasing interaction between Brazil and China projects as well as non-GEF projects as well.

Next Steps for UNDP-GEF FCB Projects

From the low 15 demonstration projects reported in the earlier ProDoc of FCB Phase II project, latest data from US NREL indicate 26 FCB projects involving 44 buses in the US alone. Worldwide including the US, the number is much larger as 29 FCB projects were completed involving 147 buses. On-going FCB projects aggregate 35 involving 108 buses while there are new 25 planned FCB projects in the pipeline with 45 buses. In all these FCB projects, the main FC technology used is PEM in hybrid mode while the majority of the bus units were manufactured by Ballard, followed by Hydrogenics and UTC Power. There seems to be a mad rush among the FC technology suppliers to innovate and demonstrate their own technologies to capture future market share in this evolving international market for FCBs.

The global interest to be the leader in FCB, FCEV and FCHV technologies as manifested by the rise in the numerous demonstration projects worldwide makes it imperative for China to actively participate and focus on its built-in advantage (fuel cell stack, controls, Li-ion battery, ultra-capacitors, regenerative braking, enormous supply of platinum catalyst, large scale bus chassis manufacture, domestic bus market and widespread public acceptance of FCB). It clearly needs to proceed to the next Expanded Commercialization Fuel Cell Bus Phase III to further innovate, reduce cost, increase energy efficiency, enhance durability and reliability and ensure safety of its Chinese-made FCB fleet in the densely populated Chinese cities.

3.3.6 Others (Good Practices, Lessons Learnt and Recommendations)

The analysis and reporting of the good practices and lessons learnt during the FCB Phase II demonstration project will be presented in Chapter 5 - Lessons Learned and Best Practices.

Based on the compilation of good practices and lessons learnt prepared, the rating is ***"Satisfactory (S)".***

Likewise, recommendations on the improvement of implementation of the remaining activities to end-of-project and actions to be taken to support FCB Phase II expanded demonstration is shown in Chapter 4 – Recommendations.

Based on the compilation of recommendations prepared, the rating is ***"Satisfactory (S)".***

3.4 *Project Implementation Review*

The FTR team also assessed the FCB Phase II project implementation taking into account the status of the project activities and outputs and the resource disbursements made up to 30 June 2011 and 4th Quarterly Operation Report till end of December 2011. A summary of the status of project activities (accomplishment vs. target) is shown in Table 2-3 while the status of financial disbursements (expenditure vs. budget) is likewise shown in Table 3-1.

The evaluation of project implementation will involve analysis at two levels: component level and project level.

3.4.1 **Component Level**

The responses to the survey conducted during the site visit for the component level are summarized below:

Component Level	Beijing	Shanghai
- Is there effective relationship and communication between/among components so that data, information, lessons learned, best practices, outputs and cross-cutting issues are shared efficiently?	Y	Y
- Are the performance measurement indicators and targets used in the project monitoring system specific, measurable, achievable, reasonable and time-bounded to achieve desired project outcomes?	Y	Y
- Was the use of consultants successful in achieving the component outputs?	Y	Y
- Appropriateness and relevance of work plan, compliance with the work and financial plan with the budget allocation	Y	Y
- Timeliness of disbursements, procurement, coordination among project team members and committees and UNDP country office support	Y	Y
- Any issue or factor that impeded or accelerated the implementation of the project or any of its components, including actions taken and resolutions made should be highlighted	Y	Y

Based on the compilation of response on effectiveness of project implementation at the component level, the rating is ***"Satisfactory (S)".***

All the survey results are stored in a separate excel file (TOR worksheet) containing all the data obtained and summarized in this final-term report.

3.4.2 **Project Level**

In a similar manner, the PMO and sub-contracts that responded during the site visit provided the following evaluation for the four groups (a, b, c, d) of project level performance.

Project Level	Beijing	Shanghai
a) Progress towards achievement of results		
- Is the project making satisfactory progress in achieving project outputs vis-à-vis the targets and related delivery of inputs and activities?	Y	Y
- Are the direct partners and project consultants able to provide necessary inputs or achieve results?	Y	Y

- Given the level of achievement of outputs and related inputs and activities to-date, is the Project likely to achieve its purpose/objective and contribute to the realization of its goal?	Y	Y
b) Factors affecting successful implementation and achievement of results		
- Is the project implementation and achievement of results proceeding well and according to plan?	Y	Y
- Or are there any outstanding issues, obstacles, bottlenecks, etc. on the following sectors that are affecting the successful implementation and achievement of project results?		
consumer (riding public)	Y	Y
government (national and local)	Y	Y
private sector (bus companies, FCB manufacturers)	Y	Y
public transport sector as a whole	Y	Y
- To what extent does the broader policy environment remain conducive to achieving expected project results, including existing and planned		
legislations	Y	Y
rules and regulations	Y	Y
policy guidelines	Y	Y
government priorities	Y	Y
- Is the project logical framework and design still relevant in the light of the project experience to date?	Y	Y
- To what extent do critical assumptions/risks in project design make true under present circumstances and on which project success still hold?	Y	Y
has the project team validated these assumptions as presently viewed by the project management?	Y	Y
are there new assumptions/risks that should be raised?	N	N
- Is the project well-placed and integrated within the national government development strategies such as community development, poverty reduction, etc. and related global development programs?	Y	Y
- Are the Project's institutional and implementation arrangements still relevant and helpful or hinder in achieving the Project's objectives and outcomes?	Y	Y
or are there any institutional concerns that hinder the Project's implementation and progress	Y	Y
c) Project management framework (adaptive management framework)		
- Are the project management arrangements adequate and appropriate?	Y	Y
- How effective is the project managed at all levels?	Very	Very
- Is it results-based and innovative?	Y	Y
- Do the project management systems, including progress reporting, administrative and financial systems, and monitoring and evaluation system operate as:	Y	Y
effective management tools	Y	Y
aid in effective implementation, and	Y	Y
provide sufficient basis for evaluating performance and decision making?	Y	Y
- Is technical assistance and support from project partners and stakeholders appropriate, adequate and timely?	Y	Y
- Validate whether the risks originally identified in the Project Document and currently in the APR/PIR are the most critical and the assessments and risk ratings placed are reasonable	Y	Y
- Describe additional risks identified during the evaluation, if any, and suggest risk ratings and possible risk management strategies to be adopted	N	N

- Assess the use of project logical framework and work plans as management tools and in meeting with UNDP-GEF requirements in planning and reporting	Y	Y
- Assess the use of electronic information and communication technologies in the implementation and management of the project	Y	Y
- On the financial management side, assess the cost effectiveness of the interventions and note any irregularities	Y	Y
- How have the APR/PIR process helped in monitoring and evaluating the project implementation and achievement of results?	Y	Y
d) Strategic partnerships (project positioning and leveraging)		
- Are the project partners strategically and optimally positioned and effectively leveraged to achieve maximum effect of the sustainable transport and Energy Efficiency program objectives for the country?	Y	Y
- How do the project partners, stakeholders and co-financing institutions involved in the Project's adaptive management framework?	Y	Y
- Are there further opportunities for stronger collaboration and substantive partnerships identified to enhance the project's achievement of results and outcomes?	Y	Y
- Are the project information and progress of activities disseminated to project partners and stakeholders? Are there areas to improve in the collaboration and partnership mechanisms?	Y	Y

Based on the compilation of response on effectiveness of project implementation at the project level, the rating is *"**Satisfactory (S)**".*

All the survey results are stored in a separate excel file (TOR worksheet) containing all the data obtained and summarized in this FTR report.

3.5 *Conclusions*

The most important conclusions arising from this final-term evaluation includes:

- The rapid economic development of China has catapulted the country from being 2nd in global CO2 emission in 2003 to being the largest emitter of CO2 in 2010, having overtaken the US as largest emitter in 2009. As such, it needs valuable UNDP and GEF assistance in addressing the great responsibility arising from this recent global development. This development has provided great impetus to the Chinese Government to address the need to reduce China's CO2 and overall GHG emissions in the various sectors of Chinese economy, especially the transport sector.
- The FCB Project (Phases I and II) is very important to the Chinese Government. The development and commercialization of FCBs responds to sustainable "clean fuel" and "clean vehicle" policies and has obtained support from the Chinese Government, both central and municipal. The Phase I procured 3 FCBs while the Phase II purchased 6 FCBs of which 3 were funded by the project budget and the other 3 by the Shanghai municipal government.
- The partnership that developed among the various stakeholders (government agencies and ministries, central and municipal government units, academic institutes and private sector firms), has led to significant achievements. Significant design innovations (hybrid design, regenerative braking, ultra capacitors, Li-ion battery), system integration and use of GPRS and internet communications have resulted in reduction of power requirement, higher energy efficiency, durability and reliability, safety and lower FCB unit cost. Also, the maintenance and operation of the FCB fleet and the hydrogen refueling system were tested leading to accumulation of valuable operating data. Fuel economy has significantly improved from Phase I Daimler FCBs of 20 kg/100 km (baseline Beijing) to 12 kg/100

km (target Shanghai) with Phase II domestic FCBs (3 Foton and 6 SAIC) at 11.60 (2009-2011) for both running and maintenance operation.

- Improving alone the energy efficiency of private and public transport systems may not be enough alone in reducing CO2 emission. Government policies must also direct and encourage the paradigm shift from inefficient private transport to highly integrated, optimized and energy efficient public transport modes such as buses, inland waterways and railways powered by low-carbon and low-pollution emitting vehicle technologies. This is where the Eco-Transport in City Clusters Program and the Urban Transport Program could complement the efforts of the FCB project in achieving CO2 emission reduction for transport sector in China.
- The use of fuel cell hybrid technology is the leading global innovation to raise energy efficiency and lower the CO2 emission of public transit buses worldwide. The global interest among suppliers to be the leader in FCB, FCEV and FCHV technologies as manifested by the rise in the numerous demonstration projects worldwide makes it imperative for China to actively participate in fuel cell and electric vehicle R&D to remain updated with recent global developments and to focus on its built-in advantage (fuel cell stack, controls, Li-ion battery, ultra-capacitors, regenerative braking, enormous supply of platinum catalyst, large scale bus chassis manufacture, largest domestic bus market in the world and widespread public acceptance of FCB).
- It is in China as well as the world's interest that China expands its FCB demonstration to other cities or cluster of cities in a sustainable manner so it may encourage shift from inefficient and high-carbon footprint private motoring and diesel-fed bus systems with advanced transport systems to reduce its CO2 and GHG emission using a proven FCB technology that is nearing commercialization with minimal or nil subsidy. China needs to expand the demonstration to other City Clusters and Urban Cities in order to optimize the technology mix of its public transit system (e.g. 70% diesel-hybrid bus, 20% CNG-hybrid bus, 10% FC hybrid bus from Shanghai interview). By improving both the current diesel and CNG bus system hand-in-hand with the FC hybrid bus, the overall cost of the bus system is kept low since the diesel and CNG bus will be able to cross-subsidize the fare of the more expensive FC hybrid bus.
- Because of China's satisfactory completion of the FCB Phase II project, and together with non-GEF initiatives in "clean energy" vehicles and continuing implementation of integrated and optimized transport modes for both City Clusters (e.g. inland waterways) and Urban Transport (e.g. bus rapid transit or BRT), China is a good candidate for "*Expanded Demonstration of Fuel Cell Bus in China (Phase III)*". Stopping the project at Phase II and not proceeding to Phase III Expanded Demonstration will result in lost momentum in terms of partnerships cemented by the FCB project, forgone R&D innovations that are in the pipeline such as utilization of more advanced FCB units from the world's leading suppliers and innovators of FC technology, and inability to raise existing diesel-fed and CNG-fed bus efficiencies that will provide cross-subsidy to the more expensive FC bus (due to higher capital cost and cheaper fossil fuels compared to hydrogen) at this point in time. The Phase III must focus on the newer FC technologies available compared to when Phase I and Phase II were implemented, test the various newer FC technologies and compare performance and economics with current diesel-fed and CNG-fed buses that also needs performance improvements (such as hybrid and regenerative braking), so that overall, the Chinese commuter will benefit from the positive results of Phase III which includes overall reduction in bus fares of diesel and CNG hybrid buses, require minimal subsidy for the newer FC hybrid bus, and sustainable reduction of CO2 and GHG emissions which would not be possible unless the entire public transit system is made modern and energy efficient also.

With respect to evaluation of performance at the component level, the following could be concluded from the response to the excel survey form that was carried out by the FTR Team. The survey results were concurred by the FTR team:

- There is effective relationship and communications between team members so that data, information, lessons learned, best practices and outputs are shared efficiently, including cross-cutting issues (Yes in B & S)

- The performance measurement (success) indicators and targets used in the project monitoring system are specific, measurable, achievable, reasonable and time-bounded to achieve desired project outcomes (Yes in B & S)
- The use of consultants has been successful in guiding the Chinese experts and research institutions in implementing the various activities of the FCB Phase II project (Yes in B & S)

With respect to performance at the project level, the following conclusions were deduced from the response to the excel survey form, which was also concurred by the FTR team:

(c) Progress towards achievement of results (internal and within the project's control):

- The project is making satisfactory progress in achieving project outputs vis-à-vis the targets and delivery of inputs and activities at the end of project *(the project has resulted in cheaper FCB compared to high-end imported FCB, more efficient FCB as shown by declining hydrogen consumption per km traveled, and safe and reliable operation as shown by operating and maintenance reports)* (Yes in B & S)
- The direct partners and project consultants were able to provide necessary inputs and results (Yes in B & S)
- The project is likely to achieve its purpose/objective *(operational viability of FCB and HRS)* and contribute to the attainment of its goal *(reduction of GHG emissions and air pollution in urban areas of China)* (Yes in B & S)

(d) Factors affecting successful implementation and achievement of results (beyond the Project's immediate control or project-design factors that influence outcomes and results):

- The project implementation and achievement of results are proceeding well and according to plan, and there are no outstanding issues, obstacles, bottlenecks, etc. from various stakeholders (national and local government, research institutes, sub-contractors, private sector). *(The SHANGHAI EXPO have special permit so there was no purchase tax on the demonstration FCBs. However, after EXPO, there was no budget for purchase tax once municipal permit is secured; hence, need for a new exemption policy for FCB once permit is secured. Without a service permit, the Shanghai team used dummy weights as passengers in order to continue testing the FCBs after the EXPO and collect data needed to achieve the targets.)* (Yes in B & S)
- The broader policy environment remain conducive to achieving expected project results, including existing and planned legislations, rules, regulations, policy guidelines and government priorities. *(In China, policy on environment is supportive of FCV. There is plan to have 1,000 cars in the next 5 years by SAIC. The demonstration of Phase II promoted this plan. The main reason for non-issuance of service permit to the Shanghai FCBs after the EXPO is to avoid an accident involving real passengers for the purpose of obtaining real-time test data which would have a significant negative public news impact as to the safety of FCBs. Using weight dummies to simulate passengers and obtain real-time data would be a better alternative according to the Shanghai team.)* (Yes in B & S)
- The project's logical framework and design remain relevant in the light of the implementation experience to date. (*The minor modifications were largely in the performance indicators for the goal, objectives and outcomes. In particular, the revised project planning matrix (PPM) renamed the outcomes as components A, B and C, and their title were revised accordingly. Outcome A was expanded from 11 to 18 success indicators; Outcome B as is at 7 success indicators; and Outcome C from 11 to 13 success indicators. Annual targets were also provided to guide the team in implementing the 4-year project. The effect of the revision is providing more clarify in the expected outputs, what activities to pursue in order to attain the success indicators at the specified time frame.)* (Yes in B & S)

- There are no new critical assumptions / risks that need to be raised on top of what were previously validated by the project team. (*There was a risk that the 200,000 kms target for the 6 FCBs would not be met by end-of-project because of the delay in obtaining a service permit from the Shanghai municipal government. This was mitigated, however, by conducting test runs using weight dummies instead of live passengers, and tests were then accelerated.)* (Yes in B & S)
- The project is well-placed and integrated within the national government development strategies such as community development, poverty reduction, etc. and aligned to global development programs. *(The FCB project is important not only to the Chinese Government but also aligned to global development program since addressing CO2 and GHG emissions and mitigating climate change has positive impact on community development and power reduction since the first and significant victims of climate change disturbances are the poor communities and urban centers who suffer from sea level rise, severe flooding and loss of live, severe drought and reduced food production, and higher incidence of respiratory illness arising from polluted environment and warmer temperatures.)* (Yes in B & S)
- The project's institutional and implementation arrangements are still relevant and helpful in achieving its goal, objective and outcomes; there are no institutional concerns that hinder its implementation and progress towards completion (Yes in B & S)

(c) Project management (adaptive management framework):

- The project management arrangements remain adequate and appropriate as evidenced by the progress reports (PIR, APR, Beijing and Shanghai presentation and site visits to SAIC fuel cell bus factory and Anting hydrogen refueling station facility) and is observed to be results-based and innovative (Yes in B & S)
- The project is well managed at all levels as per excel survey (Yes in B & S)
- The project management systems (progress reporting, administrative and financial systems, and monitoring and evaluation systems) are effective and provide sufficient basis for evaluating performance and facilitating decision making (Yes in B & S)
- Technical assistance and support from project partners and stakeholders were found to be appropriate, adequate and timely (Yes in B & S)
- The risks originally identified in the revised Project Document and currently in the APRs/PIRs are indeed the most critical and the assessments and risk ratings placed are still reasonable for which the FTR team also concurs (Yes in B & S)
- During the interview by the FTR team, there are no additional risks, except for the risk of non-completion of the Shanghai demos due to non-issuance of municipal service permits, identified as the risk of not procuring the required number of FCBs with the funding budget available and permits by local government were identified in advance. *(Without the permits, the Shanghai team decided to conduct the test runs using weight dummies to gather real-time operating data to reach the target of 200,000 kms at end-of-project.)* (No in B & S)
- The use of project's logical framework and work plans as management tools and in meeting with UNDP-GEF requirements in planning and reporting is deemed effective and the FTR team itself found it useful in organizing and analyzing the final-term evaluation results (Yes in B & S)
- The effective use of electronic information and communication technologies in the implementation and management of the project has greatly automated, simplified, expedited and made more accurate the gathering of data, reports, calculations and results (Yes in B & S)
- The financial management of the project is effective and none noted any irregularities (Yes in B & S)
- The APR/PIR process has helped in monitoring and evaluating the project implementation and achievement of results as it tracks the time of delivery of outputs (Yes in B & S)

(d) Strategic partnerships (project positioning and leveraging):

- The sub-contracts responded that project partners are strategically and optimally positioned and effectively leveraged to achieve maximum effect of the sustainable Transport and Energy Efficiency program objectives for the country. *(The project partners such as the municipal governments of Beijing and Shanghai, universities, bus operators and bus manufacturers have effectively contributed their unique expertise to the greater pool of technical excellence needed to perfect the FC hybrid bus and to do innovative work in their respective areas.)* (Yes in B & S)
- The project partners, stakeholders and co-financing institutions are involved in some aspects of the project's adaptive management framework since they provide us comments and suggestion during the projects. *(The municipal government of Shanghai suggested instead to use weight dummies instead of live passengers when conducting the test runs for accumulating 200,000 kms of bus operating experience.)* (Yes in B & S)
- There are opportunities for stronger collaboration and substantive partnerships identified to enhance the project's achievement of results and outcomes (Yes in B & S)
- The project information and progress of activities are disseminated to project partners and stakeholders (Yes in B & S)

4.0 Recommendations

At the component level, the following monitoring and evaluation issues were obtained for both cities. In particular, the Shanghai PMO indicated that there were some initial issues regarding the imported hydrogen storage tanks. This issue has been resolved in Beijing as the hydrogen storage tanks can now be manufactured locally in China.

This FTR examines that status of the previous MTR recommendations for both Phase II and Phase III with the end in view of determining whether the project team and its sub-contractors have addressed and provided closure to the issues raised in the MTR recommendations.

Likewise, two sets of recommendations were prepared in relation to the current FCB Phase II and the proposed FCB Expanded Demonstration Phase III which aims to further reduce the acquisition cost of FCBs and FCVs in general, improve fuel utilization efficiency in particular, and verify the safety and economical operation of both the FCB and HRS components of the project.

4.1 *Status of MTR Recommendations for Phase II*

"For the Shanghai FCBs, it is recommended that the testing program be accelerated in order to attain the planned 200,000 km by securing as soon as possible permits for city bus operation. It is recommended that the Shanghai PMO secure the municipal service permits for the 6 FCBs purchased in this Phase II project considering that EOP is fast approaching." Testing with sand-bag dummies were carried out in the absence of permit. It was more prudent to use weight dummies for conducting the test runs instead of live passengers to avoid negative publicity arising from any accident or equipment failure during testing if passengers are used to simulate bus load capacity.

"In the case of Beijing FCBs which has attained so far 60,198 km traveled in its one year planned operation. It is recommended that the 3 Beijing FCBs be preserved in good running condition before they are distributed to the final recipients for museum display and training purposes." The 3 Phase I FCBs are preserved. Present status is one FCB is preserved in museum, one FCB with a university for student and faculty research and one FCB on stand-by demonstration for Beijing to continue its mission for public awareness on the benefits of "clean fuel" FCB. The 6 Phase II FCBs are in good running condition and continuing their test runs to attain the planned 200,000 km target by end-of-project. These Shanghai FCBs could also be retrofitted with latest FC vehicle technology enhancements to enlarge the fleet for the FCB Phase III expanded demonstration in City Cluster and Urban City driving modes.

"The numerous studies completed and in the possession of the PMO can be combined into a technical volume that could be accessed readily by interested researchers throughout the world, and possibly be used as reference for future policy development and fuel cell hybrid technology improvements…" The reports have been posted on-line at the UNDP-China FCB Phase II project website for appropriate viewing and downloading by the public.

"China appears to have successfully carried out the procurement, testing and demonstration of this hydrogen fuel cell technology. It is highly recommended that this enabling experience be shared throughout the world to highlight its successful efforts..." This has been done and available at the website.

4.2 *Status of MTR Recommendations for Phase III*

"The development of FC vehicle technologies is rapidly evolving. Thus, it is recommended that in the preparation of the Phase III proposal, the project team shall endeavor to evaluate which FC hybrid technology/manufacturer to commercialize in China…" This will be reflected in the PIF for Phase III as it conduct further tests on the newer FC hybrid buses that entered the market very recently to ensure that the best FC hybrid technology is adopted for the expanded demonstration in several Chinese cities.

"In the design of the FCB III project proposal, there is now an earnest need to conduct scientific parallel tests between the baseline diesel engine bus and the alternative hydrogen fuel cell hybrid bus. This means procuring the same identical bus chassis of same length, height, weight, passenger capacity…" This will also be reflected in the PIF for Phase III which will evaluate the comparative economics of the newer FC hybrid buses vs. the conventional diesel-fed and CNG-fed buses fitted preferably with hybrid technology also in order to optimize the bus fleet mix that will enable sustainable CO2 and GHG emission reduction in the Chinese transport sector for City Cluster and Urban City driving conditions. Existing information for determining comparative economics under current conditions is not recommended due to significant rise in conventional fossil fuel costs and FCB price and performance improvements (lower price, higher efficiency, longer fuel cell lifetime).

4.3 *Recommendations for Phase II*

"For the Shanghai FCBs, it is recommended that the testing program be accelerated in order to attain the planned 200,000 km." Without the municipal service permit, the 6 Shanghai FCBs continued their test runs by using weight dummies instead of live passengers in order to avoid accidents with passengers on board. This has led to attainment of 183,558 km and transport of 106,040 dummy passengers as of 13 Dec 2011.

"In the case of Beijing FCBs which has attained so far 75,460 km (no requirement in the project document), it is recommended that the 3 Beijing FCBs be preserved in good condition." The 3 FCBs were purchased under Phase I for the Beijing demonstration. One FCB is preserved in a museum, another one is preserved in a university for continuing research by students and faculty and the last one is kept on running condition to continue its role as Beijing's clean vehicle demonstration to continue public interest and awareness of hydrogen FC bus as a cleaner alternative vehicle for densely populated Chinese cities, and thus contribute to the commercialization of FCB in China.

"The Beijing PMO has already secured municipal service permit for its 3 existing FCBs as a result of diligent follow-ups and it is recommended that the Shanghai PMO do the same expeditiously for the 6 FCBs purchased in this Phase II project considering that EOP is fast approaching." While this is now water under the bridge since the 6 Shanghai FCBs continued their test runs without live passengers by using instead weight dummies to simulate passenger service, it would be a prudent move for the Shanghai Government to initiate an independent evaluation on the reliability and safety of the said FCBs so that after the 200,000 km test, the said FCBs may be granted the necessary permit for test runs under the expanded demonstration under Phase III and its technical and economic performance be compared with the current conventional bus fleet in Shanghai. In this way, the FCBs and the conventional buses could run in a sustainable manner by means of cross-subsidy mechanism within the bus mix without the need for external budget support from either the municipal or central government of China.

Recommended FCB II exit plan if there will be no FCB III

- What is the plan for the 6 FCBs in Shanghai? Will these be placed in operations as regular bus transport vehicles? Who will own and operate these FCBs?

  The FTR team recommends that it secure the needed municipal service permits after it has been fully authorized as a regular bus fit for public transit service. The ownership of the bus will remain with the entity that purchased them (Shanghai municipal government and FCB project), but will be operated as a regular bus by the local bus company operating the regular bus fleet. Its fuel costs, operating costs and other maintenance costs shall be monitored by the bus fleet operator using the FCB project staff who will continue to get paid by the FCB project using funds from the entity that owns the bus with additional funding to be provided by the Chinese central government.

- How will the CO2 emission reductions from the use of the 6 FCBs be monitored?

  The operating parameters (km traveled, H2 consumption for revenue run and maintenance, kg H2 per 100 km revenue run, passengers carried, CO2 emission reduction) should be monitored specially up to the next 5 years. After 10 years of operation of each FCB unit, it is deemed to have reached its economic life and shall be kept in preservation mode, preferably in a public museum, university campus for student/faculty research or instructional purposes, as may be practicable.

- How will these be reported and to which entity will these be reported?

  The operating parameters monitored, stored and analyzed shall be reported to the PMO, UNDP, GEF and central GHG emission monitoring body of the China central government in charge for GHG emission inventory (as agreed or identified in the SNC Project).

4.4 *Recommendations for Phase III*

The development of FC vehicle technologies is rapidly evolving. Thus, it is recommended that in the preparation of the Phase III proposal, the project team shall endeavor to evaluate which FC hybrid technology/manufacturer to commercialize in China in order to adopt the most optimal and economical FC hybrid technology for commercialization in China's cluster cities and urban areas.

In this manner, as China endeavors to reduce its CO2 and GHG emission from the transport sector, it will be done in a sustainable manner as the FC hybrid technology chosen shall be the cheapest in terms of long run marginal cost (LRMC, expressed as RMB per passenger-km) that considers the initial capital cost of the FCB unit, its capacity factor and passengers carried, fuel cost and energy efficiency, operating and maintenance costs, and fuel cell stack overhaul and replacement cost during the expected 10-15 years economic life of the FCB unit and driving cycle mode for city cluster (long distance intra city travel) and urban city (short distance heavy traffic stop and go).

In the design of the FCB III project proposal, there is now an earnest need to conduct scientific parallel tests between the baseline diesel-fed and CNG-fed bus and its hybrid variants and the alternative hydrogen fuel cell hybrid bus that will be procured in FCB III. This means procuring the same identical bus chassis of same length, height, weight, passenger capacity. In this manner, the current conventional bus fleet for City Cluster and Urban City applications are also optimized and made energy efficient and cost effective. Such improvement of existing conventional bus fleet will result in cheaper bus fares whose cost savings may be applied to cross-subsidize the more expensive FC hybrid buses.

Only by having an optimal mix of energy-efficient bus technologies will China be able to address long-term and in a sustainable manner the need to reduce pollution (NOx, SO2, CO, UHC, particulates) from bus transit fleet, lower commuter transport fare and reduce CO2 and GHG emissions.

Thus having together an optimal vehicle mix and policy initiatives that promotes a paradigm shift from inefficient private motoring to optimized, integrated and "clean fuel" and "clean vehicle" technology applicable to both driving modes from City Cluster (long distance) and Urban City (short distance heavy traffic stop and go) will enable China to address in a sustainable way its global responsibility of significantly contributing to CO2 and GHG emission reduction.

In a way, the FCB Phase III would be essentially an expanded demonstration to remove the barriers that prevent its commercialization in China's city clusters and urban cities. Of course, among the main barriers to commercialization are: higher cost of the FCB unit relative to conventional fossil-fed engine buses; higher fuel cost of hydrogen compared to diesel, gasoline or CNG; need for higher efficiency to over come higher fuel cost; shorter fuel cell stack lifetime and frequent replacement; durability and reliability issues; and safety concerns as it carries compressed hydrogen – all of which conspire form a barrier to commercialization of FC hybrid technology.

The PMO is now drafting the Project Information Form (PIF) of the next Phase III expanded demonstration of the latest FC hybrid bus technology and of conventional diesel-fed and CNG-fed buses preferably with hybrid technology to improve energy efficiency and reduce cost of commuting using public bus fleet in City Clusters and Urban Cities in China and thus remove the main barriers identified above; hence, it should pursue its development into a full-pledged Project Document for approval by the GEF/MoF so it may commence by 2012 after the project ends by Dec 2011.

4.5 *Components of Phase III – Expanded Demonstration*

The goal of Phase III is to expand and optimize the reduction of GHG emissions and air pollution in city clusters and urban cities of China using both the latest FC hybrid bus and updated conventional diesel-fed and CNG-fed bus preferably with hybrid technology. The objective of Phase III is to verify the operational viability and economic performance of newer FC hybrid bus and that of conventional diesel-fed and CNG-fed bus preferably with hybrid technology. Lastly, the recommended activities for Phase III are as follows:

- Expand commercial demonstration in several cities (city clusters and urban city) with differing driving modes (long distance intra-city vs. short distance heavy traffic stop and go) and types of vehicles (newer FC hybrid bus, diesel-fed and CNG-fed buses preferably in hybrid mode)
- Conduct parallel tests on pure diesel, gasoline/diesel electric hybrid, pure electric vehicle and fuel cell hybrid vehicle as well as policy reviews (taxation, permits, emissions, safety) in order to determine the comparative economics of various transport vehicles driving under different driving modes (city cluster vs. urban city). In this way, the optimal mix for diesel, CNG and hydrogen fueled vehicles are determined for each type of driving mode so that overall economics and cheaper commuter fare is possible (conventional diesel and CNG buses cross-subsidizing fuel cell buses)
- Study further hydrogen fuel source route (electrolysis, natural gas reforming, biomass, steel and chemical plant by-product). The previous studies need to be updated considering that crude oil prices have risen from previous levels of about US$38 per barrel to over US$100 as of today (end 2011).
- Study further fuel cell technology to use. Since FCB Phase II, numerous developments have been introduced to FC hybrid bus so the Phase III needs to evaluate and test which one is to be adopted.
- Expand demonstration fleet - buses, taxi fleet, hotel car fleet, car rental fleet, government and post office fleet, fixed-route delivery truck fleet. Aside from buses, Phase III needs to test and demonstrate other fleet types. Involving the government and post office fleet, for instance, will provide a steady market for fuel cell stack and accessories that it will reduce R&D and mass production costs for FC vehicles in China.
- Expand hydrogen refueling station infrastructure
- Expand fuel cell hybrid bus manufacturing capacity
- Review and expand government regulatory, permitting and taxation policies for FCB, FCEV, FCHV and other "clean energy" vehicles for both private and public transport in China

5.0 Best Practices and Lessons Learned

Best practices are meant to document and give recognition to the innovative approaches undertaken by the project team (UNDP, Project Team, stakeholders, government and private sectors) to overcome difficulties in order to accomplish the tasks in a cost-effective manner resulting in leading-edge and quality outputs.

On the other hand, lessons learned are highlighted to remind the project implementers as well as future project undertakers of potential problems or difficulties that may be encountered so as to ensure that such problems are adequately addressed in advance to avoid implementation difficulties in the future. One learns indeed from past mistakes in order to avoid repeating them again in the future.

5.1 *Best Practices*

- The exceptional effort of the MoST in convincing and lobbying the Shanghai municipal government to purchase 2 FCBs out of the required 6 FCBs when it was clear that the allocated budget for FCB purchase can accommodate only 4 FCBs.

- The strong stakeholder support and good working relationship among all project participants is needed at all times. The close cooperation between the UNDP-China FCB demonstration project team and other national electric vehicle (EV) project teams under the National 863 Program is essential in avoiding potential problems along the way such as in Beijing which obtained city bus operating permit from municipal authorities to allow continued testing and demonstration of the FOTON FCB buses even after the end of the Beijing Olympics and Paralympics.

- Having strong technical support from the universities and industry associations is a key to a successful project implementation as it contributed to assisting the fuel cell and hybrid bus fabricators and systems integrators by way of innovative research and technical support.

- The show casing of the Fuel Cell Hybrid technology in the 2008 Olympic Games and 2010 World Expo that were attended by the top management of GEF, UNDP, ADB, WB and Government of China ministries is highly commendable as it provided the opportunity to observe the enthusiasm of the recipients of the new technology.

- By implementing the demonstration in time for the Beijing Olympics and Paralympics for the 3 FCBs procured under the National 863 Program as well as the Shanghai World Expo for the 6 FCBs procured under the FCB Phase II project, a wider audience from both local and foreign guests were able to observe the clean, noise-free and comfortable experience in riding the fuel cell hybrid buses.

5.2 *Lessons Learned*

- Had the local municipal government service permits for city bus operation been issued prior to the ending of the 2010 Shanghai Expo, the demonstration and evaluation of the Shanghai FCBs would have proceeded at a faster pace so that the target 200,000 km would have been attained sooner. As a corrective measure, however, the central PMO and local PMO found another way to continue testing by utilizing sand-bag dummies as passengers. In this manner, the safety concern raised by the Shanghai municipal government of conducting the test runs with live passengers have been addressed by substituting weight dummies as passengers. Operational and safety data were thus obtained and collected continuously until the target 200,000 km run would be attained. It was felt that any accident or equipment failure with live passengers on board would have been a publicity debacle if accidents and equipment failure would occur during actual runs.

On the other hand, the Beijing FCBs continued their testing program without major interruption after the ending of the 2008 Beijing Olympic and Paralympics through the active lobbying and follow-up of the project team and cooperation of the local government. The positive response of the Beijing municipal government to allowing testing with live passengers as opposed to the negative response of the Shanghai municipal government of not allowing testing with live passengers on board shows the variability in government perception on safety issues regarding hydrogen-powered vehicles as well as its pragmatic approach to tests. The Shanghai government thought it would be most prudent to conduct tests using weight dummies instead rather than live passengers since an accident may impact negatively on the FCB demonstration project.

- Greater effort in estimating the future cost of a fuel cell hybrid bus is needed in order to ensure that adequate project funding is secured from the potential sources of funding and investors. This could have avoided the need for Shanghai municipal government to provide funding for 2 FCBs since the budget was sufficient only for the purchase of 4 FCBs. However, this initial funding problem became a blessing in disguise for the project as it provided a unique opportunity for the Shanghai municipal government to participate intimately by providing its own funds for 2 FCBs and claim significant ownership and participation in this project of great importance to the Chinese government.

6.0 Annex A1 - FTR Schedule of Meetings and Site Visits

Date	Agenda	Participants
Dec.14, Wed	Arriving	
Dec.15 Thu	AM 9:00-11:30 Briefing at UNDP China Office PM 13:00 Leaving for Shanghai CA1521 14:30-16:40	Natl. & Intl. Consultants, UNDP, PMO
Dec.16, Fri	09:30-12:00 Introduction of Shanghai project 14:00-17:00 Visit the Shanghai FCBs and Hydrogen Refueling Station 19:00-21:30 MU5123 Leaving for Beijing	Shanghai PMO, Tongji University, SAIC, Shanghai STCM, Natl. & Intl. Consultants, UNDP, PMO, etc.
Dec.17, Sat	Document review and writing report	
Dec.18, Sun	Document review and writing report	
Dec.19, Mon	13:00-16:00 Debriefing in UNDP, reviewing major findings and key recommendations	Natl. & Intl. Consultants, UNDP, PMO
Dec.20, Tue	Departing to Manila	

7.0 Annex A2 - List of Exhibitions, Conferences, Workshops and Seminars

	Title	Location	Date	Number of participants
Exhibitions or road shows	Service for 2008 Olympics female marathon	Beijing	August 17	1200
	Service for 2008 Olympics male marathon	Beijing	August 24.	2000
	The GEF Honor Day during 2010 Shanghai World Expo.	Shanghai	July 20, 2011	60
	Accept 45VIP visits			
Conference	Launch Ceremony of Project Phase II	Shanghai	Nov.15, 2007	250
	Fuel Cell & New Energy Vehicle of 2009 SAE-China Congress	Beijing	Oct.21-22, 2009	300
	The New Energy Vehicles Demonstration & Batteries Technology Session of 2011 SAE-China Congress	Beijing	Oct.26-28, 2011	500
Workshop	Inception Workshop on Fuel Cell Vehicle Commercialization Strategy	Shanghai	Nov.14, 2007	60
	Evaluation Workshop for the Procurement of Hybrid Fuel Cell Buses	Beijing	Oct.8, 2008	30
	Hydrogen and Fuel Cell Session of the Technical Session of the 6th International Energy-Efficiency and New Energy Vehicles Innovation Development Forum	Shenzhen	December 12, 2009	200
	The final delivery meeting of the FCBs	Shanghai	April 27, 2010	20
	The Fuel Cell & New Energy Vehicles Session of 2010 China International Automotive Forum	Changchun	July 15-18, 2010	300
	The Workshop of Energy Vehicles and Fuel Cell Technology	Shanghai	Nov.2-4, 2011	120
Seminar	Review the Request For Proposal (RFP) for the FCB project phase II	Shanghai	March 4, 2008	16
	The Tripartite Project Review Meeting	Beijing	March 12, 2009	6
	Review AWP 2010 and APR2009; review proposals for decorating the GEF Pavilion at the Shanghai World Expo 2010	Beijing	February 8, 2010	6
	The Tri-partite Project Review Meeting	Beijing	January 19, 2011	6

	Review the Logical Framework and Annual Targets	Beijing	Aug.10, 2009	5
	Review draft PIR was conducted by UNDP CO and RTA (Manuel Soriano), along with PMO staff.	Beijing	July 28, 2010	5
	Introduction of Beijing FCB project for the Mid-term evaluation	Beijing	November 9, 2010	10
	Introduction of Shanghai FCB project for the Mid-term evaluation	Shanghai	November 11, 2010	15
	Kick-off meeting of Final Evaluation	Beijing	Dec.15, 2011	6
	Introduction of FCB project for the final evaluation	Shanghai	Dec.16, 2011	15
	Review the Request For Proposal (RFP) for the FCB project phase II	Shanghai	January 7, 2008	15
	Steering Committee Meeting	Beijing	June 20, 2008	7
	Revised Project Planning Matrix	Beijing	April 16, 2009	5
	Kick-off meeting of Mid-term evaluation	Beijing	November 9, 2010	5
	Revised Progress of the FCB operation in Shanghai	Shanghai	May 27, 2011	12

8.0 Annex B - List of Persons and Their Affiliations

No.	Name	Unit	Function
1.	Marcial T. Ocampo	Energy Technology Selection & Business Development Consultant	International evaluator
2.	Tian Guangyu	Tsinghua University	National evaluator
3.	Carsten Germer	UNDP	Team Leader
4.	Zhang Weidong	UNDP	Programme Manager
5.	Shuhua Fan	UNDP	Programme Assistant
6.	Wang Ju	National PMO	Project Manager
7.	Yu Dan	National PMO	Project Assistant
8.	Li Jianqiu	Tsinghua University	Beijing FCB
9.	Yu Qing	Science & Technology Commission of Shanghai Municipality	Dept. of Social Development
10.	Liang Dai	Shanghai Science & Technology Information Center	Information Officer
11.	Ma Qiao	Shanghai Public Transport Industrial Association	Secretary
12.	Zhuoping Yu	Tongji University	President Assistant
13.	Yu Jian	Shanghai Clean Energy Research And Industry Promotion Center	Senior Engineer
14.	Yan Zhiguo, Ph.D.	SAIC Motor Corporation Limited	Shanghai FCB
15.	Pan Xiangmin	Tongji University	Shanghai Hydrogen Refueling Station
16.	Liu Shaojun	Shanghai Sunwise Energy Systems Co., Ltd.	Project Manager
17.	Gao Dingyun	Shanghai Sunwise Energy Systems Co., Ltd.	General Manager
18.	Hedy He	Tongji University	Lecturer & Dean's Assistant

9.0 Annex C - List of Documents Reviewed and Status of Sub-Contracts

Annex C1 - List of Documents Reviewed (FTR 2011)

No.	Title
1.	Phase I Final Evaluation Report (2004)
2.	Phase II Mid-Term Evaluation Report (2010)
3.	Phase II Final-Term Review Terms of Reference (2011)
4.	Phase II Project Document (2007)
5.	Revised Logical Framework Analysis (Log Frame)
6.	LFA and Annual Targets
7.	Quarterly Operating Reports (2008, 2009, 2010, 2011)
8.	APR/PIR (30 June 2010, 30 June 2011)
9.	CDR (2007, 2008, 2009, 2010, 2011)
10.	Status Quo and Development Mode Research of China's Fuel Cell Vehicle Industry.pdf
11.	Research on the Development of Innovation System of Fuel Cell Automobile Industry in China.pdf
12.	Fiscal and Taxation Policy in Promoting the Development of Fuel Cell Vehicle Industry in China.pdf
13.	A Study on Roadmap for Development of Fuel Cell Buses in China.pdf
14.	Vehicle Optimization and Integration Design Plan of Fuel Cell Bus for China City Demonstration.pdf
15.	Techno-economic analysis of Domestic Hydrogen Fuel Cell Vehicles and Relevant Industrial Chains.pdf
16.	Research on Energy Efficiency and Emission of FCV Vehicle Cycle under Mass Production Situation.pdf
17.	Life-cycle Energy Efficiency Analysis and Technology Industry Chain Research for the Fuel Pathway of Hydrogen Fuel Cell Vehicles (HFCV)
18.	Summary Report on FCB Demonstration Operation Programs in China and Abroad
19.	Analysis Summary Report of Hydrogen Infrastructure Operation
20.	Legal Research on Improvement of Industrialization of Fuel Cell Bus (FCB)
21.	Policy Study on the Development and Application of Fuel Cell Bus (FCB)
22.	China Eco-Transport in City Clusters - Model Development & Pilots
23.	China Urban Transport Concept Nov 12

24.	The World's Largest Economies 2011(Richest People)
25.	BP Statistical Review of World Energy June 2011
26.	List of Countries by 2010 Emissions Estimate (CDIAC, US DOE)
27.	Fuel Cell Technologies - Performance, Status and Cost (US NREL)
28.	List of Fuel Cell Bus Projects in US (US NREL)
29.	List of Worldwide Fuel Cell Bus Projects Completed, On-Going and Planned (US NREL)
30.	China: Eco-Transport in City Clusters: Model Development & Pilots
31.	GEF-World Bank-China Urban Transport Partnership Program (CUTPP)
32.	Analysis Report on the Vehicle Operation of Beijing FCB Demonstration Program
33.	Report on Production, Storage and Transportation of Hydrogen
34.	Analysis of China Fuel Cell Bus Demonstration Operation and Optimized Design Research Report
35.	Hydrogen Energy Infrastructure Policies Tracking and Research Report
36.	Research Report on current Status of Hydrogen Resources and its Utilization
37.	Analysis Report on Technology of Preparation and Application and Storage of Hydrogen & Industrial Development of Hydrogen

Annex C2 - Status of the Different Sub-Contracts as of Dec 2011

No.	Title	Status
1.	001-Status Quo and Development Mode Research of China's Fuel Cell Vehicle Industry	Submitted
2.	002-Research on the Development of Innovation System of Fuel Cell Automobile Industry in China	Submitted
3.	003-Fiscal and Taxation Policy in Promoting the Development of Fuel Cell Vehicle Industry in China	Submitted
4.	004-A Study on Roadmap for Development of Fuel Cell Buses in China	Submitted
5.	005-Vehicle Optimization and Integration Design Plan of Fuel Cell Bus for China City Demonstration	Submitted
6.	006-Techno-economic analysis of Domestic Hydrogen Fuel Cell Vehicles and Relevant Industrial Chains	Submitted
7.	007-Research on Energy Efficiency and Emission of FCV Vehicle Cycle under Mass Production Situation	Submitted
8.	008-Life-cycle Energy Efficiency Analysis and Technology Industry Chain Research for the Fuel Pathway of Hydrogen Fuel Cell Vehicles (HFCV)	Submitted
9.	009-Summary Report on FCB Demonstration Operation Programs in China and Abroad	Submitted
10.	010-Analysis Summary Report of Hydrogen Infrastructure Operation	Submitted
11.	011-Legal Research on Improvement of Industrialization of Fuel Cell Bus (FCB)	Submitted
12.	012-Policy Study on the Development and Application of Fuel Cell Bus (FCB)	Submitted
13.	013-Analysis Report on the Vehicle Operation of Beijing FCB Demonstration Program	Submitted
14.	014-Report on Production, Storage and Transportation of Hydrogen	Submitted
15.	015-Analysis of China Fuel Cell Bus Demonstration Operation and Optimized Design Research Report	Submitted
16.	016-Hydrogen Energy Infrastructure Policies Tracking and Research Report	Submitted
17.	017-Research Report on current Status of Hydrogen Resources and its Utilization	Submitted
18.	018-Analysis Report on Technology of Preparation and Application and Storage of Hydrogen & Industrial Development of Hydrogen	Submitted

10.0 Annex D - Modifications in the Implementing Plans

Components/Outcomes	**Budget, US$**						
	Budget US$	year 1 2007	year 2 2008	year 3 2009	year 4 2010	y5 2011	Project Total
A. Clearer understanding of the operational viability of FCBs and their refueling infrastructure	4,365,000	40,753	28,409	3,005,216	1,143,076	707,722	4,925,176
B. Availability of adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems	796,000	0	5,000	37,742	0	0	42,742
C. Improved awareness and conducive enabling environment for FCB applications and support for the commercialization of FCBs in China	606,000	34,477	18,982	44,053	59,038	111,158	267,708
TOTAL GEF for Components	**5,767,000**	**75,230**	**52,391**	**3,087,011**	**1,202,114**	**818,880**	**5,235,626**
UNDP contribution	196,000	4,000	17,714	1,546	100,000	104,335	227,595
Total GEF and UNDP Contribution	**5,963,000**	**79,230**	**70,105**	**3,088,557**	**1,302,114**	**923,215**	**5,463,221**

11.0 Annex E - Project Budget and Co-Financing

GEF Budget Allocation	**Budget As per ProDoc**		**Actual As of 31 Oct 2010**		**Actual As of Dec 2011**	
	US$	**% of Total**	**US$**	**% of Budget**	**US$**	**% of Budget**
A. To demonstrate the operational viability of FCBs and their refueling infrastructure by setting up FCB fleets and supportive facilities in China	4,365,000	75.69%	4,217,454	96.62%	5,304,841	121.53%
B. To accumulate technical, policy knowledge for advancing commercialization of FCB technology and hydrogen refueling system	796,000	13.80%	42,742	5.37%	146,732	18.43%
C. Promote enabling environment for FCB expansion and support the design of roadmap for commercialization of Fuel Cell buses in China	606,000	10.51%	156,550	25.83%	305,023	50.33%
TOTAL GEF for Components	**5,767,000**	**100.00%**	**4,416,746**	**76.59%**	**5,756,596**	**99.82%**
UNDP contribution	196,000		123,260	62.89%	193,303	98.62%
Total GEF and UNDP Contribution	**5,963,000**		**4,540,006**	76.14%	**5,949,899**	99.78%
CICETE Commission	161,000					
Project Management Cost*	951,000					
***Project Management Cost**						
Local recruited personnel	280,000					
International consultants	190,000					
Office equipment, communication	30,000					
Travel	35,000					
Miscellaneous	351,000					
Total Project Management Cost	**886,000**					
***Technical Assistance Components**						
Local recruited personnel	40,000					
International consultants	25,000					
Total Technical Assistance Components	**65,000**					
Total Project Management Cost	**951,000**					

Co-Financing Inputs	**Budget As per ProDoc**		**Actual As of 31 Oct 2010**		**Actual As of Dec 2011**	
	US$	**% of Total**	**US$**	**% of Budget**	**US$**	**% of Budget**
A. To demonstrate the operational viability of FCBs and their refueling infrastructure by setting up FCB fleets and supportive facilities in China	9,934,000	86.84%	8,312,000	83.67%		
B. To accumulate technical, policy knowledge for advancing commercialization of FCB technology and hydrogen refueling system	876,000	7.66%	648,000	73.97%		
C. Promote enabling environment for FCB expansion and support the design of roadmap for commercialization of Fuel Cell buses in China	629,000	5.50%	549,000	87.28%		
TOTAL GEF	**11,439,000**	100.00%	**9,509,000**	**83.13%**		
Detailed Co-Financing	**Confirmed As per ProDoc**		**Actual As of 31 Oct 2010**		**Actual As of 31 Oct 2010**	
	US$	**% of Total**	**US$**	**% of Budget**		
MoST	3,519,000	18.89%	3,167,100	90.00%		
Beijing	3,536,000	18.99%	3,536,000	100.00%		
Shanghai	4,384,000	23.54%	2,805,760	64.00%		
Private Sector	1,223,000	6.57%	1,223,000	100.00%		
Sub-total Co-Financing	**12,662,000**	**67.98%**	**10,731,860**	**84.76%**	**12,662,000**	**100.0%**
GEF/UNDP Contribution	5,963,000	32.02%	5,779,392	96.92%		
Total Cost of Phase II	**18,625,000**	**100.00%**	**16,511,252**	**88.65%**		

GoC	11,439,000	61.42%	9,508,860	83.13%		
Private Sector	1,223,000	6.57%	1,223,000	100.00%		
GEF	5,767,000	30.96%	4,416,746	76.59%		
UNDP	196,000	1.05%	123,260	62.89%		
Total Cost of Phase II	**18,625,000**	**100.00%**	**15,271,866**	**82.00%**		

12.0 Annex F - Budget Utilization and Financial Performance

GEF Budget Allocation	**Budget US$**	**%**	**Actual Expenditure US$** year 1 2007	year 2 2008	year 3 2009	year 4 2010	year 5 2011	Sub Total	% of Total	**Balance US$** year 6 2012	**Total US$**
A. To demonstrate the operational viability of FCBs and their refueling infrastructure by setting up FCB fleets and supportive facilities in China	4,365,000	73.2%	39,646	32,004	2,916,012	1,710,142	707,722	5,405,526	123.8%	(1,040,526)	4,365,000
B. To accumulate technical, policy knowledge for advancing commercialization of FCB technology and hydrogen refueling system	796,000	13.3%	0	0	37,742	2,710	0	40,452	5.1%	755,548	796,000
C. Promote enabling environment for FCB expansion and support the design of roadmap for commercialization of Fuel Cell buses in China	606,000	10.2%	34,209	16,582	44,053	11,912	111,158	217,914	36.0%	388,086	606,000
TOTAL GEF for Components	**5,767,000**	**96.7%**	**73,855**	**48,586**	**2,997,807**	**1,724,764**	**818,880**	**5,663,892**	**98.2%**	**103,108**	**5,767,000**
UNDP contribution	196,000	3.3%	1,375	(947)	0	(1,680)	104,335	103,083	52.6%	92,917	196,000
UN Agencies			0	0	0	0		0			
Encumbrance			0	0	0	15		15			
Total GEF and UNDP Contribution	**5,963,000**	**100.0%**	**75,230**	**47,639**	**2,997,807**	**1,723,099**	**923,215**	**5,766,991**	**96.7%**	**196,024**	**5,963,000**
D. Project Management	951,000		0	4,752	89,203	0	0	93,955	9.9%	857,045	951,000

13.0 Annex G - GEF Budget Allocation and Co-Financed Inputs

GEF Budget Allocation	**Budget US$**	**%**	**Actual Expenditure US$** year 1 2007	year 2 2008	year 3 2009	year 4 2010	Sub Total	% of Total	**Balance US$** year 6 2012	**Total US$**
A. To demonstrate the operational viability of FCBs and their refueling infrastructure by setting up FCB fleets and supportive facilities in China	9,934,000	86.8%	2,901,800	2,409,900	1,808,840	1,191,460	8,312,000	83.7%	1,622,000	9,934,000
B. To accumulate technical, policy knowledge for advancing commercialization of FCB technology and hydrogen refueling system	876,000	7.7%	0	150,000	278,700	219,300	648,000	74.0%	228,000	876,000
C. Promote enabling environment for FCB expansion and support the design of roadmap for commercialization of Fuel Cell buses in China	629,000	5.5%	0	0	233,200	315,800	549,000	87.3%	80,000	629,000
TOTAL	**11,439,000**	**100.0%**	**2,901,800**	**2,559,900**	**2,320,600**	**1,726,560**	**9,508,860**	**83.1%**	**1,930,140**	**11,439,000**
Co-Financing Inputs	**Budget US$**	**%**	**Actual Expenditure US$** year 1 2007	year 2 2008	year 3 2009	year 4 2010	Sub Total	% of Total	**Balance US$** year 6 2012	**Total**
MoST	3,519,000	18.9%	2,767,100	299,400	100,600	0	3,167,100	90.0%	351,900	3,519,000
Beijing	3,536,000	19.0%	90,500	2,245,500	1,200,000	0	3,536,000	100.0%	0	3,536,000
Shanghai	4,384,000	23.5%	44,200	15,000	1,020,000	1,726,560	2,805,760	64.0%	1,578,240	4,384,000
Sub-total Government of China	**11,439,000**	61.4%	**2,901,800**	**2,559,900**	**2,320,600**	**1,726,560**	**9,508,860**	**83.1%**	**1,930,140**	**11,439,000**
Private Sector	1,223,000	6.6%	14,500	436,700	728,110	43,690	1,223,000	100.0%	0	1,223,000
Sub-total Co-Financing	**12,662,000**	68.0%	**2,916,300**	**2,996,600**	**3,048,710**	**1,770,250**	**10,731,860**	**84.8%**	**1,930,140**	**12,662,000**
GEF/UNDP Contribution	5,963,000	32.0%	79,230	70,105	3,088,557	2,541,500	5,779,392	96.9%	183,608	5,963,000
Total Cost of Phase II	**18,625,000**	100.0%	**2,995,530**	**3,066,705**	**6,137,267**	**4,311,750**	**16,511,252**	**88.7%**	**2,113,748**	**18,625,000**

14.0 Annex H - Progress in Achieving Project Impacts

Beijing (2010)						
Emission	**Diesel Bus**	**Units**	**L / 100 km**	**FC Bus**	**bus-km**	**tons**
C	0.77	kg C / L	26	0	60,198	12.1
CO	5.80	g / km		0		0.35
NOX	8.40	g / km		0		0.51
THC	1.79	g / km		0		0.11
					C	CO2
H2 produced from Natural Gas (CH4):					12	44
Carbon emission from diesel			**12.1**	tons C	**44.2**	tons CO2
Diesel fuel consumption			26	L / 100 km		
Assume half of energy use per km			50%			
Natural gas energy			14	kg C / GJ CH4		
Energy ratio			1.25	GJ CH4 / GJ H2		
Diesel energy			0.039	GJ / L		
Bus kilometers			60,198	bus-km		
Carbon emission from natural gas			**5.3**	tons C	**19.6**	tons CO2
Net Savings of C Emission of project			**6.7**	tons C	**24.6**	tons CO2
	Beijing				81 tons CO2	
	2.69	41	100	75,460	83,225	83.2
	2.69	40	100	75,460	81,195	81.2

Shanghai (2010)						
Emission	**Diesel Bus**	**Units**	**L / 100 km**	**FC Bus**	**bus-km**	**tons**
C	0.77	kg C / L	26	0	7,750	1.6
CO	5.80	g / km		0		0.04
NOX	8.40	g / km		0		0.07
THC	1.79	g / km		0		0.01
					C	CO2
H2 produced from Natural Gas (CH4):					12	44
Carbon emission from diesel			**1.6**	tons C	**5.7**	tons CO2
Diesel fuel consumption			26	L / 100 km		
Assume half of energy use per km			50%			
Natural gas energy			14	kg C / GJ CH4		
Energy ratio			1.25	GJ CH4 / GJ H2		
Diesel energy			0.039	GJ / L		
Bus kilometers			7,750	bus-km		
Carbon emission from natural gas			**0.7**	tons C	**2.5**	tons CO2
Net Savings of C Emission of project			**0.9**	tons C	**3.2**	tons CO2
	Shanghai				28 tons CO2	
	2.69	41	100	26,261	28,963	29.0
	2.69	40	100	26,261	28,257	28.3

CO2 Emission Reduction for Shanghai (as of Dec 13, 2011)

FCB No.	Kilometers run	H2 consumption	kg/100kms	CO2 emission reduction(kg)	Passengers
1#	31,735	2,861.03	11.04	34,147	
2#	31,188	2,936.42	11.05	33,558	
3#	30,790	3,024.15	11.06	33,130	
4#	29,932	3,241.35	12.14	32,207	
5#	30,546	3,117.75	12.15	32,867	
6#	29,367	3,214.65	12.14	31,599	
Total	183,558	18,395.34	11.60	197,508	106,040
By end Dec 2011	200,000	23,192.22	11.60	215,200	

CO2 emission reduction = 2.69 x 40/100 x km run
(H2 consumption for travel and maintenance)

CO2 Emission Reduction for Beijing (Aug 1, 2008 - Jul 31, 2009)

FCB No.	Kilometers run	H2 consumption	kg/100kms	CO2 emission reduction(kg)
1#	28,741	1,989.01	9.30	30,925
2#	25,467	1,918.50	9.56	27,402
3#	21,252	1,845.49	9.20	22,867
Total	75,460	5,753.00	9.35	81,195

CO2 emission reduction = 2.69 x 40/100 x km run
(H2 consumption for travel and maintenance)

15.0 Annex I - Actual Achievements as of Dec 13, 2011 (Revised Log Frame)

Strategy	Indicators	Baseline	Achieved by Dec 2011 (year 4)	Target	Sources of Verification	Assumptions
GOAL: Reduction of GHG emissions and air pollution in urban areas of China.	Annual CO_2 emissions reduction in the transport sector in Beijing & Shanghai during project		Beijing = 65,460 km = 81 tons CO2; Shanghai = 183,558 km = 198 tons CO2; total CO2 = 279	198 tons of CO_2 or 54 tons C for 6 buses over two years	FCB trip logs FCB performance monitoring reports FCB H2 consumption records ways of hydrogen production	FCBs are in operation as planned FCB ridership is high, i.e., bus commuters use FCB trip logs and performance monitoring regularly done. CO2 emission of the Diesel is 2.69 kgCO2/liter*41liter/100km =110kg/100km The total mileage of 6 buses over 2 years
	CO2 emissions reduction in the Chinese transport sector five years after the end-of-project (EOP)			198 tons of CO_2 or 54 tons C		H2 sales data are available and can be shared to the project stakeholders International funding will be available FC and FCB technology will be greatly improved and their costs are reduced
Objective: Demonstration of the operational viability of FCBs and their refueling infrastructure under Chinese conditions	Number of FCBs in commercial operation in Beijing and Shanghai (B&S) during the project	3 in Beijing (Phase 1)	6 in Shanghai 3 in Beijing	6 in Shanghai; 3 in Beijing funded by in-kind finance (national 863 projects)	FCB trip logs FCB performance monitoring reports	Shanghai FCBs are delivered on time
	Number of additional FCBs in commercial operation in China by EOP	0	0	12	Documentation of purchase of new FCBs H2 sales in areas where FCBs are operating	Local manufacturing of FCBs (except maybe for the FC stacks) becomes commercially viable

	Number of H2 refueling stations installed and in operation during the project	1 in Beijing (Phase 1)	2 in Shanghai	1 in Shanghai	Documentation of the design and installation of new H2 refilling stations Business permit of each H2 refilling station	
	Number of additional H2 refueling stations installed and in operation at EOP	0	1	1	Documentation of the design and installation of new H2 refilling stations	International funding will be available for the purchase of news FCBs
Outcome A: Clearer understanding of the operational viability of FCBs and their refueling infrastructure	Completed FCB and H2 refilling station operational guidelines	1	1 set of guidelines for Beijing; 1 set of guidelines for Shanghai	1 set of guidelines for Shanghai	Documentation of the guidelines for the demonstration of all aspects of FCB and H2 refilling station operations	Guidelines is based on internationally accepted FCB and H2 handling design and operational procedures
	Number of demo FCBs that are operational by EOP	3 in Beijing (Phase 1)	6 FCBs procured in Shanghai 3 FCBs in Beijing funded by in-kind finance (national 863 projects)	6 in Shanghai 3 in Beijing	Documentation of purchase of new FCBs	
	Number of trained and practicing FCB drivers in B&S by EOP	3 in Beijing (Phase 1)	Beijing: 3 drivers Shanghai: 18 drivers	In Shanghai: 3 drivers for each FCB, target 18 drivers	Documentation of FCB drivers training and certification program Documentation of certified FCB drivers training by the bus company	Drivers are interested to learn and committed to apply learned skills

	Cumulative number of trained and practicing FCB mechanics trained in B&S by EOP	1 in Beijing	Beijing: 1 mechanic Shanghai: 16 mechanics	7	Documentation of FCB mechanics training and certification program Documentation of certified FCB mechanics trained by the bus company	Mechanics are interested to learn and committed to use learned skills
	Number of demo H2 refilling stations installed and operational by EOP	1 in Beijing (Phase 1)	1 in Beijing 2 in Shanghai	1 in Shanghai	Documentation of the design and installation of new H2 refilling stations Business permit of each H2 refilling station	Demo H2 refilling stations operate regularly as planned. Adequate supply of H2
	Number of operators H2 refilling station operators in B&S by EOP	3	Beijing: 3 operators Shanghai: 17 operators for a total of 20 operators	17	Documentation of H2 refilling station operators training and certification program Documentation of certified H2 refilling station operators trained by the station owner	Operators are interested to learn and committed to use learned skills
	Number of trained and practicing: * FCB drivers * FCB mechanics * H2 refilling station operators in China five years after EOP	3 drivers 3 mechanics 3 operators	3 in Beijing; 18 in Shanghai	18 drivers 6 mechanics 16 operators	List of certified FCB drivers and mechanics employed by FCB bus operators List of certified FCB mechanics companies List of certified operators employed by H2 refilling stations	International funding will be available for the purchase of new FCBs. The demonstration training classes are well held
	Frequency of receipt of acceptable demo FCB performance reports		Quarterly reports submitted	quarterly	Demo FCB reports received	Host FCB and H2 refilling station operators regularly comply with submission of performance reports

	Average annual passengers of a FCB in B&S		Beijing: 75,460 km and 39,995 passengers; 15,262 km test runs Shanghai: 183,558 km and 106,040 passengers, to reach 200,000 km by end Dec 2011	80,000 passengers in Shanghai38,000 passengers in Beijing	FCB trip logsFCB performance monitoring reports	FCBs are in operation as plannedFCB trip logs and performance monitoring regularly done.The minimum kms travelled by 6 buses are 200,000 over two years
	Average annual energy consumption of a FCB in B&S	20 kg/100Km	Beijing: 9.56 kg/100km Shanghai: 11.60 kg/100km	12 kg/100km	FCB trip logs FCB performance monitoring reports FCB H2 consumption records	FCB trip logs and performance monitoring regularly done. H2 sales data are easily available
	Annual volume of supply of H2 to H2 refilling stations (tons) in B&S	15,813 kg in Beijing	Beijing: 5,753 kg (Aug 2008-Jul 2009) Shanghai: 18,395 kg (Dec 13, 2011) to reach 23,192 kg by end Dec 2011	21,600 kg in Shanghai 5,000 kg in Beijing	H2 supply data from H2 refilling stations and H2 suppliers	H2 supply data are available and can be shared to the project stakeholders
	Overall annual revenues from the commercial operations of FCBs in B&S	20,000 RMB		80,000 RMB	Operating cost, sales and revenue data from the bus company	Operating cost, sales and revenue data are available and can be shared to the project stakeholders
	Overall level of satisfaction of FCB service in B&S	85%		90%	Ridership survey and market survey of FCB operators	Public participation in the ridership survey is high
	Overall level of comfort and safety of FCB operation in B&S	50%		80%	Ridership survey and market survey of FCB operators	Public participation in the ridership survey is high

	Overall level of satisfaction of H2 refilling station service in B&S	90%		95%	Market survey of FCB operators and H2 refilling station owners	FCB and H2 refilling station operators fully participate in the survey
	Overall level of safety of H2 refilling station operation in B&S	100%		100%	Market survey of FCB operators and H2 refilling station owners	FCB and H2 refilling station operators fully participate in the survey
	Number of new FCBs deployed by transport companies in other Chinese cities five years after EOP	0		12	Documentation of purchase of new FCBs H2 sales in areas where FCBs are operating	Local manufacturing of FCBs (except maybe for the FC stacks) becomes commercially viable. International funding will be available.
	Number of new H2 refilling stations established in Chinese cities five years after EOP	0		1	Documentation of the design and installation of new H2 refilling stations Business permit of each H2 refilling station	International funding will be available for the purchase of news FCBs and local government funding for the hydrogen refilling station.
Outcome B: Availability of adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems	Number of "FCB value chain" research reports prepared and submitted to MoST by Year 4	0	Study completed as of Nov 2011	3	Documentation of the research reports	
	Established FCB Certification program by Year 3	0	FCB certification program established	1	Documentation of the established FCB certification procedure	FCB and H2 refilling station operators will participate in this program
	Number of proposed implementing rules and regulations on FCB certification by Year 4	0	Implementing rules and regulations on FCB certification established	1	Official documentation of the proposed implementing rules and regulations	

	The total number of technical materials made available for the public on FCB and FCB systems by the end of EOP: * Newsletters * Technical reports * Study trip reports	15 newsletters 5 technical reports 6 study trip reports	15 newsletter issues 7 annual reviews 9 study tour report	12 newsletters 6 technical reports 8 study trip reports	Copies of published newsletters, technical reports and study trip reports Record of volume of these technical materials that were disseminated or downloaded if available on internet	
	Overall level of satisfaction and/or acceptance by the public and project stakeholders of the technical materials by the end of EOP			90%	Customer surveys	High survey response rate
	Completed "Well-to-Wheel" Analysis of the FCB system in B&S and FCB fuel supply options		Study completed as of Dec 2011	Completed report by Year 3	Study report	
	Completed study on the improvement of local FCB design		Study completed as of Dec 2011	Completed report by Year 4	Study report	Government authorities endorse and local manufacturers adopt the local FCB designs
Outcome C: Improved awareness and conducive enabling environment for	Number of policy studies on the development and promotion of FCB applications carried out by EOP	0	Completed report as of Dec 2011	1	Documentation of the policy studies conducted	

FCB applications and support for the commercialization of FCBs in China	Number of policies and regulations proposed in cities supporting the utilization of FCBs for urban transport by EOP	0	Completed report as of Dec 2011	1	Documentation of proposed policies supporting FCB applications in urban transport	
	Number of policies and regulations proposed in cities supporting the implementation of "FCB value chain" projects in cities by EOP	0	Completed report as of Dec 2011	1	Official documentation of enforced policies supporting "FCB value chain" projects in cities.	Policy enforcement is strict and adequate.
	Number of completed techno-economic feasibility studies of FCB and "FCB value chain" applications in other Chinese cities by EOP	0	Completed report as of Dec 2011	1	Documentation of the techno-economic feasibility studies prepared for interested Chinese cities	City governments are interested in, and supportive of FCBs and "FCB value chain" initiatives
	Number of cities interested in implementing FCB and "FCB value chain" projects by EOP	2		at least 3	Documentation of proposed "FCB value chain" projects endorsed by city governments	City governments are interested in, and supportive of FCBs and "FCB value chain" initiatives
	Level of satisfaction of stakeholders about the FCB information exchange system service			90-95%	Customer surveys	High survey response rate
	Established project website by Year 2	1	1 keep updating	1 keep updating	Official website	Website will be maintained even after EOP

	Level of satisfaction of stakeholders about the FCB website service			90-95%	Customer surveys	Part of the website
	Number of promotional campaigns: * Exhibitions/ road shows * Conferences * Workshops * Seminars on FCBs implemented annually starting Year 2	1 exhibition1 and/or road show 1 conference 4 workshops 5 seminars	10 exhibitions and/or road shows 3 conferences 6 workshops 15 seminars	10 exhibitions and/or road shows 2 conferences 6 workshops 15 seminars	Documentation of the proceedings of each exhibition/road show, conference, workshop and seminar conducted	There is expressed and wide interest in the city governments and in the transport industry on FCBs and "FCB value chain" activities
	FCB Roadmap completed and approved by Year 4		in progress	Completed report by Year 4	Documentation of the FCB roadmap	Roadmap document adequately presented and disseminated
	Number of cities that are interested in deploying FCBs in their transport sector five years after EOP	2		at least 3	Special survey of cities on sustainable urban transport systems Documentation of proposed FCB projects of cities	There is expressed and wide interest among the city governments on FCBs and "FCB value chain" activities
	Number of approved "FCB value chain" businesses in China five years after EOP			3	Documentation of proposed private sector "FCB value chain" projects	There is expressed and wide interest among the city governments on FCBs and "FCB value chain" activities
	Completed FCB III project strategy and proposal		in progress (long process)	Completed report by Year 4	Completed project information form (PIF) for FCB III project	GEF 5

16.0 ANNEX J - Annual Targets (Revised Log Frame)

			2007	2008	2009	2010	2011
Strategy	**Indicators**	**Year 0**	**Year 1**	**Year 2**	**Year 3**	**Year 4**	**EOP Target**
GOAL: Reduction of GHG emissions and air pollution in urban areas of China.	Annual CO_2 emissions reduction in the transport sector in Beijing & Shanghai during project				79 tons of CO_2 or 21.6 tons C	119 tons of CO_2 or 32.4 tons C	198 tons of CO2 or 54 tons C for 6 buses over two years
	CO2 emissions reduction in the Chinese transport sector five years after the end-of-project (EOP)				79 tons of CO_2 or 21.6 tons C	119 tons of CO_2 or 32.4 tons C	198 tons of CO2 or 54 tons C
Objective: Demonstration of the operational viability of FCBs and their refueling infrastructure under Chinese conditions	Number of FCBs in commercial operation in Beijing and Shanghai (B&S) during the project		3		6	6 in Shanghai; 3 in Beijing	6 in Shanghai; 3 in Beijing funded by in-kind finance (national 863 projects)
	Number of additional FCBs in commercial operation in China by EOP					12	12
	Number of H2 refueling stations installed and in operation during the project	1 in Shanghai				1 in Shanghai	1 in Shanghai
	Number of additional H2 refueling stations installed and in operation at EOP	0				1	1

Outcome A: Clearer understanding of the operational viability of FCBs and their refueling infrastructure	Completed FCB and H2 refilling station operational guidelines			1			1 set of guidelines for Shanghai	1 set of guidelines for Shanghai
	Number of demo FCBs that are operational by EOP		3		6		6 in Shanghai 3 in Beijing	6 in Shanghai 3 in Beijing
	Number of trained and practicing FCB drivers in B&S by EOP		3				In Shanghai: 3 drivers for each FCB, target 18 drivers	In Shanghai: 3 drivers for each FCB, target 18 drivers
	Cumulative number of trained and practicing FCB mechanics trained in B&S by EOP		1		6		7	7
	Number of demo H2 refilling stations installed and operational by EOP	1					1 in Shanghai	1 in Shanghai
	Number of operators H2 refilling station operators in B&S by EOP	3					16	17
	Number of trained and practicing: * FCB drivers * FCB mechanics * H2 refilling station operators in China five years after EOP	3 drivers 3 mechanics 3 operators					18 drivers 6 mechanics 16 operators	18 drivers 6 mechanics 16 operators

	Frequency of receipt of acceptable demo FCB performance reports		quarterly		quarterly	quarterly	quarterly
	Average annual passengers of a FCB in B&S			38,000 passengers in Beijing	32,000 passengers in Shanghai	48,000 passengers in Shanghai	80,000 passengers in Shanghai 38,000 passengers in Beijing
	Average annual energy consumption of a FCB in B&S	20 kg/100 km			12 kg/100km	12 kg/100km	12 kg/100km
	Annual volume of supply of H2 to H2 refilling stations (tons) in B&S			5,000 kg in Beijing		21,600 kg in Shanghai	21,600 kg in Shanghai 5,000 kg in Beijing
	Overall annual revenues from the commercial operations of FCBs in B&S	20000RMB				80,000 RMB	80,000 RMB
	Overall level of satisfaction of FCB service in B&S	85%				90%	90%
	Overall level of comfort and safety of FCB operation in B&S	50%				80%	80%
	Overall level of satisfaction of H2 refilling station service in B&S	90%				95%	95%

	Overall level of safety of H2 refilling station operation in B&S	100%				100%	100%
	Number of new FCBs deployed by transport companies in other Chinese cities five years after EOP	0				12	12
	Number of new H2 refilling stations established in Chinese cities five years after EOP	0				1	1
Outcome B: Availability of adequate technical, policy and market information on the commercialization of FCB technology and hydrogen refueling systems	Number of "FCB value chain" research reports prepared and submitted to MoST by Year 4	0			1	2	3
	Established FCB Certification program by Year 3	0			1		1
	Number of proposed implementing rules and regulations on FCB certification by Year 4	0				1	1

	The total number of technical materials made available for the public on FCB and FCB systems by the end of EOP: * Newsletters * Technical reports * Study trip reports	15 newsletters 5 technical reports 6 study trip reports	2 newsletters 1study tour report	3 newsletters 2 technical reports 1 study trip report	3 newsletters 2 technical reports 1 study trip report	3 newsletters 2 technical reports 1 study trip report	12 newsletters 6 technical reports 8 study trip reports
	Overall level of satisfaction and/or acceptance by the public and project stakeholders of the technical materials by the end of EOP					90%	90%
	Completed "Well-to-Wheel" Analysis of the FCB system in B&S and FCB fuel supply options				1		Completed report by Year 3
	Completed study on the improvement of local FCB design					1	Completed report by Year 4
Outcome C: Improved awareness and conducive enabling environment for FCB applications	Number of policy studies on the development and promotion of FCB applications carried out by EOP	0				1	1

and support for the commercialization of FCBs in China	Number of policies and regulations proposed in cities supporting the utilization of FCBs for urban transport by EOP	0				1	1
	Number of policies and regulations proposed in cities supporting the implementation of "FCB value chain" projects in cities by EOP	0				1	1
	Number of completed techno-economic feasibility studies of FCB and "FCB value chain" applications in other Chinese cities by EOP	0				1	1
	Number of cities interested in implementing FCB and "FCB value chain" projects by EOP	2				3	at least 3
	Level of satisfaction of stakeholders about the FCB information exchange system service					90-95%	90-95%
	Established project website by Year 2	1		Website by year 2		1 keep updating	1 keep updating

	Level of satisfaction of stakeholders about the FCB website service					90-95%	90-95%
	Number of promotional campaigns: * Exhibitions/ road shows * Conferences * Workshops * Seminars on FCBs implemented annually starting Year 2	1 exhibition 1 conference 4 workshops 5 seminars	1 workshop 3 seminars	3 exhibitions 1 workshop 3 seminars	3 exhibitions and/or road shows 1 conference 2 workshops 4 seminars	3 exhibitions and/or road shows 1 workshops 4 seminars	10 exhibitions and/or road shows 2 conferences 6 workshops 15 seminars
	FCB Roadmap completed and approved by Year 4					1	Completed report by Year 4
	Number of cities that are interested in deploying FCBs in their transport sector five years after EOP	2				at least 3	at least 3
	Number of approved "FCB value chain" businesses in China five years after EOP				1	2	3
	Completed FCB III project strategy and proposal					1	Completed report by Year 4

17.0 Annex K - Terms of Reference (ToR)

Terms of Reference for the Final-term Evaluation

UNDP/GEF Project

Demonstration for Fuel-Cell Bus Commercialization in China (Phase II)

1. Introduction:

In response to the global environment challenges linked to the air pollution problems and the public transportation needs in the developing countries, the project on Demonstration for Fuel Cell Bus (FCB) Commercialization (Phase II) was supported by the Global Environment Facility (GEF) and UNDP, and implemented by the Ministry of Science and Technology (MoST). The FCB II Project covers Beijing and Shanghai, two mega-cities, which have different geography, climate, road infrastructures, traffic conditions and severity, as well as social and market conditions. Both mega-cities are facing fast growing needs to upgrade the public transit and to address the critical challenge of air pollution.

The Project Document for the China FCB Project II was approved by GEF in July 2006 and the Project Document was signed in May 2007. The project was launched in November 2007. A Mid-Term Review (MTR) was conducted on 8 – 24 November 2010. The goal of the project is to reduce GHG emissions and air pollution through widespread commercial introduction of FCBs in urban areas of China. The objective of this project is to demonstrate the operational viability of FCBs and their refueling infrastructure under Chinese conditions.

Partnership building between the private sector and the government is crucial for the success of the project inasmuch as the commercialization of FCBs, which are new environmentally-friendly means of transportation in China, will involve the active and serious participation of the private sector. The project involves the development of strategies to build and expand such partnerships. As part of the project, the procurement of the six FCBs from Shanghai Automotive Industry Corporation (SAIC) and the construction of the hydrogen refueling station in partnership with Shell and Chinese partners have resulted from such kind partnership. These partnerships not only enable the business sector to enter this potential market but also lower the cost to be covered by the government to improve the public services of transport and environment.

2. Key findings and recommendations of the MTR.

In summary, the MTR, which was conducted in late 2010, concluded that:

1) The progress towards achievement of results for the FCB Phase II, based on the project work plan, is Satisfactory.
2) Overall, the project design and work plan remain valid and still consistent with the project strategy, objectives and outcomes. In the remaining half of the project, the PMO has to pay greater attention to the changes in the country's national strategies, international developments in fuel cell and hybrid technology leading to higher efficiency and lower cost of FCB and HRS, diesel fuel supply, natural

gas supply, advances in industrial chemical processes particularly those that could be potential sources of hydrogen, biomass and wastes, power generation mix and hydrogen supply from petroleum fuels, natural gas, by-product of chemical processes, water electrolysis. Part of the activities of this FCB Phase II project is the planning and preparation of project proposal for the FCB Phase III (expanded demonstration to other cities after feasibility studies have been prepared) leading to Phase IV (market penetration which will signal full commercialization of hydrogen-powered fuel cell hybrid buses in major cities and the birth of the hydrogen economy in China – a very significant milestone for the entire world).

3) On the progress in the achievement of project impacts, as of 31 October 2010 MTR, the CO2 emission reduction target for a combined 400,000 km (based on ProDoc) travel of the FCBs is 44.6 tons C or 163.5 tons CO2 till EOP while the target up to mid-term review is 79 tons CO2. Actual emission reduction to date, however, is low for Shanghai FCB: 2.69kg/L*40L/100km * 26,261 km = 28,257 kg = 28.2 tons CO2 and for Beijing 2.69kg/L * 40L/100km * (60,198 + 15,262) km = 81,195 kg = 81.2 tons CO2. (See calculation procedure in Annex H - Progress in Achieving Project Impacts). For the Beijing FCBs, there is currently no target for the FCB mileage since it is using the existing FCB buses procured in Phase I. In the case of Shanghai, which purchased 6 FCBs under the Phase II project, there is a target/assumption of 6 buses traveling over 180,000 km in 2 years.
4) Internal project factors such as timing of inputs and activities, quality of products and services, coordination, other management issues were not a hindrance in the implementation during the first half of the project and is expected to be the same during the late half of the project, There were no new major issues and corresponding recommended action plan that were identified during the MTR. However, both the Beijing and Shanghai demo teams need to follow-up their city bus operating permit from the local municipal government units in order to resume the testing and demonstration of the FCBs under actual city bus route operation to augment the limited demo runs during the Beijing Olympics and the Shanghai World Expo events.
5) External project factors such as external funding, availability of FCB hybrid technology, cost of FCB hybrid, availability of international consultants and experts and other factors beyond the projects control were absent and there were likewise no new risks and corresponding mitigation measures that were identified during the MTR. All the risks were anticipated clearly during the project document preparation stage such as purchase cost and operational cost of FCB, hybrid electric batteries, and hydrogen refueling station, local manufacturing capability for FCB bus and hydrogen storage tanks, fuel cell hybrid component reliability and durability were managed effectively by the project team during the first half of the project and are expected to be effectively managed at the late half of the implementation.

3. Description of the Assignment

As part of its project management activities, the China FCB II project is up for final-term review (FTR). The purpose of the FTR is to evaluate the project implementation and management performances. It will determine whether the project is on track to achieve the project objective and therefore just need to be sustained. The project evaluation will also determine and report on the experiences and lessons learnt during the project implementation so as to provide guidance in determining the targets and strategies for the planned next Phase of the China FCB Commercialization Project. In this regard, the findings and recommendations of the evaluation will contribute to identify best possible ways to advance the modern public transportation technology by commercializing FCBs in the cities.

3.1 Scope of the Evaluation

The scope of the FTR covers the entire UNDP/GEF-funded FCB Phase II project and its components as well as the co-financed activities in each component of the project.

The FTR will assess the FCB II Project implementation taking into account the status of the project activities and outputs and the resource disbursements made up to the final evaluation review date.

The evaluation will involve analysis at two levels: component level and project level. On the component level, the following shall be assessed:

- Whether there is effective relationship and communication between/among components so that data, information, lessons learned, best practices and outputs are shared efficiently, including cross-cutting issues;
- Whether the performance measurement indicators and targets used in the project monitoring system are specific, measurable, achievable, reasonable and time-bounded to achieve desired project outcomes; and,
- Whether the use of consultants has been successful in achieving component outputs.

The FTR will include such aspects as appropriateness and relevance of work plan, compliance with the work and financial plan with budget allocation, timeliness of disbursements, procurement, coordination among project team members and committees, and the UNDP country office support. Any issue or factor that has impeded or accelerated the implementation of the project or any of its components, including actions taken and resolutions made should be highlighted.

At the project level, the FTR will assess the project performance in terms of: (a.) Progress towards achievement of results, (b.) Factors affecting successful implementation and achievement of results, (c.) Project Management framework, and (d.) Strategic partnerships.

(a) Progress towards achievement of results (internal and within project's control)

- Is the Project making satisfactory progress in achieving project outputs vis-à-vis the targets and related delivery of inputs and activities?
- Are the direct partners and project consultants able to provide necessary inputs or achieve results?
- Given the level of achievement of outputs and related inputs and activities to date, is the Project likely to achieve its purpose/objective and contribute to the realization of its goal?

(b) Factors affecting successful implementation and achievement of results (beyond the Project's immediate control or project-design factors that influence outcomes and results)

- Is the project implementation and achievement of results proceeding well and according to plan, or are there any outstanding issues, obstacles, bottlenecks, etc. on the consumer (riding public), government (national and local) or private sector (e.g., bus companies, FCB manufacturers) or the public transport sector as a whole that are affecting the successful implementation and achievement of project results?
- To what extent does the broader policy environment remain conducive to achieving expected project results, including existing and planned legislations, rules, regulations, policy guidelines and government priorities?

- Is the project logical framework and design still relevant in the light of the project experience to date?
- To what extent do critical assumptions/risks in project design make true under present circumstances and on which the project success still hold? Has the project team validated these assumptions as presently viewed by the project management and determine whether there are new assumptions/risks that should be raised?
- Is the project well-placed and integrated within the national government development strategies, such as community development, poverty reduction, etc., and related global development programs to which the project implementation should align?
- Are the Project's institutional and implementation arrangements still relevant and helpful in the achievement of the Project's objective and outcomes, or are there any institutional concerns that hinder the Project's implementation and progress.

(c) Project management (adaptive management framework)

- Are the project management arrangements adequate and appropriate?
- How effectively is the project managed at all levels? Is it results-based and innovative?
- Do the project management systems, including progress reporting, administrative and financial systems and monitoring and evaluation system, operate as effective management tools, aid in effective implementation and provide sufficient basis for evaluating performance and decision making?
- Is technical assistance and support from project partners and stakeholders appropriate, adequate and timely?
- Validate whether the risks originally identified in the project document and, currently in the APR/PIRs, are the most critical and the assessments and risk ratings placed are reasonable.
- Describe additional risks identified during the evaluation, if any, and suggest risk ratings and possible risk management strategies to be adopted.
- Assess the use of the project logical framework and work plans as management tools and in meeting with UNDP-GEF requirements in planning and reporting.
- Assess the use of electronic information and communication technologies in the implementation and management of the project.
- On the financial management side, assess the cost effectiveness of the interventions and note any irregularities.
- How have the APR/PIR process helped in monitoring and evaluating the project implementation and achievement of results?

(d) Strategic partnerships (project positioning and leveraging)

- Are the project partners and their other similar engagements in the FCB II project, strategically and optimally positioned and effectively leveraged to achieve maximum effect of the sustainable transport and Energy Efficiency program objectives for the country?
- How do the project partners, stakeholders and co-financing institutions involved in the Project's adaptive management framework?

- Are there further opportunities for stronger collaboration and substantive partnerships identified to enhance the project's achievement of results and outcomes?
- Are the project information and progress of activities disseminated to project partners and stakeholders? Are there areas to improve in the collaboration and partnership mechanisms?

3.2 Specific Tasks for the Evaluation

Through the review of pertinent documents related to the project such as project document, quarterly and annual progress reports, other activity/component specific deliverables, reports and evaluation, if there are any, etc; conduct of structured interview with knowledgeable parties (e.g., PMO, GOC personnel, Beijing & Shanghai government officials, Sub-Contracting Parties/Entities, National Consultants, UNDP Country Office Counterparts, members of the Project Steering/Advisory Committee/s, Project Beneficiaries or grantees, etc.); and visits to various pilot project sites the evaluation mission will carry out the following tasks:

1) Review of the project design, and planning to find out whether: (a) the project approaches and strategy are sound; (b) the immediate objectives and outputs are properly stated and verifiable in the project logical framework; (c) the timeframe of the project is feasible and practicable; and, (d) others.

2) Review of project performance: timeliness and quality of inputs; timeliness and cost-effectiveness of activities undertaken; quality and quantity of outputs produced; achievement of outcomes; and a financial review against the project budget.

[Note: Whatever format is deemed appropriate for the presentation of the assessment results in the evaluation report, the evaluation should come up with a summary of information as in the following table.]

Activities		Budget		
Planned	Actual	As per ProDoc	Actual Expenditures	% of Project Budget

3) Review the project impact: determine the extent to which the project objectives are expected to be achieved and what are the short-term and long-term impact of the project, including efficiency of the project, cost-effectiveness of the project;

4) Study the government policies in development of FCBs for the Chinese cities and assess the relevance of the project against the national development priorities and objectives;

5) Analyze the current FCB projects in other countries, and the domestic and international market developments in supply and demand of the technology to find out and advise potentials for possible project expansion;

6) Analyze and report on the good practices and lessons learnt in partnership building of the project with companies and agencies in introducing the FCBs and designing and building the refuelling station in expanded demonstration cities in China

7) Provide recommendations on the improvement or sustenance of the implementation; potential aspects of FCB commercialization that can be covered in a planned Phase III of the project; and actions to be taken to support the sustainable development of FC vehicle technologies and applications in China.

8) Revisit the MTR Report to see if the key recommendations have been put into practice in the process of project implementation.

4. Qualifications

The FTR assignment requires an evaluation team that will consist of: one international expert and one national expert. Both experts should have basic knowledge of fuel cell technology development globally and practical experience in public-private partnership building for advancing the new technologies from the research to the market.

The experts should hold an advanced degree in studies related to the subject, and have at least 10 years of working experience in the area of energy and EE technologies (preferably in transport). The international expert will act as the team leader and the national expert will support in the gathering and provision of inputs on the national context in development of the technology, the public transport systems and the local FC vehicle development and production. The final evaluation report should be finalized by the evaluation team.

It is desired that the international and national consultants have as many as possible the following qualifications:

1) Project development, implementation and evaluation experience;
2) Professional experience with clean energy vehicle R&D or management
3) Knowledgeable about the relevant policies of the GEF;
4) Good communications and writing skills in English;
5) Knowledge of GEF projects and project requirements;
6) Good experiences in working in China and with Chinese counterparts.

5. Roles and Responsibilities

The UNDP-GEF Regional Technical Advisor (based in Bangkok, Thailand) who oversees the UNDP-GEF FCB II project will assist the UNDP CO and the FTR team in preparing for the Final-term Review of the project. The FTR Team reports to the UNDP CO and MoST. The project's executing agency (MoST) shall coordinate all relevant national and the international agencies and companies and provide in advance copies of the necessary documents needed by the evaluation expert/s. Likewise, the MoST shall arrange and finalize the itinerary/schedule for the FTR in consultation with all parties concerned. The project's Chief Technical Advisor (CTA) will provide insights of the global FCB market to the FTR Team and discuss with them in detail the technology selection for future FCB development. The EA and UNDP CO will coordinate the logistical arrangements for the evaluation.

6. Support to the Evaluation Team

UNDP will provide policy guidance to the FTR Team, and the PMO will arrange necessary briefings, background materials, meetings, travel and other logistical support.

The following documents and reports shall be provided to the FTR Team to assist them in the conduct of the final-term evaluation:

FCB Commercialization (Phase II) Project document (UNDP)
Evaluation Guideline (UNDP)
Project Implementation Report (UNDP)
Comprehensive reports including subcontracts, newsletters etc. (PMO)

7. FTR Schedule

The FTR is scheduled to be conducted in early December 2011, for a period of 5 working days in China and 11 home base working days. A preliminary schedule for the FTR assignment in China is proposed as follows and shall be finalized by the PMO in consultation with respective agencies.

Tentative Schedule in China

Day	Activity	Lead Agency
1	Briefing at UNDP office and meetings with the project management office and CICETE,	UNDP PMO
2-3	Visit to Shanghai to meet the Shanghai PMO and Shanghai Automotive Industry Corporation and hydrogen refilling station operation people	FTR Team
4	Drafting of the evaluation report	FTR Team
5	Debriefing to share recommendations and findings of the evaluation	FTR Team

8. Outputs

The FTR Team is expected to deliver the following outputs:

1) An evaluation report presenting the final-term evaluation results of the project and recommendations for the next step implementation strategy. The report should be submitted to UNDP CO and MoST before departure from Beijing. The documents should be submitted in electronic format.

2) Presentation of findings to UNDP CO and project key stakeholders in a wrap-up meeting in UNDP CO.

The findings of the evaluation will be used by Ministry of Finance as the GEF Operational Focal Point in China, MoST as the implementing partner and UNDP to better adjust project strategy and approaches to guide the project implementation in a FCB-III.

9. Payment Schedule

The terms of payment for the services rendered by the consultants (evaluators) are in conformity to the UNDP standards.

30% of the total amount due the consultant will be paid upon signature of the contract for mobilization. 70% of the total amount will be paid upon receiving a final draft of the Final Evaluation Report and acceptance by UNDP of the evaluation report in its final form.

10. Start of the Assignment

The FTR is planned to be conducted starting from the first week of December.

11. Documents to be provided to the Consultants:

- China FCB Commercialization (Phase II) Project document;
- Project implementation reports (PIRs);
- Mid-Term Evaluation report
- Comprehensive report of subcontracts; and
- Other related documents

18.0 Annex L - Fuel Cell Technologies - Performance, Status and Cost (Wikipedia)

Fuel cell name	Electrolyte	Qualified power (W)	Working temperature (°C)	Efficiency (cell)	Efficiency (system)	Status	Cost (USD/W)
Metal hydride fuel cell	Aqueous alkaline solution		> -20 (50% P_{peak} @ 0°C)			Commercial / Research	
Electro-galvanic fuel cell	Aqueous alkaline solution		< 40			Commercial / Research	
Direct formic acid fuel cell (DFAFC)	Polymer membrane (ionomer)	< 50 W	< 40			Commercial / Research	
Zinc-air battery	Aqueous alkaline solution		< 40			Mass production	
Microbial fuel cell	Polymer membrane or humic acid		< 40			Research	
Upflow microbial fuel cell (UMFC)			< 40			Research	
Regenerative fuel cell	Polymer membrane (ionomer)		< 50			Commercial / Research	
Direct borohydride fuel cell	Aqueous alkaline solution		70			Commercial	
Alkaline fuel cell	Aqueous alkaline solution	10 – 100 kW	< 80	60–70%	62%	Commercial / Research	
Direct methanol fuel cell	Polymer membrane (ionomer)	100 mW – 1 kW	90–120	20–30%	10–20%	Commercial / Research	125
Reformed methanol fuel cell	Polymer membrane (ionomer)	5 W – 100 kW	250–300 (Reformer) 125–200 (PBI)	50–60%	25–40%	Commercial / Research	

Direct-ethanol fuel cell	Polymer membrane (ionomer)	< 140 mW/cm²	> 25 90–120			Research	
Proton exchange membrane fuel cell	Polymer membrane (ionomer)	100 W – 500 kW	50–120 (Nafion) 125–220 (PBI)	50–70%	30–50%	Commercial / Research	30–35
RFC - Redox	Liquid electrolytes with redox shuttle and polymer membrane (Ionomer)	1 kW – 10 MW				Research	
Phosphoric acid fuel cell	Molten phosphoric acid (H3PO4)	< 10 MW	150-200	55%	40% Co-Gen: 90%	Commercial / Research	4–4.50
Molten carbonate fuel cell	Molten alkaline carbonate	< 100 MW	600-650	55%	47%	Commercial / Research	
Tubular solid oxide fuel cell (TSOFC)	O2--conducting ceramic oxide	< 100 MW	850-1100	60–65%	55–60%	Commercial / Research	
Protonic ceramic fuel cell	H^+-conducting ceramic oxide		700			Research	
Direct carbon fuel cell	Several different		700-850	80%	70%	Commercial / Research	
Planar Solid oxide fuel cell	O2--conducting ceramic oxide	< 100 MW	500-1100	60–65%	55–60%	Commercial / Research	
Enzymatic Biofuel Cells	Any that will not denature the enzyme		< 40			Research	
Magnesium-Air Fuel Cell	salt water		20 - 55	90%		Commercial / Research	

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

FUEL CELL TECHNOLOGIES PROGRAM

Comparison of Fuel Cell Technologies

Fuel Cell Type	Common Electrolyte	Operating Temperature	Typical Stack Size	Efficiency	Applications	Advantages	Disadvantages
Polymer Electrolyte Membrane (PEM)	Perfluoro sulfonic acid	50-100°C 122-212° typically 80°C	< 1kW–100kW	60% transportation 35% stationary	• Backup power • Portable power • Distributed generation • Transporation • Specialty vehicles	• Solid electrolyte reduces corrosion & electrolyte management problems • Low temperature • Quick start-up	• Expensive catalysts • Sensitive to fuel impurities • Low temperature waste heat
Alkaline (AFC)	Aqueous solution of potassium hydroxide soaked in a matrix	90-100°C 194-212°F	10–100 kW	60%	• Military • Space	• Cathode reaction faster in alkaline electrolyte, leads to high performance • Low cost components	• Sensitive to CO_2 in fuel and air • Electrolyte management
Phosphoric Acid (PAFC)	Phosphoric acid soaked in a matrix	150-200°C 302-392°F	400 kW 100 kW module	40%	• Distributed generation	• Higher temperature enables CHP • Increased tolerance to fuel impurities	• Pt catalyst • Long start up time • Low current and power
Molten Carbonate (MCFC)	Solution of lithium, sodium, and/ or potassium carbonates, soaked in a matrix	600-700°C 1112-1292°F	300 kW-3 MW 300 kW module	45-50%	• Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Can use a variety of catalysts • Suitable for CHP	• High temperature corrosion and breakdown of cell components • Long start up time • Low power density
Solid Oxide (SOFC)	Yttria stabilized zirconia	700-1000°C 1202-1832°F	1 kW–2 MW	60%	• Auxiliary power • Electric utility • Distributed generation	• High efficiency • Fuel flexibility • Can use a variety of catalysts • Solid electrolyte • Suitable for CHP & CHHP • Hybrid/GT cycle	• High temperature corrosion and breakdown of cell components • High temperature operation requires long start up time and limits

For More Information

More information on the Fuel Cell Technologies Program is available at *http://www.hydrogenandfuelcells.energy.gov*.

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19.0 Annex M - U.S. Fuel Cell Bus Projects

#	Project	City	State	Total Buses	Active	In Development	Status of Project	Fuel	Bus System Type	Fuel Cell Manufacturer
1	AC Transit ZEBA Demo (in partnership with other Bay Area Transit Agencies), UTC Power, Van Hool	Oakland	CA	12	11	1	Active	Hydrogen	Hybrid	UTC Power
2	City of Burbank FCB Demo (Proterra)	Burbank	CA	1	1		Active	Hydrogen	Battery dominant hybrid	Hydrogenics
3	Compound FC Hybrid Bus for 2010 - BAE, Hydrogenics, Orion (FTA-CALSTART)	San Francisco	CA	1	1		Active	Diesel/ Hydrogen	Diesel hybrid with Fuel Cell APU	Hydrogenics
4	CT Nutmeg FCB Demonstration - UTC Power, Van Hool (FTA-NAVC)	Hartford & New York	CT	4	4		Active	Hydrogen	Hybrid	UTC Power
5	CTTRANSIT FCB Demo (ISE/ UTC Power/Van Hool)	Hartford	CT	1	1		Active	Hydrogen	Hybrid	UTC Power
6	Dual Variable Output FCB - Proterra/Hydrogenics (FTA-CTE) currently in Austin, TX	Columbia, Austin (1 year each)	SC, TX	1	1		Active	Hydrogen	Battery dominant hybrid	Hydrogenics
7	Ft. Lewis Army Base - Proterra/Hydrogenics	Tacoma	WA	1	1		Active	Hydrogen	Battery-dominant, plug-in, hybrid FCB	Hydrogenics
8	HyRide - Greater New Haven Transit District (Ebus, Ballard)	New Haven	CT	1	1		Active	Hydrogen	Plug-in Hybrid	Ballard
9	SunLine Advanced Technology FCB (New Flyer, Ballard, ISE)	Thousand Palms	CA	1	1		Active	Hydrogen	Hybrid	Ballard
10	SunLine FCB Demo (ISE/UTC Power/Van Hool)	Thousand Palms	CA	1	1		Active	Hydrogen	Hybrid	UTC Power
11	University of Delaware - Phase 1 (Ebus, 22-foot)	Newark	DE	1	1		Active	Hydrogen	Battery-dominant, plug-in, hybrid FCB	Ballard
12	University of Delaware - Phase 2 (Ebus, 22-foot)	Newark	DE	1	1		Active	Hydrogen	Battery-dominant, plug-in, hybrid FCB	Ballard
13	US Air Force/Enova/Hydrogenics/HTDC	Honolulu	HI	1	1		Active	Hydrogen	Battery-dominant, plug-in, hybrid FCB	Hydrogenics
14	Advanced Composite 35-ft FCB Demo - Proterra/Ballard (NFCBP-CTE)	Columbia, Washington	SC, DC	1		1	Planning	Hydrogen	Hybrid	Ballard

15	American FCB Program - SunLine, BAE, El Dorado, Ballard (FTA-CALSTART)	Thousand Palms	CA	1		1	Planning	Hydrogen	Hybrid	Ballard
16	Birmingham FCB Demo - EVAmerica/Ballard (NFCBP-CTE)	Birmingham	AL	1		1	Planning	Hydrogen	Hybrid	Ballard
17	Chicago Transit Authority FCB Demo - BAE Systems/Ballard/ElDorado (NFCBP-Calstart)	Chicago	IL	1		1	Planning	Hydrogen	Hybrid	Ballard
18	ECO Saver IV Hybrid FCB Demo - DesignLine/Ballard (NFCBP-CTE)	Columbus	OH	1		1	Planning	Hydrogen	Hybrid	Ballard
19	Georgetown University Phase III (CTE, EVAmerica, Nucellsys, EPRI)	Chattanooga, Traverse City	TN, MI	1		1	Planning	Methanol with reformer	Plug-in Hybrid	Ballard
20	Lightweight FC hybrid bus - GE, A123Systems (FTA-NAVC)	Albany	NY	1		1	Planning	Hydrogen	Hybrid	Ballard
21	Massachusetts H2 FC Powered Bus - Nuvera/ Mass. Port Auth. (FTA-NAVC)	Boston	MA	1		1	Planning	Hydrogen	Hybrid	Nuvera
22	University of Delaware - Phase 3 (30-foot)	Newark	DE	1		1	Planning	Hydrogen	Hybrid	Ballard
23	University of Delaware - Phase 4 (30-foot)	Newark	DE	1		1	Planning	Hydrogen	Hybrid	Ballard
24	AC Transit HyRoad (ISE/UTC Power/Van Hool)	Oakland	CA	3			Retired	Hydrogen	Hybrid	UTC Power
25	Santa Clara VTA FCB Demo (Gillig/Ballard)	San Jose	CA	3			Retired	Hydrogen	Non-hybrid	Ballard
26	University of Texas (Ebus)	Austin	TX	1			Retired	Hydrogen	Battery-dominant, plug-in, hybrid FCB	Ballard
			Total	44	26					

20.0 Annex N - Heavy-Duty Fuel Cell and Hydrogen Vehicle Projects (completed)

#	Project	Agency/Organization	City	State	Country	Vehicle Type	Project Start Date	No. in Project	Type	Power (kW)	Manufacturer	Type
1	AutoTram - Fraunhofer Institute for Transportation and Infrastructure Systems		Dresden		Germany	Artic bus	2005	1	PEM		Ballard	FC/Flywheel system
2	Ballard/Newflyer/CTA (P3)	CTA, BC Transit	Chicago, Vancouver	IL, BC	USA, Canada	Bus	Dec-97	6	PEM	205	Ballard	PEM fuel cell
3	CUTE Project /Daimler - Demo continued under HyFLEET:CUTE	Various Transit Agencies	Various		Europe	Bus LF	Mid-2003	27	PEM	205	Ballard	Ballard fuel cell system
4	ECTOS project (Daimler) - Demo continued under HyFLEET:CUTE	Icelandic New Energy	Reykjavik		Iceland	Bus LF	Mid-2003	3	PEM	205	Ballard	Ballard fuel cell system
5	Ford (Canada)	Various	Vancouver (2), & others to be announced		Canada	E450 shuttle	Dec-06	7			none	Ford E-450 chassis, 6.8L Triton V-10 H2ICE
6	Ford (USA)	Various	Orlando (8), Las Vegas (2), San Mateo (1), Missouri S&T (2) & others	FL	USA	E-450 Shuttle Bus	late 2006	20			none	Ford E-450 chassis, 6.8L Triton V-10 H2ICE
7	Georgetown Univ./ DOE/FTA/ (Gen I)	Univ. Fla, Gainesville, Univ. of CA, Davis, Georgetown Univ., Washington, DC			USA	Bus	R&D testing 93	3	PAFC	100	Fugi Electric	Fuel cell/ battery hybrid system
8	Georgetown/Novabus/Ballard (Gen II)				USA	Bus	Dec-01	1	PEM	100	Ballard	Ballard FC w/methanol reformer- hybrid
9	Georgetown/Novabus/UTC Power(Gen II)	Georgetown	Washington	DC	USA	Bus	1998	1	PAFC	100	UTC Power	UTC FC w/methanol reformer - hybrid
10	Gillig/Ballard	Santa Clara VTA	San Jose	CA	USA	Bus	Apr-04	3	PEM	205	Ballard	Ballard Mark 902 PEM FC
11	Hino/Toyota FCHV-BUS1	Toyota			Japan	Bus LF	prototype		PEM	90	Toyota	Toyota FC stack

12	HyFLEET:CUTE (Daimler)	10 cities in Europe, Iceland, China, and Australia				Bus		33	PEM		Ballard	Evobus/Ballard Citaro non-hybrid FCB
13	HyFLEET:CUTE (Daimler)	Hochbahn	Hamburg		Germany	Bus	First went into service in 2003	6	PEM		Ballard	Evobus/Ballard Citaro non-hybrid FCB
14	HyFLEET:CUTE (MAN Lion's City low floor bus)	Berlin Transport Utility (BVG)	Berlin		Germany	Bus	Jul-06	10		200	none	H2ICE with turbo charged, direct injection engine
15	HyFLEET:CUTE (MAN Lion's City low floor bus)	Berlin Transport Utility (BVG)	Berlin		Germany	Bus	Jul-06	4		150	none	H2ICE with naturally aspirated engine
16	Irisbus - CityCell		Turin		Italy	Bus	Nov-04	1	PEM		UTC Power	Hybrid FC system
17	MAN	Berlin, Copenhagen, Lisbon	Berlin, Copenhagen, Lisbon		Germany, Denmark, Portugal	Bus LF	2004		PEM		De Nora	FC hybrid w/ Supercaps
18	MAN/Ballard (H2argemuc)	Munich Airport	Munich		Germany	Bus LF	Mid 2005 - 12/2006	1		65	Ballard	Hybrid FC system
19	MAN/Siemens Bavarian Fuel Cell Bus	VAG Nuremberg	Nuremberg & Erlangen		Germany	Bus LF	10/2000 - 4/2001	1	PEM	120	Siemens	Hybrid FC system (Siemens ELFA drive system)
20	Natural Resources Canada/Hydrogenics/New Flyer	Winnipeg Transit	Winnipeg		Canada	Bus	Fall 2006 demo	1	PEM		Hydrogenics	Hydrogenics FC system integrated by ISE
21	Penn State/Collier Technologies	Centre Area Transportation Authority	State College	PA	USA	Bus	Mid-2007	3				ICE modified to operate on blend of up to 30% hydrogen
22	Sustainable Transport Energy for Perth (STEP) - Demo continued under HyFLEET:CUTE	Perth Central Area Transit	Perth	WA	Australia	Bus	Jul/Aug 2004	3	PEM	205	Ballard	Ballard fuel cell system
23	Tsinghua Univ., Beijing/Beijing Green Power Co.				China	Shuttle			PEM			PEM fuel cell
24	UNDP-GEF China (Citaro) Phase I - Demo continued under HyFLEET:CUTE		Beijing		China	Bus LF	Sep-05	3	PEM	205	Ballard	Evobus/Ballard Citaro (same as CUTE buses)
25	UTC Power/ISE/Van Hool	AC Transit	Oakland	CA	USA	Bus	Oct-05	3	PEM		UTC Power	Hybrid FC system w/ Elfa drive system by Siemens

26	UTC Power/Thor/ISE Research (30-foot)	SunLine, AC Transit	Thousand Palms, Oakland	CA	USA	Bus LF	Aug-02	1	PEM	75	UTC Power	Hybrid FC system w/ Elfa drive system by Siemens
27	Van Hool/UTC Power	De Lijn (and others)	Antwerp		Belgium	Bus LF	Jun-07	1	PEM		UTC Power	Hybrid FC system
28	ISE Research (New Flyer) HHICE bus	SunLine	Thousand Palms	CA	USA	Bus	Dec-05	1			N/A	H2 ICE ELFA hybrid w/Ford Triton V10
29	Hydrogen on the Hill (Industry Canada, NRC, Ford, ATFCAN)	Senate Fleet	Ottawa		Canada	E450 shuttle	Dec-06	3			none	Ford E-450 chassis, 6.8L Triton V-10 H2ICE
							Total	147	29			

21.0 Annex O - Heavy-Duty Fuel Cell and Hydrogen Vehicle Projects (on-going)

#	Project	Agency/Organization	City	State	Country	Vehicle Type	Project Start Date	No. in Project	Type	Power (kW)	Manufacturer	Type
1	AC Transit - Bay Area Advanced FCB Demo	AC Transit and 4 other Bay Area agencies	Oakland, SF Bay area	CA	USA	Bus	May-10	12	PEM	120	UTC Power	Hybrid FC system; Bus and hybrid system by Van Hool
2	Advanced Technology FCB - SunLine, Bluways, Ballard, New Flyer	SunLine	Thousand Palms	CA	USA	Bus	Feb-10	1	PEM	130	Ballard	FC hybrid system - Bluways hybrid w/Ballard FC
3	APTS-Philias FCB	City of Amsterdam GVB	Amsterdam		Netherlands	Artic	2009-2010	2	PEM	150	Ballard	Hybrid FCB, drive system by Vossloh Kiepe
4	BC Transit/New Flyer/Bluways/ Ballard	BC Transit	Whistler	BC	Canada	Bus LF	Dec-09	20	PEM	150	Ballard	FC hybrid system - Bluways hybrid w/Ballard FC
5	Burbank FCB demo -Proterra/Hydrogenics	City of Burbank	Burbank	CA	USA	Bus	May-11	1	PEM	32 total	Hydrogenics	Battery-dominant, plug-in, hybrid FCB
6	CHIC: London (Wrightbus, Bluways, Ballard)	Transport for London/London Bus Services Ltd.	London		England	Bus	Dec-10	8	PEM	75	Ballard	FC hybrid, Wright Group Bus chassis, Bluways hybrid system
7	Citaro FuelCELL Hybrid	Hochbahn	Hamburg		Germany	Bus	2010	10	PEM	150 total	Ballard	FC bus using BlueTec hybrid system
8	Compound FC Hybrid Bus for 2010 - BAE, Hydrogenics (FTA NFCBP-CALSTART)	San Francisco MTA	San Francisco	CA	USA	Bus	2010	1	PEM		Hydrogenics	Diesel hybrid with FC APU
9	Dual Variable Output FCB - Proterra/Hydrogenics (FTA NFCBP-CTE) currently in TX	Univ. SC, Central Midlands RTA/ Univ. TX	Columbia, Austin	SC, TX	USA	Bus	Aug-09	1	PEM	32 each	Hydrogenics	Battery-dominant, plug-in, hybrid FCB
10	EXPO Zaragoza - Hydrogenics/Tecnobus		Zaragoza		Spain	Midi bus	Summer 2008	3	PEM	12	Hydrogenics	Hybrid FC system
11	Foton Motors (Tsinghua University)	Beijing (2008 Olympics)	Beijing		China	Bus	Jul-08	3				Fuel cell/ battery hybrid system based in Tsunghua University system

12	GreenLite project - Nanyang Technological University (NTU) & Tsinghua University	Singapore bus company, SBS/ Youth Olympic Games			Singapore	Bus	Aug-10	1	PEM	40		Hybrid FC bus
13	HCNG Transit Bus demo (TransLink, Westport)	TransLink	Vancouver	BC	Canada	Bus	Nov-07	4			none	Modified 8.3L C Gas Plus ICE engine tuned to operate on HCNG blend
14	Heliocentris FCB		Barth		Germany	Midi bus	Fall 2008	1	PEM		Hydrogenics	Hybrid FCB integrated by Heliocentris on a Neoplan Mic N8008 chassis
15	Hino/Toyota FCHV-BUS2 (JHFC Project)	Toyota/ Chitanorial Company Ltd.	Nagoya (Centrair Airport)		Japan	Bus LF	Demo 2006	1	PEM	90 ea.	Toyota	2 TMC FC stacks - hybrid system
16	HyChain Minitrans - Hydrogenics/Tecnobus		Castille y Leon, Emscher-Lippe, Herten & Bottrop		Spain & Germany	Midi bus	Jan-07	3	PEM	12	Hydrogenics	Hybrid FC system
17	HyCologne APTS-Philias FCB	Stadtverkehr Hürth	Cologne		Germany	Artic	2009-2010	2	PEM	150	Ballard	Hybrid FCB, drive system by Vossloh Kiepe
18	Hydrogenics/Tecnobus	Klinik Logistics Eppendorf GnBH	Hamburg		Germany	Midibus	Dec-09	1	PEM	12	Hydrogenics	Hybrid FC system
19	Hydrogenics/Tecnobus	Owned by Hydrogenics and operated at major events in Europe	Various		Various	Midi bus	Nov-05	1	PEM	12	Hydrogenics	Hybrid FC system
20	Hydrogenics/Tecnobus - Reinbahn FCB	Rheinbahn and Ohlmann	Dusseldorf		Germany	Midi bus	Jan-07	2	PEM	12	Hydrogenics	Hybrid FC system
21	HySUT (Hydrogen Supply/Utilization Technology) FCB - Toyota/Hino	Airport Transport Service	Tokyo		Japan	Bus	Dec-10	1	PEM	180 total	Toyota	Hybrid FC system
22	Hyundai Motor Co. (Gen 1 FCB)	Shuttle between Hyundai facilities in Seoul and Jeju Island	Seoul		South Korea	Bus LF	Dec-06	4		200	Hyundai	Hybrid FC system
23	Mecklenburg-West Pomerania FCB	Ostseebus	Barth		Germany	Midi bus	Sep-06	1	PEM	80	Proton Motor	Hybrid FC system by Proton Motor (PM Turnkey)
24	Nutmeg FCB Demonstration (FTA NFCBP-NAVC)	CTTRANSIT & NYCT	Hartford, New York	CT, NY	USA	Bus	2009	4	PEM	120	UTC Power	Hybrid FC bus

25	Rampini ZEV Ale Hidrogeno		Perugia		Italy	Bus LF		1	PEM	16	Hydrogenics	Hybrid FC system
26	TriHyBus (Skoda, Proton Motor)	Nerabus	Neratovis		Czech Republic	Bus	Jun-09	1	PEM	48	Proton Motor	TriHyBus system: FC, batteries, and ultracaps in a hybrid configuration
27	UNDP-GEF China Phase II (Shanghai Automotive Industry Corporation)		Shanghai		China	Bus	April 2010	6			Ballard	Next generation system from Phase I, hybrid FCB
28	UNDP-GEF Brazil (Marcopolo, Ballard, NUCELLSYS, EPRI)	EMTU	Sao Paulo		Brazil	Bus LF	Nov-08	5	PEM	170 total	Ballard	Fuel Cell Hybrid - NuCellSys system (HY-80 for prototype; HY-86 for rest)
29	University of Delaware - Phase 1 FCB	UD, Delaware Transit	Newark	DE	USA	Bus	Spring 2007	1	PEM	19.4	Ballard	Hybrid FCB with Ebus battery dominant system
30	University of Delaware - Phase 2 FCB	UD, Delaware Transit	Newark	DE	USA	Bus	Early 2009	1	PEM	40	Ballard	Hybrid FCB with Ebus battery dominant system
31	University of Rome - Hydrogenics/Tecnobus		Rome		Italy	Midi bus		1	PEM	12	Hydrogenics	Hybrid FC system
32	University of Texas/ Ebus/ GTI	UT	Austin	TX	USA	Bus	Oct-07	1	PEM	20	Ballard	Hybrid FCB with Ebus battery dominant system
33	US Air Force/Enova/Hydrogenics/HTDC	Hickam Air Force Base	Honolulu	HI	USA	Bus	Dec-03	1		20	Hydrogenics	Battery dominant FC hybrid using Enova Drive system
34	UTC Power/ISE/Van Hool	CTTRANSIT	Hartford	CT	USA	Bus	Apr-07	1	PEM	120	UTC Power	Hybrid FCB (same as AC Transit)
35	UTC Power/ISE/Van Hool	SunLine	Thousand Palms	CA	USA	Bus	Nov-05	1	PEM	120	UTC Power	Hybrid FC system w/ Elfa drive system by Siemens
							Total	108				

22.0 Annex P - Heavy-Duty Fuel Cell and Hydrogen Vehicle Projects (planned)

#	Project	Agency/Organization	City	State	Country	Vehicle Type	Project Start Date	No. in Project	Type	Power (kW)	Manufacturer	Type
1	Advanced Composite 35-ft FCB Demo - Proterra/Ballard (NFCBP-CTE)	CMRTA	Columbia	SC	USA	Bus		1	PEM		Ballard	
2	American FCB Program - SunLine, BAE, ElDorado, Ballard (FTA NFCBP-CALSTART)	SunLine	Thousand Palms	CA	USA	Bus	late 2011	1	PEM		Ballard	ElDorado bus with BAE hybrid system and fuel cell
3	Athens Hydrogen Minibus Project		Athens		Greece	Mini Bus		1			Advent Technologies	
4	Birmingham FCB Demo - EVAmerica/Ballard (NFCBP-CTE)	Birmingham-Jefferson County Transit Authority, UAL	Birmingham	AL	USA	Bus		1	PEM		Ballard	
5	BVG/ Solaris	BVG	Berlin		Germany	Artic	2006	1	PEM		Proton Motor	FC hybrid system
6	CHIC: Aargau	PostAuto	Aargau		Switzerland	Bus		5				
7	CHIC: Bolzano	STA				Bus	Spring 2012	5				
8	CHIC: Hynor Oslo Buss (Van Hool, Ballard)	Unibuss	Oslo		Norway	Bus	Mar 2012	5	PEM	150	Ballard	FC hybrid bus with Siemens system
9	CHIC: Milan (Evobus)	Azienda Trasporti Milanesi	Milan		Italy	Bus	Nov - 2011	3		120		FC hybrid system
10	Chicago Transit Authority FCB Demo - BAE Systems/Ballard/ElDorado (NFCBP-Calstart)	Chicago Transit Authority	Chicago	IL	USA	Bus		1	PEM		Ballard	
11	Coppe/FINEP/Petrobras (Electra, Caio)		Rio de Janero		Brazil	Bus		1	PEM			Fuel Cell hybrid
12	ECO Saver IV Hybrid FCB Demo - DesignLine/Ballard (NFCBP-CTE)	Ohio State	Columbus	OH	USA	Bus		1	PEM		Ballard	

13	Ft Lewis Army Base FCB demo (CTE/Proterra/Hydrogenics)	U.S. Army	Tacoma	WA	USA	Bus	2011	1	PEM	32 total	Hydrogenics	Battery-dominant, plug-in, hybrid FCB
14	Gelderland Hydrogen Bus (HyMove)	Connexxion	Arnhem		Netherlands	Bus	2010	1		30	Nedstack	Hybrid FCB - e-Traction hybrid system
15	Georgetown/EPRI (Gen III)		Chattanooga, Traverse City	TN, MI	USA	Bus	2010	3	PEM	60 net	Ballard	Hybrid fuel cell system by NuCellSys
16	Hyundai Motor Co. (Gen 2 FCB)		Various cities TBD		South Korea	Bus	2010			200	Hyundai	Upgraded hybrid system from Gen 1 bus
17	ISRO/Tata FCB				India	Bus	2009	1		80		
18	King Long United Automotive				China							
19	Lightweight FC hybrid bus - GE (FTA NFCBP-NAVC)		Albany	NY	USA	Bus	2010	1	PEM		Hydrogenics	Hybrid FC system
20	Massachusetts H2 FC Powered Bus - Nuvera/ISE Corp./ Mass. Port Auth. (FTA NFCBP-NAVC)	MBTA - Logan Airport	Boston	MA	USA	Bus	2011	1		82	Nuvera	Hybrid FC drive system (ISE)
21	UNDP-GEF China Phase II (Shanghai Automotive Industry Corporation)		Shanghai		China	Bus	2010	6				Next generation system from Phase I, hybrid FCB
22	University of Delaware - Phase 3 FCB	UD, Delaware Transit	Newark	DE	USA	Bus	2011	1			Ballard	Hybrid FCB
23	University of Delaware - Phase 4 FCB	UD, Delaware Transit	Newark	DE	USA	Bus	2012	1				Hybrid FCB
24	University of Glamorgan Hydrogen "Tribrid" Bus (Dragon Coachworks bus)	University of Glamorgan, Wales	Treforest		Wales	Minibus		1			Hydrogenics	FC-battery-ultra cap hybrid system
25	Volvo/Proton Motor		Berlin		Germany	Double decker bus		2			Proton Motor	FC system
							Total	45				