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UNDP-GEF FUEL-CELL BUS PROGRAMME: UPDATE

(Prepared by the United Nations Development Programme)

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INTRODUCTION

1. Since 2002, as requested by the Global Environment Facility (GEF) Council, UNDP provides yearly progress reports on the implementation of the UNDP-GEF Fuel-Cell Bus (FCB) Programme. As in past years, the purpose of this year's report continues to be updating the status of these FCB projects and also providing additional information on the deployment of FCBs around the world.

2. This paper includes four main sections. The first section, which includes the same content as the update from the previous year, is intended to remind the reader of the objective and strategy of the FCB Programme. The second section presents recent developments in the FCB market and focuses on non-GEF FCB activities, as they greatly impact and inform the implementation of the UNDP-GEF FCB projects. The third section outlines the implementation status of each FCB project. The paper concludes with a summary discussion and next steps including a timetable.

1. OVERVIEW OF THE UNDP-GEF FUEL-CELL BUS PROGRAMME

3. To help catalyze the commercialization of FCB technology for urban areas of developing countries, the GEF and UNDP launched a program to set the stage for large-scale commercial deployment of FCBs in developing countries. The UNDP-GEF FCB Programme intended to support the commercial demonstrations of FCB and associated refueling systems in the largest bus markets in the developing world: Beijing, Cairo, Mexico City, New Delhi, Sao Paulo, and Shanghai. The Development Objective of the Program was to reduce the long-term greenhouse gas (GHG) emissions from the transport sector in GEF program countries. The achievement of this development objective involved GEF support for preparatory activities and demonstration projects. For the five projects, the total proposed GEF commitment was originally US$ 59.6 million, with approximately US$ 36 million approved by the GEF Council.

4. Through the support of FCBs in GEF program countries, the GEF has taken on a role as an important agent of technology transfer in support of the UNFCCC. By encouraging the early adoption of these buses in a process of "technological leapfrogging", UNDP-GEF intended to assist developing countries in gaining experience with FCBs early in its product cycle. GEF program countries would then develop partnerships with technology developers, thereby increasing technological competence and adapting the technology to local needs. GEF Program countries would also benefit from reduced local air pollution, new export opportunities attributable to local manufacturing, and improved quality of public transit service. Finally, the UNDP-GEF would also be assisting developing countries in preparing for a future transition to newer, cleaner and more efficient fuel-supply systems based on hydrogen.

5. The GEF's justification for participating in FCB project was the reduced GHG emissions that FCBs offer over conventional diesel buses. Fuel cells fired by hydrogen can offer dramatic reductions in system-wide GHG emissions from the urban transport sector if the system is carefully designed. Although fuel cells are technically proven, they are not yet economically competitive in commercial applications: early investments in the technology were anticipated to reduce its costs to a commercially competitive level within 7 to 15 years. The volume of production required to attain this goal is estimated at between 2000 and 5000 buses, in both developed and GEF program countries. Once fully commercialized, the technology can then play an important role in the stabilization of GHGs by the year 2100, as represented in IPCC scenarios.[1]

6. The UNDP-GEF strategy for FCB commercialization involves a working partnership between GEF, private industry, and local/national governments in GEF Program Countries. The GEF plays three important roles. The first role is funding the incremental costs of FCB projects in recipient countries. The second is facilitating the process of FCB commercialization in developing countries by convening various parties to discuss, collaborate in, and finance the commercialization program. The final role is that of enabling information exchange within and between program countries, industry, and other FCB demonstrations in both donor and recipient countries. By assuming each of these roles, the GEF is placing a reciprocal responsibility on the counterparts in the partnerships. Their contributions to the partnership will include the provision of financing, cooperation, and information to the FCB development process.

7. To meet the development objective of this programmatic initiative, the UNDP-GEF strategy of support involves three distinct phases of support: (I) Preparatory Phase; (II) Demonstration Phase; and (III) Commercialization Phase. GEF is now funding Phase II — the Demonstration Phase — with countries in early implementation of full demonstration activities and proposals for follow-on commercialization work. Whether GEF support will continue to be warranted in Phase III will depend largely on the nature of the 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. Therefore, at present, it is not recommended to commit the GEF to one specific program of support for Phase III projects. Rather, the GEF must make an informed decision most likely between the years 2005 and 2007 (or more likely in the next 3 to 8 years).

[1] *Climate Change 2001: Mitigation* - Contribution of Working Group III to the third assessment report of the Intergovernmental Panel on Climate Change. Edited by B. Metz *et al.* 2001, p 240.

2. MAJOR FUEL-CELL BUS DEMONSTRATION EFFORTS

8. During the past year, there has continued to be a steady stream of new fuel cell buses (FCB) being put into revenue service worldwide as part of demonstration programs. Cumulatively, the total number of buses that have operated on roadways through the end of 2004 was about 80 (Figure 1). All known FCB projects, as tabulated by the fuel cell industry watching organization, Fuel Cell Today, are summarized in a table in the appendix.

9. The DaimlerChrysler-Ballard FCB demonstration program, involving 33 buses in 11 cities, continues to be the single most significant demonstration program. Ballard announced some important milestones in fuel cell engine development early in 2005 and appears to be on-track for achieving performance and cost levels to enable commercial viability by their target date of 2010. Meanwhile, Toyota has quietly moved into second place in terms of total number of fuel cell engines operating in buses on the road today, and Toyota is also targeting 2010 for reaching commercial viability. The California Fuel Cell Partnership will see 7 FCBs begin revenue service this year. Hydrogenics, a Canadian fuel cell engine developer relatively new on the scene, will provide engines for two FCB demonstrations in 2005.

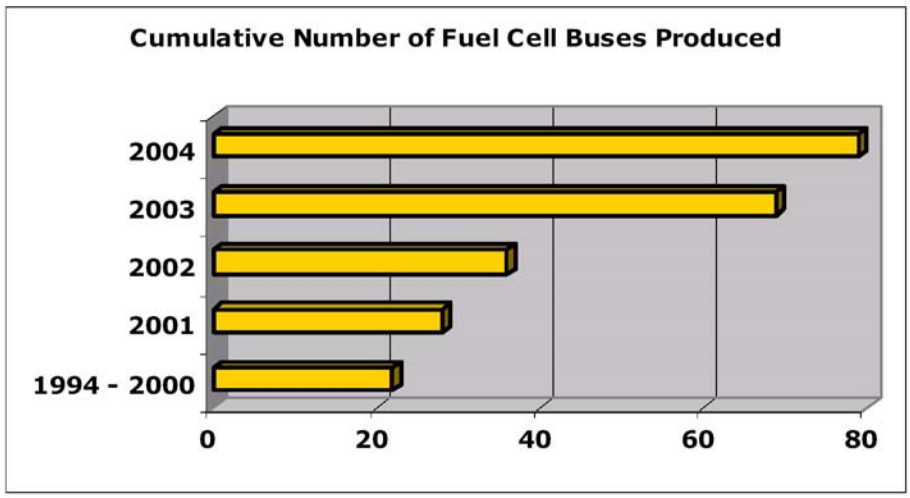

Figure 1. Source: K. Adamson, "Fuel Cell Market Survey: Buses," *Fuel Cell Today*, November 2004 (www.fuelcelltoday.com).

2.1 DAIMLERCHRYSLER/BALLARD FCB DEMONSTRATION PROGRAM

10. Within the CUTE/ECTOS/STEP[2] program, three full-size (12 meter) Citaro buses have been operating successfully in revenue service during most of the past year in each of 9 cities in Europe, in Reykjavik, and in Perth. 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 fuelling, and exchange experiences including bus operation under differing conditions among the participating companies. In June 2004, the program established a Task Force for Security and Safety to facilitate incident-reporting. The objective is to provide a system that encourages incident reporting, improves communication and contributes to safety improvements across all three projects (CUTE, ECTOS, and STEP).

[2] CUTE = Clean Urban Transport for Europe; ECTOS = Ecological City Transport System (Reykjavik); STEP = Sustainable Transport Energy for Perth (Australia). An early summary of the CUTE program is "Hydrogen Supply Infrastructure and Fuel Cell Bus Technology" (available via http://www.fuel-cell-bus-club.com/).

11. As of the end of 2004, the 33 Citaro buses had collectively logged 500,000 km of revenue service. As of April 13, 2005, they had accumulated 50,000 bus-hours of operation. In Perth, the last of the cities to receive its three buses, revenue service commenced at the end of September 2004. Meanwhile, in Reykjavic and some other cities, the end of planned two-year revenue-service road testing/demonstration is approaching. The completion of the full 33-bus Citaro program is slated for April, 2006.

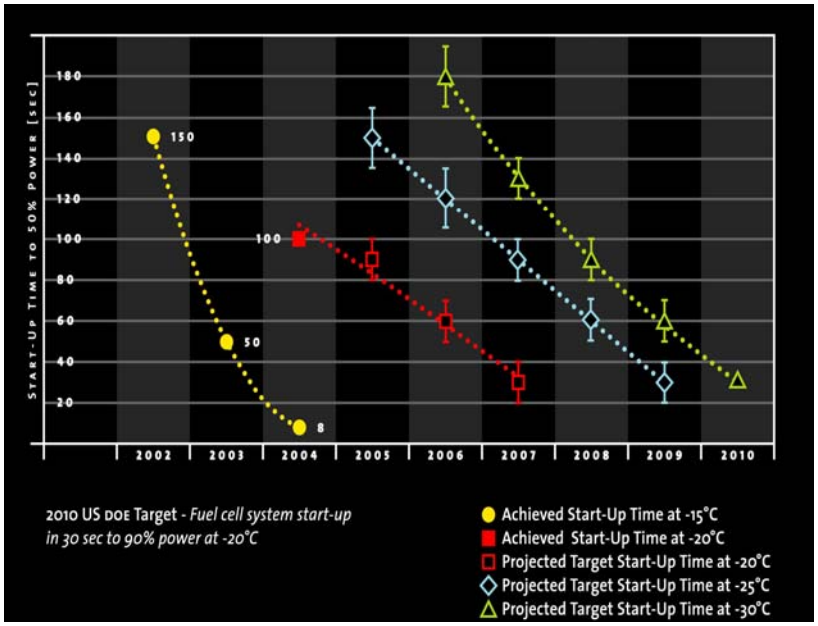

Figure 2. Freeze-start capability of Ballard fuel cell stack. (Source: Ballard web site.)

12. Detailed information regarding bus performance and other aspects of the CUTE/ECTOS/STEP project are made available to members of the "Fuel Cell Bus Club", and aggregate information is made available more widely through workshops, in newsletters,[3] and on the internet. The Second International FCB Workshop, which took place in Porto, Portugal in November 2004 in conjunction with a Fuel Cell Bus Club meeting, included presentations from CUTE, ECTOS, and STEP representatives.[4,5]

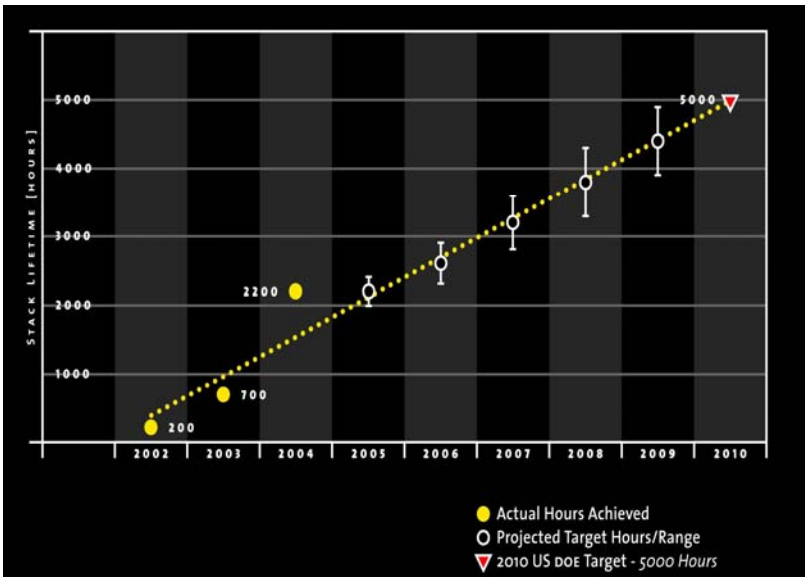

Figure 3. Lifetime of Ballard fuel cell stack. (Source: Ballard web site.)

13. Ballard has provided all of the fuel cell engines for the 33 Citaro buses. Ballard is also[6] providing fuel cells for 3 Gillig buses which recently entered revenue service at the Santa Clara VTA – see next section – as well as for a MAN bus demonstration at Munich Airport that began in 2004,[7] 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. While the FCB (and additional light-duty vehicle) demonstrations have been

[3] For example, the STEP program publishes a newsletter (November 2004 and March 2005 have been issued to date).
[4] Talks given at the workshop included the following: J.B. Skulason, *ECTOS – A case study for introducing hydrogen*; M. Schuckert and W. Rau, *The DaimlerChrysler fuel cell bus activities – a major step towards cleaner urban transport*; S. Whitehouse, *The Perth fuel cell bus trial*.
[5] Proceedings of the workshop are available for download via http://www.electricdrive.org/
[6] A. Martin (Ballard Chairman of the Board), *Industry perspective: the commercialization of fuel cell buses*, talk presented at the Second International Fuel Cell Bus Workshop, Porto Portugal, November 2004.
[7] Last year MAN was projecting series production of fuel cell drive systems starting in 2010. See news release at http://www.mn.man.de/presse/en/aae/aa52e.htm.

ongoing, Ballard has been actively pursuing in-house R&D toward this goal. A recent Ballard press release (16 February 2005) announced the achievement of three major technology milestones demonstrated with a 10-cell stack:

- Repeated freeze-start at -20 °C (50 cycles) without performance degradation or stack damage.
- Stack lifetime greater than 2000 hours. A total of 2200 operating hours were logged before a 5% performance reduction was observed (but with no damage to the proton exchange membrane).
- A 30% reduction in platinum loading (from 1 mg/cm^2 to 0.7 mg/cm^2) without performance compromise. The fuel cell stack with which the freeze-start and durability milestones were achieved included the 30% reduced platinum loading. Reduced platinum loading is important for achieving competitive costs.

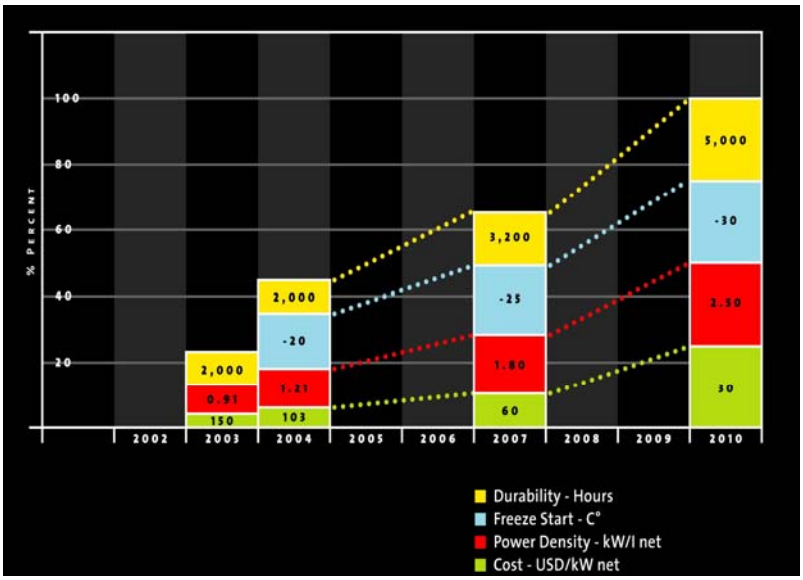

Figure 5. Technology trendlines for Ballard fuel cell stacks. (Source: Ballard web site.)

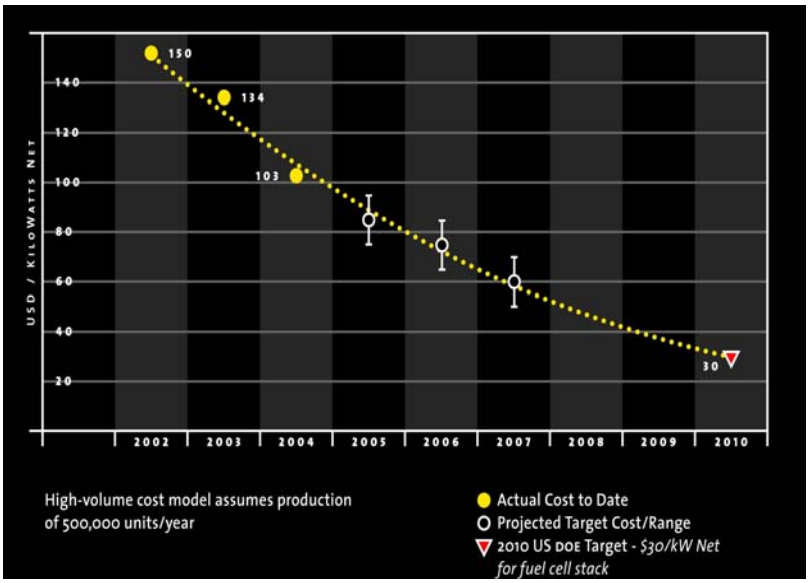

Figure 4. Cost projections for Ballard fuel cell stacks. (Source: Ballard web site.)

14. Based on advances like these, Ballard has established a fuel cell "roadmap" for achieving commercially viable automotive fuel cell stack technology by 2010. Ballard's future performance and cost targets, as well as achievements to date, are summarized in Figures 2 to 4 for freeze-start capability, lifetime (durability), power density, and cost, respectively. Figure 5 summarizes Ballard's projections for all of these parameters.

15. While the roadmap refers to targets for automotive fuel cells, if the automotive targets are achieved, it is likely that commercial viability will also be achieved for bus fuel cell engines, since power density and cost targets are not as severe for buses as for cars.

2.2 CALIFORNIA FUEL CELL PARTNERSHIP FCB DEMONSTRATIONS

16. California continues to lead US-based FCB demonstration efforts. While delayed somewhat from earlier announced startup dates, three FCB demonstration projects should get started in earnest in 2005 as part of the California Fuel Cell Partnership (CaFCP). The Santa Clara Valley Transportation Authority (VTA) in San Jose took delivery late in 2004 of three forty-foot FCBs with 205 kW Ballard fuel cell engines integrated with Gillig chassis. A planned two-year period of revenue service began in March 2005. AC Transit in Oakland will take delivery in September 2005 of three forty-foot van Hool buses with United Technologies fuel cell engines (PC40 120 kW PEM + 100 kW nickel-sodium chloride battery) integrated by ISE. The buses will also have regenerative braking. Sunline Transit in Thousand Palms will take delivery this year of a bus similar to the AC Transit buses, but with a composite body made by North American Bus Industries (NABI). AC Transit has previous successful demonstration experience with a thirty-foot ThunderPower bus with a United Technologies fuel cell engine. Since September 2003, this bus has logged 7600 revenue-service miles, 556 revenue-service hours, and more than 1500 hours of stack operating time (compared to the original design life of 1000 hours),[8] with 83% availability and fuel economy of 7.6 mpg.[9] (These latter figures can be compared with those for the established AC Transit diesel buses: 93% availability and 3.8 mpg.)

2.3 TOYOTA'S FCB PROGRAM

17. Toyota, in collaboration with the bus manufacturer, Hino, and with support from the Japanese government has continued its quiet, but active development of FCBs. Their activities are being given greater public prominence this year. The most recent model of Toyota's FCB is the FCHV-BUS2 (see Table 1). To optimize energy management on the bus (including fuel cell power, battery power, and regenerative braking), the bus uses a system based on the energy management system used commercially in the Prius hybrid-electric automobile. Four FCHV-BUS2 buses have been on Tokyo roads since 2002, primarily in non-revenue service. From August 2003 until December 2004 one of the buses was operated in revenue service.

18. In the first three months of 2005, Toyota delivered eight FCHV-BUS2 buses for a 6-month run (March through September 2005) at the World Exposition ongoing in Aichi, Japan. This puts Toyota second only to Ballard in terms of the number of fuel cell engines it has put into passenger-carrying buses operating today. Toyota has indicated that it is aiming for commercialization of fuel cell buses by 2010.

Table 1. Characteristics of Toyota's FCHV-BUS2.

Vehicle	Base platform	Blue Ribbon City (Hino low-floor commuter)
	Overall length/width/height (mm)	10,515 / 2,490 / 3,360
	Occupant capacity (persons)	60
Performance	Max urban-route range (km)*	250
	Maximum speed (km/h)	80
Fuel cell	Name	Toyota FC Stack
	Type	PEM
	Output (kW)	2 x 90
Motor	Type	Permanent magnet
	Maximum output (kW)	2 x 80
	Maximum torque (N-m)	2 x 260
Fuel	Type	Hydrogen
	Storage method	tanks
	Maximum storage pressure (MPa)	35
Battery	Type	Nickel-metal hydride

[8] M. Tosca, *UTC Fuel Cells overview and transportation applications*, talk presented at the Second International Fuel Cell Bus Workshop, Porto, Portugal, November 2004.
[9] Source: http://www.actransit.org/environment/hyroad_evaluation.wu.

2.4 ADDITIONAL FCB DEMONSTRATION ACTIVITIES

19. Though smaller in scale than the activities described above, there are nevertheless a number of other relevant FCB demonstration activities ongoing worldwide.

- *China (separate from UNDP/GEF)*

20. China has continued intensive development efforts on fuel cell vehicles (in addition to the UNDP/GEF efforts). The "863 Program" (named for the date it was originally created, March 1986) of the Ministry of Science and Technology is funding US$106 million of hybrid-electric drive and fuel cell vehicle development work during 2001-2005. Private companies are investing an estimated additional $200-300m during this period. The emphasis of the 863 program is on demonstration, commercialization, and support of the Chinese vehicle industry (as distinct from fundamental R&D, which is supported under the separate "973 Program"). Most of the $106 million of 863 funds are being spent on buses (rather than cars), as well as on H_2 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 are viewed as key opportunities to show case Chinese FCB development efforts and major demonstrations of vehicles are likely around these events.

21. An estimated 60 organizations are currently involved in fuel cell research, development and demonstration in China. Two especially prominent companies are Shanghai's Shen-Li High Tech and Dalian's Sunrise Power (a spin-off of the Dalian Institute of Chemical Physics – DCIP). Both of these are developing FC engines for buses, with system integration work being done by Tsinghua University and the Shanghai Fuel Cell Vehicle Powertrain Company. DCIP developed and demonstrated 30-kW engines in FCBs during 2001-2003, and they delivered a 75-kW engine in the spring of 2003 to Tsinghua University, which integrated it into a bus. In August of 2003, DCIP signed an agreement with Toyota to jointly develop clean energy vehicles, including FCVs. Shen-Li, which was founded in 1998, has already developed 40 kW (car) and 80 kW (bus) fuel cell engines.

- *Hydrogenics (Canadian company)*

22. Hydrogenics, the Canadian fuel cell engine company, continued to be active during the past year. Reference can be found in the literature to at least 3 Hydrogenics FCB projects.

- With support from Natural Resources Canada, and partnering with New Flyer Bus Company, it has developed a 40-foot FCB (180 kW PEM plus regenerative braking and ultra-capacitors) for demonstration and testing in Winnipeg. Partners in the three-year project include Dynetek Industries, ISE Research, and Maxwell Technologies. The FCB was to be ready for demonstration in April 2005. The Canadian government is targeting larger in-service fleet demonstrations (15-25 buses per demo) for late 2008/early 2009.[10]
- Hydrogenics has also signed a contract (in November 2004) with the Ministry for Transport Energy and State Planning of the State of North-Rhine-Westphalia (NRW), Germany, to demonstrate in NRW a fully-operational "midi" bus, a 17-foot bus that will use Hydrogenics "HyPM" power module technology. (The HyPM-10 module is a 10-kW module that can be combined in parallel or series combinations.) NRW is funding 50% of the project cost up to $735,000. (This suggests the bus cost will be about US$1.5 million.)
- In February 2004, the United States 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.

[10] R. Harmer (BC Transit), *Fuel cell powered buses in Canada*, talk at the Second International Fuel Cell Bus Workshop, Porto, Portugal, November 2004.

- *Proton Motor (German Company)*

23. Proton Motor Fuel Cell GmbH (Germany) continues to exhibit some activity around FCBs. In an August 2004 article in the *Berliner Zeitung* newspaper, Berlin's public transportation body, BVG, confirmed that construction plans have been completed for double-decker FCBs with fuel cell engines to be provided by Proton Motors. Currently, Berlin buses can only hold an average of 95 passengers, but the new buses will be able to pack in 120 to 130. In order to accommodate the load, the buses will be 1.8 meters longer than the current 13.5 meter-long double-deckers in the city's fleet. The FCBs are expected to be tested on the streets of Berlin starting sometime in 2005. The Proton Motor website indicates that the company is planning for mass production of fuel cell engines and FCBs.

- *Other activities*

24. The National Fuel Cell Bus Technology Initiative (NFCBTI) is an effort in the United States spearheaded by Westart/Calstart, which has corporate supporters that include component suppliers (e.g., Ballard), vehicle manufacturers (e.g., Volvo, GM, Catepillar), and vehicle users (e.g., Sunline, AC Transit, Fedex). The goal of the NFCBTI is to accelerate development of commercially viable fuel cell and hydrogen buses in the U.S. Accordingly, the focus of the initiative is on reducing bus costs and increasing durability and reliability. U.S. federal funding of $25 million/year for 6 years ($150 million total) is being sought for the NFCBTI through a Congressional "earmark". In March 2005, the US House of Representatives passed HR3, "The Transportation Equity Act: A Legacy for Users," a 6-year, $284 billion federal highway, transit, and highway safety program. HR3 includes $65 million for R&D to make hydrogen FCBs commercially viable. The R&D must be 50% cost shared by partners. The US Senate must also approve the bill before it becomes law. If funding for the NFCBTI is secured, the FCB development and commercialization effort in the U.S. may begin to rival that of Europe's CUTE program.

25. A consortium involving Air Liquide, Axane Fuel Cell Systems (France), Nuvera, Irisbus, Johnson Matthey, and others is involved in a project launched in 2002 with 7.84 million Euro (US$9.6m at current exchange) of European Union funding to develop a standardized 100 kW PEMFC system for buses, heavy-duty vehicles, and stationary power.[11] Taking advantage of standardization, the project is aiming at a target mass-production cost of 300 Euro/kW for the fuel cell plus hydrogen storage. This "FEBUSS" project is slated to run until 2006, culminating with one or more FCB demonstration. No new information on this project (since the May 11, 2004 update to GEF Council) was found through an internet search, suggesting that progress may be slower than originally planned.

26. The European Citycell Project was designed to involve the operation of four different hybrid fuel cell buses in Berlin, Madrid, Paris, and Turin. According to Adamson,[12] delivery of the buses to Paris and Turin has been stopped, and the Madrid bus (an Irisbus with UTC fuel cell engine unveiled in May 2003) has been taken off the road. The fate of the Berlin bus is not known.

27. Georgetown University has long maintained demonstration efforts with methanol fuel cell buses (using on-board reforming of methano) in hybrid configuration with batteries. Their efforts have been supported primarily by U.S. government funding. No significant developments have been reported for the past year. The project website indicates future plans (unspecified schedule) for demonstrating a "third generation" bus that will use methanol, but without battery hybridization.

[11] See http://www-leg.ensieg.inpg.fr/eur_procourl3.html.
[12] K. Adamson, "Fuel Cell Market Survey: Buses," *Fuel Cell Today*, November 2004 (www.fuelcelltoday.com).

3. FCB PROGRAMME IMPLEMENTATION

3.1 BRAZIL

28. In the past year, the Brazilian FCB project has made very good progress in the complex and unprecedented negotiations with the FCB Consortium. This Consortium will be responsible for designing, developing and producing the hydrogen FCBs, supply equipment, storage and refueling systems under the project. After two years of continuous work, the Consortium signed the MOU establishing its existence and presented this MOU to UNDP on 25 November 2004.

29. Also during the past year, the Consortium presented a technical and commercial proposal to UNDP for the FCBs. The terms for the procurement contract are currently being finalized for official approval by the local contracts committee. It is anticipated that signature of the procurement contract, or Consortium Agreement, will take place in July 2005.

30. A key achievement reached over the past year is that there is now agreement that a FCB prototype will run first in Sao Paulo, to be followed by a proposal from the Consortium for production of up to 8 FCBs. The next steps for the upcoming FCB deployment have been established as follows:

- Signature of UNDP contract by the Consortium
- Completion of Prototype
- Completion of verification test protocol
- Preparation of next phase proposal and related decision making process
- Launch of full series of production buses.

31. As soon as official testing is finalized, the Consortium will present a proposal for production of the full FCB fleet. Information gathered throughout the testing (verification) period would allow for necessary technical adjustments to the buses.

32. In the past year, an official Tripartite Review (TPR) was not held as the project waited for the official establishment of the Consortium; however, a meeting was held with the Government, EMTU and UNDP to discuss the annual project revision. An official TPR will be held in mid 2005 after signing the budget revision and the procurement contract with the Consortium.

33. Efforts to disseminate information about the UNDP-GEF initiative in Brazil have continued. The project participated in the UNDP-GEF FCB Programme Meeting held in London on 15 June 2004. The project was also represented at the Second International FCB Workshop in Portugal 18-20 November 2004, and was invited to present at the Hydrogen and Fuel Cell Futures Conference held in Perth Australia in September 2004.

3.2 MEXICO

34. In December 2004, the Secretary of Environment and Natural Resources (SEMARNAT) of Mexico, through the Operational Focal Point, determined that they will pursue official cancellation of the UNDP-GEF FCB project. The main reasons officially quoted for cancellation of this project, executed by STE (Electric Transport Service of Mexico City), were substantial changes in conditions originally foreseen for the project, in particular technical, financial and institutional aspects of the project.

35. Official processes for canceling the UNDP-GEF FCB project in Mexico are being initiated. Exploration of potential reformulation of the FCB project into a non-technology focused Sustainable Transport project will also be undertaken, in parallel with the official cancellation activities, during the upcoming months.

36. During the past year, the Mexico project had been implementing a revised workplan initiated after the change of STE's top management in February 2004. The focus was on developing technical and operational capacity related to FCBs through proposed collaboration with Mexican institutions familiar with fuel cells and transportation technologies.

3.3 CHINA

37. In late 2003, the China International Center for Economic and Technical Exchanges (CICETE), entrusted by the project 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 winner. In May 2004, intense negotiations were conducted with DaimlerChrysler and a contract to procure FCBs was signed. Three Citaro buses are anticipated to be delivered to Beijing in September 2005.

38. The corresponding Beijing hydrogen fueling system is being built by BP and a Chinese counterpart. Beijing SinoHytec Limited, BP and Beijing Tongfang Co. Ltd have been working together to do the feasibility study report for the Beijing Hydrogen Fueling Station Project. For the UNDP-GEF project, the hydrogen source will initially be compressed hydrogen, then hydrogen produced on site using electrolysis of water, and finally hydrogen produced from industrial waste gas and/or reformed natural gas.

39. Under Tranche I (formerly referred to as Phase II of Part I) of the FCB project, a number of study tours was conducted to gather up-to-date information on FCB technologies, hydrogen fueling systems and equipment suppliers. The national FCB project office organized a delegation to visit Germany, Netherlands, Belgium, Luxembourg, Sweden, Iceland and France from 11-26 September 2004. The objectives of the visit included gaining an increased understanding of the planning, operation, and policies for FCB projects through studying the experience of the European projects. During the study tour in Europe, the delegates increased their understanding of the "Clean Urban Transport in Europe" (CUTE), which remains the world's largest FCB demonstration project, and the ECTOS project. The policies and measures adopted by the EU to secure energy safety, environmental protection, clean energy vehicles development and sustainable transportation were noted. During the study tour to the six European cities, the delegation met with managers and technical people engaged in the CUTE project, toured the on-site hydrogen production and refueling facilities, took the opportunity to ride the Citaro FCB running on its regular demonstration route and discussed with CUTE issues such as the operation of the FCB, construction and maintenance of hydrogen filling stations, and certification of vehicles.

40. The China FCB Project has been formulated in two Tranches, with Tranche II already in the GEF pipeline and subject to GEF Council approval when submitted as part of a work programme. Proceeding with Tranche II of the project is triggered by the procurement of the first set of buses under Tranche I. According to the decision made by the Ministry of Science and Technology - the Executing Agency - and UNDP at the Project Review meeting in June 2004, and the subsequent consultations with UNDP-GEF, the project has started the preparation for Tranche II of the project.

41. To summarize the experiences and lessons learned during Tranche I, so as to provide guidance in determining the targets and strategies for Tranche II of the project, an evaluation was conducted. This project evaluation was conducted on 15-26 November 2004 and the evaluation report has been finalized. The objectives were to assess the efforts made and results achieved in partnership building among the

respective agencies and companies, and to review the approaches to access potential partners; and to examine the methodologies used in the selection of FCB technologies and relevant supporting infrastructure for commercializing environmentally-friendly public transportation in Chinese cities. The report made specific recommendations to the relevant parties for the design and support for the Tranche II project. Major observations included:

- The Tranche I project performance and results were found to be satisfactory despite that the project had faced technical regulations, standards and national policies constraints, which caused some difficulties with project implementation and coordination.

- The evaluation mission suggested that Shanghai procures a newer generation FCB in Tranche II of the project. Because of the current active state of FC development in China and abroad, a new generation of FCBs will likely be available within two years. These new FCBs will likely have improved durability and reliability characteristics, as well as lower costs. Thus introducing FCBs in Shanghai that were different from those implemented in Beijing will help to enlarge the benefits of the overall project. Furthermore, this phased approach would better meet the project objectives of advancing FCBs towards commercialization.

- The project was found to have effectively built capacity within various Chinese academic and government agencies, and a major positive impact of the project to date has been to create a wider awareness within China of FCBs and the use of hydrogen fuel.

- Considering that China has the world's largest public transit sector and is rapidly becoming the one of the world's largest energy consumers of fossil fuels, the overall impact of a successful FCB demonstration in China was considered to be extremely significant in reducing GHG emissions and sustainability. Furthermore, the opportunity of internationally showcasing FCBs during the 2008 Olympics was recognized as significant.

42. Soon after the Project Review Meeting, the Project Management Office (PMO) started the preparation of the Project Brief for Tranche II. Several meetings were organized to brainstorm and discuss the objectives and strategies of the Tranche II project, and a draft project brief has been prepared for submission to the December 2005 GEF Council.

3.4 EGYPT AND INDIA

43. The progress of the Brazil and China FCB projects, and other FCB demonstrations around the world, has shown that it is possible for FCBs to be procured through a competitive process[13]. Although the production of FCBs is still at a non-commercial stage, it was thought sufficient to support the UNDP-GEF FCB projects in both India and Egypt. Indeed, in May 2004 UNDP-GEF recommended to the GEF Council that the India and Egypt FCB projects, approved as part of the May 2001 Work Programme and the February 2001 Intersessional respectively, proceed to Project Document submission to either the November 2004 or May 2005 GEF Councils. Prior to that time, UNDP and the participating governments were to ensure that:

- cofinancing from governments were finalized and committed to the project with the relevant cofinancing letters obtained;
- implementation arrangements were negotiated and finalized;

[13] Assumption of Immediate Objective 1 of the Demonstration phase is that bus companies and FC suppliers will respond to the RfP's issued—as a result, FCBs can be procured.

- project documentation was brought up-to-date to reflect the recent changes in the FCB market and learnings from the other UNDP-GEF project under implementation; and,
- all other project documentation, including technical specifications, monitoring and evaluation plan, were finalized.

44. If these projects failed to meet the above requirements prior to the May 2005 GEF Council, the Council would reserve the right to recommend cancellation of either or both of the Egypt and India FCB projects.

Egypt

45. While an official cancellation letter from the Egyptian government has not been received, the government determined during 2004/2005 that the FCB project should be closed. Co-financing from the government and other sources were not finalized, and implementation arrangements were not negotiated. As such, other project documentation was not brought up-to-date nor finalized for submission to the GEF Council.

46. Egypt has since revised its priorities for transport and a new GEF project is being officially proposed. The new project has the objective of reducing the growth of energy consumption and related greenhouse gas emissions of the transport sector in Egypt while simultaneously mitigating the local environmental and other problems of increasing traffic such as deteriorated urban air quality and congestion.

47. This new project intends to reduce the growth rate of energy consumption of the transport sector and to facilitate market development towards "sustainable mobility"[14]. Key stakeholders in Egypt will be supported to 1) reduce the growth of overall transport demand by improved land use and other urban planning measures, especially in new urban areas currently under development; 2) maintain or increase the modal share of sustainable public transport and reduce the use of private cars and other low capacity motorized transport for regular daily commuting; 3) maintain or increase the modal share of non-motorized transport, with a focus on the provincial medium size cities; and 4) improve the energy efficiency and logistics of freight transportation by promoting a modal shift from road to rail and inland waterways, and by promoting measures towards optimizing the cargo transport system and vehicles used for that purpose. GEF funds will not be requested for subsidizing demonstration fleets, but for technical assistance activities and for sharing the costs and/or risks of selected pilot activities demonstrating the potential for full cost recovery.

48. During the remainder of 2005, activities will be undertaken by UNDP and relevant parties to officially cancel the "*Fuel Cell Bus Demonstration Project in Cairo*" UNDP-GEF project.

India

49. 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 must be cleared by the GEF for implementation within six months (i.e., November 2004) or be cancelled. The India FCB project implementation arrangements, as envisioned at the time the FCB project brief was submitted to the May 2001 GEF Council, remained a major stumbling block. This challenge was mainly due to changes in key decision-making personnel since the project was first designed. During 2004, UNDP continued to explore the possibilities of pursuing the project with other organizations and ministries. Ultimately, it appears that national counterparts and the government have accepted the need to cancel the FCB project.

[14] Defined as "the ability to meet the needs of the society to move freely, gain access, communicate, trade and establish relationships without sacrificing other essential human or ecological values, today or in the future"

50. India is now pursuing a Cleaner Mobility project. This project entered the GEF pipeline on January 11, 2005. The project's major objectives include the following: reduce greenhouse gas (GHG) emissions associated with transportation in urban areas through 1) greater reliance on public transport, (2) greater reliance on non-motorized vehicles and (3) incorporation of sustainable transport principles into the urban design of new settlements.

51. During the remainder of 2005, activities will be undertaken by UNDP and relevant parties to officially cancel the "*Fuel Cell Bus Demonstration Project in New Delhi, India (Part I)*" UNDP-GEF project.

3.5 PROGRAMME COMMUNICATION AND NETWORKING

52. The UNDP-GEF FCB Programme has participated in the First and Second International Fuel Cell Bus Workshops held in 2003 and 2004, respectively. These meetings were attended by representatives of FCB demonstration projects from the European FCB Project (CUTE); Japanese Transit Operation; and the California Fuel Cell Partnership; in addition to UNDP-GEF FCB projects. In 2004, the UNDP-GEF programme was represented by representatives of the Brazil, China, and Mexico FCB projects. Each made separate presentations on their GEF-funded FCB initiatives. This Workshop also provided an ongoing opportunity for the international community to learn about the UNDP-GEF initiatives, and for the UNDP-GEF project teams to learn first-hand about similar experiences happening all over the world.

53. In an effort to promote an exchange of experiences and technical information within the UNDP-GEF FCB Programme, representatives from the Brazil, China, and Mexico participated in a workshop held in London on 16 June 2004. Each project representative presented their project, discussing both its status and lessons learned to date. The challenges associated with data collection systems, and potential approaches to sharing data acquired through the projects, were explored. This meeting also discussed the concept, approach and logistics of setting up the "twinning" of the GEF FCB cities with others around the world. The twinning links would be between the transit authorities rather than the fuel cell or bus suppliers. While UNDP core funds were earmarked to ensure the matching and communication arrangements between cities, it was determined by the project representatives that such an initiative was premature and would be more welcome once the FCBs were operational.

54. In addition, the UNDP-GEF project representatives attended a conference hosted by the CUTE and ECTOS projects (14-15 June 2004). The purpose of this conference was to provide an overview of the activities undertaken for setting up the 10 participating sites and preparing for the actual operation phase which started in November 2003; to demonstrate the first London hydrogen refueling station and FCBs; and, to provide an introduction to the evaluation process and methodology. Participants will include international government officials, transport authority representatives, representatives from regional, national and international regulating authorities, international fuel cell and hydrogen experts, and the interested industry and scientific community.

4. NEXT STEPS

55. The FCB Programme has witnessed dramatic changes in the past year. Major achievements have been realized by the Brazil and China projects, which have now both procured FCBs. Major losses have also been felt within the FCB Programme with the cancellation of the Mexico, Egypt and India projects. While the May 2005 GEF Council had reserved the right to recommend cancellation of either or both of the Egypt and India FCB projects, both of these projects have already been terminated by their respective countries.

56. The cancellation of three of the original five projects participating in the FCB Programme has provided several lessons, outlined below.

- When the FCB projects were initially formulated all seemed viable. From a pool of five projects, despite efforts from the UNDP, the GEF Secretariat, governments, academia and technology suppliers, only two projects have proceeded to full project operational status. Therefore, picking individual "winners" at the outset of such a challenging Programme is risky, and spreading that risk requires pursuing several promising initiatives.

- For GEF projects involving a technology that is proven, yet non-commercial, it is challenging to predict timing. In the Brazil project, for example, significant time has been devoted to negotiations to establish the consortium of suppliers. While a GEF project is not typically well suited to accommodating implementation delays, Brazil has kept its project moving forward through frequent discussions among stakeholders, yearly reviews, and continuous attention to its budgets.

- The corrective action applied to the FCB Programme has proven cost effective and prudent. The transaction costs associated with pursuing the three cancelled GEF projects to this point have been absorbed internally, mainly through preparatory funds and IA costs. In addition, the funds expended to date are minimal compared to the total cost to the GEF of the FCB Programme. The GEF funds allocated to the three cancelled FCB projects will be reprogrammed consistent with new GEF priorities and procedures.

57. The cancellation of three FCB projects also has significant implications for the FCB implementation strategy. Phasing of the projects, intended to maximize the structured learning from the earlier projects to the later projects, is no longer relevant. The Brazil project is fully funded, having been approved by the GEF Council in November 1999 and begun implementation in November 2001. In 2005, China is gearing up for funding of Part II and is expected to submit its request for funding to the next GEF Council.

58. The role of the GEF in enabling information exchange within and between program countries will also change. In future, communication approaches will focus on increasing interaction between Brazil and China. Information exchange with non-GEF projects will become even more relevant.

59. During the remainder of 2005, emphasis will be placed on officially canceling and closing the Mexico, Egypt and India projects.

60. Due to the reduced scope of the FCB Programme, the recommendation by UNDP-GEF to the GEF Council is that annual reporting on the FCB Programme cease after the May 2006 Update. As Implementing Agency, UNDP will continue monitoring and reporting on the status of the Brazil and China FCB projects through regular channels (i.e., PIR). A review on the deployment of FCBs around the world could be included as part of a mid-term review of the Brazil and China FCB projects, or as a component of a future GEF climate change portfolio review.

61. A summary of key planned activities for the UNDP-GEF FCB Programme during May 2005-2006 are summarized in Table 2 below.

Table 2 - Summary of Key Planned Activities for UNDP-GEF FCB Programme May 2005-2006

UNDP-GEF FCB Project	***Key Planned Activities for May 2005 - 2006***	***Timeline***
Brazil	• Finalize MOU for supply of buses • Delivery of first bus	• Second quarter 2005 • Second quarter 2006
China	• First delivery of buses • Submission of Tranche II of the project to the December 2005 GEF Council Work Program	• September 2005 • September 2005
Mexico	• Official cancellation and closure of the full-size UNDP-GEF project	• Third and fourth quarters 2005
Egypt	• Official cancellation of the full-size UNDP-GEF project	• Third quarter 2005
India	• Official cancellation of the full-size UNDP-GEF project	• Third quarter 2005

APPENDIX 1: SUMMARY OF FUEL CELL BUS PROJECTS, NOV. 2004

Source: http://www.fuelcells.org/fct/buses.pdf

Bus Mfr.	Operation	Model	Year Shown	Engine Type	Fuel Cell Size/Type	Fuel Cell Mfr.	Range (mi/km)	Max. Speed	Fuel Type	Picture
Bus Manufacturing U.S.A., Inc.	Generation I of Georgetown University's program	30-foot Transit Bus	1994	Fuel cell/ battery hybrid	50kW/ Phosphoric Acid FC (PAFC)	Fuji Electric	250mi 402km	55mph 90km/h	Methanol	
Bus Manufacturing U.S.A., Inc.	Generation I of Georgetown University's program	30-foot Transit Bus	1995	Fuel cell/ battery hybrid	50kW/ PAFC	Fuji Electric	250mi 402km	55mph 90km/h	Methanol	
Bus Manufacturing U.S.A., Inc.	Generation I of Georgetown University's program	30-foot Transit Bus	1995	Fuel cell/ battery hybrid	50kW/ PAFC	Fuji Electric	250mi 402km	55mph 90km/h	Methanol	
NovaBus Corporation (a subsidiary of Volvo)	Generation II of Georgetown University's program This bus will start a 1 yr. demonstration with Washington DC's Metro Area Transit Authority	40-foot heavy duty transit buses	1998	Fuel cell/ battery hybrid	100kW/ PAFC Ambient-pressure	UTC Fuel Cells	350mi 563km	66mph 106km/h	Methanol	
NovaBus Corporation (a subsidiary of Volvo)	Generation II of Georgetown University's program This bus is used for national demonstration purposes	40-foot heavy duty transit buses	2000	Fuel cell/ battery hybrid	100kW/ PEMFC	Ballard	350mi 563km	66mph 106km/h	Methanol	
Undetermined	Generation III of Georgetown University's program	40-foot low-floor bus platform	2003	Fuel cell	At least 240 kW/ PEMFC	Undeter.	N/a	N/a	Methanol	
New Flyer Industries Ltd.	Proof of Concept	**P1**; low fl. transit bus based on New-Flyer model 40	1993 world's first	Fuel cell/ battery hybrid	90kW/ PEMFC	Ballard	250mi 400km	60mph 95km/h	Compress. Hydrogen	
N/a	Proof of Concept	**P2**: full-sized, 40-foot	1995	Fuel cell/ battery hybrid	205kW/ PEMFC	Ballard	250mi 400km	N/a	Compress. Hydrogen	
Enova Systems	U.S. Air Force, State of Hawaii's High Technology Development Corporation and Hydrogenics partnership	**N/a**	2004	Fuel cell/battery hybrid	20kW	Hydrogenics	N/a	N/a	Hydrogen	
EvoBus: a Daimler Chrysler company	Accumulated over 540 hrs driving exper. By 1997; two week road test in Oslo, Germany 1999	**Nebus**: 405 low-fl. urban regular-service bus	1997	Fuel cell/ battery hybrid	205kW/ PEMFC	Ballard	155mi 250km	50mph 80km/h	Compress. Hydrogen	
EvoBus: a Daimler Chrysler company	Demonstrated at SunLine Transit, AC Transit, and CaFCP	**Zebus** (P4): 40 ft. (1 year demo with SunLine)	1999	Fuel cell/ battery hybrid	205kW/ PEMFC	Ballard	N/a	N/a	Compress. Hydrogen	
EvoBus: a Daimler Chrysler company	Sold as part of the CUTE; ECTOS; Perth, Australia programs. Cost ~US$3 million unsubsidized each.	**Citaro** (P5): (33 for the CUTE, ECTOS, STEP)	2003	Fuel cell/ battery hybrid	205kW/ PEMFC	Ballard	124mi 200km	50mph 80km/h	Compress. Hydrogen @ 5,000 psi	
Gillig Corporation	VTA, San Metro Transportation District, CaFCP & CARB - 3 FC Buses will be operated at VTA in San Jose, Ca	N/a	2004	Fuel cell/ battery hybrid	205 kW/ PEMFC	Ballard	N/a	N/a	Hydrogen	
Irisbus: a Renault V.I. and Iveco Co.	Demonstrated in Torino, Italy beginning in 2002	40 foot	2001	Fuel cell/ battery hybrid	60kW/ PEMFC Ambient-pressure	UTC Fuel Cells	N/a	N/a	Compress. Hydrogen	

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