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GEF/UNDP FUEL-CELL BUS PROGRAMME: UPDATE

(Prepared by the United Nations Development Programme)

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INTRODUCTION

1. As requested by the Global Environment Facility Council at its May 2002 meeting, UNDP provides yearly progress reports on the implementation of the GEF/UNDP Fuel-Cell Bus (FCB) Programme. The purpose of this year's paper, therefore, is to provide an update on the status of these FCB projects and also to provide 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 GEF-UNDP FCB projects. The third section outlines the implementation status of each FCB project. The paper concludes with a recommended next steps including timetable.

1 OVERVIEW OF THE GEF/UNDP 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 GEF-UNDP FCB Programme is supporting 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 is to reduce the long-term greenhouse gas (GHG) emissions from the transport sector in GEF program countries. The achievement of this development objective involves GEF support for preparatory activities and demonstration projects. For the five projects, the total proposed GEF commitment is US$ 59.6 million, with approximately US$ 36 million already approved.

4. Through the support of FCBs in GEF program countries, the GEF is fulfilling its role as an important agent of technology transfer in support of the UNFCCC. By encouraging the early adoption of these buses in a process of "technological leapfrogging", GEF/UNDP is helping developing countries gain experience with the FCB early in its product cycle. GEF program countries can then develop partnerships with technology developers, thereby increasing technological competence and adapting the technology to local needs. GEF Program countries will also benefit from reduced local air pollution, new export opportunities attributable to local manufacturing, and improved quality of public transit service. Finally, the GEF-UNDP will 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 interest in FCBs is justified on the basis of 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 can 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 GEF-UNDP strategy for FCB commercialization involves a working partnership between GEF, private industry, and local/national governments in GEF Program Countries. The GEF will play three important roles. The first role is funding the incremental costs of FCB projects in recipient countries. The second is facilitating the process of FCB commercialization in developing countries by convening various parties to discuss, collaborate in, and finance the commercialization program. The final role is that of enabling information exchange within and between program countries, 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 GEF/UNDP 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.

[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

2.1 DaimlerChrysler/Ballard Fuel-Cell Bus demonstration program[2]

8. In by-far the largest of the demonstration projects reviewed here, a total of 33 full-size (12 meter) Citaro buses built by EvoBus, a wholly-owned subsidiary of DaimlerChrysler, will be operated for approximately 2 years each in 11 different cities to test and demonstrate FCBs in revenue service. Each bus is powered by a 250 kW gross (200 kW net shaft power) Ballard fuel cell engine and operates using hydrogen stored at 350 bar pressure in roof-top cylinders. The delivery of the first bus (in April 2003 to Madrid) was preceded by an 18-month engine testing program. Three buses were delivered to the transit agencies in each of ten of the eleven cities between April and December of 2003, and revenue service began in some of these cities in 2003. Delivery of three buses to Perth is anticipated in 2004. The demonstration period is planned to last until late 2005, after which ramp up to commercialization by 2010 is planned.

9. The participating cities in CUTE are Amsterdam (Figure 1), Barcelona, Hamburg, London, Luxembourg, Madrid, Perth, Porto, Reykyavik, Stockholm, and Stuttgart. With the exception of Reykyavik and Perth, the activities in these cities are tied together under the CUTE (Clean Urban Transport for Europe) Project. The Reykyavik activity falls under the ECTOS (Ecological City Transport System) project, and the Perth effort is part of the STEP (Sustainable Transport Energy for Perth) Project. The eleven cities have a wide variety of climates, topographies, and traffic patterns under under which the buses will operate. Additionally, a variety of hydrogen sources will be demonstrated, including steam methane reforming (Madrid and Stuttgart), oil refinery excess hydrogen (London and Perth), electrolysis with grid electricity (Luxembourg and Porto), and electrolysis from geothermal and hydropower (Reykyavik), among others. The breadth of conditions under which testing will be conducted and the expected extensive amount of data that will be collected should provide considerable advances in understanding the prospects for near-term commercialization of FCBs.

10. The cost of the Citaro buses in this program is difficult to ascertain with accuracy. One report[3] indicates that the total cost for the CUTE project (purchase of 9 buses, associated refueling station, and operating and maintenance costs) is 52 million Euro or US$63m at the early-April 2004 exchange rate, which is an average of $2.3m per bus including the refueling station and all other costs. The European Union is funding 18.5 m of the 52m Euro cost. An article in Fuel Cell Today[4] reports that the purchase price of each Citaro bus is around US$1.5m, including all maintenance required to keep the buses operating for two years. This cost estimate appears to be consistent with the total average per-bus cost (including refueling station) of US$2.3m/bus mentioned earlier.

[2] W. Rau, "DaimlerChrysler Fuel Cell and Alternative Powertrain Vehicles Strategy and Bus Program," presentation at the International Fuel Cell Bus Workshop, Nov. 19/20, 2003, Long Beach, CA, organized by Electric Drive Transportation Association in conjunction with the America Public Transit Association and Federal Transit Administration of the US Department of Transportation. (Held at EVS-20, The International Electric Vehicle Symposium.)
[3] "DaimlerChrysler hands over first fuel cell bus to Madrid," *Fuel Cells Bulletin*, June 2003.
[4] M. Cropper, "Fuel Cell Market Survey: Buses," *Fuel Cell Today*, 26 November 2003 (www.fuelcelltoday.com).

Figure 1 - The Citaro bus in Amsterdam was delivered in December 2003 as part of the CUTE program

2.2 California Fuel Cell Partnership Fuel-Cell Bus Demonstrations[5,6]

11. All California transit bus agencies will be required to purchase some zero emission buses (ZEBs) by 2010, with agencies on the “diesel path” required to begin such purchases by 2008. The ZEB mandate is driving projects in California to help catalyze the commercialization of FCBs. Three FCB demonstration projects have been launched as part of the California Fuel Cell Partnership (CaFCP). The Santa Clara Valley Transportation Authority (VTA) in San Jose will take delivery this year of three forty-foot FCBs with 205 kW Ballard fuel cell engines integrated with Gillig chassis. AC Transit in Oakland will take delivery in late 2004 of three forty-foot FCBs utilizing 170 kW UTC fuel cells and either batteries or ultra-capacitors (to meet peak loads and for regenerative braking) integrated by ISE Research onto Van Hool chassis. The Sunline Transit Agency in Thousand Palms will have one bus similar to the AC Transit buses, but will use a composite body made by North American Bus Industries (NABI). Sunline has previous demonstration experience with the ThunderPower FCB (UTC fuel cell engine in a Thor Industries bus) in late 2002 (Figure 2) and prior to that (2000-2001) the Zebus, featuring an Xcellsis/Ballard fuel cell engine.

12. The cost of the buses for the California projects is apparently considerably higher than the cost for the CUTE buses. It is reported that Santa Clara VTA has budgeted $10.5 million for delivery of three buses in 2004,[4] or $3.5 million per bus. It is unclear whether this is the total project cost (e.g., including the cost for the refueling station) or just the price for the buses.

[5] K. Koyama, “California’s Fuel Cell Bus Program,” presentation at the International Fuel Cell Bus Workshop, Nov. 19/20, 2003, Long Beach, CA, organized by Electric Drive Transportation Association in conjunction with the America Public Transit Association and Federal Transit Administration of the US Department of Transportation. (Held at EVS-20, The International Electric Vehicle Symposium.)

[6] Information available at http://www.navc.com/.

13. The data collection period for the seven CaFCP buses is planned for 2004 to 2006. The National Renewable Energy Laboratory (NREL) of the US Department of Energy will be working with the transit agencies to collect data and evaluate bus performance and fueling. Data to be collected include O&M costs, range and fuel consumption, stack reliability, service availability, operator training effectiveness, public acceptance, safety, and others. A similar data collection/evaluation effort was completed by NREL for Sunline testing of the ThunderPower Bus during late 2002/early 2003.[7]

Figure 2 - The Thor Industries ThunderPower bus with a UTC fuel cell engine was operated in revenue service in 2003 at Sunline Transit in Thousand Palms, California

2.3 Japanese Hydrogen Fuel-Cell Bus Demonstration Program[8]

14. Toyota, in collaboration with the bus manufacturer, Hino, and with support from the Japanese government has been quietly, but actively developing FCBs. Their activities have been given greater prominence in public forums during the past year. Their efforts date to 1999, when a Hino bus with a 90 kW Toyota stack was operated on a test track. Subsequently, the development of a Hino bus with twin 90 kW Toyota stacks was initiated, and in September 2002 four buses (model name FCHV-BUS2) were certified by the Japanese government for public road tests (non-revenue service) to take place through 2004. The FCHV-BUS2 model is 10.5 meter long and supplements the two 90-kW PEMFC stacks with nickel-metal hydride batteries. Hydrogen is stored at 350 bar on the roof.

15. One of the four buses was subsequently certified in July 2003 for operation in revenue service by the Tokyo city government (Figure 3). Service on two routes (3 to 4 round trips per day) began in August 2003 and will continue through the end of 2004. Refueling takes place at a station provided by Iwatani and Shell. Following the Tokyo demonstration, one or more of the buses are to be operated for a 6-month

[7] Center for Transportation Technologies and Systems, "Fuel Cell Transit Buses: ThunderPower Bus Evaluation at SunLine Transit Agency," DOE/GO-102003-1786, National Renewable Energy Laboratory, Golden, CO, November 2003.
8 H. Ishitani, "JHFC Demonstration Project – FC Bus Project," presentation at the International Fuel Cell Bus Workshop, Nov. 19/20, 2003, Long Beach, CA, organized by Electric Drive Transportation Association in conjunction with the America Public Transit Association and Federal Transit Administration of the US Department of Transportation. (Held at EVS-20, The International Electric Vehicle Symposium.)

run at the 2005 World Exposition in Aichi, Japan. According to an article in *Fuel Cell Today*,[4] Toyota is hoping to commercialize FCBs around 2010.

Figure 3 - This bus, jointly developed by Toyota and Hino, entered public revenue service with Toei Bus (Tokyo Metropolitan Bus Service) in August 2003.

2.4 Chinese Fuel-Cell Bus Development Effort[9]

16. Perhaps spurred by UNDP/GEF FCB project development efforts, the Chinese government is pursuing an aggressive FCB commercialization program, with an interim goal of placing 100 FCBs in service at the Beijing Olympics in 2008.[10] The "863 Program" (named for the date it was created) 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 expected to invest an additional $200-300m during the next 5 years. 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, leading to 100 FCBs at the 2008 Olympics.

17. Two companies, the Shanghai Shen-Li High Tech and Dalian Sunrise Power (a spin-off of the Dalian Institute of Chemical Physics – DCIP) are developing FC engines for the vehicles, and system integration work will be done by Tsinghua University and the Shanghai Fuel Cell Vehicle Powertrain Company (Figure 4). A key player in the Chinese FCB development efforts has been the DCIP. Its engineers 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. While the DCIP is among the most prominent Chinese fuel cell engine technology developers, there are many other Chinese research institutes and companies participating in a myriad of FC-related development efforts.[10]

[9] These efforts are separate from the UNDP/GEF FCB in China.
[10] S. Geiger, "Fuel Cells in China – A Survey of Current Developments," *Fuel Cell Today*, 15 October 2003 (www.fuelcelltoday.com).

Figure 4 - The Dalian Institute of Chemical Physics (DICP) unveiled this hybrid fuel cell bus (30 kW fuel cell) in December 2002.

2.5 Other Fuel-Cell Bus Demonstration Activities

18. Several additional FCB demonstration projects, briefly mentioned here, have been launched recently. None of these are at the scale of more than one or two buses. A summary of all FCB projects is provided in Annex I.

- **Hydrogenics** is a relatively new Canadian fuel cell engine company that has gotten significant exposure recently as a result of its involvement with two FCB projects.[4,11] **Natural Resources Canada (NRCAN)** is providing US$2 million to support the integration of a 180 kW Hydrogenics PEMFC into a New Flyer transit bus, with ultracapacitors included for regenerative breaking. Apparently, the bus design will be such that it can supply electricity to the grid when not in transit duty. **ISE Research** is participating as a system integrator. Testing of the bus is slated to begin at Winnipeg Transit in late 2004. In a separate project, the **United States Air Force** contracted Hydrogenics beginning in July 2003 to provide a 20 kW PEMFC module for a 30 foot hybrid bus that will be demonstrated in Hawaii.

- **Proton Motor** (Germany), of which **Volvo** holds a minority share, is also a relatively new PEMFC developer/supplier. To date, Proton Motor has built two prototype FCBs using **Neoplan** buses. Now, with backing from the German government, it will supply a demo bus to Berlin. Evidently, FCBs for other European cities are in the pipeline. Proton Motor also is planning actively for mass production of fuel cell engines and FCBs.[4]

- **UTC Fuel Cells** has previously supplied automotive-scale fuel cell engines to **Thor Industries** and to **Irisbus (a Fiat subsidiary)** for use in hybrid configurations. In November 2002, it won a $2.6m award from the **U.S. Department of Transportation** to develop a 200kW PEMFC engine for buses. UTC is adding $2m of its own money to this effort, which is being managed by the **Northeast Advanced Vehicle Consortium**. An FCB demonstration in Connecticut is being targeted for 2004.[4]

- **Ballard** is working with **MAN** to integrate a 65 kW PEMFC to power a forty-foot bus in a demonstration at **Munich Airport** expected to begin in 2004.[11] MAN is projecting series production of fuel cell drive systems starting in 2010.[12]

[11] Information found at the website of the Northeast Advanced Vehicle Consortium (www.navc.com).
[12] See news release at http://www.mn.man.de/presse/en/aae/aa52e.htm.

- 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. [4] 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.[13] This "FEBUSS" project is slated to run until 2006, culminating with one or more FCB demonstration.

- The **European Citycell Project** was designed to involve the operation of four different hybrid FCBs in Berlin, Madrid, Paris, and Turin. The Turin bus, an **Irisbus** using a **UTC Fuel Cell** engine, was developed in 2001 however its operating history is not clear. The Madrid bus, also an Irisbus with a UTC fuel cell engine, was unveiled in May 2003. Completion dates for the Paris and Berlin buses, which are to use fuel cell systems developed by **Axane** and **Hydrocell**, respectively, have evidently not yet been announced.

- **Georgetown University** has long maintained demonstration efforts with methanol FCBs (using on-board reforming of methanol) in hybrid configuration with batteries. Their efforts have been supported primarily by U.S. government funding. The **Washington Metropolitan Area Transit Authority** was to operate Georgetown's second-generation PEMFC bus (Ballard fuel cell with methanol fuel) in revenue service during 2003. A third generation bus is being planned that will use methanol fuel, but without battery hybridization.

- The **Dallas Area Rapid Transit** plans to issue an RFP for a demonstration FCB.

- An unsuccessful demonstration project funded by the European Commission (2000-2003) was aimed at demonstrating liquid hydrogen FCBs in Berlin, Copenhagen, and Lisbon. The project evidently had technical problems that were never overcome.[11]

2.6 Trends in the Fuel-Cell Bus Market

19. FCB hardware and software (codes, standards, training protocols, etc.) have not progressed down the cost curve toward commercialization in the past one to two years as rapidly as originally anticipated. This conclusion is consistent with statements in the 2004 report from the U.S. National Research Council on hydrogen.[14] The report states that "there will likely be a lengthy transition period during which fuel cell vehicles and hydrogen are not competitive with internal combustion engine vehicles, including conventional gasoline and diesel fuel vehicles, and hybrid gasoline electric vehicles." It goes on to say "…fuel cell prototype costs for light-duty vehicles are still a factor of 10 to 20 times too expensive and are short of required durability." The analysis of hydrogen vehicles in the NRC report was limited to cars, but these conclusions can be extended reasonably to buses (though the cost targets are not as severe for buses as for cars, so the factor may be lower than 10 to 20). Similar conclusions emerge from a report of the American Physical Society published in March 2004.[15]

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[13] See http://www-leg.ensieg.inpg.fr/eur_procourl3.html.

[14] Committee on Alternatives and Strategies for Future Hydrogen Production and Use, *The Hydrogen Economy: Opportunities, Costs, Barriers, and R&D Needs,* National Research Council, National Academy of Engineering, The National Academies Press, Washington, DC. prepublication copy (www.nap.edu), 2004.

[15] Panel on Public Affairs, *The Hydrogen Initiative,* American Physical Society, Washington DC, March 2004.

20. Despite less optimism today about the rate of commercialization, industry and government investment in the FCB industry have been sustained, helped in part by the U.S. government's new hydrogen initiative (announced in January 2003) that makes available $1.2 billion over five years for hydrogen and fuel cell research, development, and demonstration.[16] The first major vehicle demonstration projects under the initiative will be awarded in 2004.

21. Even before the new U.S. initiative was announced, there had been put in motion significant steps forward in FCB development. One important indicator of progress is the doubling from 2002 to 2003 in the cumulative number of FCBs built and operated worldwide (Figure 5), with the European Clean Urban Transport for Europe (CUTE) project accounting for the lion's share of the added units. There will be an additional significant quantum jump in number of FCBs in 2004 as a result of the activities of the California Fuel Cell Partnership and other announced FCB demonstration activities. Understanding of the major remaining challenges today to FCB commercialization – cost, durability, and reliability – will be greatly advanced by the current demonstration efforts. Also, there are some notable new entrants (e.g., Hydrogenics) or newly-prominent entrants (e.g., Toyota) in the transit bus fuel cell engine supplier market, which bodes well for future increased competition that can help further reduce costs and improve performance.

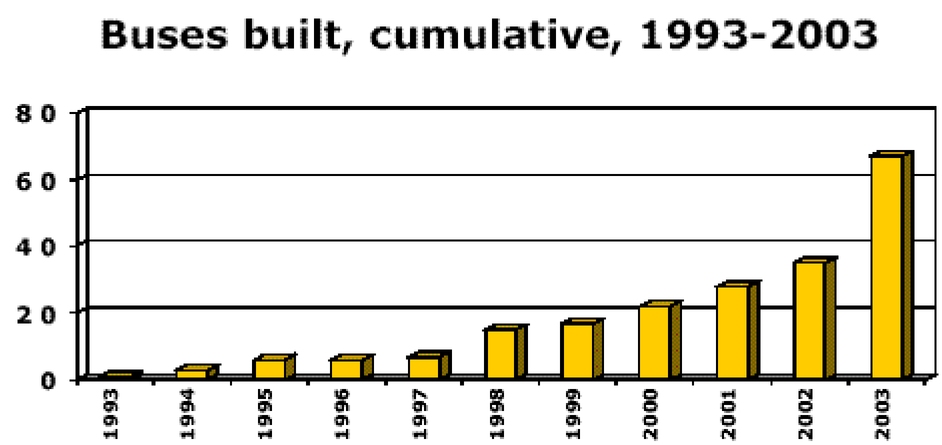

Figure 5 – Cumulative FCB production worldwide: 1993 to 2003
(Source: M. Cropper, "Fuel Cell Market Survey: Buses," *Fuel Cell Today*, 26-11-03, www.fuelcelltoday.com)

22. Based on a NAVC survey of a wide range of industry experts published in late 2003, there appears to be a consensus that transit bus applications will reach commercialization at least 5 years ahead of private cars. The primary reasons for this are the easier (centralized) refueling and maintenance, easier cost target, and higher value of environmental attributes of fuel cell engines relative to internal combustion engines in densely populated urban settings. It appears that most of the major FCB demonstration projects ongoing today will have significant new data in hand by late 2005, at which point suppliers can be expected to be actively looking for opportunities to test/demonstrate their next-generation of FCBs incorporating learning from their current efforts. (The delivery of any significant number of FCBs in the immediate future may be problematic due to the limited capacity of the fuel cell engine industry to both support existing demonstration efforts and launch new ones.) Depending on what

[16] K. Wipke (NREL), "Data Collection and Evaluation: Thoughts for the Fuel Cell Bus Market," presentation at the International Fuel Cell Bus Workshop, Nov. 19/20, 2003, Long Beach, CA, organized by Electric Drive Transportation Association in conjunction with the America Public Transit Association and Federal Transit Administration of the US Department of Transportation. (Held at EVS-20, The International Electric Vehicle Symposium.)

lessons are learned from the current round of demonstrations, it is conceivable that suppliers will be looking to begin ramping up toward series production building on the next round of demonstrations. Several fuel cell engine suppliers have announced that they have targets for commercialization of buses by 2010 (e.g., Toyota and MAN by 2010, and China is planning to have 100 buses on the road by 2008).

23. While not directly involving FCB demonstration efforts, several important initiatives have been launched and assessments have been published that have a bearing on the commercialization of FCBs. These are briefly reviewed below.

2.6.1 U.S. Federal Transit Authority (FTA) Initiative[17]

24. The U.S. FTA has a goal that 10% of new U.S. transit bus purchases will be FCBs by 2015 and maintains an initiative to catalyze the commercialization process. The activities under the initiative include support for research, development, and demonstration related to transit buses and hydrogen infrastructures, facilitating development of FCB guidelines for transit applications, and education and outreach efforts. Under this initiative, the FTA is supporting RD&D on three hydrogen bus concepts: 1) a full-FCB (with a 200-300 kW fuel cell providing all power), 2) a hybrid FCB using an automotive fuel cell (25-75 kW) and batteries for peak power and regenerative braking, and 3) a hybrid internal combustion engine/battery bus. With current technology, the first option is high cost. The second option involves more modest cost. The third option is not based on a fuel cell engine, but its introduction might help accelerate development of the hydrogen refueling infrastructure needed for FC vehicles.

2.6.2 National Fuel Cell Bus Technology Initiative (NFCBTI)[18]

25. The 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, Caterpillar), 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 an "earmark" in the Transportation Efficiency Act (TEA) of 2004, which will determine how U.S. gasoline taxes (~$0.18/gallon) are spent for the next six years. Discussion of funding appropriations under the TEA are ongoing in the U.S. Congress as of this writing. If funding for the NFCBTI is secured, the FCB development and commercialization effort in the U.S. would rival that of the European Union's CUTE program.

2.6.3 Northeast Advanced Vehicle Consortium (NAVC)[6,19]

26. The NAVC, based in Boston, has organized the U.S. Fuel Cell Bus Work Group (with FTA funding) to help catalyze commercialization of transit FCBs. The NAVC activities include offering a

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[17] S. Hsuing (FTA), "Hydrogen & Fuel Cell Bus Initiative Paving the Way Nationally & Internationally, presentation at the International Fuel Cell Bus Workshop, Nov. 19/20, 2003, Long Beach, CA, organized by Electric Drive Transportation Association in conjunction with the America Public Transit Association and Federal Transit Administration of the US Department of Transportation. (Held at EVS-20, The International Electric Vehicle Symposium.)

[18] J. Boesel, "National Fuel Cell Bus Technology Initiative: Accelerating the Use of Hydrogen in Transportation," presentation at the International Fuel Cell Bus Workshop, Nov. 19/20, 2003, Long Beach, CA, organized by Electric Drive Transportation Association in conjunction with the America Public Transit Association and Federal Transit Administration of the US Department of Transportation. (Held at EVS-20, The International Electric Vehicle Symposium.)

[19] L. Callaghan, "Forming an International Fuel Cell Bus Working Group," presentation at the International Fuel Cell Bus Workshop, Nov. 19/20, 2003, Long Beach, CA, organized by Electric Drive Transportation Association in conjunction with the America Public Transit Association and Federal Transit Administration of the US Department of Transportation. (Held at EVS-20, The International Electric Vehicle Symposium.)

forum for national/international cooperation and information exchange on the status of demonstration efforts, development of hydrogen delivery infrastructures, and relevant partnerships among bus manufacturers, integrators, transit agencies, etc. The NAVC is seeking to address early challenges to FCB deployment and commercialization through activities such as setting targets/goals for next generation FCBs and establishing data collection and evaluation norms.

27. The NAVC also conducts occasional surveys on relevant topics. A survey of the Fuel Cell Bus Work Group (slated for publication in Feb 2004, but not available at the NAVC website as of this writing) offers some insights on FCB commercialization.[19] Most survey respondents believe comparable performance and reliability to diesel buses are 10+ years away for FCBs, and comparable costs to diesel (not counting the cost of health and environmental impacts of diesel buses) are 15 years away, if ever. Durability, reliability, and cost are viewed as the key remaining obstacles to commercialization. Respondents felt that government-supported demonstrations are essential in shaking-out problems and providing trial and error testing opportunities.

28. The September 2003 report, "*Future Wheels II*,"[20] summarizes the findings from another relevant NAVC survey. Following up on *Future Wheels*, a similar survey report published in 2000, the 2003 report describes answers given by a variety of industry experts in interviews. Some of the findings relevant to the present discussion:

- The overall consensus of respondents was that there have not been any major fuel cell vehicle-related breakthroughs (e.g., a quantum leap in hydrogen storage technology) in the past three years, although there have been some advances in engineering issues with fuel cells (robustness, cost, efficiency).
- There was a striking consensus among respondents that the vehicle fuel choice debate has been settled. Direct hydrogen is considered the best and most attractive option, not only for FCBs (a long-held view among most in the field), but also for automobiles. There is still some work being pursued with on-board reforming, but progress in this area has not been what was anticipated three years ago.
- Competition is beginning to emerge around the potential engine suppliers for the fuel cell vehicle industry, with some shakeout of weaker technologies/businesses. This suggests an evolution toward maturity for this industry.
- Given the developmental status and low production volumes for fuel cell vehicles, costs are not necessarily out of line with where they should be expected to be. Three competing theories of the future commercialization pathway emerged from respondents:
    - (i) "Following the cost curve." In this scenario, premium stationary-power applications and high-value micro applications (PDAs, PCs, etc.) will be commercialized first, followed by transit and fleet vehicles, followed by cars, the latter requiring the lowest FC cost per kW to be competitive;
    - (ii) "Following the durability curve." In this scenario, infrequently-used back-up stationary power supplies and cars, which need only ~5000 hour stack life, enter the market first because increased lifetimes will require further development. Transit vehicles, needing 10,000+ hour lifetimes and primary stationary-power systems, needed 40,000+ hour lifetimes, will enter the market later;[21]
    - (iii) "Market volume is the driver." In this scenario, the only application that is commercialized is automobiles, since this is the only market large-enough to justify the large investments required for commercialization. The market for new cars in the U.S. is 17 million/year. The U.S. transit vehicle market is 5000 new units/year and similar to the stationary applications

[20] NAVC, "Future Wheels II: A survey of Expert Opinion on the Future of Transportation Fuel Cells and Fuel Cell Infrastructure," Northeast Advanced Vehicle Consortium, Boston, MA, September 2003. (www.navc.org)
[21] Estimates gleaned from various sources suggest stack lifetime currently is in the range of 2000 to 4000 hours.

market. (The NAVC report notes that this is a U.S.-centric perspective. Thus, it does not take into account large transit bus markets in many other countries.)

- While these three views of commercialization pathways were expressed, there was, nevertheless, general agreement among respondents that commercial applications of transit buses would precede private cars by ~5 years due to *(i)* cost being less of an issue, *(ii)* centralized refueling and maintenance, greatly simplifying both of these, and *(iii)* the greater value of zero emissions in transit applications, since buses operate disproportionately in dense urban areas. The most significant obstacle to FCB commercialization mentioned by respondents is achieving 10,000+ hour stack lifetime.
- Competition from other governments, e.g. China 2008 Olympics and EU activity, is creating incentive to accelerate FC transit applications in the U.S.
- While there are some synergies between different fuel cell applications (e.g., stationary vs. mobile, car vs. bus, etc.), these don't appear to be considered as important in accelerating commercialization for any particular market as they were in the 2000 Future Wheels report.
- President Bush's hydrogen/fuel cell initiative (announced January 2003) has had a major positive impact on fuel cell development in the U.S., both in terms of funding and public awareness.
- The commercialization time frame has slipped since the 2000 Future Wheels report. Market penetration is now "a decade or more away". However,
  - All but one respondent believed fuel cells will eventually capture a significant share of U.S. auto and transit markets;
  - Three-quarters of respondents said significant market penetration (10% to 20% of new sales) would be reached sometime during 2010-2020. This is a less optimistic view than in the 2000 Future Wheels report; and,
  - Timing of market penetration will be affected by many factors, including petroleum prices, durability and life expectancy of fuel cells, level of government incentives and investment, evolution of codes and standards related to hydrogen, development of hydrogen fuel infrastructure.
- Cost, durability, reliability are key challenges. Demonstrations that have been set in motion will, during the next 1-2 years, help clarify the extent of these challenges and prospects for overcoming them.

3 FCB PROGRAMME IMPLEMENTATION

29. Consistent with the FCB Programme strategy, the five projects in the FCB Programme are being implemented in a phased manner as requested by the GEF Council. The major advantage of this phased approach to implementation is to maximize the structured learning from the earlier projects to the later projects. The Brazil project was first approved by the GEF Council in November 1999 and began implementation in November 2001. Mexico's FCB project began implementation in January 2002, followed by China in November 2002. Both Egypt and India's FCB projects have not yet been finalized. The status of each project is outlined below.

3.1 Brazil

30. In 2003, negotiations took place between eligible companies to form a consortium able to provide the hydrogen FCBs, supply equipment, storage and refueling systems under the project. A schedule was prepared to enable the signature of the supply contract with the project in 2004. Activities included technical updates (e.g., drive cycle studies and revision of technical specifications for the buses) and discussions among eligible suppliers to finalize a Memorandum of Understanding (MOU) for the consortium establishment.

31. The consortium of suppliers has been working towards finalizing the proposal for the project and all participating companies are actively interested in making this project viable. The structure of the consortium has been designed, and the final details concerning working relationships and respective responsibilities are now being addressed. Due to the slow development of the fuel cell market, the estimation of costs is also being revised. The MOU for the FCB suppliers' consortium is targeted for signature by the end of May 2004, and the contract for the provision of the buses is expected to be signed in July 2004. The first prototype is scheduled for delivery in September 2005, with the remaining buses delivered by early 2006.

32. As part of the development of the "Brazilian Strategy for Fuel Cell Technology" an agreement is being discussed between the Government of Brazil and other key national stakeholders. A first Ministerial working session was held on November 18-21, 2003 regarding this agreement and also to discuss the composition of the Executive Committee and its working groups. The UNDP/GEF FCB project is a fundamental part of the Brazilian strategy on fuel-cell technology. Discussions on the agreement will be informed by the UNDP/GEF project's results, while increased support from the Government to fuel cells will likely help to improve the FCB project's execution.

3.2 China

33. After the Project Management Office (PMO) was established, the project Inception Workshop was launched in Beijing on 27 March 2003. This workshop was attended by more than 100 representatives from the Ministry of Science and Technology, state government organizations, the cities of Beijing and Shanghai, UNDP China, technical experts, and potential FCB and hydrogen facilities suppliers including DaimlerChrysler, Toyota, ISE and Tsinghua University. More than ten media organizations reported on the meeting.

34. To fully understand the present status of potential suppliers' technologies, their capabilities for supplying FCBs, their level of interest in responding to a bid and to encourage wide participation in the bidding, the PMO and key stakeholders from Beijing and Shanghai conducted international study tours to Canada, Japan, USA and Germany. These tours included visits to FCBs and hydrogen refueling station suppliers from September to November 2003. Prior to the tours, the PMO released preliminary FCB and hydrogen supply specifications to the suppliers to seek their comments so that during the tours the teams could gather up-to-date information that was incorporated into the bid document technical specifications.

35. The China International Center for Economic and Technical Exchanges (CICETE) was entrusted by the PMO to lead the procurement activities. The international procurement document for the project was released at a news conference on 18 December 2003. This document was based on the Beijing and Shanghai requirements for the FCB performance, and included domestic and foreign technical standards and codes as well as conformed to national and GEF/UNDP procurement requirements. Four manufacturers participated in the bid prior to the bid opening on 18 March 2004.

36. According to the principles of "best value for money" and "fairness, integrity and transparency", the PMO set up the evaluation on 22-23 March 2004 based on the evaluation criteria included in the RfP. A bidder has been selected for award of contract, and negotiations with that bidder will start on 10 May 2004.

3.3 Mexico

37. During 2003, the national executing agency STE (Servicios de Transportes Eléctricos/Electrified Transport Agency) initiated and oversaw scoping studies to assist in identifying possible strategies for the procurement of FCBs. While the scoping activities indicated that a call for expression of interest at this time would most likely result in delivery dates beyond what is currently contemplated in the project

document, nevertheless, STE strongly supports the continued development of the project. STE plans to update technical specifications and submit a call for expression of interest in the second quarter of 2004. The second quarter of the 2004 work program will also concentrate on human resource development, and resolving technical issues related to the hydrogen generation and refueling infrastructure.

38. Current thinking within the Mexican project team points towards the inclusion of hybrid FCBs in the technical specifications, as the transport sector in Mexico City is gradually expected to incorporate both clean diesel and compressed natural gas hybrid electrical vehicles to replace the existing fleet. These technical specifications (and eventual delivery of vehicles) would be tiered to provide the most flexibility in an uncertain supply market, as well as to ensure an adequate transition from Part I to Part II. Overall, the Mexico FCB project is working with the World Bank project on modal shifts in the transport sector to promote synergies and complementary activities between the various activities of these projects.

3.4 Egypt and India

39. One of the main implementation strategies of the FCB Programme is project phasing for structured learning, where FCB projects underway provide lessons learned to those beginning implementation at a later time. A key lesson learned concerns the procurement of FCBs, and specifically the validation of the FCB Programme strategic assumption that FCBs can be procured. To this end, the Egypt and India FCB projects had been advised by UNDP, with the guidance of the GEF Secretariat and the support of the GEF Council, to wait for the Brazil, China and Mexico FCB projects to advance sufficiently that the procurement related assumption could be validated.

3.5 Networking Initiatives

3.5.1 First International FCB Workshop

40. The FCB Programme has continued to pursue opportunities for effective information exchange serve to strengthen GEF/UNDP's FCB Programme. The GEF/UNDP FCB Programme participated in the First International Fuel Cell Bus Workshop held in Long Beach, California on November 19-20, 2003. The Electric Drive Transportation Association (EDTA) and the U.S. Department of Transportation's Federal Transit Administration organized this meeting that was 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 GEF/UNDP FCB projects.

41. This Workshop provided an opportunity for the international community to share, first-hand, information about the current, worldwide status and prospects for fuel cell electric bus technology in the global market, and the policies and programs that have been advocated throughout the world to support their development and use. In addition, the stakeholders discussed the need for, and the appropriate elements of, an international data collection program specific to FCBs and supporting infrastructure. Finally, the workshop participants explored the idea of developing an International Fuel Cell Bus Stakeholder Group to develop and share information that would be generated by any data collection program, as well as future collaboration and coordination in the research, development, and demonstrations of future generations of FCBs.

42. At the Workshop, the GEF/UNDP programme as a whole was represented by UNDP, and the activities underway by UNDP/GEF to promote the development and use of FCBs in developing countries were highlighted. In addition, representatives of the Brazil and China FCB projects made separate presentations on their GEF-funded FCB initiatives.

3.5.2 European FCB Demonstration Projects Conference: Bringing a FCB fleet on the road in European cities

43. To continue to foster an exchange of experience between GEF/UNDP FCB Projects under implementation and other demonstration projects around the world, the GEF/UNDP FCB projects from Brazil, China, and Mexico will likely participate in an upcoming conference in London hosted by the CUTE and ECTOS projects. The purposes of this 14-15 June 2004 meeting are to give an overview of the activities undertaken for setting up the 10 participating sites and preparing 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.

44. This international meeting will also provide an opportunity to increase the sharing of lessons learned and to actively explore 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. UNDP core funding will be provided to help ensure the matching and communication arrangements between cities.

3.5.3 Australia's Hydrogen and Fuel Cell Futures Conference

45. This conference held in Perth, Australia, September 12-15 2004, will bring together international experts in the fields of hydrogen, fuel cells and sustainable transport energy policy, politics and practice. Discussion will focus on the latest developments in the world of sustainable transport energy and strategies for the future, including current research and trials of fuel cells and hydrogen powered transport, what the next steps might be in the transition to a hydrogen-based future, strategic directions in transport energy policy, the transition to sustainable energy systems, and trials and demonstrations of hydrogen and fuel cell vehicles. The Brazil FCB project will be represented by STE and will present on the experiences and achievements of the project to date.

4 NEXT STEPS

46. The next steps and associated recommendations for the GEF/UNDP projects are described in the following section. A summary of key planned activities for GEF/UNDP FCB programme during May 2004-2005 are summarized in Table 1 below.

4.1.1 Brazil

47. The Ministry of Mines and Energy will prepare a technical note outlining the new political context and discussing fuel cell technology as it pertains to Brazil, including the roadmap for the hydrogen economy in the country. The GEF/UNDP project is participating in the elaboration of this technical note and is included in the national strategy under preparation.

48. Based on the project's progress to date, and discussions on the preparation of the MOU to be presented by the suppliers Consortium, the Project is preparing a substantive revision to be submitted to UNDP and ABC/MRE (Agência Brasileira de Cooperaçâo/ Ministério das Relações Exteriores) for signature in the second quarter of 2004. As mentioned, this substantive revision will adjust the project context to reflect recent developments in Brazil, in addition to updating the work plan, project duration, and, eventually, final costs.

4.1.2 China

49. During the coming negotiation with the FCB supplier, the main focus will be on the technical specifications and commercial requirements for production and delivery of the FCBs. However, the discussion will also formalize issues such as building the hydrogen refueling stations, and how and when to request additional funding for the project.

50. After signing the contract, the first three FCBs are scheduled to be delivered by September 2005 and put into service after an evaluation period. Meanwhile, the PMO is planning construction of the hydrogen supply stations in consultation with potential companies.

51. Two policy study tours are planned to visit Spain and Sweden, in August, and England and the Netherlands, in October. The objective of these tours is to better understand policy and planning approaches that could be applied to improve public bus systems in China and to learn from the Europe FCB and hydrogen facilities operation and management experience.

52. The Chinese Government believes the China FCB project is very important. Because of this, the Ministry of Science and Technology (MoST) is planning to contribute additional funds to help build the hydrogen supplying stations and local cities are trying to mobilize additional funds to build FCB repairing facilities and to cover operation costs and unexpected costs during the life of the project.

53. Based on the outcomes of the negotiations with the FCB supplier and the establishment of the hydrogen fuel supply infrastructure, the project will prepare for submission of Part II of the project (for up to US$5,767,000 of GEF funding).

4.1.3 Mexico

54. The conclusions from the 2003 scoping activities, the change in February 2004 of STE top management, and the on-going developments of the other UNDP/GEF projects have prompted STE to initiate a substantive revision of the workplan for 2004. The revised workplan will includes specific elements for developing technical and operational capacity related to FCBs through proposed collaboration with Mexican institutions familiar with fuel cells and transportation technologies.

55. Initial outreach by the Mexican project team with the AC Transit California Hydrogen FCB project may result in the signing of an MOU during 2004 to share knowledge, experience and technology under the overall framework of the Mexican FCB project.

4.1.4 Egypt and India

56. The progress of Brazil and China, and other demonstrations around the world have shown that it is possible for FCBs to be procured through a competitive process[22]. As outlined in Section 3.1, Brazil is successfully negotiating with a consortium to supply and support a FCB fleet in Sao Paulo; and in China, the recent RfP yielded positive responses. The increased number of FCB demonstrations in developed countries (see Section 2) also indicates that the production of FCBs – although understandably at a non-commercial stage – is advancing and could support the UNDP-GEF FCB projects in both India and Egypt.

[22] 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.

57. The recommendation by UNDP-GEF to the GEF Council is 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 the November 2004 or May 2005 GEF Councils. Prior to that time, UNDP and the participating governments will ensure that:

- cofinancing from governments is finalized and committed to the project with the relevant cofinancing letters obtained;
- implementation arrangements are negotiated and finalized;
- project documentation is 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, are finalized.

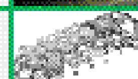
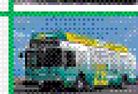
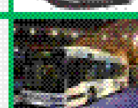
58. If these projects fail to meet the above requirements prior to the May 2005 GEF Council, the Council may reserve the right to recommend cancellation of either or both of the Egypt and India FCB projects.

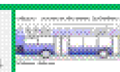
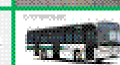
Table 1 - Summary of Key Planned Activities for GEF/UNDP FCB Programme May 2004-2005

GEF/UNDP FCB Project	***Key Planned Activities for May 2004 - 2005***	***Timeline***
Brazil	• Finalize MOU for supply of buses • First delivery of buses	• Second quarter 2004 • September 2005
China	• Finalize negotiations with supplier • First delivery of buses • Prepare for submission of Part II of the project (for up to US$5,767,000 of GEF funding)	• May 2004 onwards • September 2005 • September 2004 onwards
Mexico	• Launch call for expression of interest	• Third quarter 2004
Egypt	• Finalize cofinancing from government • Finalize implementation arrangements • Update and finalize project documentation, including technical specifications, monitoring and evaluation plan	• May 2005
India	• Finalize cofinancing from government • Finalize implementation arrangements • Update and finalize project documentation, including technical specifications, monitoring and evaluation plan	• May 2005

Annex I – Summary of fuel cell bus projects, October 2003

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 later in 2003	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/ ultra capacitors hybrid	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	
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. Madrid's 1st Citaro has been delivered.	**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.	Will be demonstrated in Torino, Italy 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 Nurenberg, 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 from early 2004 onwards.	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	Hydroge nics	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	Not Compl	Fuel cell/ battery hybrid	PEMFC Ambient-pressure	UTC Fuel Cells	250mi 400km	65mph 105km/h	5,000 psi Compress. 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
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	
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	180kW PEMFC	Toyota	186mi 300km	50mph 80km/h	Compress. Hydrogen @ 5,000 psi	
Hino Motors Ltd. (Toyota subsidiary)	Tokyo metro. gov. will use this bus during summer 2003 on Tokyo's new 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, which will start testing in 2003	15.3 meter long Double-Decker	Not Compl	N/a	N/a	Proton Motor Fuel Cell GmbH	N/a	N/a	Hydrogen