BACKGROUND THE PROJECT

The project involves the acquisition, operation and maintenance of up to five fuel cell buses, which will operate in the Metropolitan Corridor São Mateus / Jabaquara (São Paulo), as part of a four year program. A hydrogen fueling station (producing the hydrogen by electrolysing water) will be built to fuel the buses.

PROJECT HISTORY

In the period from 01/07/1997 to 30/04/2000 with the support from the Ministry of Mines and Energy (MME), the São Paulo Metropolitan Urban Transport Company (EMTU/SP), the United nations Development Programme (UNDP); and with the Global Environment Facility (GEF)'s financing of US$ 344,124.00, the first phase of the project has been completed with the following results:

- preparation of the feasibility study for the use of fuel cell buses in the Brazilian urban transport; and
- presentation of the project's proposal, phase two, for a fuel cell demonstration in revenue service and the installation of a hydrogen station by electrolysis in a bus garage.

The results of the first phase have been presented to the GEF and approved in December 1999, ratified in December 2000 to start the second phase.

The phase two of the project started in the second semester of 2001 and involves the acquisition, operation and maintenance of up to five fuel cell buses, which will operate in the Metropolitan Corridor São Mateus / Jabaquara (São Paulo), as part of a four year program. A hydrogen fueling station (producing the hydrogen by electrolysing water) will be built to fuel the buses.

The objectives of the project are:

- to develop a zero emission public transportation solution, which contributes to the reduction of carbon dioxide (CO_2), nitrogen oxide (NO_x), particulate, carbon monoxide (CO) and hydrocarbons (HC).;
- to build an understanding of fuel cell and hydrogen technology, enabling Brazil to obtain a leading position, due to its potential market;
- to work to develop expertise and knowledge in Brazil, with bus operators, manufacturers, universities, and schools, with the objective of creating a market for hydrogen and fuel cell technologies;
- to develop Brazilian specifications for the safe and efficient production, handling, stationary and automotive applications, enabling the development of a safe and efficient use of hydrogen.

For the implementation of this phase the following documents and agreements between the MME, EMTU/SP, the UNDP and FINEP have been signed:

- Project's document (PRODOC) – signed in 25/10/2001
- Agreement between the EMTU and the MME – signed in 01/11/2001
- Agreement between the MME and FINEP – signed in 26/03/2002

In 16/01/2002 a "Request for Expression of Interest" has been published for a market evaluation and a preparation for the consortium formation of the project's suppliers.

In 2003, took place the first negotiations with the technology manufacturers, which replied to the "Request for Expression of Interest" to form the consortium.

The negotiations continued until 2006, when the contract for the supply of the buses and the hydrogen infra-structure has been signed between the United Nations Development Programme (UNDP) and the companies members of the consortium.

During this phase, the project has been divided in two phases. The first phase involves the implementation of the hydrogen infrastructure and the building of a test bus prototype, which results will define the technical concept for the next buses, which will be produced and tested in the second phase.

The project established a strategy, with the objective of creating interest for the industry participation, in order to promote a new opportunity to advance one step forward in the development of this technology regarding the vehicle performance and production costs, beyond the projects already in place in several cities around the world.

This strategic objective intended also to enable a broader participation of the Brazilian manufacturers, in order to give an additional value to the project, not only internationally but also inside Brazil, to contribute for the market introduction of this technology in a mid term.

The Brazilian project will fulfil with great expectation a gap in the global process of the hydrogen technology's development, occupying a highlight position.

PARTNERS

MME – Ministry of Mines and Energy is responsible for the National Direction of the Brazilian Fuel Cell Bus Project. This Project is included in the Federal Government´s policy of hydrogen introduction in the Brazilian energy spectrum and the coordination of activities is under the Secretary of Oil, Natural Gas and Renewable Fuels, of the MME.

EMTU – São Paulo Metropolitan Urban transport Company, which belongs to the Secretary of Metropolitan Transport of the São Paulo State, is the Implementing Agency.

The EMTU/SP is one of the largest urban transit authorities in the country, working in three metropolitan regions of São Paulo State: RMSP (Grande São Paulo, with 39 cities), RMBS (Baixada Santista, with 9 cities) and RMC (Campinas, with 19 citiers). The total bus fleet of EMTU´s system is approx. 12.000 vehicles.

EMTU has developed an environmental policy to apply in its transportation system and the Brazilian Fuel Cell Bus Project is within this policy.

UNDP – The United Nations Development Program is the GEF´s implementing Agency for this project. The UNDP provides technical and administrative support to this project and its Environment, Energy, Science and
Technology Unit has participated in the project development and successfully obtained the project´s approval and financing from the GEF, which is the International financing mechanism in the benefit of the global environment.

GEF – Global Environment Facility – is the Multilateral Financing Mechanism. For this project the resources are administered through UNDP. The amount destined to this project is US$12.3 million.

The financing has been conceived by the GEF because of the environmental concept of this project: a zero emission vehicle. In addition the hydrogen, which is the vehicle´s fuel, will be produced by electrolysis, using the electricity produced by a renewable source, since more than 90% of the electricity produced in Brazil comes from hydro-power.

FINEP – Financing Agency of Studies and Projects is the National Financing Agency. Which belongs to the Ministry of Science and Technology. For this project its resources have been given to the MME – Secretary of Oil, Natural Gas and Renewable Fuels, which itself forward to the UNDP, which administrates those resources. The amount of money destined to this project is 3.3 million.

CONSORTIUM MEMBERS:

AES ELETROPAULO, a Brazilian company, the biggest electrician distributor in Latin America, will be responsible for: (i) the power substation specifications, design and approval; (ii) the connection of the power substation to the power grid; and (iii) assuring the energy quality and availability of power substation operation until the delivery point.

BALLARD POWER SYSTEMS, a Canadian company, is recognized as the world leader in the design, development and manufacture of zero-emission PEM fuel cells. More than 140 vehicles powered with Ballard fuel cells are on roads around the world today. Ballard will supply automotive fuel cell stacks to the project, as well as its extensive knowledge and experience gained through five generations of fuel cell bus demonstration projects.

EPRI INTERNATIONAL, is the international arm of the Electric Power Research Institute (EPRI), a scientific research organization established in 1973 as an independent, nonprofit center for public interest energy and environmental research. With its major locations in Palo Alto, California, and Charlotte, North Carolina, EPRI brings together member organizations, the Institute´s scientists and engineers, and other leading experts to work collaboratively on solutions to the challenges of electric power. These solutions span nearly every area of power generation, delivery, and use, including health, safety, and environment. EPRI´s members represent over 90% of the electricity generated in the United States. EPRI will be the Project Manager and Leader of the Consortium, sharing lessons learned, coordinating acceptance tests and the evaluation of final products, and performing simulations to determine an optimum hybrid concept according to the EMTU´s corridor drive cycle.

HYDROGENICS, a Canadian company, is recognized as a world leader in the development and production of electrolytic hydrogen fuelling systems. Hydrogenics, will supply eletrolyser, compression storage and dispenser equipment and technical expertise for the hydrogen station. Hydrogenics will work together with Petrobras Distribuidora and Eletropaulo to enable site preparation installation, commissioning and training for maintenance and safe operation of the hydrogen station.

MARCOPOLO, a Brazilian company, the biggest bus body builder in America, will be the bus body supplier. Its established capabilities in Brazil will ensure the continuity with the current local vehicle fleet bys production and export.

NUCELLSYS, joint-venture of Daimler-Chrysler and Ford Motor Company, located in Germany, is a world leader in the development, fabrication and marketing of fuel cells systems for automobile application, and will provide fuel cell systems, support to bus integration, training, maintenance and service.

PETROBRAS DISTRIBUIDORA, Brazil´s largest fuel distribution company with more than 7.000 service stations, will be the prime integrator of the hydrogen fueling station and will also bring the experience of Petrobras´ Research & Development Center (CENPES). Since forty years PETROBRAS is leader in byproduct distribution in Brazil, and one of the twenty major oil corporations in international ranking.

TUTTOTRASPORTI, a Brazilian company with long experience in chassis development, production, chassis modifications and alternative propulsion systems. Tutto will be the complete vehicle integrator and will work together with world class suppliers, to design and build the fuel cell bus, including technical documentation, integration of the fuel cell and electric propulsion systems, tests and certification.

TECHNICAL BACKGROUND

A fuel cell combines hydrogen fuel and oxygen from air to produce electrical energy efficiently, quietly and without combustion. The only by-products are water and heat. Fuel cells offer automotive manufacturers the opportunity to develop zero-emission vehicles. The hydrogen fuel can b e produced from renewable resources, such as biomass, wind and solar energy. This makes an important contribution to sustainable mobility and enables independence from fossil fuels. Fuel cell vehicles are two to three times more efficient than vehicles using internal combustion engines.

THE FUEL CELL

The core of the Ballard ® fuel cell consists of a membrane electrode assembly (MEA), which is placed between two flow-field plates. The MEA consists of two electrodes, the anode and the cathode, which are each coated on one side with a thin layer of catalyst, and are separated by a proton exchange membrane (PEM). The flow-field plates direct hydrogen to the anode and oxygen (from air) to the cathode.

When hydrogen reaches the catalyst layer, it separates into protons (hydrogen ions) and electrons. The free electrons, produced at the anode, are conducted in the form of a usable electric current through the external circuit. At the cathode, oxygen from the air, electrons from the external circuit and protons combine to form water and heat.

To obtain the desired amount of power, fuel cells are stacked together to form a fuel cell stack. Increasing the number of cells in a stack increases the voltage while increasing the surface area of the cells increases the current.

THE FUEL CELL SYSTEM

The balance of plant supplies the fuel cell module with hydrogen and oxygen in the right dosage, pressure and humidity. Before it fed to the fuel cell, the hydrogen is humidified and pressurized to two bar. The humidified ambient air containing the oxygen for the reaction is fed with the same pressure to the other side of the membrane.

The NuCellSys HY-80 fuel cell system delivers up to 58 kW of unregulated DC current at 250 to 450 volt. It has a total volume of about 220 liters and weights about 220 kg. The system is very dynamic, being able to increase the load from idle to 90% in less than one second.

The Power Distribution Unit (PDU) distributes the electricity produced by the fuel cell module and limits the current to the tolerance range of the main electric motor, compressor, cooling pump and other auxiliary components. Additional elements of the fuel cell system include the internal cooling cycle, various sensors and the control units that use software specially developed by NuCellSys to govern and monitor the complete fuel cell system.

THE HYDROGEN FUELING INFRASTRUCTURE

The electrolyser and compression module will generate 120 kg/day of hydrogen fuel based on a 20 hours operation. The two main inputs are electricity and water and the outputs include oxygen and pure hydrogen fuel.

The hydrogen will be pressurized to 430 bar with a purity in excess of 99.997% suitable for the fuel cell buses.

The safety systems include hydrogen and oxygen purity monitoring systems and a combustible gas detection system interlocked with the units PLC. The equipment can be monitored remotely by way of web-based software designed specifically for the unity.

The hydrogen fuel dispenser is designed to fast fill the fuel cell bus without compromising operational safety.