The Georgetown X-1 Fuel Cell Bus

IN DEPTH

Georgetown University

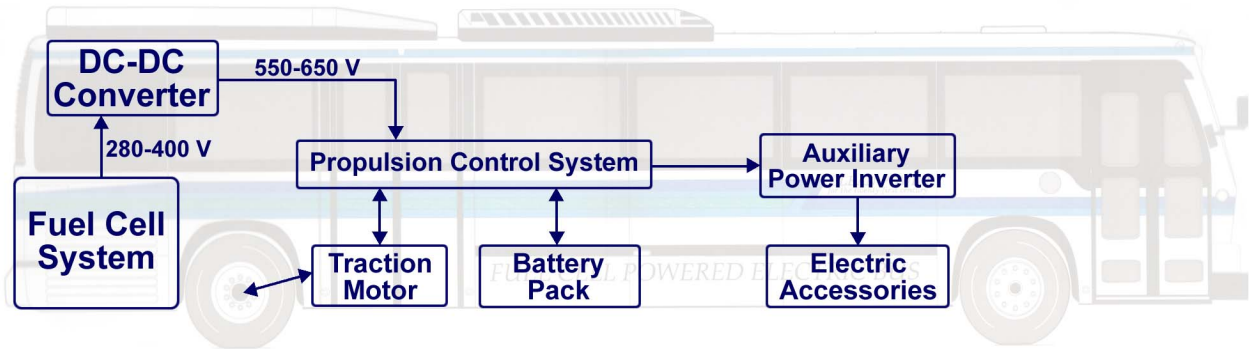
A Federal Transit Administration Project

Georgetown University's fifth liquid-fueled fuel cell transit bus combines a 100 kW Proton Exchange Membrane Fuel Cell (PEMFC) system from Ballard Power Systems and NuCellSys with a 600-volt traction battery and propulsion system from BAE Systems to create a highly efficient, ultra-low emission urban transit vehicle.

Using methanol as a hydrogen carrier yields a range of 350 miles and allows refueling to be completed in less than 5 minutes. Emission levels for this 40-passenger bus are nearly zero and well below current clean air standards.

Hybrid Electric Power & Propulsion System

BAE Systems provided the power & propulsion system for the fuel cell bus, based on their commercial HybriDrive system. This propulsion system is currently in production by BAE, and is operating aboard hundreds of diesel hybrid buses in several cities across the U.S. and Canada.



Fuel Cell System

This 100 kW (net) power plant consists of six fuel cell stacks and two methanol fuel processors. Details on this system are on the flip side of this brochure.

DC-DC Converter

This device efficiently boosts fuel cell voltage to match the higher voltage battery pack.

Propulsion Control System

The PCS generates 3-phase power for the traction motor, and manages the state-of-charge and module equalization of the batteries.

Traction Motor

The bus is driven by a 185 kW (250 hp) AC induction motor that is capable of outperforming conventional drivetrains.

Battery Pack

Consists of 46 -12 volt lead-acid batteries connected in series. The battery pack supplies extra power for acceleration and allows for regenerative braking.

Auxiliary Power Inverter

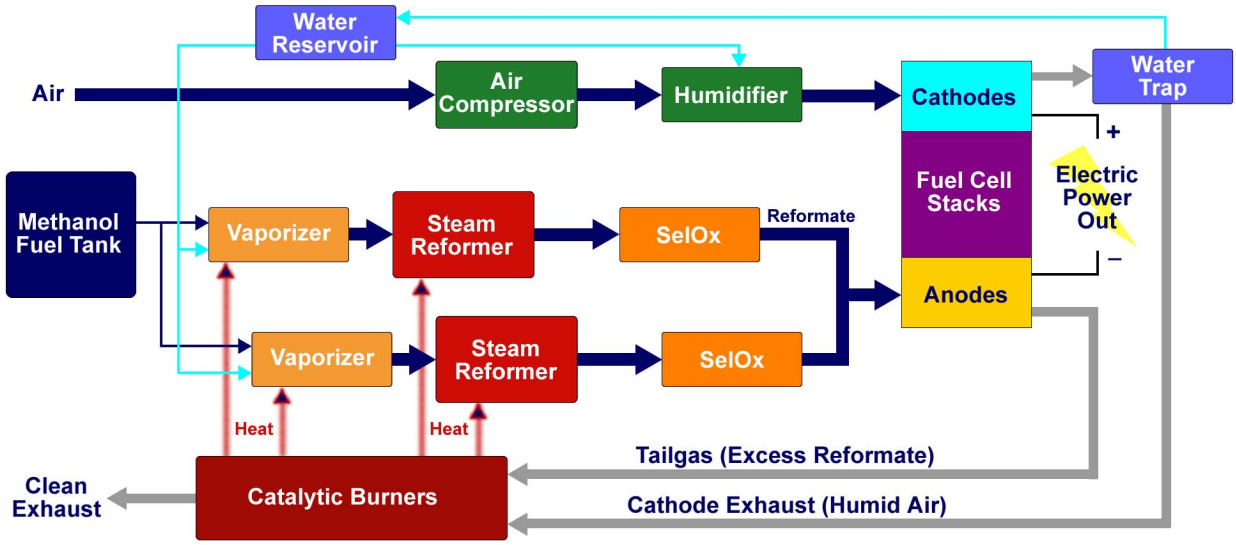
The API generates regulated 3-phase power for the bus accessories.

Electric Accessories

Includes air conditioning, power steering, and the bus air compressor.

Fuel Cell Power System

Ballard Power Systems and NuCellSys (formerly XCELLSiS) provided the fuel cell system in the X-1 Fuel Cell Bus, the world's largest liquid-fueled PEMFC system. Reformate for the fuel cell is produced with twin fuel processing systems, based on technology used in DaimlerChrysler's NeCar III methanol fuel cell car.



Methanol Fuel Tank

The methanol tank holds approximately 150 gallons, giving the bus a range of up to 350 miles. The fuel tank can be completely filled with methanol in just minutes, with the same type of pump systems used at diesel filling stations.

Vaporizers

Methanol and water are pumped into the heated vaporizers, where they are mixed and vaporized. The output gas is a mixture of steam and methanol vapor.

Steam Reformers

The heated reformers catalytically react the steam/ methanol mixture to produce reformate (hydrogen, carbon dioxide, and a trace of carbon monoxide).

SelOx Units

Since carbon monoxide is harmful to the catalyst in the fuel cell, the Selective Oxidation Units oxidize the CO produced in the reformers.

Fuel Cell Stacks

The fuel cell stacks receive the reformate along with compressed, humid air to create electrical current. The X-1 bus is equipped with 6 Ballard Mark 7 stacks, for a total net power of 100 kW.

Water Trap

Water is condensed from the cathode exhaust to be reused in the vaporizers and humidifier.

Catalytic Burners

During fuel cell operation, the burners react any excess hydrogen in the anode exhaust to keep the vaporizers and reformers hot.

Exhaust

The only significant emissions from the fuel cell system are air, carbon dioxide, and water. The exhaust water is condensed and mixed with methanol in the vaporizers to enhance hydrogen production in the steam reformers.

For more information, contact:

Georgetown University Advanced Vehicle Development
Kennedy Hall, P4 Mezzanine
37th & O Streets NW
Washington, DC 20057-1180
202-687-4503

GEORGETOWN UNIVERSITY
1789
WASHINGTON, DC