

# FUEL CELL ELECTRIC BUSES

## COLD WEATHER OPERATION

### FUEL CELL ELECTRIC BUS

#### Performance in Cold Climates

Fuel cell buses offer an emissions-free alternative for transit operators without compromising the performance and utility experienced with conventional buses. Part of this no-compromise experience is being able to operate fuel cell buses in all weather conditions.

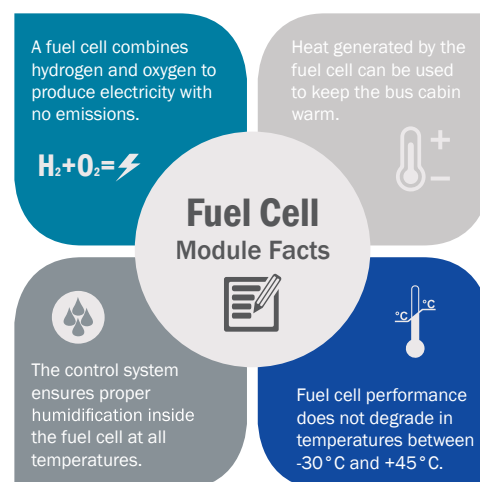
Fuel cell buses powered by Ballard's FCveloCity® motive modules have operated over 10 million kilometers and are well proven in extreme climates. During deployments in Oslo, Whistler and Aberdeen, fuel cell bus fleets have provided reliable service in cold weather conditions without impact on range or performance.



### Operating the FCveloCity® Fuel Cell Module in Cold Weather

In operation, although the outside ambient temperature may drop below 0°C, the heat generated from the fuel cell keeps the systems from freezing. This useful heat enables operation even when the air temperature drops as low as -30°C and it can be used to keep the cabin or the battery compartment warm.

Ballard's FCveloCity® power module can be stored at temperatures as low as -40°C. A 'cold weather kit' enables fast start-up down to -20°C and the control system employs freezing countermeasures to prevent the conversion of water to ice, and subsequent potential damage due to ice expansion.



## TECHNICAL NOTE

## Storage in Cold Weather

When the bus is parked, the fuel cell isn't consuming fuel, and so is no longer generating heat, allowing internal temperatures to drop. Ballard's FCveloCity® fuel cell control system looks after the fuel cell even while the bus is out of service.

### Short Stops

If the bus is parked for a short period of time, the insulation and the inherent mass of the fuel cell can hold heat for several hours. In freezing temperatures, the bus can be idle or parked for short periods without the need for the control system to initiate freeze protection measures. In this situation where the internal temperature remains above freezing, the bus can be started normally without a warm-up time.

### Longer Stops (>3 hours\*)

If the FCveloCity® module control system observes the internal temperature dropping towards 0°C, an internal sequence of actions can be initiated to prepare for freezing. Water is purged from lines, and components are dried out to remove water from the entire fuel cell system. In this dry, freeze-protected state, the bus can remain in freezing temperatures without damage to the fuel cell module.



Photo Credit: BC Transit

## Start-Up in Below Freezing Temperatures

Once frozen, the fuel cell system can be started after warming the internal temperature above freezing. In order to allow a fast start-up while temperature is still below freezing, the fuel cell should be kept warm during down-time. FCveloCity® modules offer several "cold protection" options allowing immediate start-up down to -30°C.

### 1. Plug-In Resistance Heater

If the bus can be parked near a utility grid power outlet, an optional plug-in freeze protection system keeps the fuel cell within a temperature range that allows it to start up immediately when left for long periods of time in freezing conditions.

If there is no access to utility grid connection, energy from the bus battery can maintain the fuel cell temperature above freezing. An estimated 250 W is required to maintain the module above freezing at -20°C.

### 2. Automatic Start-Up of the Fuel Cell System

The drive system can be programmed to start the FCveloCity® module automatically for a pre-set period of time when the control system observes the internal temperature approaching 0°C. As it operates, the fuel cell will generate heat to maintain the module above freezing. The module will also produce electricity which can be used to power HVAC system to pre-warm the bus cabin prior to service.

## Ballard Power Systems

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\* specific time varies with outside temperature