World leader in electric power and propulsion

Together we can save much more than fuel.
gettozero.com

This document consists of general information that is not defined as controlled technical data under ITAR Part 120.10 or EAR Part 772.
Our Mission

- Deliver propulsion and power management performance
- Provide market and customers with innovative electrification products & solutions
- Advance vehicle mobility, efficiency and capability in the transit, military, marine and rail markets.

Who are we:

- Leading provider of power & propulsion solutions
- Over 10,000 systems operating worldwide
- Significant IP portfolio; 300+ patents worldwide; $500M invested in products & capabilities
- 24/7 product support
What do we provide?

- We use the same proven technology that has been installed in over 10,000 buses and trucks operating worldwide.
- Leverage what has been done and build on what is successful.
American Fuel Cell Electric Bus Commercialization

American Fuel Cell Bus Partners:
El Dorado National – Bus Manufacturer
BAE Systems – Power & Propulsion, Lead Integrator
Ballard Power Systems – Fuel Cell

- Orange County Transit Authority
  Orange County, CA
  1 Vehicle in service

- SunLine Transit
  Thousand Palms, California
  10 Vehicles in service

- University of Calif., Irvine
  Irvine, California
  1 Vehicle in service

- Mass Transportation Authority (MTA)
  Flint, Michigan
  1 Vehicle in service

- Massachusetts Bay Transit Authority
  Boston, MA
  1 vehicle delivered & demonstrated

- Stark Area Regional Transit
  Stark County, Ohio
  7 Vehicles in service
  5 More in plan

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One common solution: Electric-Hybrid

BAE Systems’ patented HybriGen® power and propulsion system

- SAE J1939 CAN Bus
- 28 Vdc
- 3 Ph Variable speed
- 600 Vdc

Integrated Starter Generator (ISG) → Propulsion Control System (PCS) → AC Traction Motor (ACTM)

Energy Storage System (ESS) → System Control Unit (SCU) → Auxiliary Power System (APS)

Throttle and Display

Energy storage system and propulsion system combined results in:

X2 =

Bus and Ship images
One common solution: Battery Electric

BAE Systems’ patented HybriGen® power and propulsion system
One common solution: Fuel Cell

BAE Systems’ patented HybriGen® power and propulsion system

- SAE J1939 CAN Bus
- 28 Vdc
- 3 Ph Variable speed
- 600 Vdc

FUEL CELL

- Propulsion Control System (PCS)
- AC Traction Motor (ACTM)

- System Control Unit (SCU)
- Throttle and Display
- Energy Storage System (ESS)
- Auxiliary Power System (APS)
The Water-Go-Round

- Aluminum catamaran
- 70’ / 21m LOA
- 84 passenger (reconfigurable)
- 22 knot top speed
- 2 x 300 kW electric motors
- 360 kW PEM fuel cell
- 100 kWh Li-ion energy storage
- $H_2$: 242 kg @ 250 bar / 3,600psi
Challenge #1: Hydrogen availability

- Hydrogen production at point of consumption is key. On demand.
- Potential to take H\textsubscript{2} fuel production completely off grid.
- Cost effective electrolysis technology will help scale H\textsubscript{2} use.
Challenge #2: Hydrogen storage

1kg H₂ ~ 1.1 USG Diesel ~ 30kWhr ESS
Source: Alternative Fuels Data Center
https://afdc.energy.gov/fuels/fuel_comparison_chart.pdf

Water-Go-Round
- 16 x H₂ tanks
- 242 kg @ 250 bar / 3,600 psi
- Equiv. to 7.2MWhr of Energy Storage

Fuel Cell bus
- 8 X H₂ tanks
- 60 kg @ 350 bar / 5,000 psi
- Equiv. to 1.8MWhr of Energy Storage

Toyota Mirai
- 2 x H₂ tanks
- 5 kg @ 700 bar / 10,000 psi
- Equiv. to 150kWhr of Energy Storage
One common solution: Fuel Cell

BAE Systems’ patented HybriGen® power and propulsion system
One common solution: Fuel Cell Energy Module

BAE Systems’ patented HybriGen® power and propulsion system

- SAE J1939 CAN Bus
- 28 Vdc
- 3 Ph Variable speed
- 600 Vdc

FUEL CELL

Energy Storage System (ESS)

System Control Unit (SCU)

Propulsion Control System (PCS)

AC Power

Display

RTG Crane

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One common solution: Fuel Cell Energy Module

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Fuel Cell

Propulsion Control System (PCS)

System Control Unit (SCU)

Energy Storage System (ESS)

Display

AC Power

Switcher Loco

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Final thought

As we move towards a zero emission future, the first step is to select a technology provider capable of wide scale application adoption, electric hybrid, battery electric or H₂ fuel cell.

It’s a journey, we’ll get to zero together.
Thank you

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