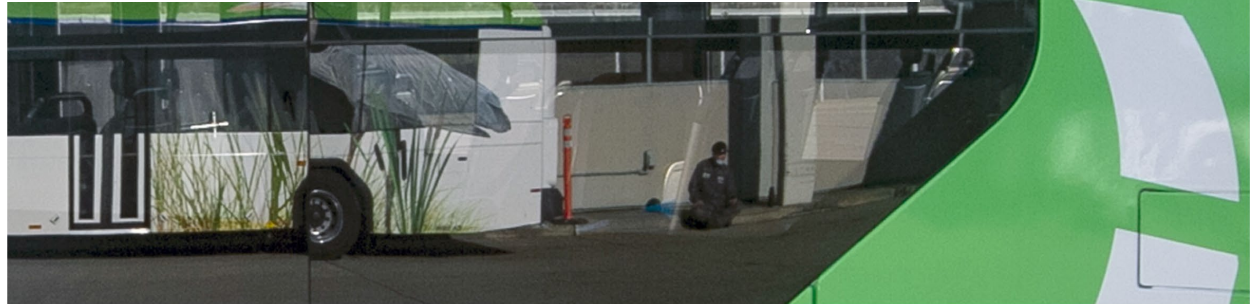




Fuel Cell Basics

Sal Llamas – Chief Operating Officer
April 18, 2023



OVERVIEW



Bus Division



Battery Electric



H2 Fuel Cell



Administrative



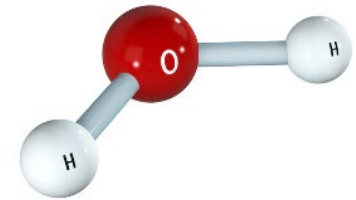
7 Elected Board Members
1.5M people in service area
364 square miles
128 lines (18 transbay)
16.7M annual service miles
2,200+ FTE's
7 facilities (4 bus-3 support)
637 buses (58 ZEBs)

HYDROGEN 101

Hydrogen - Position In The Periodic Table

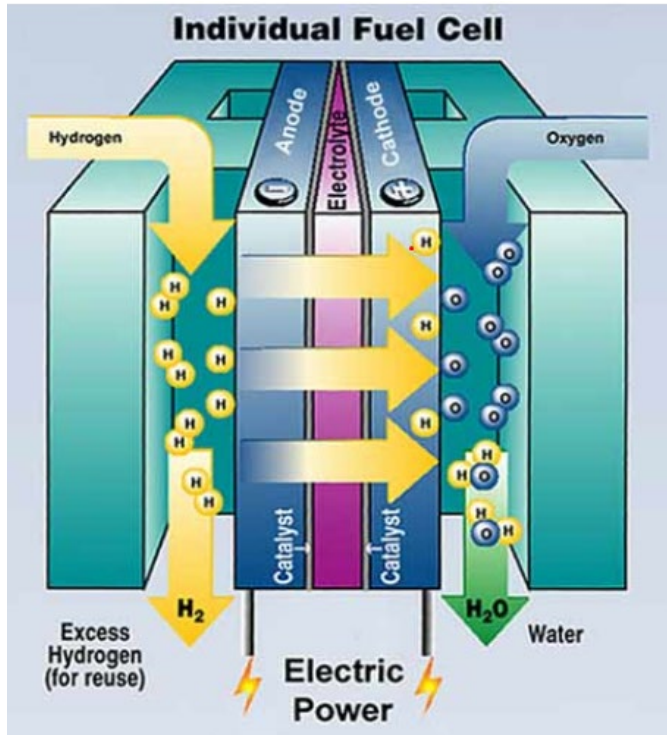
1 H Hydrogen																	2 He Helium																												
3 Li Lithium	4 Be Beryllium											5 B Boron	6 C Carbon	7 N Nitrogen	8 O Oxygen	9 F Fluorine	10 Ne Neon																												
11 Na Sodium	12 Mg Magnesium											13 Al Aluminium	14 Si Silicon	15 P Phosphorus	16 S Sulfur	17 Cl Chlorine	18 Ar Argon																												
19 K Potassium	20 Ca Calcium	21 Sc Scandium	22 Ti Titanium	23 V Vanadium	24 Cr Chromium	25 Mn Manganese	26 Fe Iron	27 Co Cobalt	28 Ni Nickel	29 Cu Copper	30 Zn Zinc	31 Ga Gallium	32 Ge Germanium	33 As Arsenic	34 Se Selenium	35 Br Bromine	36 Kr Krypton																												
37 Rb Rubidium	38 Sr Strontium	39 Y Yttrium	40 Zr Zirconium	41 Nb Niobium	42 Mo Molybdenum	43 Tc Technetium	44 Ru Ruthenium	45 Rh Rhodium	46 Pd Palladium	47 Ag Silver	48 Cd Cadmium	49 In Indium	50 Sn Tin	51 Sb Antimony	52 Te Tellurium	53 I Iodine	54 Xe Xenon																												
55 Cs Cesium	56 Ba Barium	57 La Lanthanum	72 Hf Hafnium	73 Ta Tantalum	74 W Tungsten	75 Re Rhenium	76 Os Osmium	77 Ir Iridium	78 Pt Platinum	79 Au Gold	80 Hg Mercury	81 Tl Thallium	82 Pb Lead	83 Bi Bismuth	84 Po Polonium	85 At Astatine	86 Rn Radon																												
87 Fr Francium	88 Ra Radium	89 Ac Actinium	104 Rf Rutherfordium	105 Db Dubnium	106 Sg Seaborgium	107 Bh Bohrium	108 Hs Hassium	109 Mt Meitnerium	110 Ds Darmstadtium	111 Rg Roentgenium	112 Cn Copernicium	113 Nh Nihonium	114 Fl Flerovium	115 Mc Moscovium	116 Lv Livermorium	117 Ts Tennessine	118 Og Oganesson																												
<table border="1"> <tr> <td>58 Ce Cerium</td> <td>59 Pr Praseodymium</td> <td>60 Nd Neodymium</td> <td>61 Pm Promethium</td> <td>62 Sm Samarium</td> <td>63 Eu Europium</td> <td>64 Gd Gadolinium</td> <td>65 Tb Terbium</td> <td>66 Dy Dysprosium</td> <td>67 Ho Holmium</td> <td>68 Er Erbium</td> <td>69 Tm Thulium</td> <td>70 Yb Ytterbium</td> <td>71 Lu Lutetium</td> </tr> <tr> <td>90 Th Thorium</td> <td>91 Pa Protactinium</td> <td>92 U Uranium</td> <td>93 Np Neptunium</td> <td>94 Pu Plutonium</td> <td>95 Am Americium</td> <td>96 Cm Curium</td> <td>97 Bk Berkelium</td> <td>98 Cf Californium</td> <td>99 Es Einsteinium</td> <td>100 Fm Fermium</td> <td>101 Md Mendelevium</td> <td>102 No Nobelium</td> <td>103 Lr Lawrencium</td> </tr> </table>																		58 Ce Cerium	59 Pr Praseodymium	60 Nd Neodymium	61 Pm Promethium	62 Sm Samarium	63 Eu Europium	64 Gd Gadolinium	65 Tb Terbium	66 Dy Dysprosium	67 Ho Holmium	68 Er Erbium	69 Tm Thulium	70 Yb Ytterbium	71 Lu Lutetium	90 Th Thorium	91 Pa Protactinium	92 U Uranium	93 Np Neptunium	94 Pu Plutonium	95 Am Americium	96 Cm Curium	97 Bk Berkelium	98 Cf Californium	99 Es Einsteinium	100 Fm Fermium	101 Md Mendelevium	102 No Nobelium	103 Lr Lawrencium
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Atomic weight	•1.008	1•	Atomic number
	H		Symbol
	Hydrogen		Name



Most abundant element in the universe, enables the sun to warm the Earth and help create the water that sustains life. This simplest of all the elements may also provide the key to finding a clean fuel source to power the planet.

HYDROGEN *FUEL CELL*



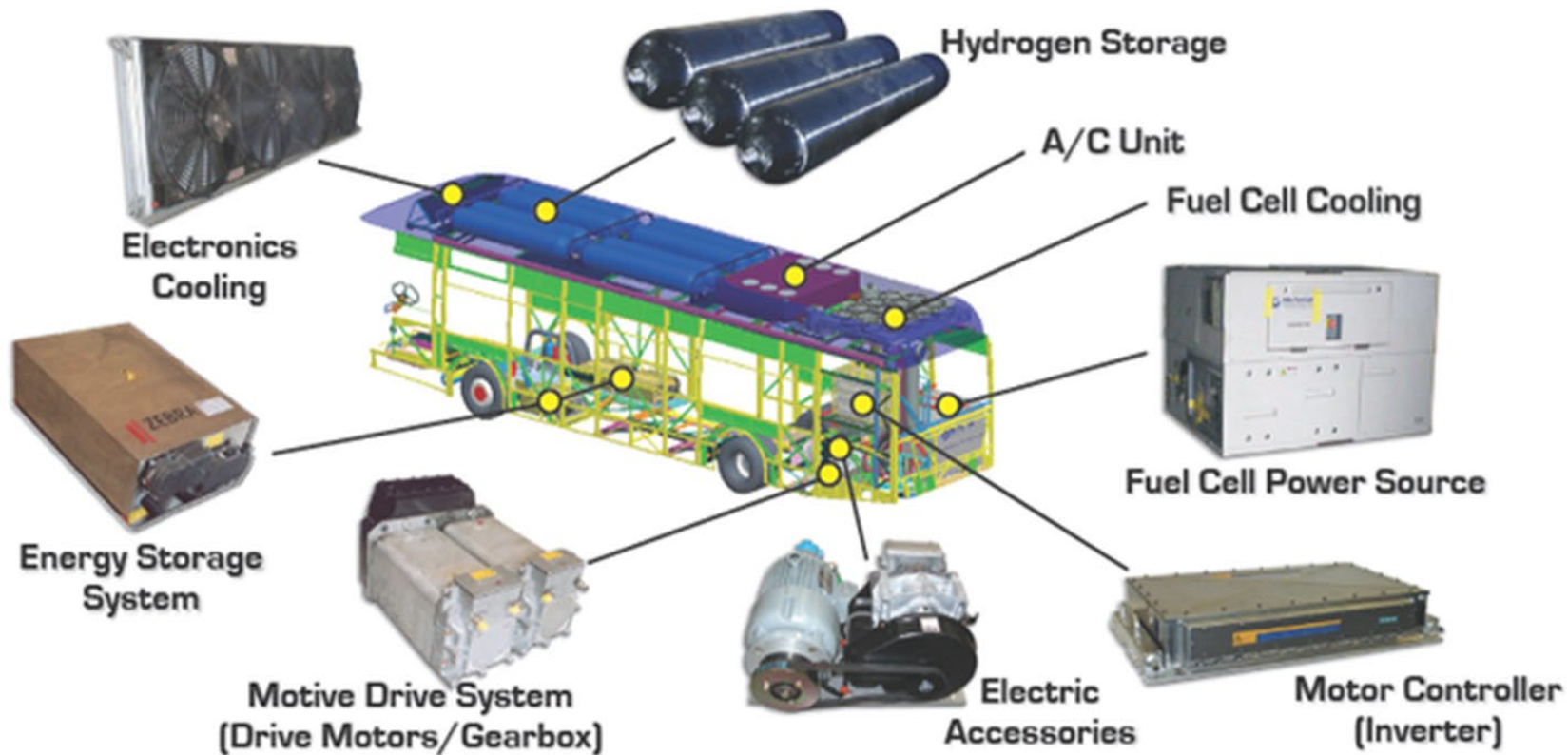
Polymer electrolyte membrane (PEM) fuel cells are used to power fuel cell vehicles.

Hydrogen is fed into one side of the fuel cell while oxygen from the air is fed into the other side of the fuel cell.

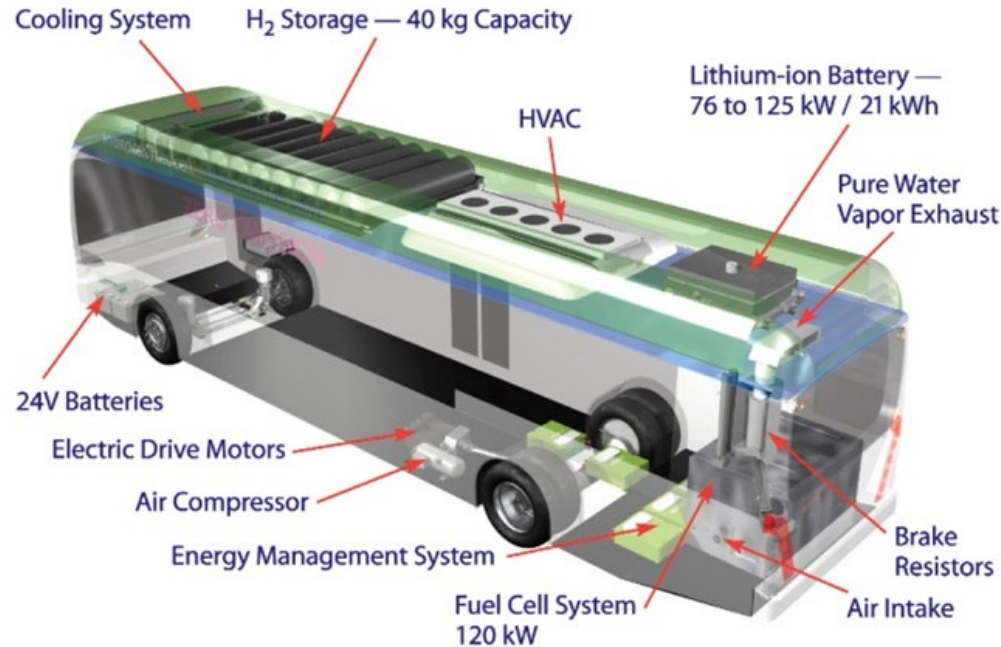
The hydrogen and oxygen combine to form water while producing electricity to move the bus.

“Proton Exchange Membrane”

COMPONENTS OF THE FUEL CELL HYBRID SYSTEM

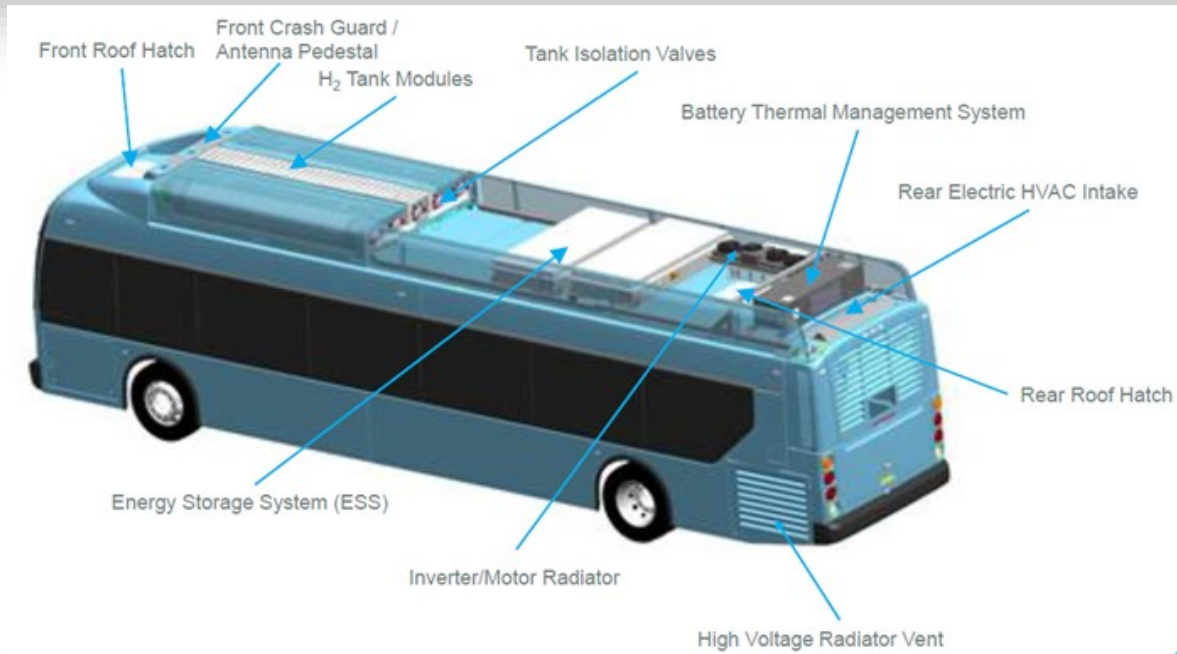


FUEL CELL - DOMINANT



Larger fuel cell provides electrical power to the traction drive motor
Fuel cell ramps up & down like an engine based on throttle demand
Great for highway commuter routes with hills

BATTERY - *DOMINANT*



Battery packs provide electrical power to the traction drive motor
Smaller fuel cell recharges batteries while the bus is on the road
More steady operation of the fuel cell

HYDROGEN BUS FUELING



HYDROGEN FUEL STATION



H2 gas buffer tubes
H2 station dispensers

80' by 40' footprint
Liquid H2 storage tank
Vaporizer towers
Compressor or cryo-pumps

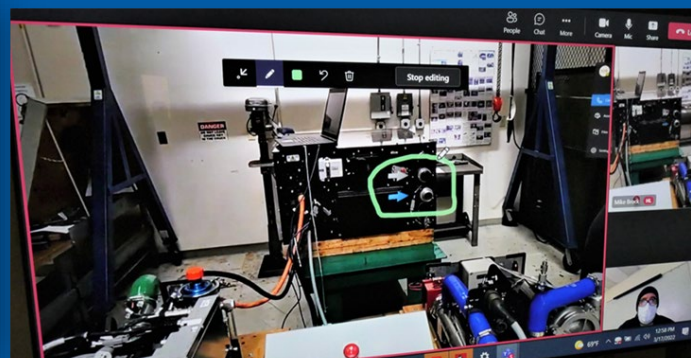
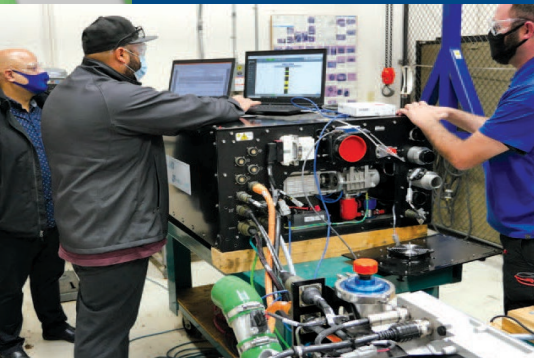


WORKFORCE DEVELOPMENT

- ❑ Safety & Familiarization
- ❑ Advanced Diagnostics
- ❑ Approx. 318 hours of ZEB specific training

Mechanic Development

FCEB-BEB Coursework	Hours
Orientation and PPE/High Voltage	8
Energy Storage System	40
Power Train Technology	40
Fuel Cell	30
5-Week Technical Training Program	200



KEY TAKE AWAYS



- Other facilities – bus servicing, washing & cleaning, maintenance buildings, paint booths
- Plan to scale for growth or do it all at once
- Technology partners – bus & infrastructure OEMs, consulting firms
- Emergency response – OEMs, first responders, LE & other regulators
- Cost analysis – do your homework, reach out to agencies/associations



QUESTIONS?



THANK YOU!

