

Plug-in Hybrid School Bus Update

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Advanced Energy



▶ Presentation Outline

- ▶ Project History
- ▶ Why plug-in hybrids?
- ▶ Performance and Monitoring
- ▶ Next Phases



▶ Who is Advanced Energy?

- ▶ An independent non-profit located in Raleigh, NC
- ▶ Our mission is to create economic, environmental and societal benefits through innovative and market-based approaches to energy issues.
- ▶ Focus on solutions that are economically viable, environmentally responsible and reduce energy consumption
- ▶ We work in residential, commercial, industrial, and transportation markets



▶ Plug-in Hybrid School Bus Project

- ▶ Collaborative effort with manufacturers, operators and environmental agencies
- ▶ Identified market barriers and reduced risk where possible
- ▶ Funding support from NC utilities, NC DENR, NC SEO, US DOE, US EPA, and AE
- ▶ Goal is to change the marketplace



▶ How did we get here?

▶ 4 Phases

- I. **Feasibility Study (2003-2005)**
- II. Pre-Production Operation (2006-2009)
- III. Fleet Testing (2008-2012)
- IV. Full Market Deployment (2013)

- Technical Feasibility
 - Business Feasibility
 - Overall Feasibility
- Completed*



▶ How did we get here?

▶ 4 Phases

I. Feasibility Study (2003-2005)

II. **Pre-Production Operation (2006-2009)**

III. Fleet Testing (2008-2012)

IV. Full Market Deployment (2013)

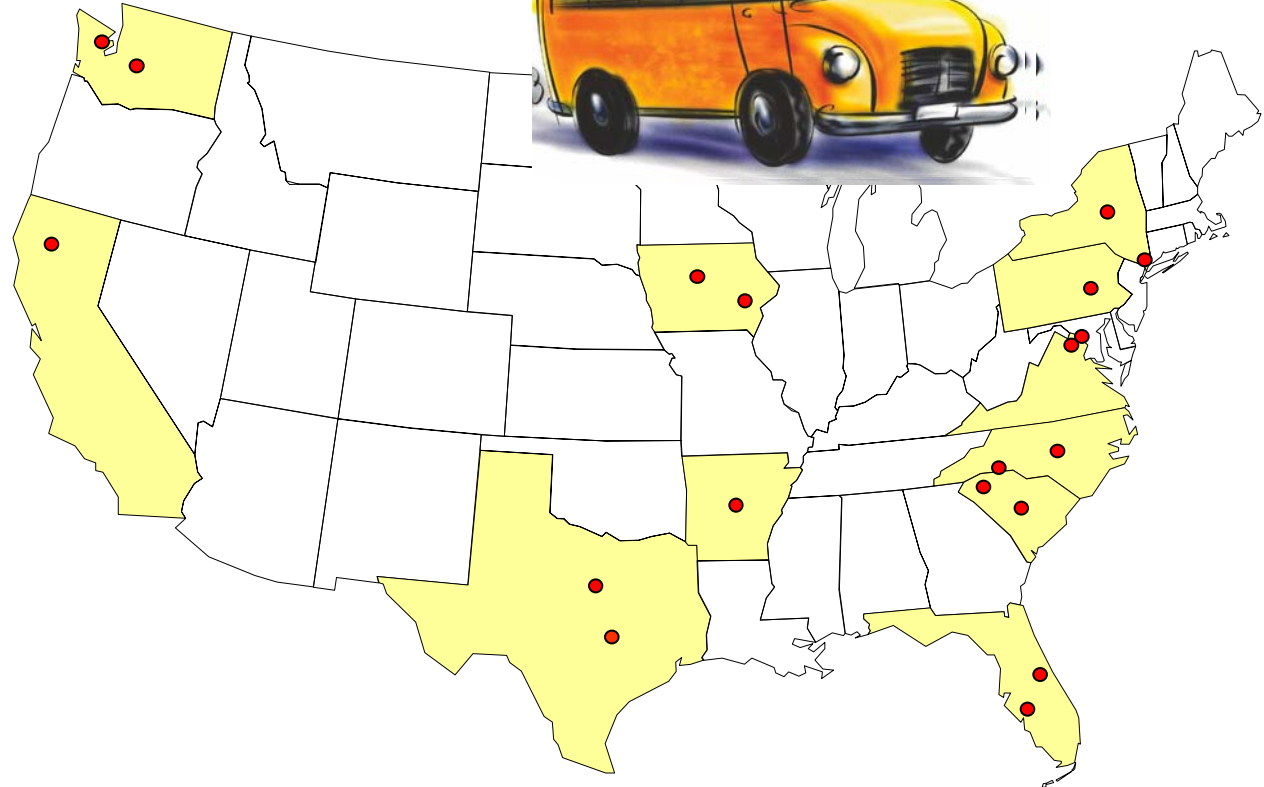
- 20 Bus Purchase
- Data Gathering
 - Emissions
 - Fuel Economy
 - Maintenance



► National Scope

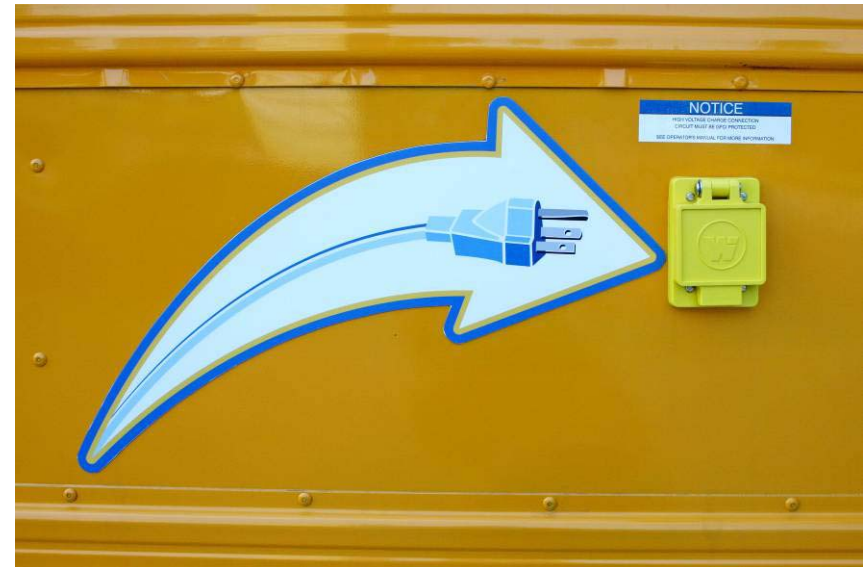


- North Carolina (2)
- South Carolina (2)
- Florida (2)
- Virginia (1)
- Washington DC (1)
- Pennsylvania (1)
- New York (2)
- Arkansas (1)
- Iowa (2)
- Washington (2)
- California (1)
- Texas (2)

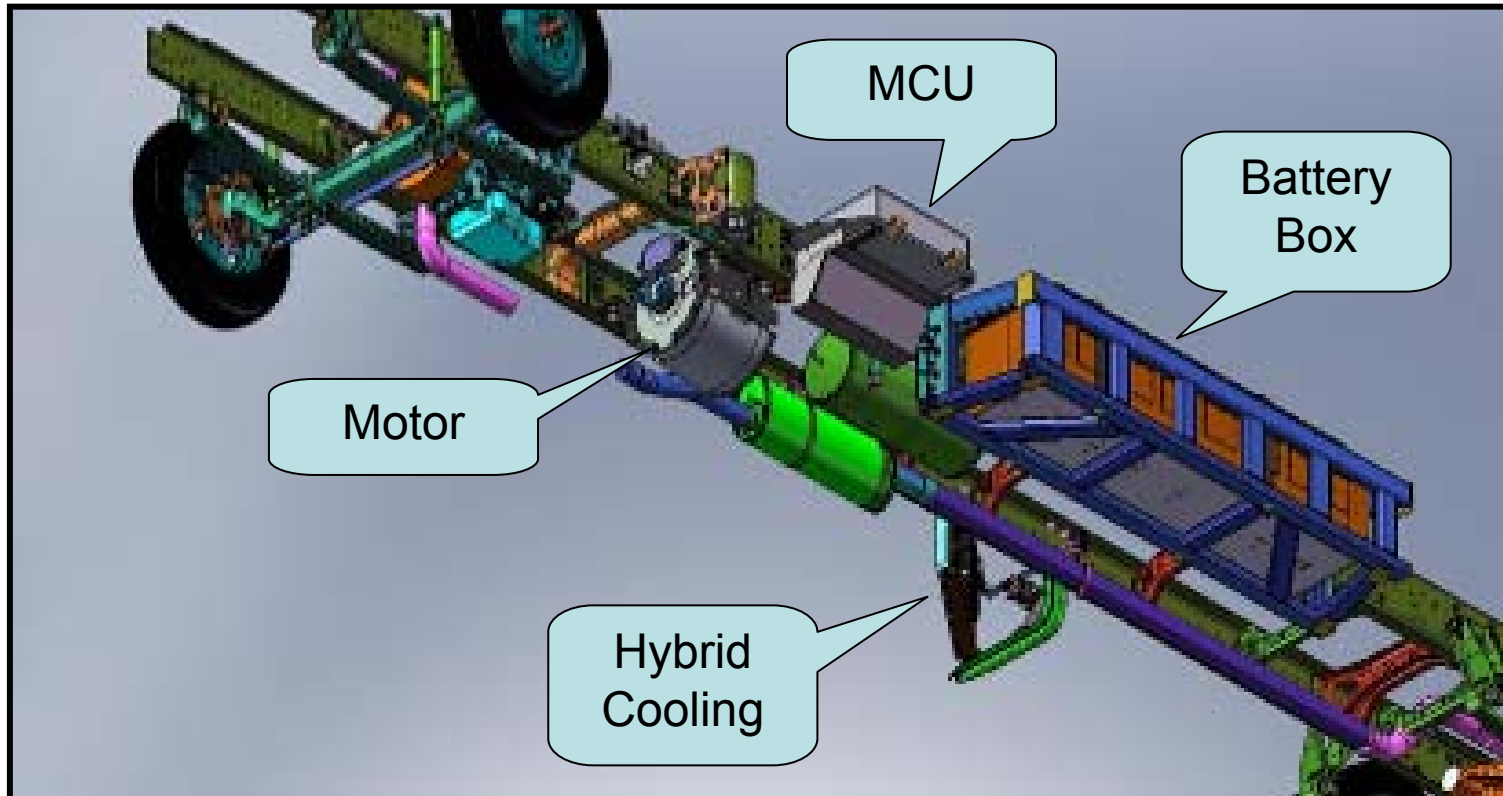


▶ Bid Award to Buses Delivered

- ▶ RFP for buses in June 2006
- ▶ IC Corporation selected based on specific criteria
 - > 80 kW parallel **plug-in** hybrid
 - > 28 kWh Li-Ion pack from Valence
 - > \$140k incremental cost
- ▶ First buses delivered to Bradenton, FL in March 2007



► Enova Systems Components



► **Enova Systems Components**



▶ Manatee County Charging



▶ Estimated Benefits

- ▶ Plugging-in is optional
- ▶ 90-100% increase in fuel economy for the first 45 miles
- ▶ 40% increase for remainder
- ▶ 90% reduction in PM
- ▶ 60% reduction in NOx
- ▶ Increased engine, transmission, and brake life
- ▶ Electricity cost of 60¢/gallon equivalent
- ▶ Option for renewable electricity at \$1 per gallon



▶ Performance and Monitoring

- ▶ Web reporting
- ▶ IC Aware
- ▶ Enova Logging
- ▶ Emissions Testing



Hybrid Electric School Bus Tier 1 Monitoring Form

School District

Bus Type

Bus ID #

Route Designation

Bus Driver

Maintenance Report

DATE	MAINTENANCE AREA	EXPLANATION OF MAINTENANCE	PERFORMED BY	HOURS UNAVAILABLE	LIST OF MATERIALS
<input type="text"/>	<input type="text" value="Please Select"/>	<input type="text"/>	<input type="text" value="Please Selec"/>	<input type="text"/>	<input type="text"/>
ROAD CALL	ODOMETER READING	LABOR HOURS	MATERIAL COST		
Yes <input type="radio"/> No <input checked="" type="radio"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>		

Submit

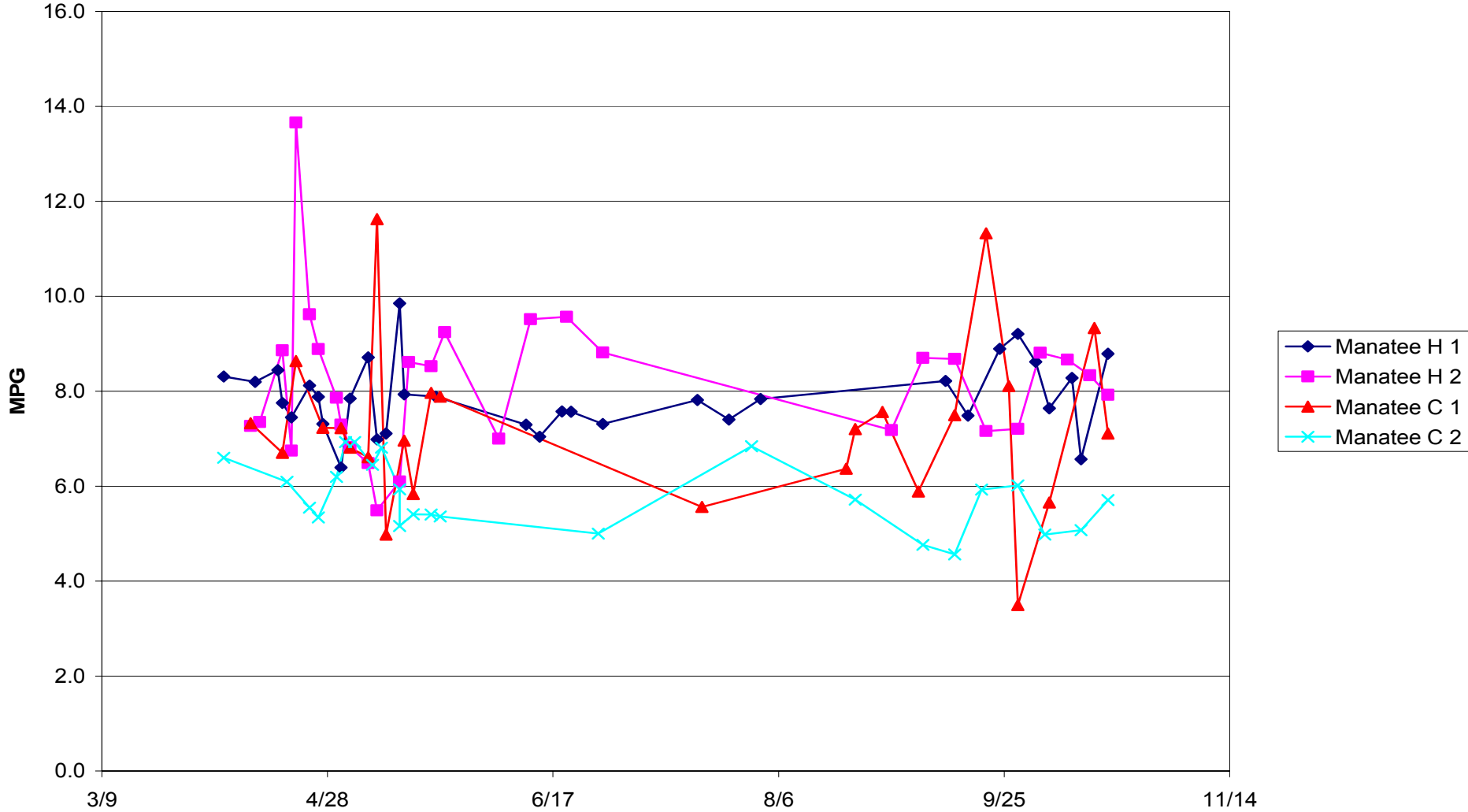
Fuel Report

DATE	ODOMETER READING	GALLONS	COST PER GALLON	KWH READING
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
NOTES				
<input type="text"/>				

Submit



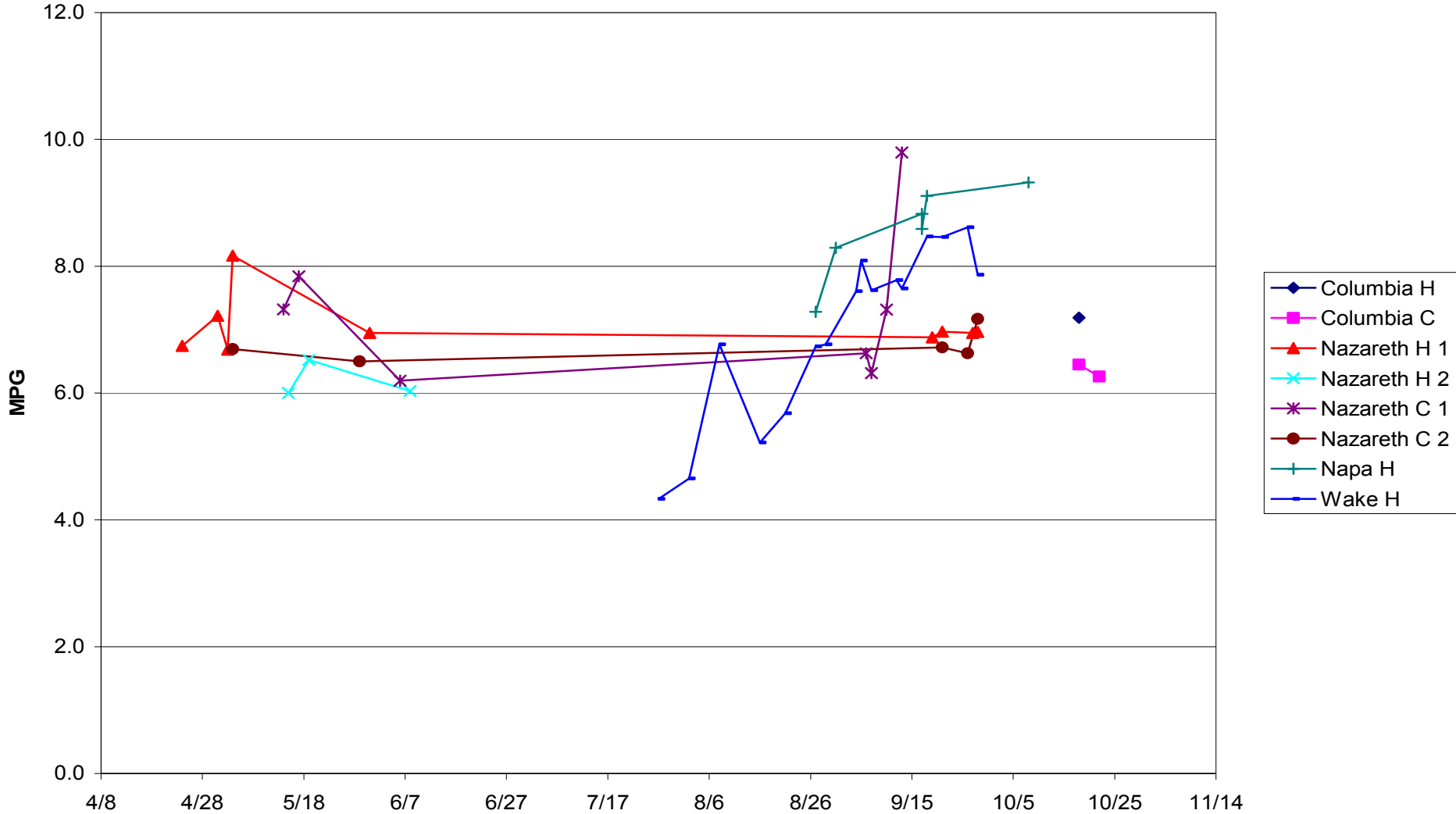
Fuel Economy Comparison



www.hybridschoolbus.org



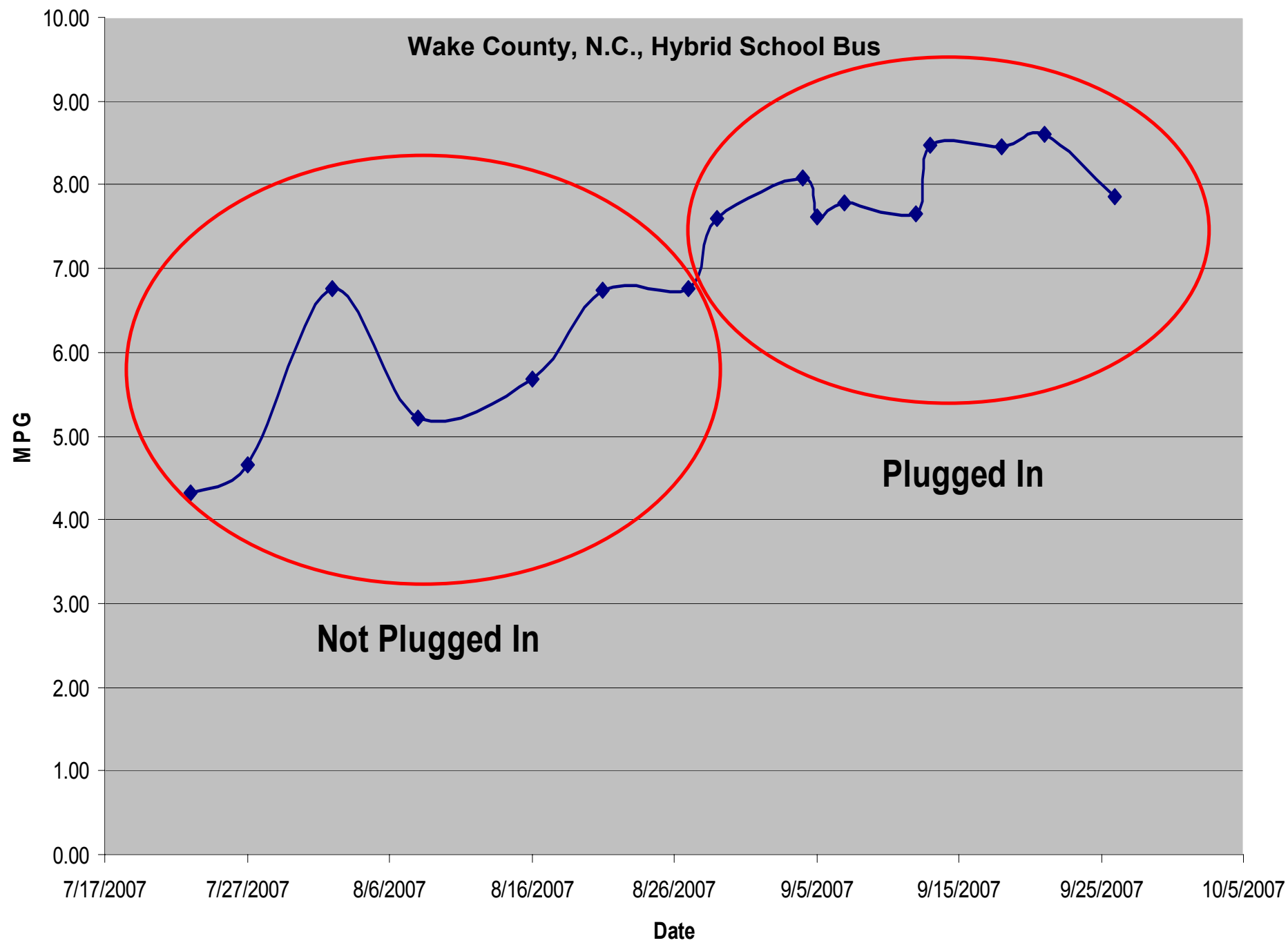
Fuel Economy Comparison



www.hybridschoolbus.org



Wake County, N.C., Hybrid School Bus



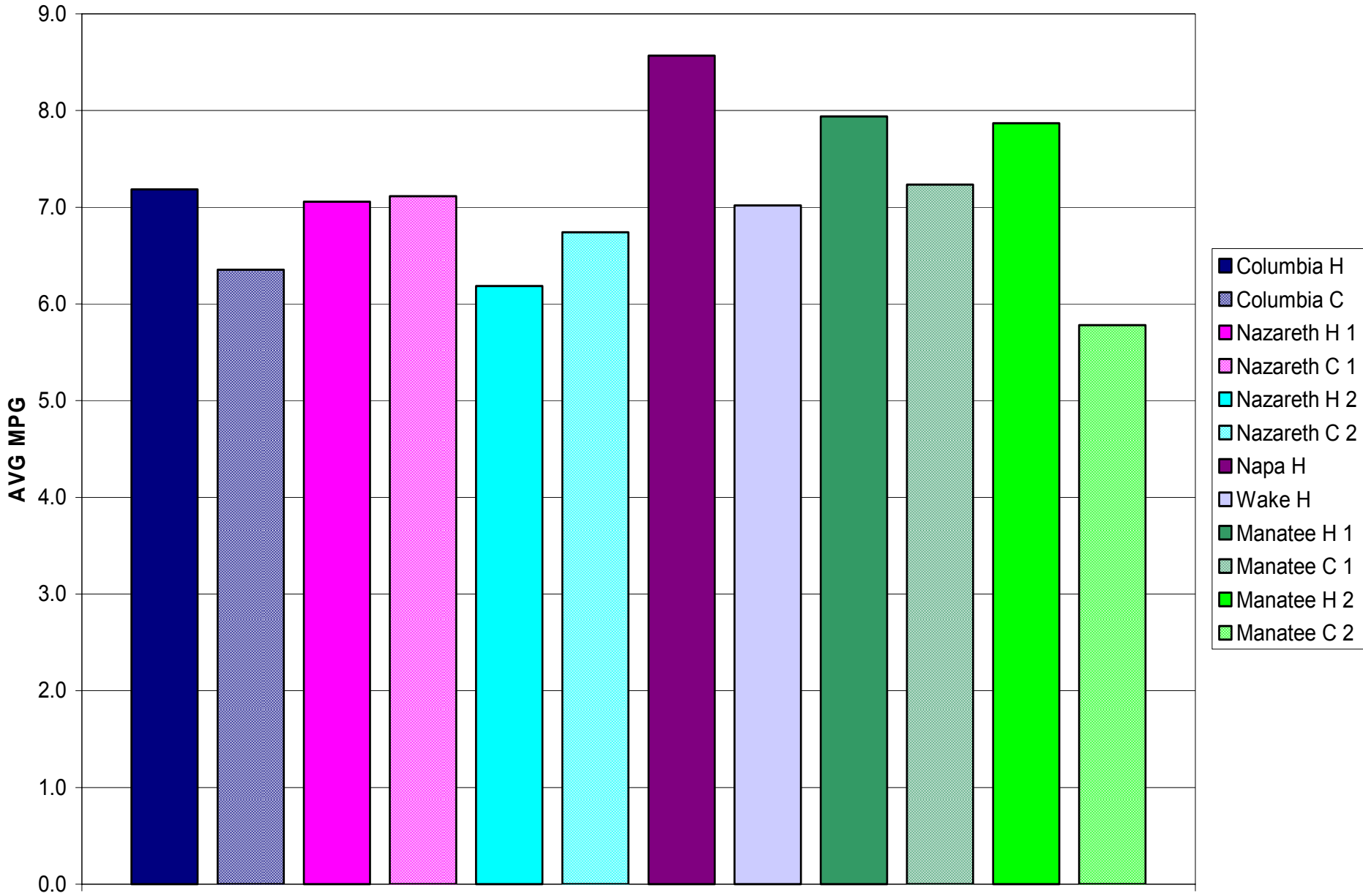
Not Plugged In

Plugged In

MPG

Date

Average Fuel Economy

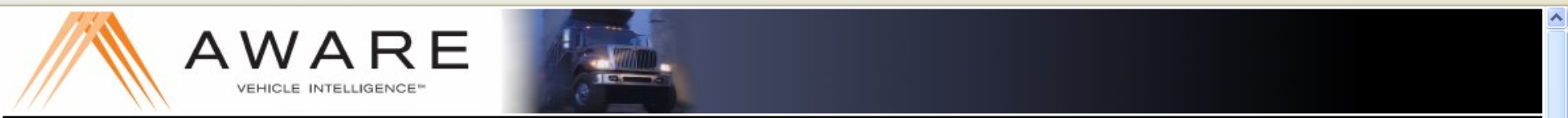


▶ IC Aware

▶ Parameters

- > Fuel economy
- > Speeds
- > Stops
- > Fleet location
- > Odometer
- > Engine run time
- > Brake count and duration
- > Alert reports
 - Fault conditions
 - Out of range parameters
(rapid accelerations or decelerations)





102062-Manatee District School
Selected Vehicles [Edit](#)

There are No Open Driver Alerts and No Open Device Alerts for account Manatee District School.

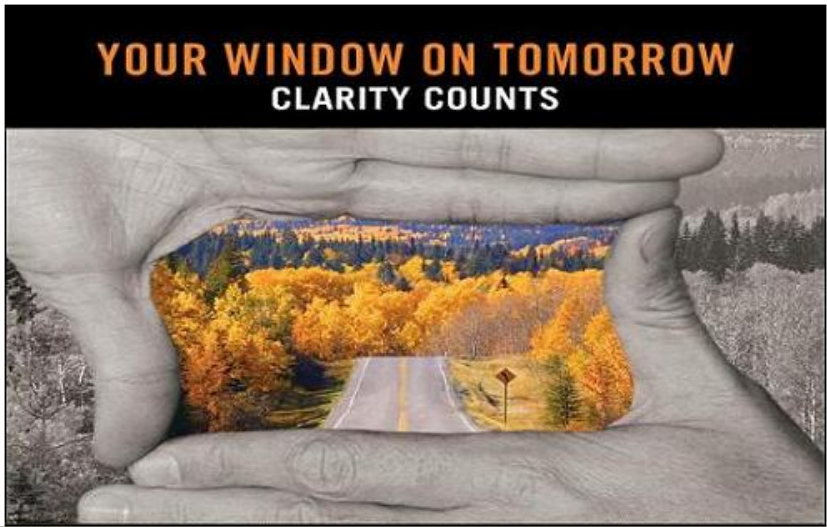
Notices □

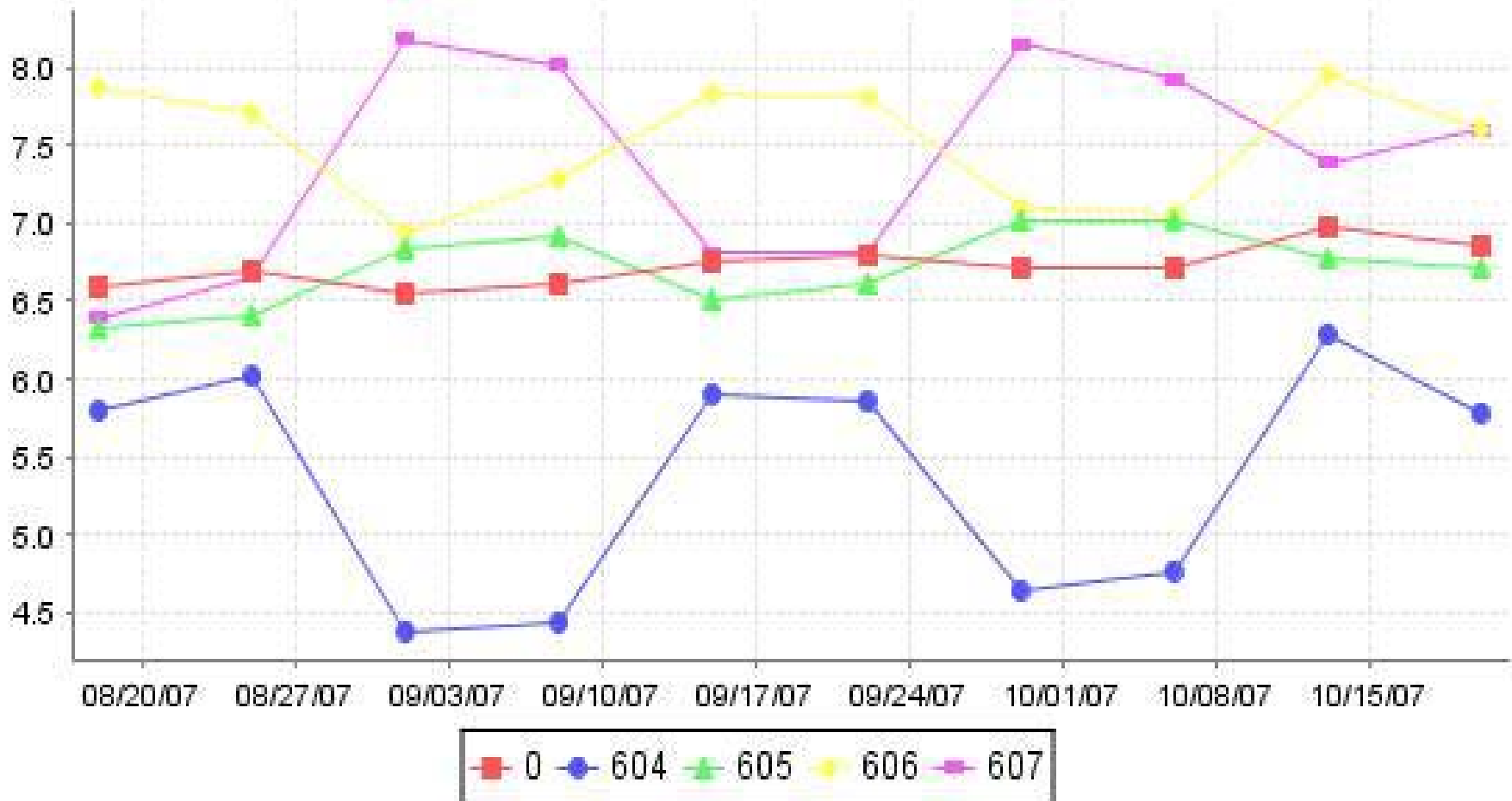
ATTENTION: An AWARE™ Software Upgrade is now available for the vehicle installed modules. We recommend that you upgrade all of your vehicles to the latest version of software as soon as possible to ensure continued communication and access to your vehicle data on the website. Customer Administrators for the accounts requiring this upgrade have been notified through email. If you have any questions please contact AWARE™ Customer Support at 1-888-883-5362, option #4.

NOTICE
With each Module Replacement or Software Upgrade please ensure that your service technician has contacted AWARE™ Customer Support at 1-888-883-5362, option #4 as part of the upgrade process. This is necessary to confirm that your modules are communicating correctly and resolve any issues at the time of service.

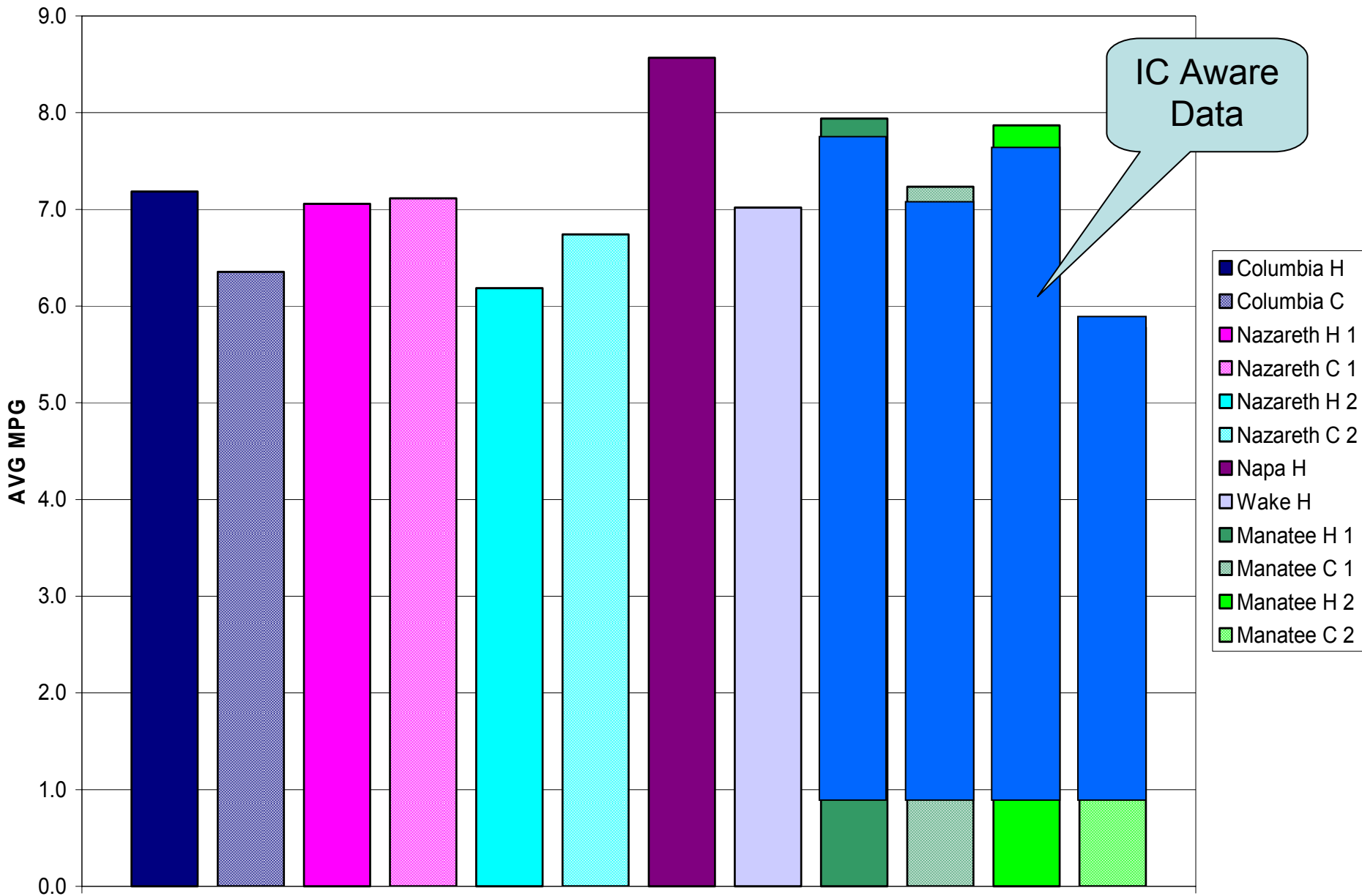
AWARE™ Customer Support is available from 7:00am to 7:00pm Central Daylight Time, Monday - Friday: 1-888-883-5362, option #4.

Bulletin Board □





Average Fuel Economy

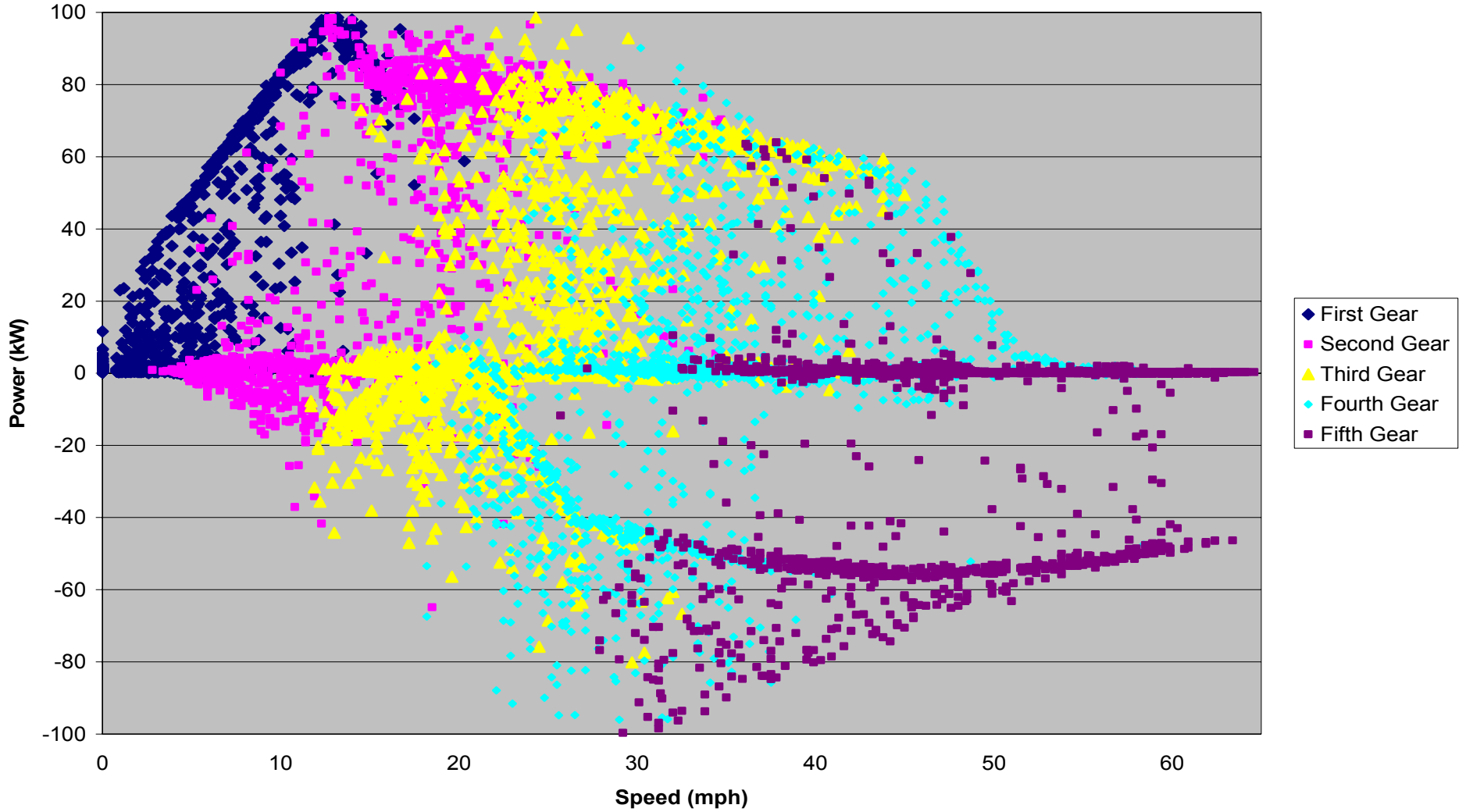


▶ Enova Logging

- ▶ Monitors hybrid system operation
- ▶ Detailed output every second
 - > Speed, SOC, Voltage, Current, Gear, RPM, Motor Temperature, Brakes, Throttle, etc.



Power Versus Speed



www.hybridschoolbus.org



▶ Emissions Testing

- ▶ Portable analyzer and Large Chassis Dynamometer
- ▶ Correlate engine operations and drive cycle with emissions

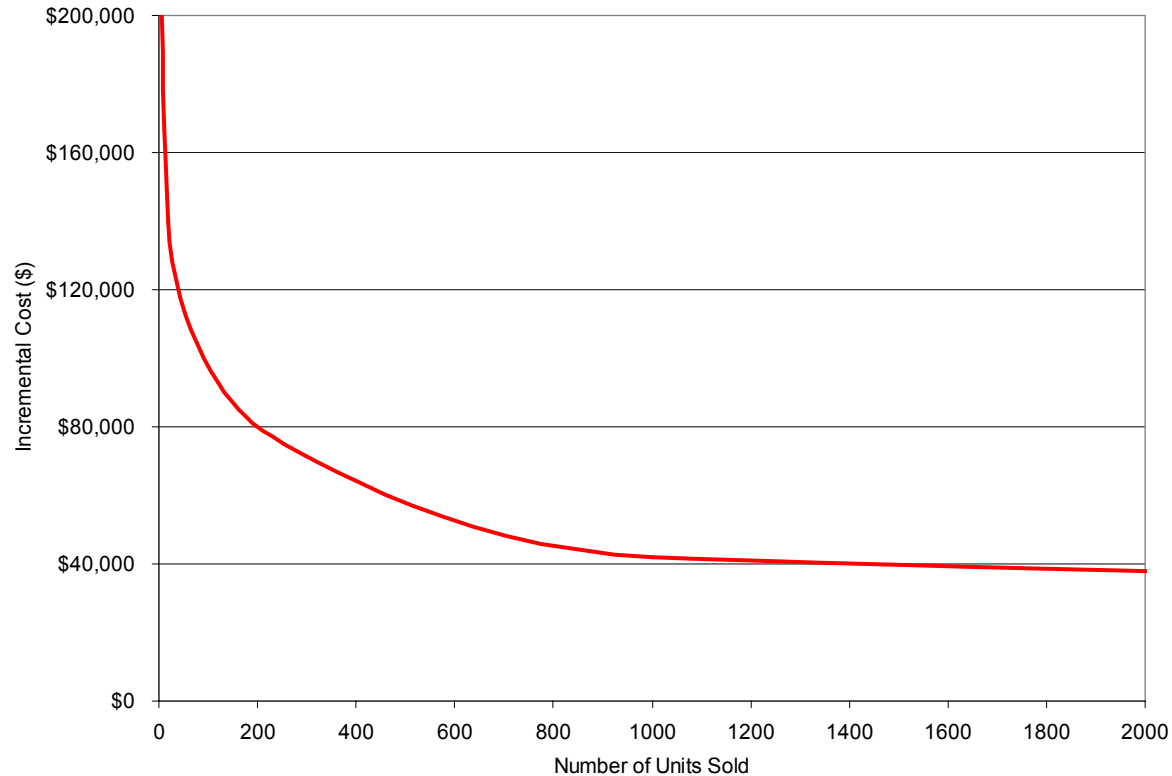


▶ Next Steps

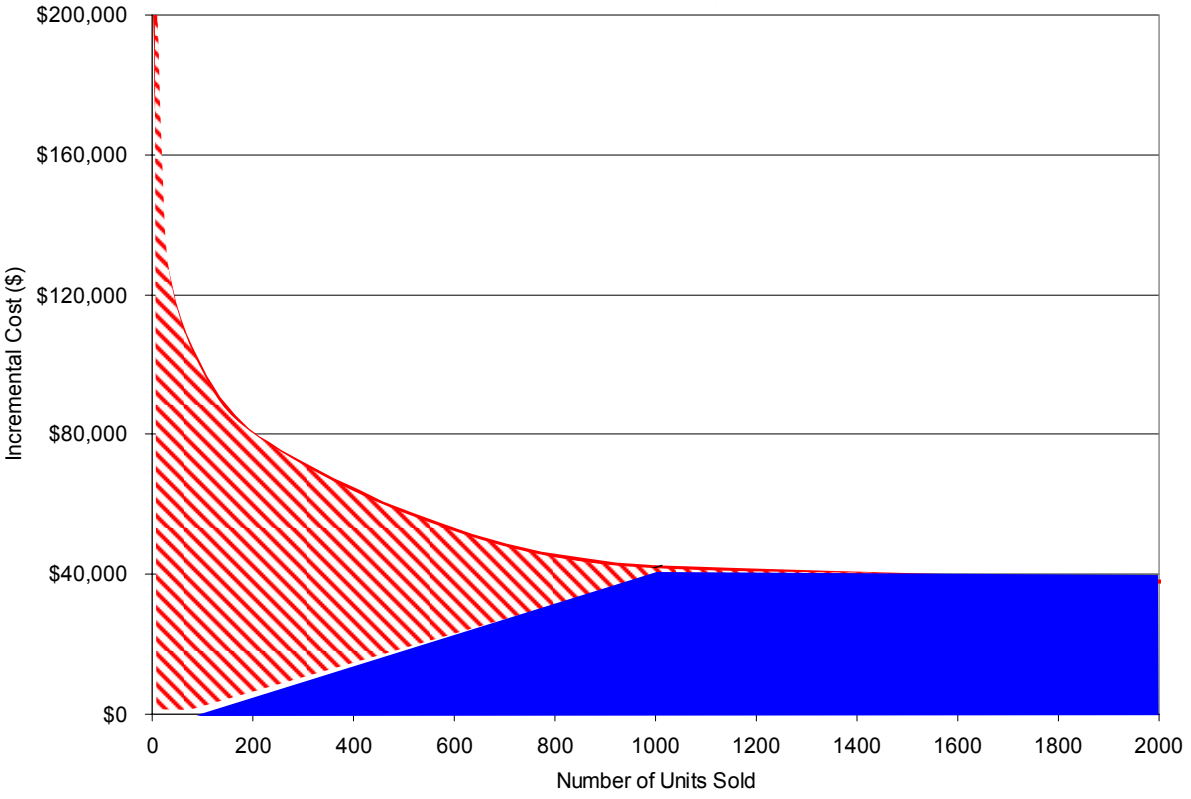
- ▶ 2 Year period of watching and recording emission, fuel economy, maintenance, general operation and driving performance.
- ▶ Program will be expanding with utility support
 - > Approximately 300 buses
 - > Estimated \$80,000 incremental cost
- ▶ Form on website for emailed program updates



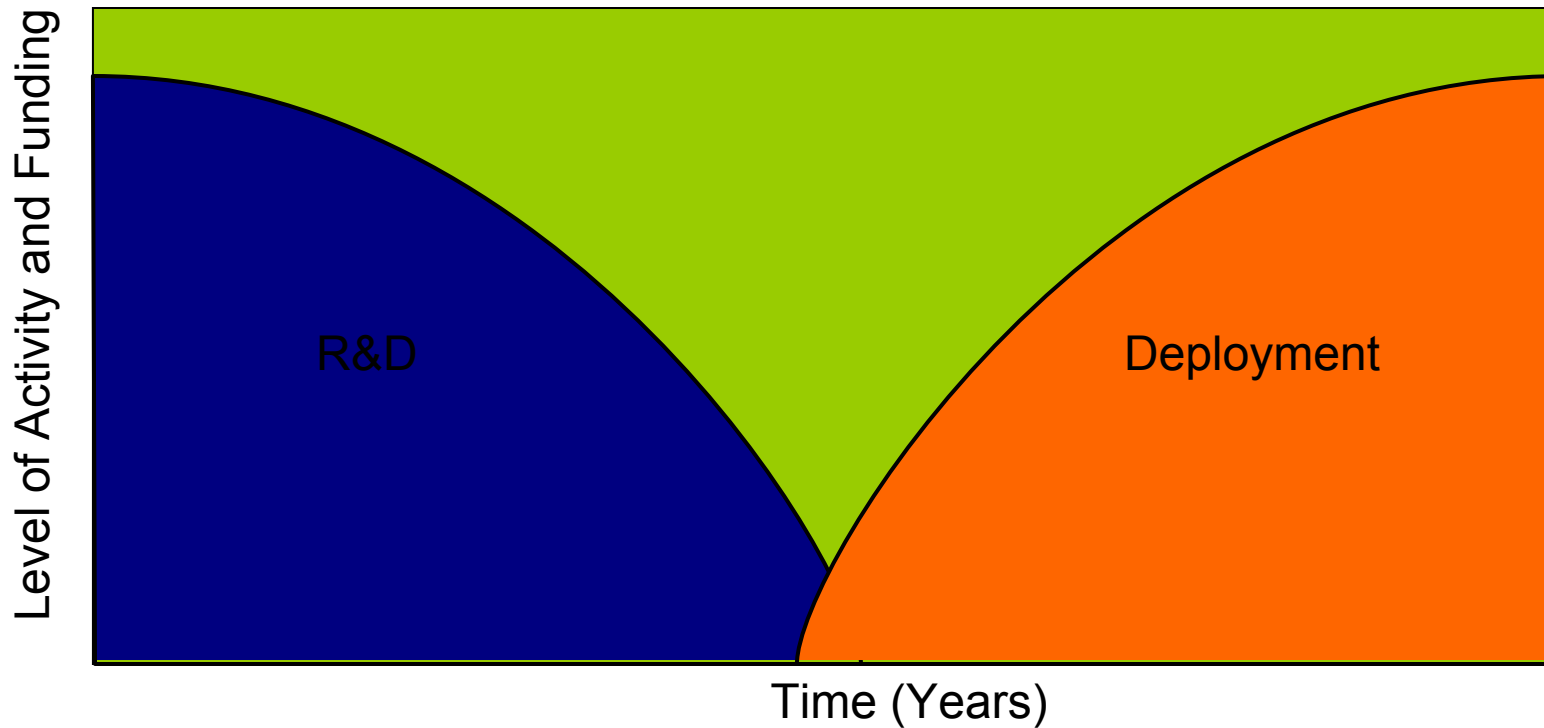
► Incremental Cost per Unit



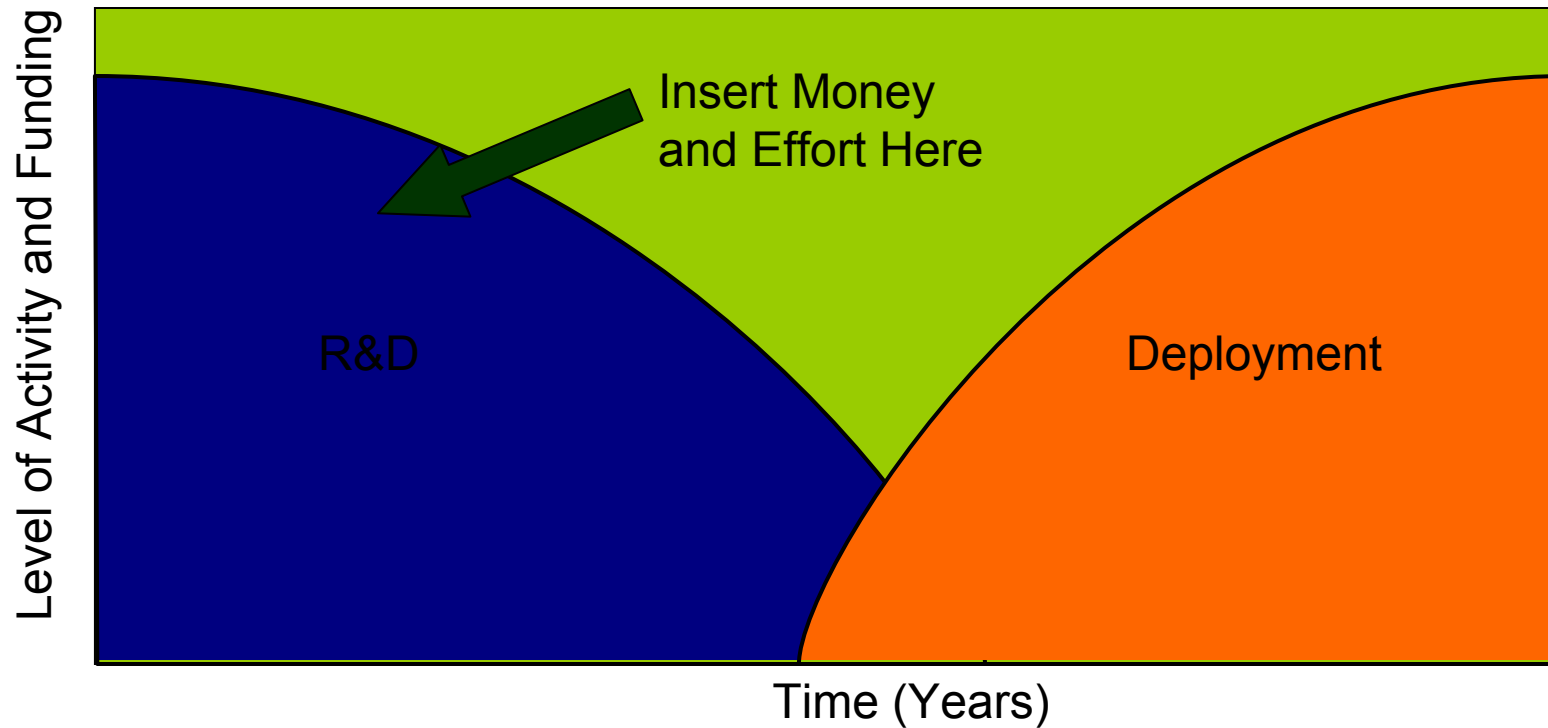
► Cost Share



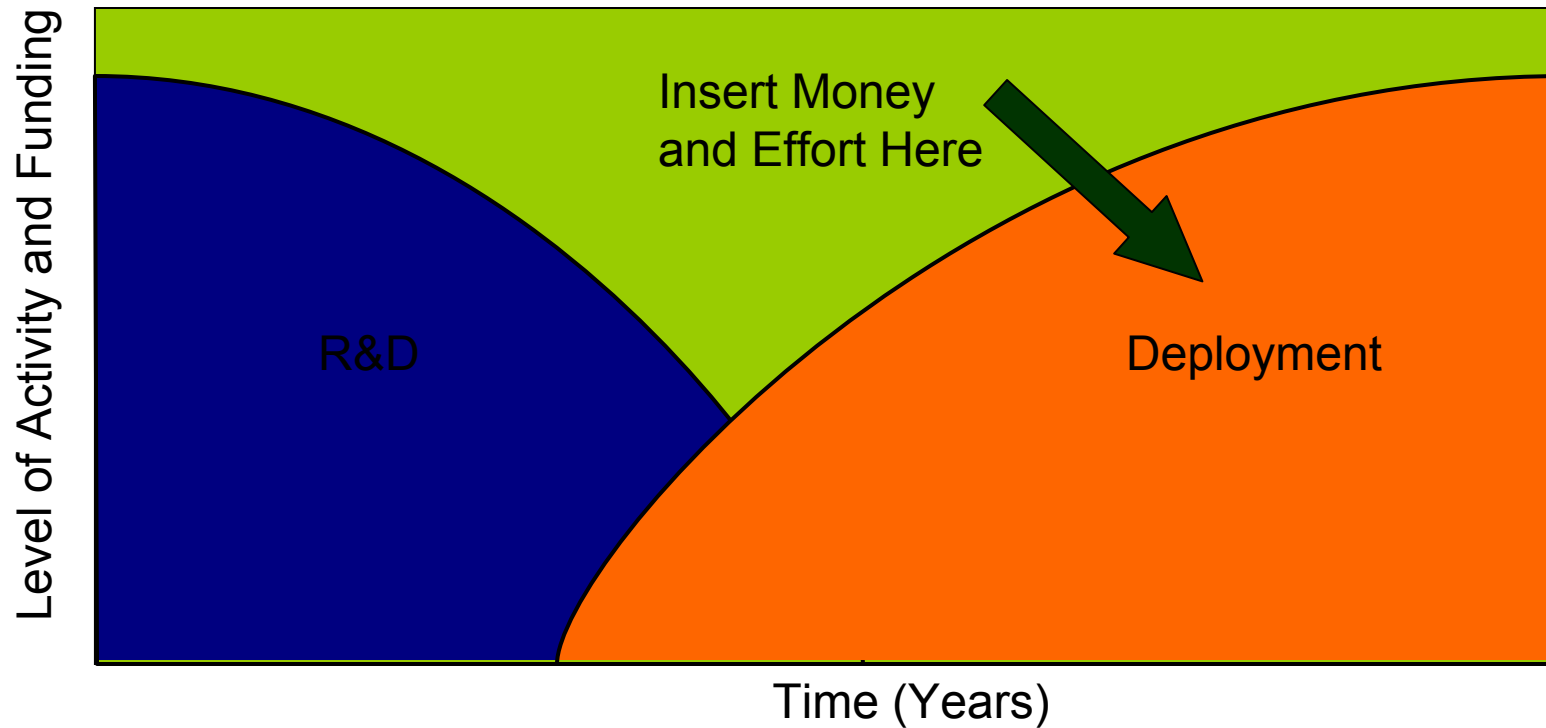
► Push vs. Pull Methodology



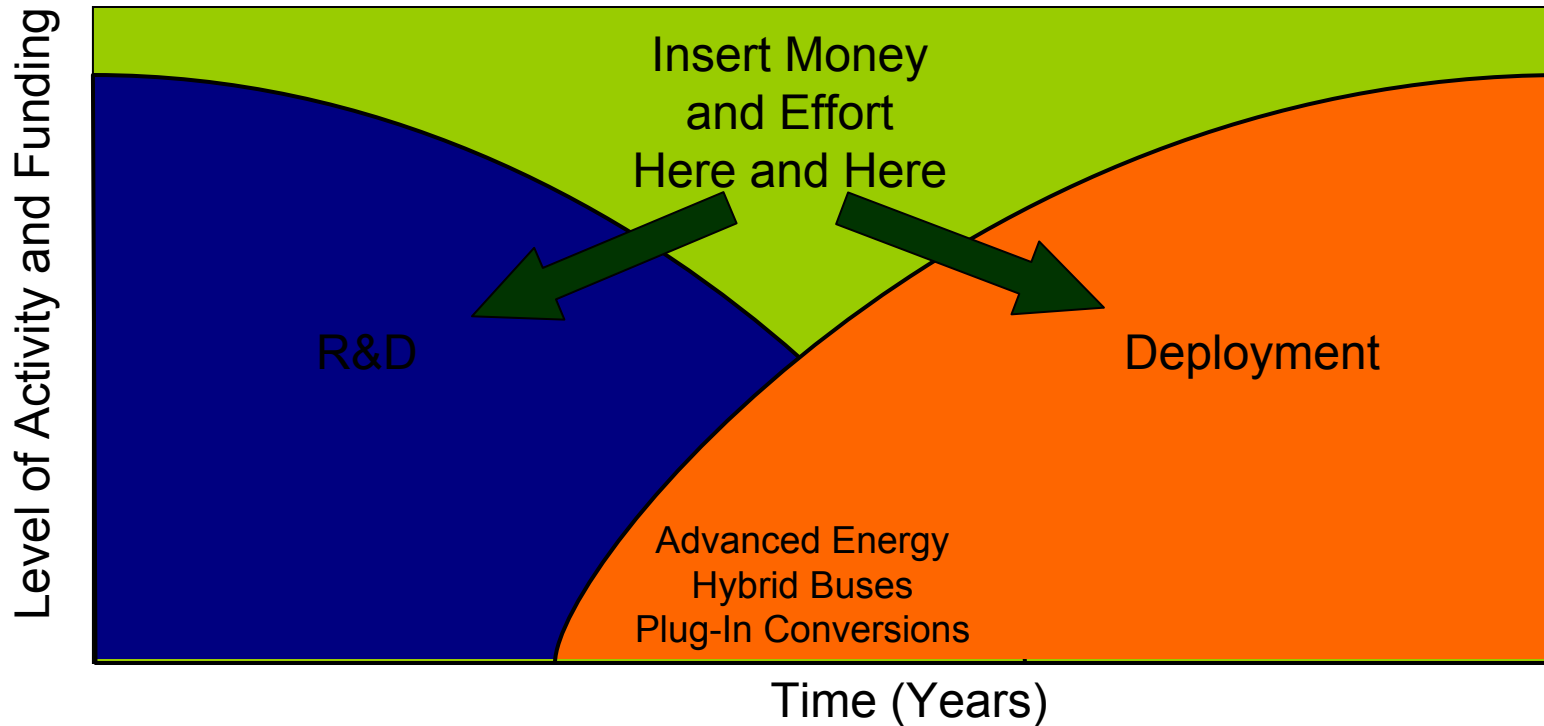
► Push Methodology



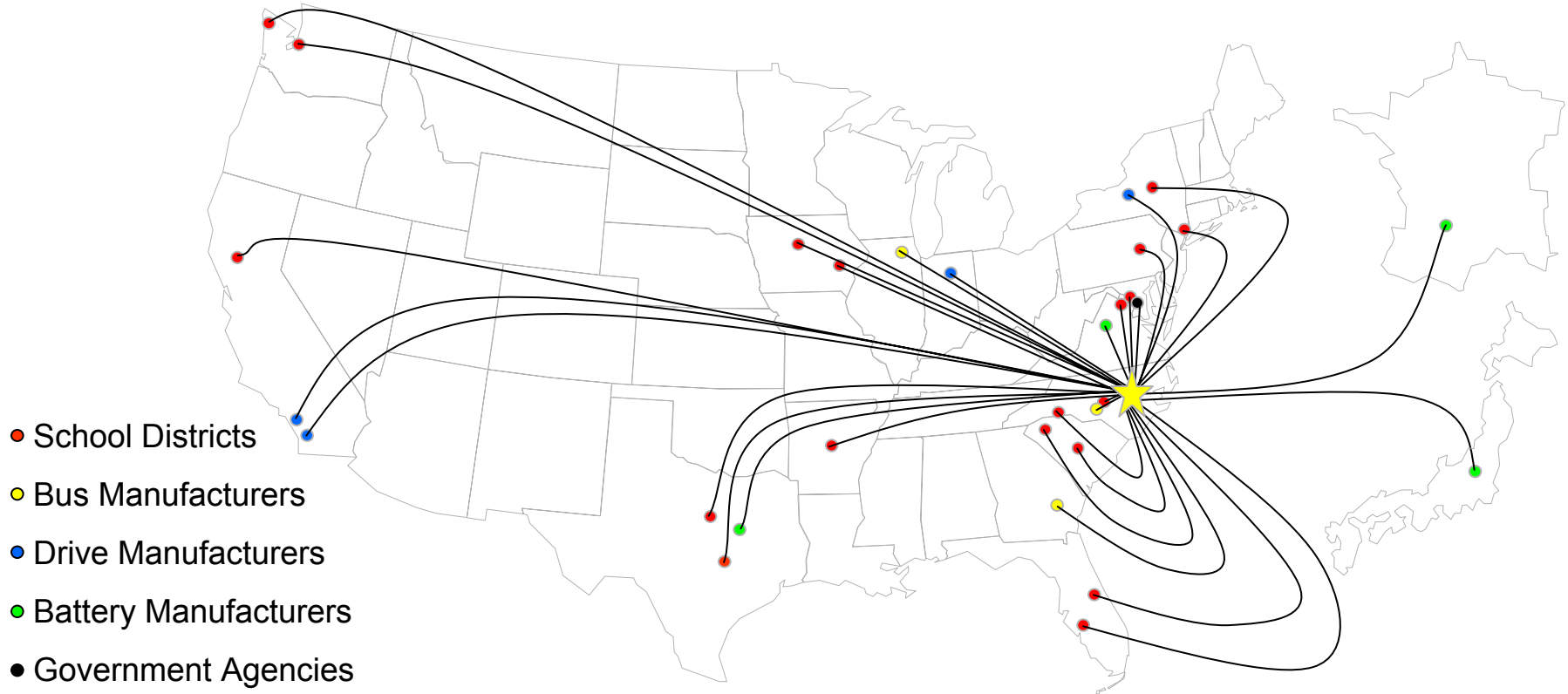
► Pull Methodology



► Balanced Methodology



▶ AE as Facilitator



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