



Electrification of Transportation
-Keshav Sondhi

October 2010



Who killed the Electric Car?

- Late 19th - early 20th century EVs were common



Oliver Parker Fritchle
Lincoln NE - NYC
31 October 1908 - 28 November 1908



100 Mile Fritchle Battery circa 1908

Who killed the Electric Car?



-
-
- Amongst other factors, ironically, the invention of the electric starter motor resulted in the first demise of the EVs in the early 20th century
-
-

FedEx Electrification

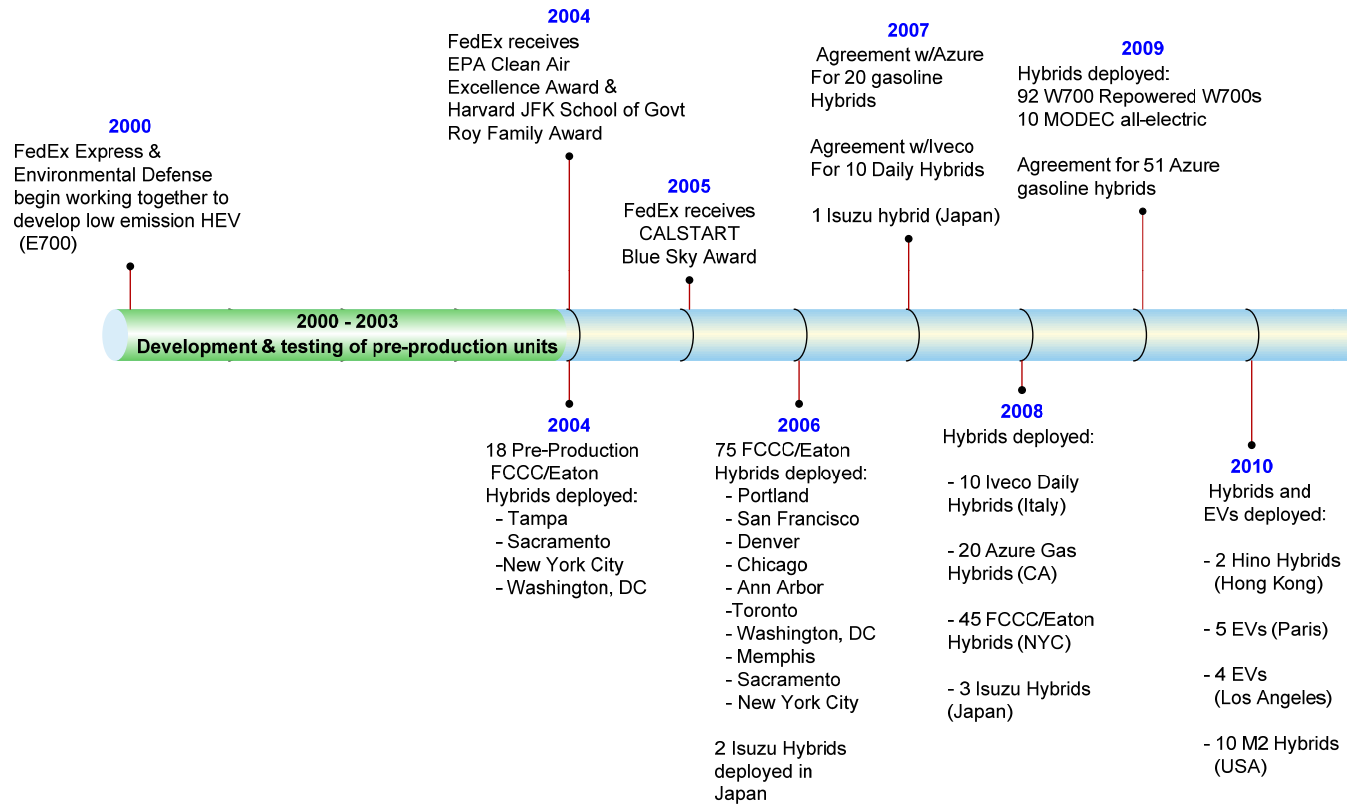
■ History – (alternative/cleaner power sources)

- Battery Electric Vehicles
- Bio-fuels
- CNG
- Fuel Cell
- Hybrid Electric vehicles
- LPG

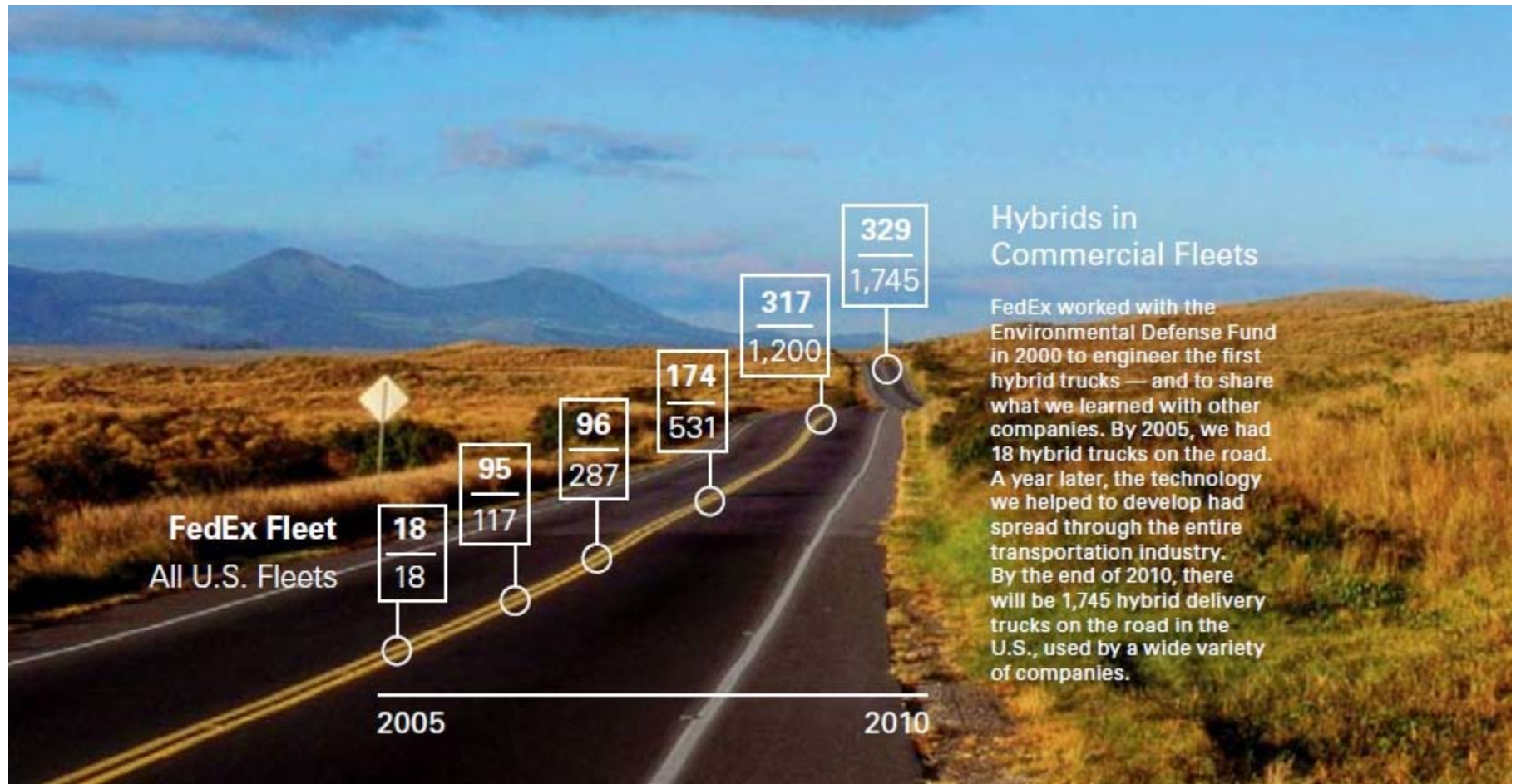
- Electric Vehicles
 - 1992 Lead Acid Battery Electric Vehicle (BEVs)
 - 2000 – Ni-MH Hybrid Electric Vehicles
 - 2006 – Li-ion BEVs



Timeline



HEV Implementation



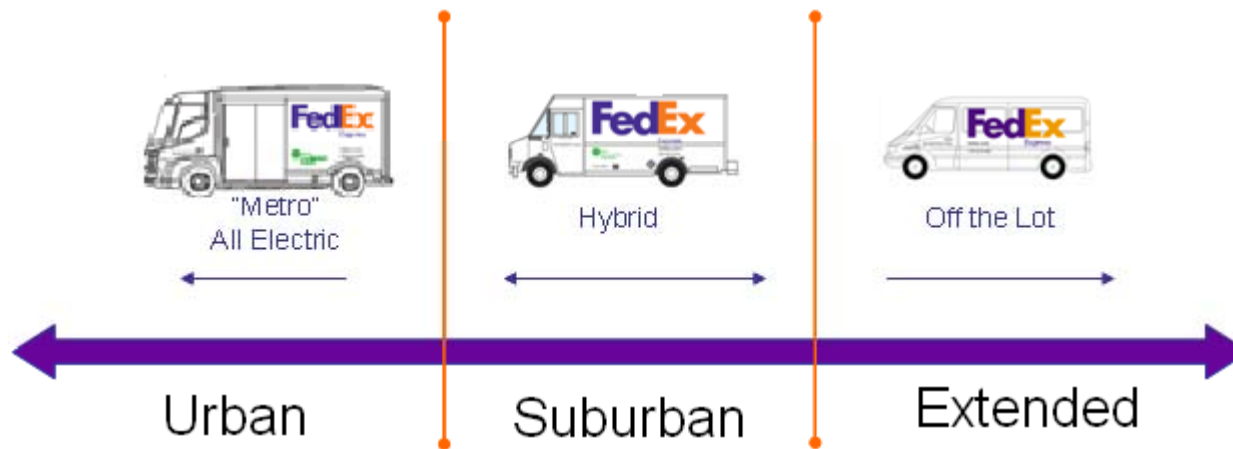
Fleet Optimization

- **Optimized fleet**

- Place the right vehicle for the mission on the route
 - Right vehicle for the route (payload, cubic capacity)
 - Right technology for the route (power source)



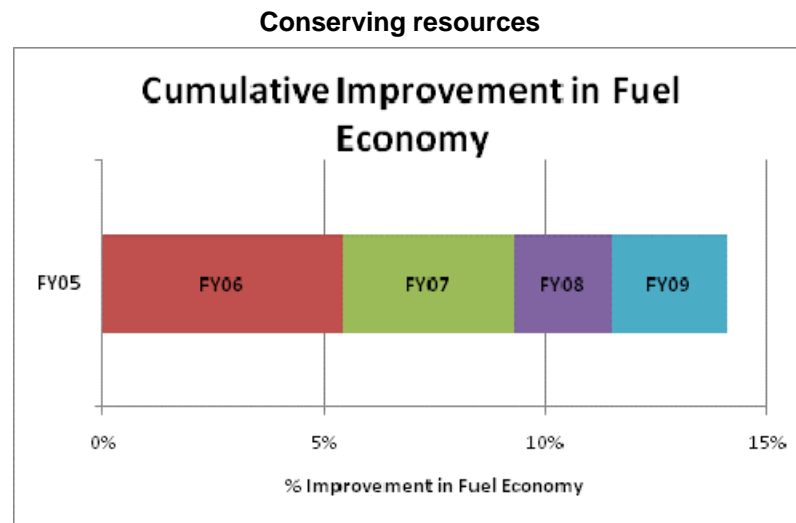
FedEx EV at a delivery depot



Fleet distribution by load requirement and periodic utilization (miles/day)

Fuel Economy Improvement

- **Optimized fleet**
 - Right vehicle
 - Right technology



FedEx' efforts in improving fuel economy of conventional fleet in the last few years (14.1%)

BEV Advantages

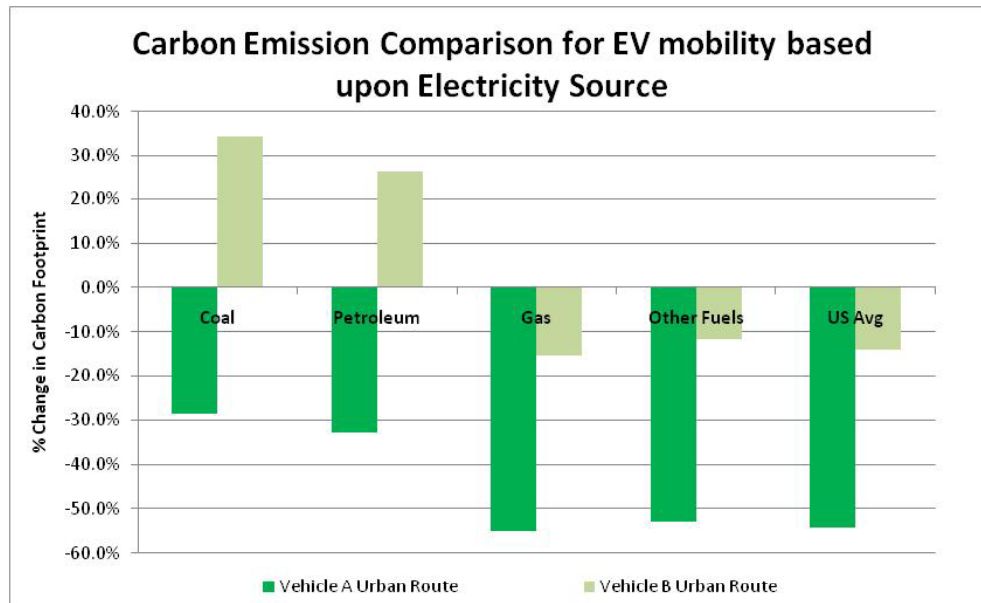
▪ Electric Vehicle Advantages:

- Zero local tailpipe emissions
- Reduced reliance on petroleum
- Torque curves - Simplicity
 - ICE vs
 - EV
- Operating costs : 1/4th of a regular diesel powered vehicles



BEV Environmental Benefits

- Environmental Benefits



Reduction in Carbon footprint by using an EV is a function of:

- Electricity generation source
- Replaced 'conventional' vehicle

Component Interchangeability

Nissan Leaf*



Navistar eStar



Performance		
<i>Driving range</i>	100miles	100miles
<i>Max speed (km/h)</i>	85 mph	50 mph
Motor		
<i>Type</i>	AC motor	DC Permanent Magnet
<i>Max power (kW)</i>	80kW	70kW
<i>Max torque (Nm)</i>	280Nm	300Nm
Battery		
<i>Type</i>	Laminated lithium-ion battery	Laminated lithium-ion battery
<i>Total capacity (kWh)</i>	24kWh	80kWh
<i>Battery layout</i>	Under seat & floor	Within frame under cargo area
Charging		
Quick charger DC 50kW (0 to 80%)	Less than 30 min	-NA-
AC200V charger	Less than 8 hrs	Less than 8 hrs

Larger scale commonality of components between electric cars and electric trucks should further enable cost reduction for trucks through economies of scale.

•LEAF data source: <http://www.nissanusa.com/leaf-electric-car/index#/leaf-electric-car/specs-features/index>

•10/1/2010

BEV Challenges

▪ Electric Vehicle Challenges:

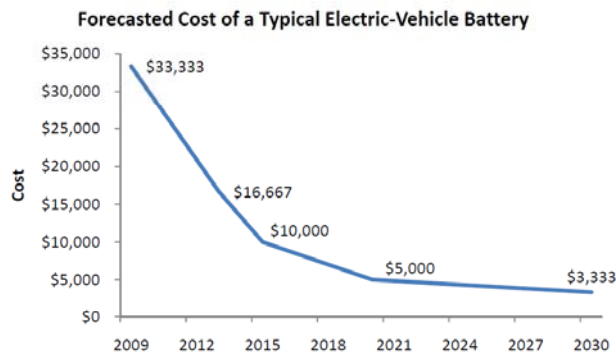
- Cost
 - Battery - cost, warranty and longevity
- Reliability
- Battery size/weight
- Grid/Utility readiness
 - Infrastructure
 - Reliability



Battery Cost and Life

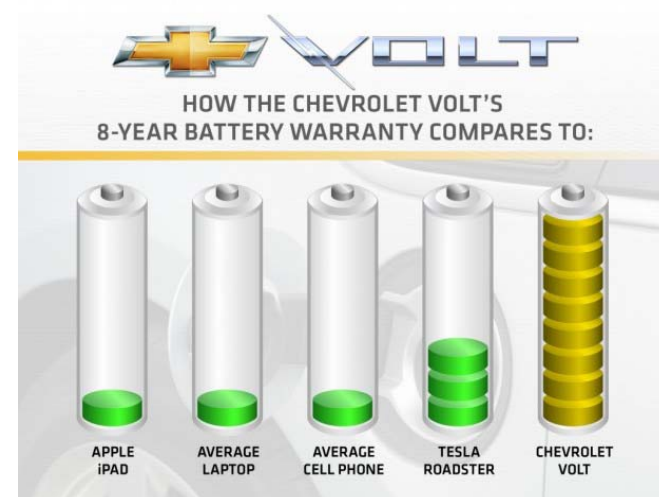
- **Battery Cost Curve**

- DOE Chart



Note: Assumes 3 miles per kilowatt hour and 100-mile range. Source: U.S. DOE Vehicle Technologies Program.

DOE expects battery costs to halve in next 3 years



Chevy Volt Marketing release

<http://gm-volt.com/2010/07/14/official-chevrolet-volt-battery-warranty-is-eight-years100000-miles/>

Battery warranties are improving

Battery Weight and Size

- **EV truck batteries**

- Could be 1,000+ kg in mass
- Heavier vehicle frame required for the added mass
- Reduced payload or higher GVW for same payload as conventional vehicles
 - May affect driver's license requirements



•Photo: Nissan – Leaf Battery – Source Autoblog

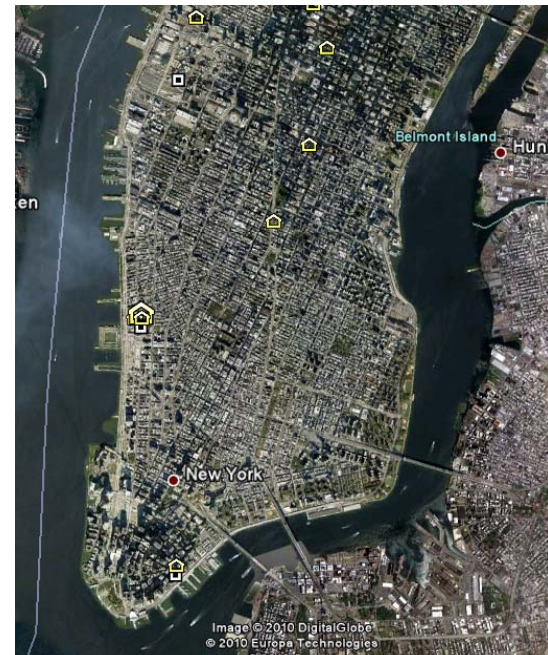


•Photo: General Motors – Volt Battery – Source Autoblog

Grid

■ Grid readiness – Supply and Infrastructure

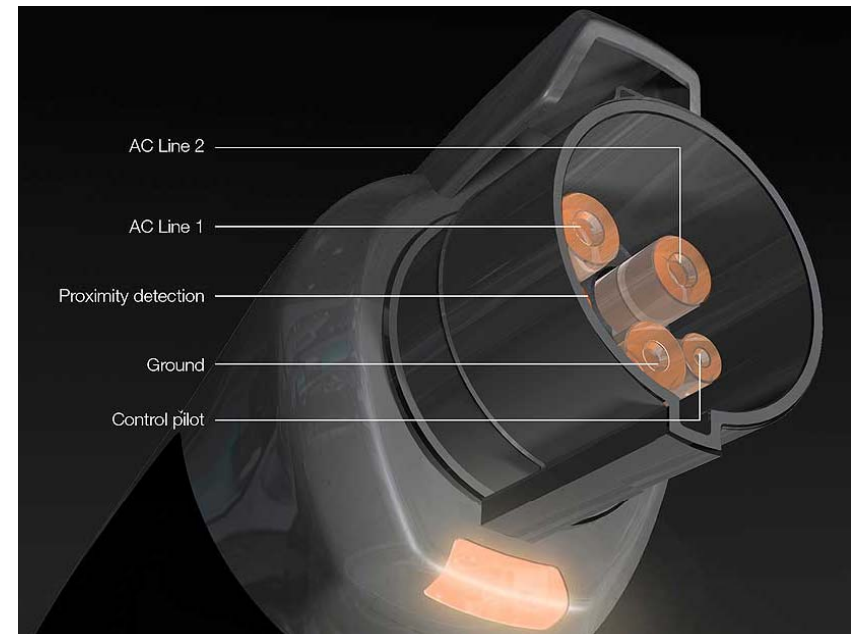
- Street side transformers 50kW powering 4/5 households
- EV loads of up-to 10kW each
- 100 Vehicle metro stations Could create MW level requirements
- Reliability – We will be the fueling station



SAE Charging Protocols

January 2010 SAE finalizes J1772 - First two levels of charging

- AC Level 1: 120 V, 1 phase, up to 16 A
- AC Level 2: 240 V, 1 phase, up to 80 A
- DC Fast Charger Level 3 being worked on



FedEx Electrification

▪ Changing Landscape

– 4 years ago:

- Modec
- Smith

– Now - Several other global mainstream manufacturers

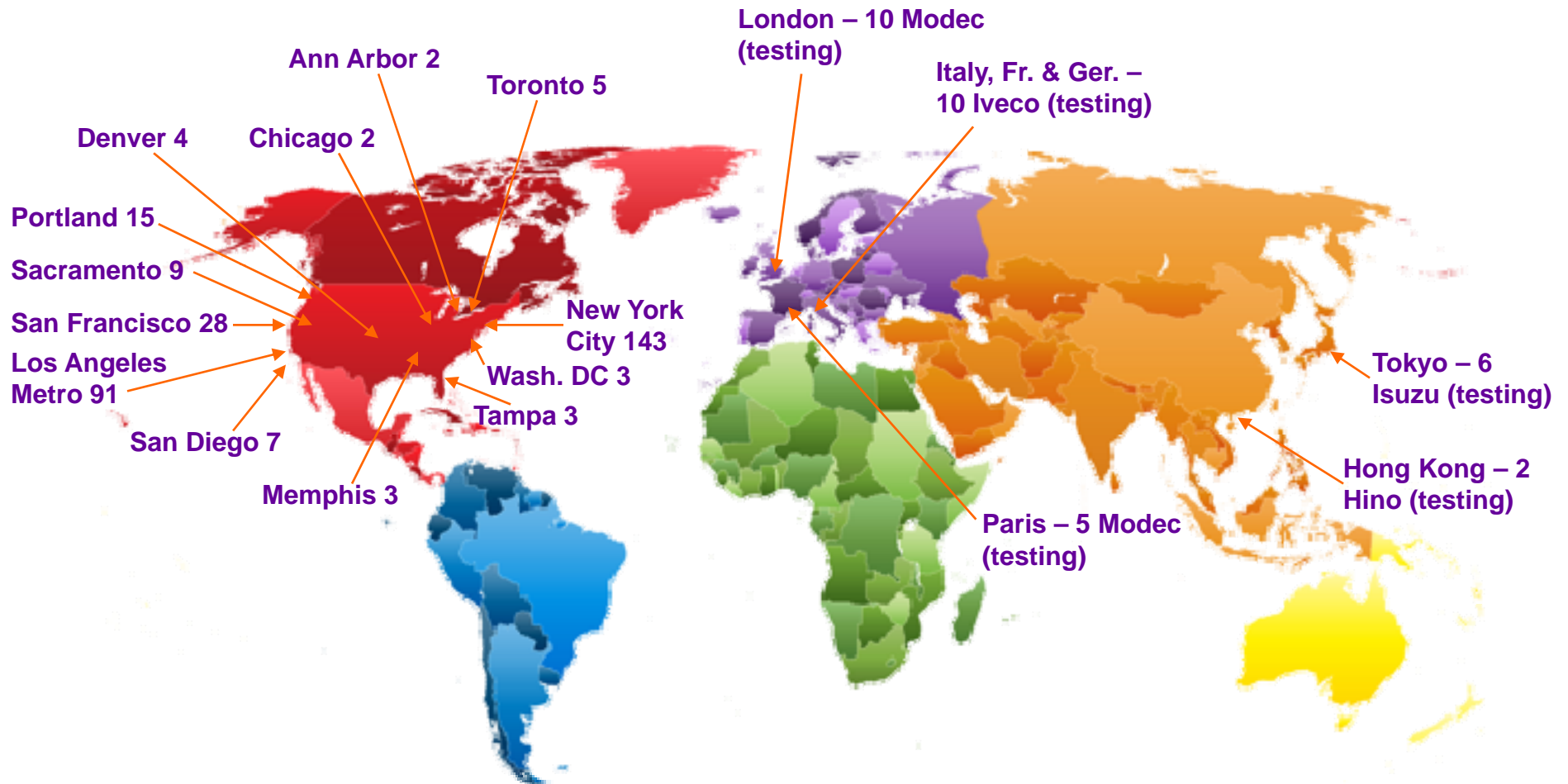
- Navistar(Modec)
- Freightliner Custom Chassis
- Mercedes
- Iveco
- Renault

Mass produced Mitsubishi iMiev



Location of FedEx Alternate Drive-train Vehicles

348 HEV & EV units in service with over 7 million miles of service to date



FedEx Express Alternate Drivetrain Family



FCCC/Eaton W700



Modec/eStar Electric



Ford/Azure W700



Isuzu Hybrid



Hino Hybrid



Iveco Hybrid