



Electrification of Transportation -Keshav Sondhi

April 2011



FedEx Corporation – Vital Statistics

- **Over 8 million shipments daily**
- **664 aircraft**
- **More than 80,000 powered vehicles**
- **More than 280,000 team members**
- **220 countries and territories served**



EarthSmart...A FedEx Commitment

- **Our goal: to connect the world in responsible and resourceful ways**
- It is our commitment to minimize our impact on the environment
- It is designed to encourage innovation that makes our business more sustainable, both economically and environmentally
- Our aim is to find or create new ways not only to improve our own environmental performance, but also to point the way for other companies

EarthSmart Solutions – Vehicles

- FedEx Express goal:
 - 20% fuel efficiency improvement in vehicles by 2020
- Improvements:
 - 14.1% vehicle fuel efficiency improvement since 2005
 - 42% fuel efficiency improvement with hybrid step vans
- Vehicles and routing efficiencies
 - Developed and implemented hybrid-electric trucks
 - Modified fleet management
 - Optimized routes for improved efficiency



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



Who killed the Electric Car?

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

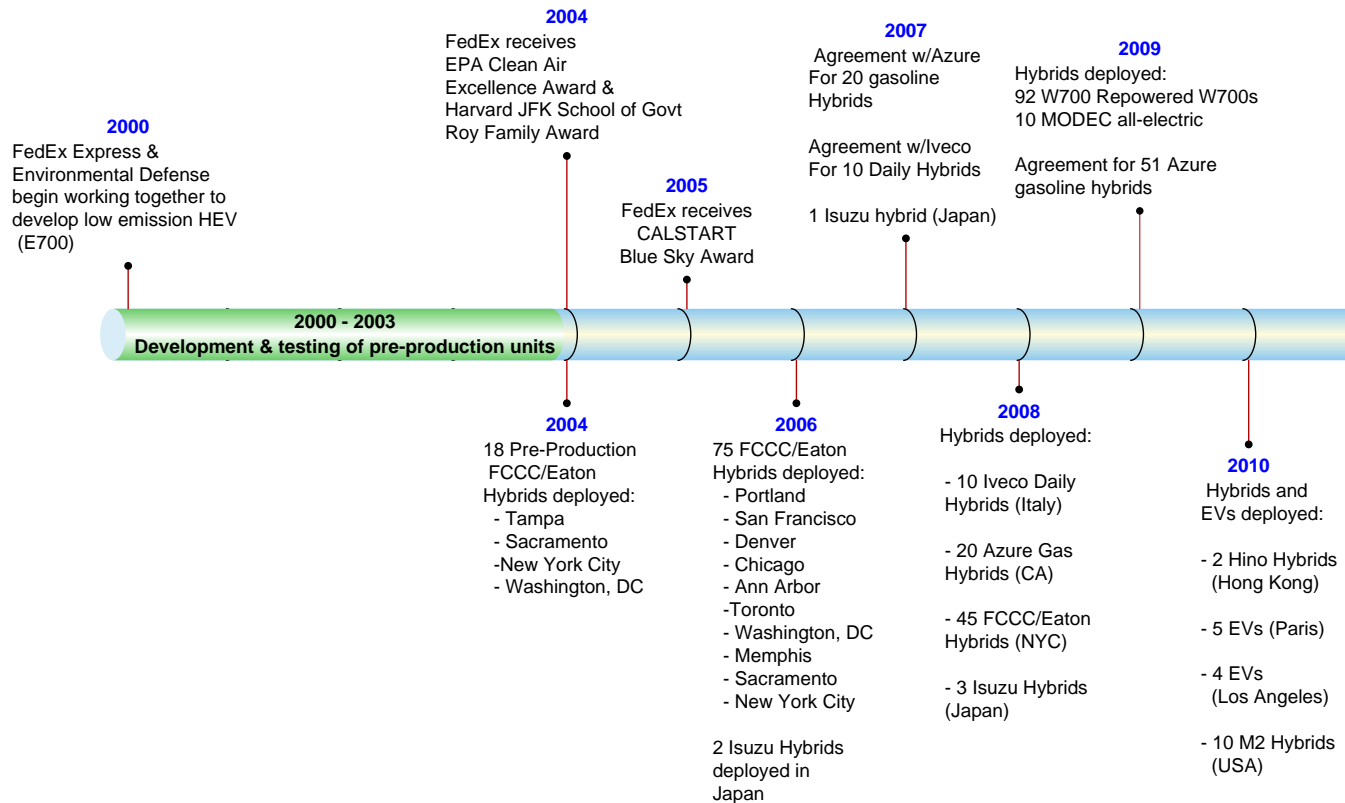


Oliver Parker Fritchle

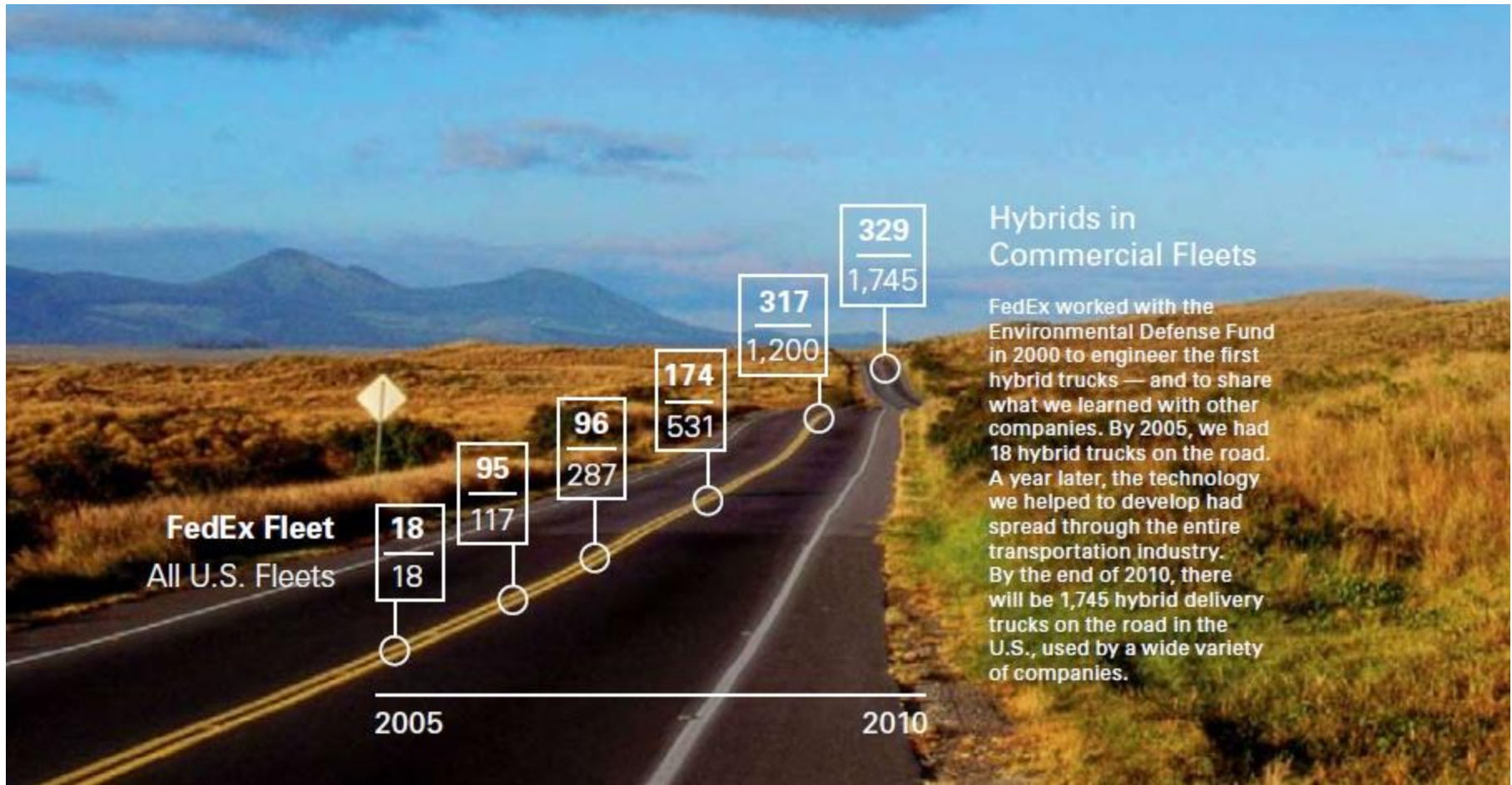
Lincoln NE - NYC

31 October 1908 - 28 November 1908

Timeline



HEV Implementation



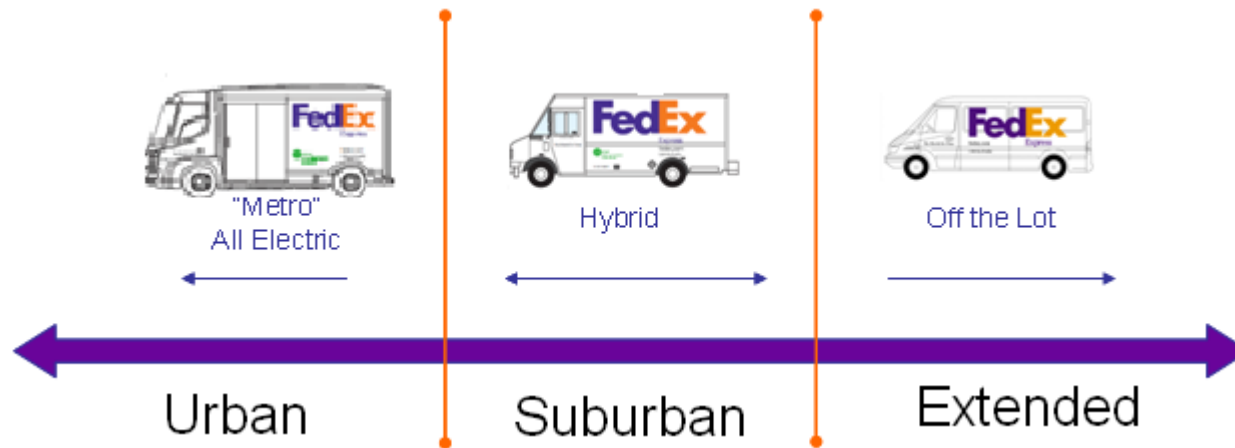
Fleet Optimization

■ 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

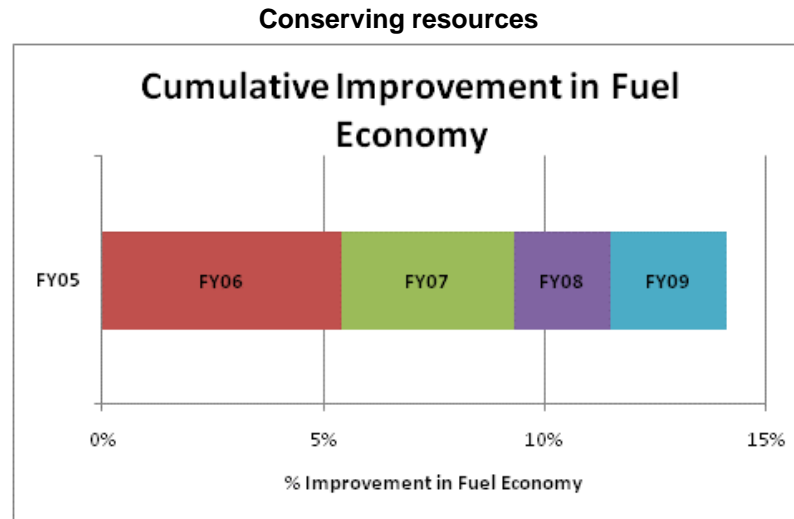


Fleet distribution by load requirement and periodic utilization (miles/day)

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

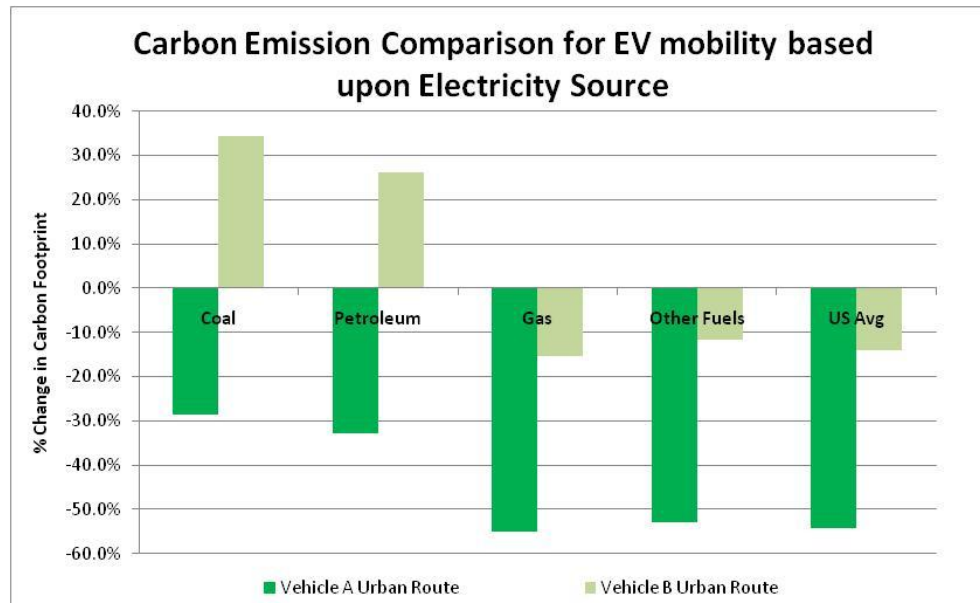
▪ Electric Vehicle Advantages:

- 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 |
| <i>Charging</i> | | |
| 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:

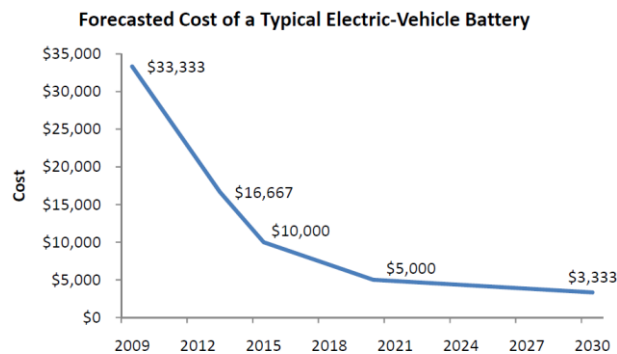
- Cost
 - Battery - cost, warranty and longevity
- Reliability
- Battery size/weight
- Grid/Utility readiness
 - Infrastructure
 - Reliability



Battery Cost and Life

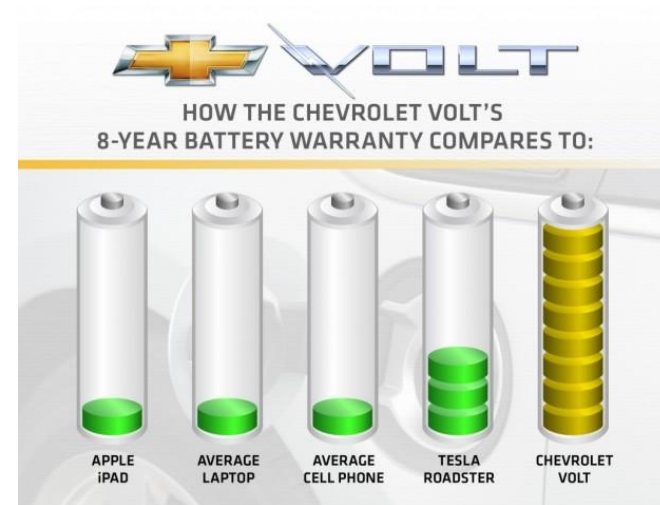
■ Battery Cost Curve

– 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



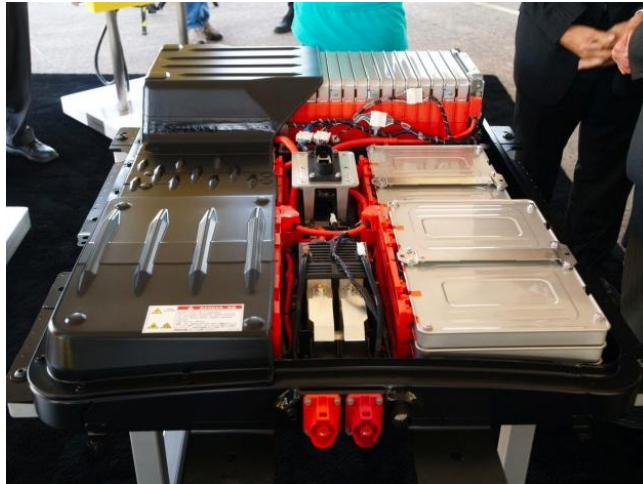
Chevy Volt Marketing release

Battery warranties are improving

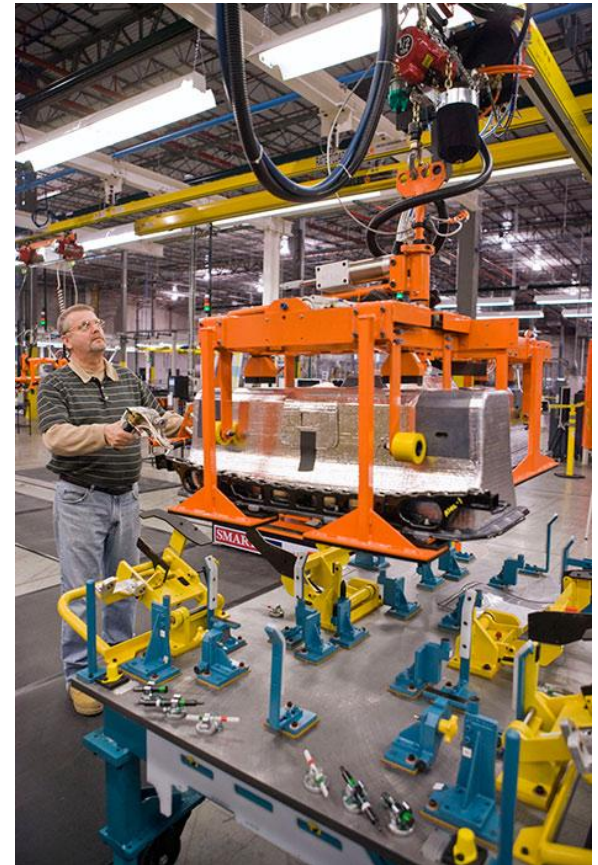
Battery Weight and Size

- **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

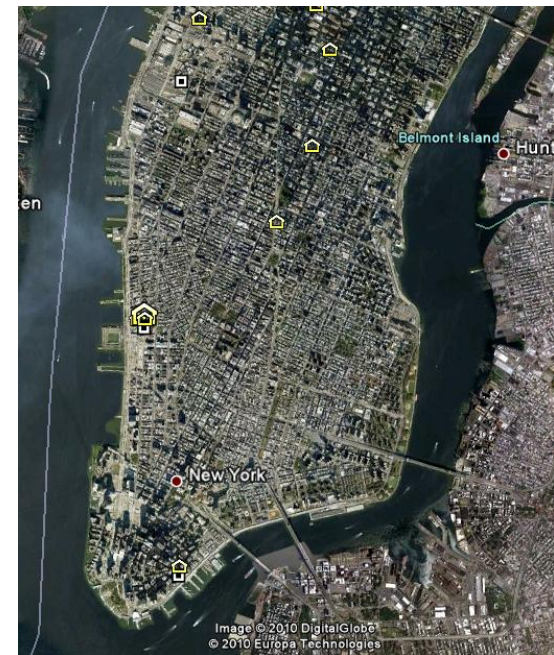


•Photo: General Motors – Volt Battery

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



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



FedEx Express Electric Vehicles



•Modec Electric Vehicle
London 10, Paris 5



•Navistar eStar Electric
Los Angeles, 4 in test

- London vehicles have been in service since May 2009, primarily in the Congestion Charge Zone and in routes less than 40 miles
- Paris and Los Angeles vehicles were delivered in May 2010; eStar vehicle has a slightly different body styling than shown

FedEx Express – Hybrid Timeline

- FY04 – **18** Pre-Production FCCC/Eaton hybrids deployed
- FY06 – **75** FCCC/Eaton hybrids and **2** Isuzu hybrids (Japan)
- FY08 – **45** FCCC/Eaton hybrids, **20** Pre-Production Ford/Azure gasoline hybrids, **10** Pre-Production Iveco Daily hybrids (Europe), and **2** Isuzu hybrids (Japan)
- FY09 – **92** existing FCCC trucks retrofitted with Eaton hybrid systems and **2** Isuzu hybrids (Japan)
- FY10 – **51** Ford/Azure gasoline hybrids, **10** Freightliner M2 hybrids, and **2** Hino hybrids (first commercial hybrids in Hong Kong)
- FY11 – **1** Hino hybrid (Japan) and more coming for US (not Hino)

Total of 330 hybrid trucks placed in operation with nearly 9,000,000 combined miles of service to date

Business and Technical Obstacles

▪ **Business case not yet viable for hybrids**

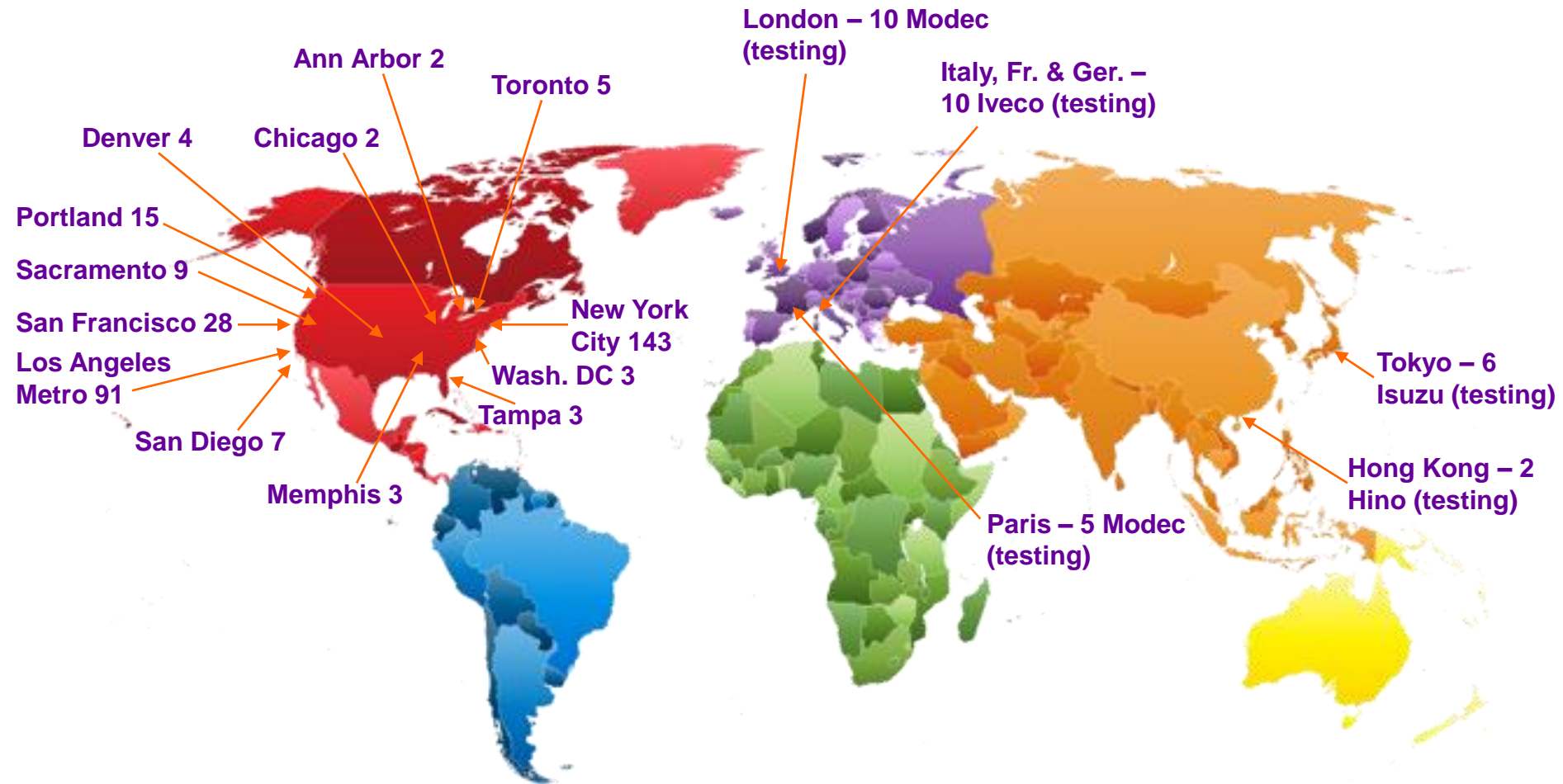
- Cost still remains too high; need premium below 20%
- Premium not reducing at significant rate

▪ **Technical restrictions**

- No four cylinder (lower HP) diesel engines available that meet EPA Emissions since 2006; need for W700
- Very limited OEM hybrid truck models
- Need smaller, Class 2-3, alternative drivetrain vehicles like the hybrids we have in Japan and Hong Kong except with pass-through bulkheads

Location of FedEx Alternate Drive-train Vehicles

349 HEV & EV units in service with over 9 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

Summary

- Largest fleet of hybrid & electric package delivery trucks...349 hybrid electric and electric vehicles with nearly 9 million miles of service to date
- Year 2020 goal...20% improvement in vehicle fuel economy by 2020
 - Expand alternate drivetrain fleet
 - Reducing CO₂ emissions, maintenance and fuel expense
- Maintain global leadership role in vehicle technology and innovation
- Respond to customer requirements in light of CSR goals and further implementation of EarthSmart commitment