EV CASE STUDY

The Electric Drive Bellwether?

FedEx Express on Lessons Learned
From Global EV Deployments
Introduction

Viewers of CNBC and other financial networks know that the FedEx Corporation quarterly earnings report is closely watched. FedEx is viewed by many as a leading indicator, or bellwether, for the spending power and confidence of consumers and businesses worldwide. When one looks at the scale and reach of its express delivery service, FedEx Express, it’s easy to understand why. Founded in 1971, FedEx Express is the original express courier service and has built a brand synonymous with its operations. We all know what it means to ‘FedEx’ something.

Today, FedEx Express is the world’s largest express transportation company, serving customers in more than 220 countries and territories. It is the core business component of FedEx’s time-sensitive shipping operations, delivering most packages in one to two business days, all backed by a money-back guarantee. In fiscal year 2012, the company delivered more than 3.5 million packages daily across its fleet of 660 aircraft and 45,000 motor vehicles, generating $26.5 billion in revenue.

For advocates interested in commercializing advanced transportation technologies and alternative fuels, FedEx Express is often a first stop. The company has the operational scale and purchasing power to impact the development of everything from advanced biofuels (used as substitutes for jet fuel) to hybrid and plug-in electric vehicles (PEVs). Of course, FedEx has a powerful incentive of its own to help commercialize new transportation technologies. As a whole, the company consumes more than 1.5 billion gallons of liquid fuel annually, so volatile fuel prices have an impact on its bottom line.

It’s no wonder then that FedEx and its various businesses have often been first movers in testing and deploying alternative transportation technologies. FedEx Express was an early supporter of traditional hybrids and has led the way on PEVs. In other words, just as FedEx provides observers with a chance to take the pulse of the global economy, as an early adopter of electric drive in the parcel delivery market, it is providing important early lessons on the future direction of the industry.
HIGHLIGHTS

- FedEx Express has been a first-mover on hybrids and plug-in electric vehicles (PEVs), deploying its first hybrids in 2005.
- As of June 2012, FedEx Express had deployed more than 130 PEVs globally, including 58 battery electric vehicles (EVs) in the United States.
- The FedEx Express PEV acquisition strategy is focused on EVs for urban routes with low variability and a maximum daily distance that is well within the range being offered by automotive original equipment manufacturers (OEMs).
- Plug-in hybrid electric vehicles (PHEVs) could be an option for FedEx Express vehicles on longer, rural routes in states where electricity is especially inexpensive.
- FedEx Express is deploying and testing EVs from a diverse range of automakers. The company sees itself as a critical proving ground and incubator. It sees EVs as “a key longterm solution.”
- While cost is the most significant barrier to EV adoption today, FedEx Express sees practical steps that both OEMs and fleets can take to help speed uptake:
  - **Battery Right Sizing:** OEMs should diversify vehicle range and right-size batteries to better fit route needs.
  - **Vehicle Life Optimization:** Fleets with long-life assets should increase flexibility by incorporating shorter-life assets to be prepared for an unexpected shift in EV economics.
- While EVs will generate savings on maintenance, fleets with in-house maintenance staff need to manage the transition. There will be a learning curve.
- Onsite charging infrastructure presents a number of cost and system challenges. FedEx Express currently limits the number of EVs it deploys at any one location in order to avoid costly panel and transformer upgrades.
- FedEx Express has deployed 10 EVs at a parcel sort in Manhattan. The vehicles are part of a grid interface study being conducted in partnership with GE and Columbia University.

### FIGURE 1. GLOBAL FLEET SEGMENTATION

<table>
<thead>
<tr>
<th>TECHNOLOGY TYPE</th>
<th>Class 1-2 Truck</th>
<th>Class 3 Truck</th>
<th>Class 4-6 Truck</th>
<th>Class 7-8 Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>North America</td>
<td>17,272</td>
<td>1,048</td>
<td>13,348</td>
<td>3,940</td>
</tr>
<tr>
<td>Rest of World</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
<td>n.a.</td>
</tr>
</tbody>
</table>

NOTE: Figures provided by FedEx Express.

### FIGURE 2. NORTH AMERICAN AFV FLEET

<table>
<thead>
<tr>
<th>TECHNOLOGY TYPE</th>
<th>Class 1-2 Truck</th>
<th>Class 3 Truck</th>
<th>Class 4-6 Truck</th>
<th>Class 7-8 Truck</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hybrid Electric</td>
<td>-</td>
<td>-</td>
<td>345</td>
<td>10</td>
</tr>
<tr>
<td>Plug-in Hybrid Electric</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Battery Electric</td>
<td>5</td>
<td>53</td>
<td>39</td>
<td>-</td>
</tr>
</tbody>
</table>

NOTE: Figures provided by FedEx Express.

### FIGURE 3. FUEL PRICE VOLATILITY INDEX

Index: Jan 2000 = 1

![Graph showing fuel price volatility index from 2000 to 2012](source)

Source: DOE, EIA

### FIGURE 4. U.S. AVERAGE RETAIL FUEL PRICES

![Graph showing U.S. average retail fuel prices from 2000 to 2012](source)

Source: DOE, EERE, Advanced Vehicles Data Center
STRAIGHT CONSIDERATIONS

Plug-in electric vehicles fit into a broader strategy of efficiency and conservation that has become a focus at FedEx Express as the price of oil has increased in recent years. Between 2002 and 2010, FedEx Express spending on fuel in its ground fleet increased by an annual average of nearly 10 percent, reaching a high point in 2008. The company has a fuel surcharge that helps defray the effect of these costs, but FedEx as a whole has been grappling with the issue of price elasticity. In other words, at what point will fuel price increases be too high to pass on to customers?

Seeking to address this challenge, in 2005 FedEx Express announced that it would target a 20 percent improvement in on-road in fuel economy by 2020. By the end of fiscal year 2011, it had already achieved a 15.1 percent improvement. In large part, it accomplished this gain by right-sizing the engines of individual vehicles based on their duty cycle, ensuring that the most efficient engines are deployed on each route. But it has also worked to deploy advanced vehicles, including traditional hybrid-electric vehicles and PEVs.

In 2004, FedEx worked with Environmental Defense Fund and Eaton Corp. to deliver what was billed as “the world’s first street-ready hybrid truck.” These and other hybrids in the FedEx Express fleet currently total 364 units and have collectively traveled more than 10 million miles. In 2008, FedEx Express was among the first companies working to deploy battery electric vehicles in its global fleet. After an initial deployment in London, additional PEVs were placed in service in Los Angeles, San Francisco, Chicago, Memphis, New York, and Paris. As of June 2012, FedEx Express had 130 electric vehicles in its fleet worldwide.

The PEV acquisition strategy at FedEx Express is generally focused on battery electric vehicles (EVs). The greater range offered by PHEVs could eventually make them an option on longer, rural routes, particularly in states where electricity prices are low. However, there are currently few PHEV options in the commercial truck space, and early FedEx Express deployments are targeting segments of the fleet where daily operating norms won’t require more than the 100 miles of range being offered by most EVs today. In North America alone, FedEx Express operates more than 25,000 medium-duty walk-in trucks whose average daily driving distance is 75 to 80 miles. In fact, the daily route for many of these trucks is much less than 75 miles, particularly for those vehicles on urban delivery routes in densely populated cities.

As automakers continue to steadily increase their range of commercial EV offerings, FedEx Express is experimenting with multiple vehicle models. The company has deployed EVs from Smith Electric Vehicles, Navistar, Freightliner, and Ford. FedEx Express sees its role as providing strict guidance on its needs (power, efficiency, cargo capacity, etc.) and then working with the automakers to deploy, test, and ultimately commercialize the best individual models. In many instances, FedEx Express is working with other key stakeholders, such as Con Edison, Columbia University, GE, and even national labs.

While some of these projects are still generally in a research and development (R&D) phase, there is clearly a sense of urgency. Going forward, FedEx Express sees EVs becoming akin to a ‘license to operate’ in key countries. The low-emissions zones (LEZs) in Italian cities like Rome, Florence, and Milan, for example, are becoming more stringent and eventually may effectively restrict today’s conventional diesel trucks from entering the city center during business hours. In London, electric vehicles are exempt from the city’s Congestion Charge Zone (CCZ) scheme, which can cost operators up to $15 daily to enter the city center during business hours. In such cases, EVs already present an opportunity to substantially reduce operating costs.

CRITICAL DECISION FACTORS

A range of factors were taken into consideration as FedEx Express explored the possibility of adding EVs to its fleet. The vehicles carry a great deal of promise due to a number of economic, regulatory, and environmental benefits, but there are also important challenges. FedEx Express offered insight into its decision-making process by ranking various factors and discussing their rationale around each one in detail. (Rankings are provided in Figure 5.)

FIGURE 5. PEV PURCHASE RATIONALE

Scale is 0 to 5, with 5 indicating a factor weighed heavily in the decision process and 0 indicating that it did not factor at all.

<table>
<thead>
<tr>
<th>Positive Factors</th>
<th>Negative Factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fuel Savings</td>
<td>Vehicle Upfront Cost</td>
</tr>
<tr>
<td>Long-term Commitment to the Technology</td>
<td>Total Cost of Ownership</td>
</tr>
<tr>
<td>Vehicle Maintenance and Support Savings</td>
<td>Operational Sacrifices</td>
</tr>
<tr>
<td>Corporate Social Responsibility Requirements</td>
<td>Concerns about Onsite Infrastructure (Cost,</td>
</tr>
<tr>
<td></td>
<td>Complexity, Mgmt)</td>
</tr>
<tr>
<td>Research and Development</td>
<td>Concerns about Battery/Vehicle Residual Value</td>
</tr>
<tr>
<td>Corporate Image with Customers</td>
<td>Vehicle Reliability</td>
</tr>
<tr>
<td>Hedge Against Fuel Price</td>
<td>Concerns about Safety</td>
</tr>
<tr>
<td>Operational Benefits (e.g., on-site power</td>
<td>Access to Competitive Financing</td>
</tr>
<tr>
<td>generation)</td>
<td></td>
</tr>
</tbody>
</table>

Note: Based on interview with FedEx Express
**Total Cost of Ownership:** Today’s PEVs carry a purchase price premium that can place them at several times the cost of a similar conventional vehicle. While FedEx Express can procure a class-3 Sprinter for as little as $40,000, recent estimates place the cost of a similarly-sized EV at $125,000 or more. Even at fuel price levels witnessed throughout 2011 and the first half of 2012, that makes EVs a difficult proposition. Moreover, today’s EVs are often competing against a fully-depreciated conventional truck.

FedEx Express is approaching the cost challenge from multiple angles. From an operations perspective, it is working with automakers to diversify vehicle range and right-size battery capacity to more closely fit route needs. Today, automakers are almost exclusively offering electric vehicles with 100 miles of range. (Exceptions like Smith Electric Vehicles don’t yet offer a variety of ranges for key platforms, such as mid-sized walk-in trucks.) This one-size-fits-all approach to vehicle range results in unnecessary cost and unused battery capacity on urban delivery routes, where a given truck may travel only 15 to 20 miles daily.

FedEx Express is also working to make its fleet more nimble so that it is prepared for a disruptive change in EV economics—for example due to sharp rise in fuel prices or an unexpected drop in battery prices. The company’s current approach of running trucks with a 20- or 30-year expected life makes it difficult to be nimble in the face of rapidly shifting market dynamics. Deploying trucks with shorter expected service lives—10 years, for example—could make the fleet more flexible. FedEx is also looking also at revising current engine replacement approach and installing electric drive systems on older trucks as drive-train replacement comes up.

**Vehicle Maintenance and Support Savings:** The early experience of numerous operators suggests that EVs will deliver substantial savings on routine maintenance costs when compared to conventional gasoline and diesel trucks. This is particularly true as vehicles age in terms of total mileage—the maintenance costs for a typical internal combustion engine vehicle increase sharply around 50,000 miles. Still, incorporating EVs into fleets will require a managed transition for maintenance staff.

Approximately 90 percent of the conventional FedEx Express fleet is currently maintained by in-house staff. So as it continues to deploy electric vehicles, FedEx Express is working to train its existing staff to service the new vehicles as needed. In the meantime, FedEx Express technicians are working with automotive original equipment manufacturers (OEMs) to learn the new technology. In addition to broadening the knowledge base of its in-house team, FedEx Express believes this collaborative process could present opportunities for joint IP development.

Of course, this is not the first time FedEx Express has deployed new technology. In the early 2000s, as FedEx Express began deploying Mercedes-Benz Sprinter vans on urban delivery routes, in-house maintenance staff made a significant transition from traditional diesel engines to vehicles with more electronic systems onboard. The shift in technology generated important learnings that FedEx Express believes it can apply to EV deployment.

First, there will be a learning curve. FedEx Express recorded its highest ever labor hours per vehicle in 2002 as employees began servicing Sprinters. This required a degree of flexibility from management in terms of employee evaluations. As employees moved down the learning curve, hours per truck returned to the historical average.

Second, once a technology shift is viewed as inevitable, it has a lot of self-sustaining momentum. There was some early inertia among service staff dealing with Sprinters, but today FedEx Express has switched almost entirely to the more efficient vehicles in urban delivery settings, and facilities that don’t have them yet are clamoring for them. As additional OEMs began announcing plans to market similar vehicles, employees could see the direction of the industry and did not want to be left behind from a skills perspective.

**Electric Vehicle Charging Infrastructure:** While its traditional vehicles typically refuel at retail gasoline stations, EVs will offer FedEx Express the opportunity to power its vehicles onsite. In urban areas like New York and Washington, DC, where gasoline stations are becoming increasingly scarce, this could present an important operational benefit. Additionally, because its parcel delivery trucks are not in operation overnight, FedEx Express will not rely on public charging infrastructure. Nonetheless, onsite charging presents its own set of costs and complexities.

As a rule of thumb, FedEx Express expects to spend roughly $10,000 per level 2 (240 Volt) electric vehicle supply equipment (EVSE) unit. This figure represents a comprehensive cost estimate that includes hardware (30 percent of the cost on average) as well as installation (conduit, cables, etc.) Interestingly, this figure has generally held across multiple regions thus far—North America, Europe and Asia.

To avoid dealing with expensive upgrades to electricity panels or utility infrastructure, FedEx Express currently limits the number of vehicles and chargers deployed at each facility. Deployments are also designed so that offpeak charging of all trucks simultaneously will not exceed an individual facility’s peak load, which tends to avoid expensive demand charges. While it will eventually move beyond this framework to deploy greater numbers of vehicles, FedEx Express believes early efforts should focus on “getting the vehicles right.”
Sam Ori, Director of Policy at the Electrification Coalition, recently sat down with Keshav Sondhi, Manager for the Asset Management Group at FedEx Express, to get a first-hand understanding of how the company’s electrification strategy is playing out in a real world project. What follows are highlights from the discussion.

**Q: Manhattan is obviously a high-profile location to test these vehicles. How did you decide to go there?**

Well, the first thing we did was look for places where we felt EVs had the best chance to succeed. There are some obvious challenges for EVs no matter where you deploy them, so we wanted to focus on locations where the factors that we could control would be conducive to electrification. We want to serve as an incubator. And, in fact, Manhattan is the ideal route structure for EVs. You have limited daily driving and the vehicles return to base at night.

From a profile standpoint, our drivers in Manhattan are like rock stars. People actually flag them down to ask questions about the vehicles. They want to know about the technology, because it looks so different and unique. I think that has real value for the FedEx brand.

**Q: The partnership set up for this project is impressive. What do you hope to accomplish?**

At a basic level, this project is about gaining a better understanding of the interface between the vehicles and the grid. All of the stakeholders in the EV ecosystem are interested in getting more data. We need to validate a lot of assumptions. But we also want to be proactive about tackling challenges. When you look at places like Manhattan, the infrastructural components of electric power grid are older, and electric vehicles can present a real challenge for the utility if they are deployed in high concentrations or charging isn’t managed properly. If we want to get past deploying just 10 vehicles at facilities like this, we need to learn a lot more.

I think we need understand the batteries better as well and really get a sense of their value outside the vehicle. We would like to eventually repurpose used batteries from these vehicles to provide ancillary grid services, like frequency regulation and load shaving. If that doesn’t work out, it’s a concern in terms of residual value.

**Q: How do you think about expanding the ROI equation for electric vehicles?**

Manhattan actually provides a great example. Gasoline stations in mid-town have been closing rapidly over the past several years due to the rising value of real estate and the high
cost of transporting fuel into downtown areas. As a result, areas of midtown Manhattan have virtually no refueling options, and fleet operators like taxis and parcel delivery vehicles have to drive to other areas of the island to refuel. The lines can sometimes stretch for blocks.

For us, this problem has necessitated dispatching a driver to go on afterhours fuel runs every other day at time and a half. Electric vehicles charged onsite and overnight obviously get us away from that process, which provides an additional financial incentive to transition away from conventional vehicles. I’d note that New York is not alone on this issue.

Q: Your business is clearly built on reliability. How have EVs performed so far?

On range, the vehicles have performed as advertised. We are not seeing the variability that people are seeing in passenger applications. On the other hand, the downtime for EVs has been higher than expected. So we actually keep backup diesel vehicles on hand. We have seen issues with high-dollar components. It’s a learning process. But the fact is that EVs have to be equivalent in performance to conventional trucks. We can buy 2 trucks or 10 trucks even if there is still some uncertainty on reliability. But if we are ever going to buy 1,000 or 10,000, the vehicle has to meet the mission.

We can help play a role in getting there, by the way. We are constantly approached by suppliers for service learnings. We have billions of miles on our vehicle platforms. So there is value to be extracted—we know so much about the vehicles we run. There is a lot FedEx could offer the EV industry in that regard—in terms of operational experience. Today, we know exactly when a conventional engine is going to need service, based on extensive experience. Think about extrapolating that to EV batteries, and the role we could play in accelerating industry learning and improvement.

Q: What will it take to get to commercialization?

Over the long-term, FedEx is a believer in electric drive. The electric motor is the most efficient mechanism available for powering the wheels. The biggest barrier is cost. Although battery prices have come down, they have not reached the $200 to $225 per kWh that we think the industry needs to make the vehicles competitive at today’s fuel prices.

But there is a lot we could do today to begin addressing cost. Right-sizing is a big opportunity. In Manhattan, our trucks are running only 12 to 18 miles per day, but they are hauling 100 miles worth of battery capacity. That ROI will never pencil. If we got down to a 50-mile battery, we think there could be value even at today’s battery price. Match the range to the duty cycle. If that happens, FedEx could switch entire depots like Manhattan over to electric vehicles. We could get rid of our tailpipe in dense urban environments, which would have obvious benefits for everyone.

We need to continuously innovate. The competition for EVs is only getting tougher. Conventional vehicle efficiency has improved in recent years as OEMs innovate due to high fuel prices and new fuel-economy standards for all of these vehicles will drive additional gains in the coming years. The reference conventional vehicle against which EVs are compared in commercial fleets is likely to be increasingly competitive from an efficiency standpoint going forward.