Myths and Realities of Electric Vehicles (EVs)

**Myths**

1. EVs are too expensive
2. EVs won’t perform
3. EVs have a “long tailpipe”
4. Charging infrastructure must be built before people will adopt EVs
5. Electric cars will put excessive strain on the electrical grid

**Realities**

1. EV prices are falling
   - Battery costs ↓, models ↑, incentives help
   - Consumers avoid price volatility of gasoline
2. New models have greater mileage range on a single charge; no torque curve means smooth, quick acceleration; no cold or durability issues
3. EVs more efficient, such that even when electricity source is non-renewable, emissions are lower
4. EV charging is becoming more available and affordable, and owners can charge on 110-V overnight
5. Managed charging can provide demand response, and V2G can offer frequency regulation, spinning reserves, and grid backup; DCFC may present other issues
What Are Automakers’ Plans for Vehicle Electrification?

Aston Martin to electrify its entire lineup by 2025.

Mercedes to offer an electrified version of every model by 2022.

Porsche to release an electric vehicle by 2020.

BMW to introduce 25 electrified models by 2025, including 12 all-electric cars.

Daimler to electrify some, not all, commercial vehicles.

Hyundai/Kia to add 31 new all-electric and hybrid models by 2020.

Ford models in the pipeline.

Electrified models to make up two-thirds of Honda global sales by 2030.

Every new Jaguar to feature hybrid, plug-in hybrid, or all-electric powertrains by 2020.

Peugeot, Citroën & DS partnership to produce 7 plug-in hybrids and 4 electric vehicles.

Toyota to launch a mass-market electric car by 2020, while continuing to sell its Prius plug-in hybrid.

Subaru to offer first plug-in hybrid in 2019, followed by all-electric versions of existing models.

Every new Volvo to have hybrid, plug-in hybrid, or all-electric powertrain by 2019.

VW/Audi to offer a hybrid or all-electric of every model by 2030.

SAAB/National Electric Vehicle Sweden (NEVS) to begin electric vehicle production in China.

GM to launch 20 new all-electric vehicles by 2023.

Renault, Nissan & Mitsubishi to launch 12 new all-electric vehicles by 2022.


**Expected EV Growth**

37% Year-over-year national sales growth of EVs in 2016

Source: Insideevs.com

62% Year-over-year national EV sales growth in 2017

Source: Insideevs.com

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**2025 Sales Projections**

- **Aggressive Scenario:** 3.1M, CAGR of 29%
- **Moderate Scenario:** 1.7M
- **Conservative Scenario:** 1.0M

**Annual EV Sales**

Sources embedded in chart above
Global EV Numbers Are Growing

Global EV Outlook 2017
Two million and counting

© OECD/IEA, 2017
International Energy Agency
Website: www.iea.org
Batteries and Electrification

Cost Trends for Lithium-based EV Batteries

- **Graphite/High Voltage NMC**
  - 4V, NMC
  - 4.2V, 10% Si

- **Silicon/High Voltage NMC**

- **Lithium-Metal or Lithium/Sulfur**

Li-Metal Battery projection assumes cycle life, cell scale-up, and catastrophic failure issues have been resolved.

System Cost ($/kWh) vs. Year:
- 2012
- 2013
- 2014
- 2015: $268/kWh
- 2016: $245/kWh
- 2017: $219/kWh
- 2018: $212/kWh
- 2019: $229/kWh

1.5x excess Li, 75% S, ~$80/kWh

4.7 Volt

4.7 Volt, 30% Si
Environmental Impacts

Well to Wheel Emissions

- No tailpipe emissions
- Lifecycle emissions are heavily dependent on fuel source
- Far more efficient than internal combustion engines

www.afdc.energy.gov/vehicles/electric_emissions.php

Figure created using World Energy Outlook 2013 Data and GREET Model
An EV is responsible for just half the annual carbon emissions of a gasoline vehicle

9,276 less pounds of carbon dioxide emissions compared to a similar gasoline vehicle

Climate Action in Delaware: 2016 Progress Report
Combination of fast charge batteries and a network of high capacity chargers can minimize range anxiety, promote the market penetration of BEVs, and increase total electric miles driven.

<table>
<thead>
<tr>
<th>Type of Charging Station</th>
<th>Level 2 220V (~7.2kW)</th>
<th>DC Fast Charger (50kW)</th>
<th>Tesla Super Charger (140 kW)</th>
<th>Extreme Fast-Charging (350kW)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to charge (for 200 miles)</td>
<td>8 hours</td>
<td>2 hours</td>
<td>25 mins</td>
<td>10-15 mins</td>
</tr>
</tbody>
</table>

### Charging Device

- ![Level 2 220V Charger](image1.png)
- ![DC Fast Charger](image2.png)
- ![Tesla Super Charger](image3.png)
- ![Extreme Fast-Charging](image4.png)

Source: Alternative Fuels Data Center afdc.energy.gov; 2015 NACS Retail Fuels Report,
Utility Implications of High PEV Penetration

Utility Stresses

• DC Fast Chargers presently can use up to 145 kW for passenger cars or 500 kW for transit buses
• Banks of Level 2 EVSE can raise facility demand by hundreds of kW
• PEVs could represent a 16% increase to California’s peak summer demand by 2025
• Controlled charging could avoid peak time charging almost completely AND align with intermittent renewable generation
• V2G could shave peak demand
Transmission Grid Issues

- Individual’s charging times aggregated affects overall load
- Intermittent renewable generation (particularly solar) can stress the grid
- EVSE can act as demand response (and even storage)
Distribution Grid

Distribution Grid Issues

- System upgrades
- Distributed generation interaction
- Demand management

2030 Distribution System Upgrades Driven by PEV Charging: Los Angeles Area

California Transportation Electrification Assessment Phase 2: Grid Impacts
Utility Rates

Demand Charges

- Can exceed 90% of total cost for charging with underutilized DC fast chargers or poorly managed banks of Level 2 EVSE

Time of Use Rates

- PEV charging can shift to off-peak hours in most cases
- May result in response peaks

SINTEF Energy Research in Norway and Center for Electric Power and Energy in Denmark [25].
Demand Management Strategies

- Charging managed by customer (opportunity charging) or customer allows system operator to manage charging
- Delayed charging is a simple and effective method for moving charging to off-peak periods
- Cost of communications, load monitoring, and calculation of bills may outweigh benefit of smart charging

- Opportunity charging (OC) is the most expensive and shifts load from peak periods least
- Delayed charging (DC) reduces peak loading and costs
- Smart charging (SC) is the most effective for reducing peak load and costs, but public charging is needed to fully realize benefits

Zhang and Markel: Charge Management Optimization for Future TOU Rates.
Fleets and EVs

• Fleets want in
  o EPAAct 1992 requires federal and certain state agency fleets to acquire alternative fuel vehicles
  o Fear price tag of a poor decision

• Pilot project demonstration for low-cost telematics approach
  o Small-scale pilot analysis of light-duty vehicles
  o 5 fleets: state, university, and utility
  o Deploy smartphone telematics
  o Use of telematics → ezEV analytics
  o Establish individual vehicle suitability for transition to EVs
  o Analysis to inform cost-effective rollout of EVs and EVSE
Fleets and EVs (cont’d)

**Basic Stats**
- 17 drivers
- 814 days of use
- 10,152 trips
- 68,900 miles
- Parking locations

**Takeaways**
- Service territory fleet
- Highly variable daily driving needs
- Low-mileage trips but high-mileage overall
- Nearly across the board, transitioning to EVs makes sense, but not always, or not always pure EVs
- Data Source: Petrolr/ezEV
Fleets and EVs (cont’d)

Recommendations:
• 10 Chevy Bolts, 5 Nissan Leafs
• In a PHEV, these vehicles would average 81% of miles on electricity
• Use of existing EVSE at 9 FPL facilities; addition of EVSE at 6 facilities
EVSE Tiger Teams
- Team of EVSE experts and electrical engineers from NREL

Objectives
- Develop plans for charging infrastructure
- Save money on installation

Activities
- Visit potential EVSE locations
- Develop site-specific recommendations

Tiger Teams offer project assistance for federal fleets
Federal Fleets and EVSE Tiger Team -- Project Approach

Review Materials
- Completed Questionnaires
- Anticipated PEV Acquisitions
- Aerial Maps
- Assess Workplace Charging

Phased Approach to Implementation
- Where is Level 2 Necessary?
- Socialize PHEVs in High Use Areas
- BEVs in Areas of High Utilization but Low Maximum Distance
- Combine with Workplace Charging

Assess Electrical Infrastructure
- Identify Transformers Near PEV Parking
- Electric Panels with Additional Circuits
- Minimize Trenching

Minimize Electricity Costs
- Manage Charging to Avoid Demand Charges
- Consider Level 1 or Limited Level 2
- Integrate with Workplace Charging Needs and Facility Demand
# Federal Fleet EVSE Tiger Team Questionnaire for Federal Fleet EVSE Planning

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Number of Vehicles Planned</th>
<th>Preferred Make</th>
<th>Preferred Model</th>
<th>Normal Trip Type</th>
<th>Alternative Trip Type</th>
<th>Average Miles Per Trip</th>
<th>Average Trips Per Day</th>
<th>Maximum Mileage Per Day</th>
<th>Annual VMT Estimate (auto calc)</th>
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<tbody>
<tr>
<td>1</td>
<td>Anticipated PEV Acquisitions</td>
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</table>

## Step 2: EVSE Location Plan and Electrical Input

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Vehicle Parking Options</th>
<th>Preferred/Alt Site?</th>
<th>Recurring Destinations</th>
<th>Site Plan Attached?</th>
<th>Available Electrical Amperage</th>
<th>Available Electrical Voltage</th>
<th>Distance from EVSE to Electrical Service</th>
<th>Total Planned Number of Level 1 EVSE Connectors</th>
<th>Total Planned Number of Level 2 EVSE Connectors</th>
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</thead>
<tbody>
<tr>
<td>2</td>
<td>EVSE Location Plan and Electrical Input</td>
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<td></td>
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<td></td>
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</tbody>
</table>

## Step 3: Workplace Charging

<table>
<thead>
<tr>
<th>Step</th>
<th>Description</th>
<th>Number of Employees Driving BEVs and PHEVs</th>
<th>Number of Employees Considering BEVs or PHEVs</th>
<th>Employee Parking Options</th>
<th>Preferred/Alt Site?</th>
<th>Available Electrical Amps</th>
<th>Available Electrical Voltage</th>
<th>Distance from EVSE to Electrical Service</th>
<th>Total Planned Number of Level 1 EVSE Connectors</th>
<th>Total Planned Number of Level 2 EVSE Connectors</th>
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<tbody>
<tr>
<td>3</td>
<td>Workplace Charging</td>
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</tbody>
</table>
Federal Fleets and EVSE Tiger Team -- Aerial Map

Current GOV sedan parking

Existing transformer

Recommended EVSE location
Federal Fleets and EVSE Tiger Team -- EVSE Installation

Completed 14 Tiger Team visits in 2016 calendar year

- Estimated savings between $5,000 and $20,000 per EVSE

Ten agencies have requested site visits

- Over 120 sites would like support
- Army is seeking funding to support Tiger Teams at every installation
## Federal Fleets and EVSE Tiger Team -- Controlling Charging Times

<table>
<thead>
<tr>
<th>Administrator</th>
<th>PEV Interface</th>
<th>EVSE Network</th>
<th>Facility Energy Management</th>
<th>Price Signals</th>
</tr>
</thead>
<tbody>
<tr>
<td>Consumer, fleet manager</td>
<td>Consumer, fleet manager, facility manager, utility</td>
<td>Facility manager</td>
<td>Utility, facility manager</td>
<td></td>
</tr>
</tbody>
</table>

### Application
- **Control individual vehicle**
- **Control individual or multiple vehicles**
- **Control building and vehicles**
- **Influencing charging using electricity price**

### Benefits
- **No cost, simple**
- **Programmable for multiple vehicles, simple, flexible**
- **Improved facility load control**
- **Aggregated at utility level, relies on downstream controls**

### Drawbacks
- **Does not offer aggregation**
- **No facility integration, not standardized across brands, added cost**
- **Distance of control from users, administrative costs**
- **Potential rebound peaks or complex price signals and automated controls, communication**
Questions?

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