Electric Vehicle Grid Integration for Sustainable Military Installations

NDIA Joint Service Power Expo

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NREL/PR-5400-51519
1. NREL Transportation Research
2. Net Zero Energy Installations (NZEI)
3. Fort Carson as a Case Study
   - Vehicles On-Site
   - Utility Operations
   - Vehicle Charge Management
4. Full Fleet Simulation
5. Continuing Work
NREL is the only national laboratory solely dedicated to advancing renewable energy and energy efficiency.

Our employees are committed to building a cleaner, sustainable world.
What is Electric Vehicle Grid Integration (EVGI)?

Cross Cutting Enablers

- Strategic Energy Analysis
- Grid Operation & Reliability
- Renewable Generation Intermittency
- Grid / Renewables
- Smart Grid & Communication
- Building Energy Management
- Deployment & Partnerships
- Energy Storage Life & Cost
- Vehicle Systems Analysis & Testing
- Power Electronics Efficiency
- Infrastructure Codes & Standards
Large multi-purpose campuses benefit from reduced energy consumption and renewable resources.
Fort Carson Commuters
Hundreds of Thousands of Person-Miles Each Day…

Commerciantly available PEVs are here…

**Commuters from Local Zip Codes**

- Fort Carson
  - Over 2,000
  - 1,000 to 2,000
  - 500 to 1,000
  - 100 to 500
  - 10 to 100

Nissan Leaf
NREL PIX 18215

Chevy Volt
NREL PIX 18215
Fleet Energy Opportunities

**GSA-Approved Vehicles**

<table>
<thead>
<tr>
<th></th>
<th>Smith Newton</th>
<th>Zero Truck ZT</th>
<th>Enova Ze</th>
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<tr>
<td>GVWR Class</td>
<td>4 to 6</td>
<td>3 to 5</td>
<td>3 to 4</td>
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<td>GSA Item Number</td>
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<td>95E</td>
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<td>Maximum Range (mi)</td>
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<td>Maximum Speed (mph)</td>
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<td>Incremental Cost</td>
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**Commuter Vehicle Mix on Campus**

**Fleet Mix on Campus**

**Vehicles Parked on Campus**

*Dotted line is energy in PEVs only.*
Example Power Exchange Scenarios

1. Opportunity Charging
2. Managed Charging
3. Managed Bi-directional Charging

PEV
Normal Grid / Microgrid
PEV Charge Management

Campus Base Load with Electric Vehicle Opportunity Charging

Campus Base Load with Electric Vehicle Managed Charging
Enable greater resource stability

Generation Supply to PEVs

- Coal
- Hydro
- NG/Oil
- Solar

Power flow to vehicle battery (MW)

- Desired Load Shift

2030 Normal Grid
Load Leveling with PEVs

**Determine which vehicles are available based on day of the week** (commuters only M-F) **and situation** (fleet vehicles alternate between parked and mission driving during emergency)

**Time-step through simulation:**

1. **Identify recent peak.**
   - Avoid exacerbating demand charges

2. **Determine which vehicles need power.**
   - Order vehicles by greatest difference between range remaining and range needed (commute distance)

3. **Calculate amount to charge** (+/-). *NREL-developed Algorithm*

4. **Iteratively solve for vehicles that are ready to share the load.**

5. **Add power to total demand from those in need of charge.**

6. **Calculate miles remaining from SoC of each vehicle.**
75 electric trucks “buffer” the demand profile ...

Campus Net Load with PEVs Opportunity Charging

Campus Net Load with PEVs Managed Charging

Campus Net Load with PEVs Managed Bi-directional Charging

2030 Microgrid
... and ensures maximum renewable energy utilization.
Algorithms intelligently match vehicles with grid needs while ensuring mobility
Commuters add large benefit with little effect on each.

Frequent Solar Energy Uptake

< 25% SoC Window Used in Commuter Fleet

Generation Supply to [and Generation Offset by] PEVs

> 3 MW Load Reduction

2030 Normal Grid
Grid-Vehicle Interface Component Requirements Definition Through DOD ECIP in FY11

- US Army sponsored ECIP project
  - Energy Conservation Investment Program
- Programmatic Goals:
  - Develop models, complete analysis specific to Ft. Carson for a RE and transportation microgrid node
  - Use that information to create an RFP for the system construction
- US Army Corp of Engineers collaboration
- Supports the development of parameterized models that can be used with optimization catered to each installation
ECIP: Current Status

- Microgrid Model Complete
  - OpenDSS (EPRI) open source platform used
- Node component models started
- Cost model for Colorado Springs Utility initialized
- On track to integrate models and begin optimization
RECharge Integrated Demonstration Site

Garage + Vehicle-Grid-Renewables Testbed at NREL Campus FY11
Thank you.

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