What is Plug-in Electric Vehicle – Vehicle to Grid (PEV-V2G)?

With V2G, PEVs can receive or provide power to the grid.

**Software Capabilities**
- Fleet Management System
- Charge Control
- Grid Scheduling
- EV Asset Coordination
- Grid Interface

**Sites**
- Los Angeles Air Force Base (LAAFB), California
- Fort Hood, Texas
- Joint Base (JB) Andrews, Maryland
- JB McGuire-Dix-Lakehurst (MDL), New Jersey

Energy providers will **PAY** for V2G services – vehicle batteries provide an energy source to stabilize the grid.

Through its V2G services, a military base **REDUCES** its energy costs and greenhouse gas emissions.

DISTRIBUTION STATEMENT A: Approved for public release; distribution unlimited.
### What Plug-In Electric Vehicles (PEVs) and Plug-In Hybrid Electric Vehicles (PHEVs) are in the V2G fleet?

<table>
<thead>
<tr>
<th>Model</th>
<th>Range Description</th>
<th>General Purpose Fleet Role</th>
<th>Battery Capacity</th>
<th># at Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PEV</strong></td>
<td></td>
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<tr>
<td>Nissan LEAF Sedan</td>
<td>electric range: 75 miles fuel efficiency: 99 MPGe</td>
<td>5 seats 23.6 cubic feet cargo capacity</td>
<td>24 kWh</td>
<td>13</td>
</tr>
<tr>
<td>Ford F-Series Trucks with EVAOS PHEV kits</td>
<td>electric range: N/A fuel efficiency: 45 MPG**</td>
<td>3 seat standard cab 6 seats crew cab</td>
<td>27 kWh</td>
<td>8</td>
</tr>
<tr>
<td>VIA Motors VTRUX Van</td>
<td>electric range: 31 miles fuel efficiency: 38 MPG**</td>
<td>2 seat car 6 seat passenger</td>
<td>21 kWh</td>
<td>11</td>
</tr>
<tr>
<td><strong>PHEV</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Phoenix Motorcars Electric Shuttle</td>
<td>electric range: 100 miles fuel efficiency: 32 MPGe</td>
<td>visitor transport: 12 passengers + driver</td>
<td>102 kWh</td>
<td>4</td>
</tr>
<tr>
<td>Electric Vehicle International (EVI) Range Extended Electric Vehicle (REEV)</td>
<td>electric range: 40 miles fuel efficiency: 43 MPGe</td>
<td>2 seats</td>
<td>54 kWh</td>
<td>1</td>
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<tr>
<td><strong>PHEV</strong></td>
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</tr>
<tr>
<td>Los Angeles Air Force Base (LAAFB), Joint Base Andrews (JB Andrews), Joint Base McGuire-Dix-Lakehurst (JB MDL)</td>
<td><strong>Averaged over 60 miles</strong></td>
<td>116 cubic feet cargo capacity</td>
<td><strong>Fuel used only when electric range exceeded</strong></td>
<td>1</td>
</tr>
</tbody>
</table>

Miles per gallon (MPG), Miles per gallon equivalent (MPGe), Kilowatt-hours (kWh)

- **LAAFB**: 13
- **Fort Hood**: 8
- **JB Andrews**: 8
- **JB MDL**: -

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How is the V2G infrastructure controlled?

**Introduction**
A V2G system is comprised of plug-in electric vehicles (PEVs), bi-directional charging stations, and software controls that enable an installation to compete in utility ancillary services markets. Customized for each base, the OB-EVI provides the communication and software controls needed for all aspects of V2G.

**Goal**
Meet utility system operator’s charge and discharge requirements
- Fulfill base fleet mission requirements
- Maximize ancillary services revenues
- Minimize non-conformance penalties

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**Power Sent from Battery to Grid**
OB-EVI supplies power stored in vehicle batteries to the grid according to the award signal.

**On Base-Electric Vehicle Infrastructure (OB-EVI)**

**Performance Reporting**
OB-EVI includes a dashboard and detailed reports that provide system status, V2G participation and financial information.

**Managing fleets & participation in the ancillary services market**

**Award Signal**
Utility system operator responds to submitted bid with award signal.

**Charge Management**
OB-EVI develops an optimal charge schedule to ensure mission readiness and maximize financial benefit of V2G participation. OB-EVI controls EVSE charge/discharge according to schedule.

**Bid Submission**
OB-EVI prepares a detailed next day bid using planned vehicle availability information and submits to utility system operator.

**Vehicle to Grid**
Vehicle to Grid infrastructure

**PEV Fleet Reservations**
Base personnel reserve cars/trucks in advance of use. OB-EVI ensures V2G participation does not prevent the fleet from meeting mission requirements.
On Base-Electric Vehicle Infrastructure (OB-EVI)

The software that enables V2G integration

**Energy Market Interface Module**
- Supporting CAISO, PJM, ERCOT
- Bid-Award in Ancillary Services Energy Market
- Demand Response Market to Frequency Regulation Market Support

**Charge Control Module**
- Calculate optimal charging and discharging trajectories for both operational requirements and market participation
- Manage the aggregated state of charge across the entire fleet (Virtual Battery)
- Controls the EV Charging Station (EVSE) through industry standard protocols

**EV Fleet Management System**
- Support for base vehicle fleet
- Vehicle management to accomplish operational mission
- Assigns available vehicles to energy market participation

**Grid Scheduling Module**
- Day ahead and real-time bidding into energy markets
- Continuous monitoring and re-optimization based on actual vehicle status
- Complies with FERC-ISO rules in each energy market

**Dashboard**
- Tracks revenue generation in the energy markets
- Management tool for system monitoring and control
- Detailed views of vehicle usage, energy trading history, forthcoming schedules, audits, alerts, and dispatches
V2G integration is complex and technically challenging. Success is a reflection of collaborative communication by all parties to develop solutions and overcome obstacles.

**Consortium PEV-V2G Achievements**
- Accelerating the nation’s adoption of electric vehicles
- Advancing the state of electric vehicles and charging stations
- Advancing the state of engineering and software applications
- Providing installations with a means to lower energy and fleet vehicle costs
- Providing utility operators with an alternative energy solution for electric distribution system stability
- Promoting energy surety across the nation

**Department of Defense Organizations**
- Air Force Civil Engineer Center (AFCEC)
- Air Force Research Laboratory – Advanced Power Technologies Office (AFRL - APTO)
- Air Force Vehicle and Equipment Management Support Office (VEMSO)
- Army Engineer Research and Development Center-Construction Engineering Research Laboratory (ERDC-CERL)
- Army Tank Automotive Research, Development, and Engineering Center (TARDEC)
- Fort Carson (SPIDERS)
- Fort Hood
- General Services Administration (GSA)
- Joint Base Andrews
- Joint Base McGuire-Dix-Lakehurst (JB MDL)
- Los Angeles Air Force Base (LAAB)
- Office of the Secretary of Defense (OSD)
- Secretary of the Army Installations, Energy & Environment (ASA [IE&E])

**Private Industry**
- ACDD
- Akuacom, Inc.
- Bel Fuse Inc.
- Clean Wave Technologies, Inc
- Concurrent Technologies Corporation (CTC)
- Coritech Services, Inc.
- Eaton Corporation
- Electric Vehicle Add-On Systems, Inc (EVAOS)
- Electric Vehicles International LLC (EVI)
- ElectriCore, Inc.
- Ford® Motor Company
- Kisensum, Inc.
- Nissan® Motor Corporation
- Phoenix Motorcars, LLC
- Princeton Power Systems, Inc. (PPS)
- VIA Motors Inc.

**Energy Providers and Regulators**
- California Independent System Operator (CAISO)
- California Public Utilities Commission (CPUC)
- Electric Reliability Council of Texas (ERCOT)
- Oncor Electric Delivery Company (Oncor)
- Pepco
- PJM Interconnection LLC (PJM)
- Southern California Edison (SCE)
- Viridity Energy Inc

**State Government and National Laboratories**
- California Energy Commission (CEC)
- Lawrence Berkeley National Laboratory (LBNL)
- Massachusetts Institute of Technology Lincoln Laboratory (MIT LL)
Frequency regulation is a continuous adjustment of power generation or electrical demand to maintain the grid frequency at or near the nominal 60 hertz standard.

**What benefits will the DoD obtain from future large-scale V2G implementation?**

- **Cuts Installation Electricity Costs**
  - Earns energy revenue to offset installation utility expenses
  - Increases penetration of energy storage systems
  - Encourages use of lower cost, off-peak electricity

- **Increases Resiliency & Reliability**
  - Overcomes natural disasters and intentional threats with on-site power support
  - Serves as backup power to mission critical facilities during outages

- **Aids Energy System Stabilization**
  - Reduces failure and degradation of system’s electrical devices with bi-directional power flow
  - Increases power distribution efficiency with on-demand reserve supplies
  - Supports ancillary services market that provides grid operators with real-time adjustment capabilities
  - Cuts electrical generation operational costs

- **Provides a Positive Environmental Impact**
  - Promotes use of renewable energy
  - Supports the national goal of reducing fossil fuel and energy consumption
  - Reduces dependence on foreign energy sources
  - Reduces greenhouse gas emissions