DOD Plug-In Electric Vehicle Program



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V2G Pilot Objectives

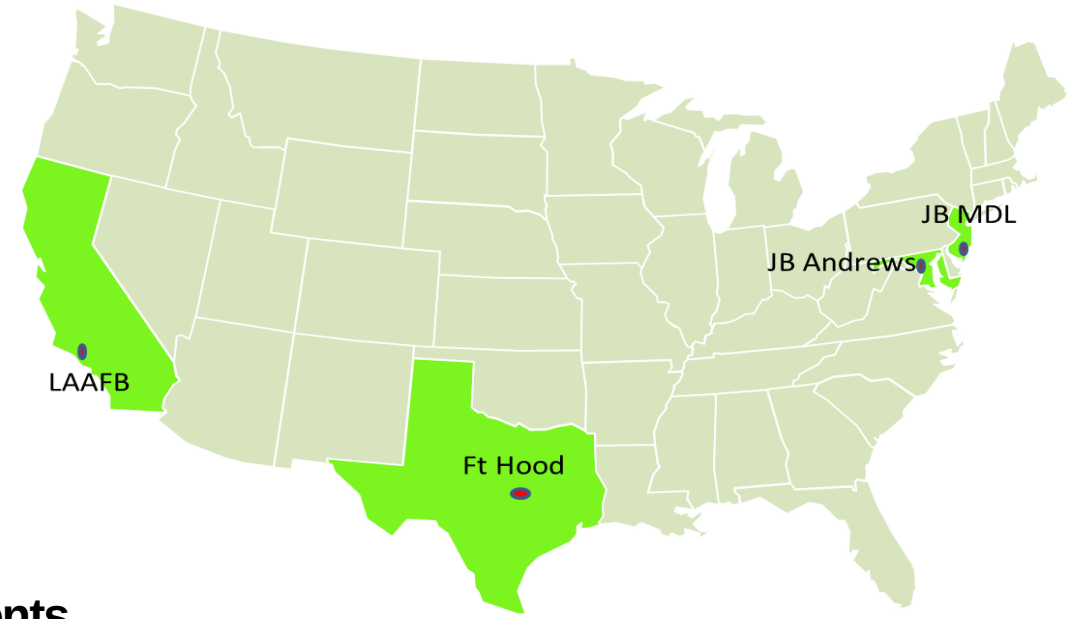
- **Demonstrate and validate V2G technology**
  - **PEVs**
  - **Bi-directional charging stations**
  - **Communication software system**
  - **Aggregator software controls**
  - **Electrical utility ancillary services markets**

V2G Pilot Objectives

- **Determine feasibility of a broad-scale V2G implementation throughout the DoD**
  - **Does the technology work?**
  - **Does operation interfere with mission activities?**
  - **Can PEVs achieve cost parity or better with conventional vehicles?**

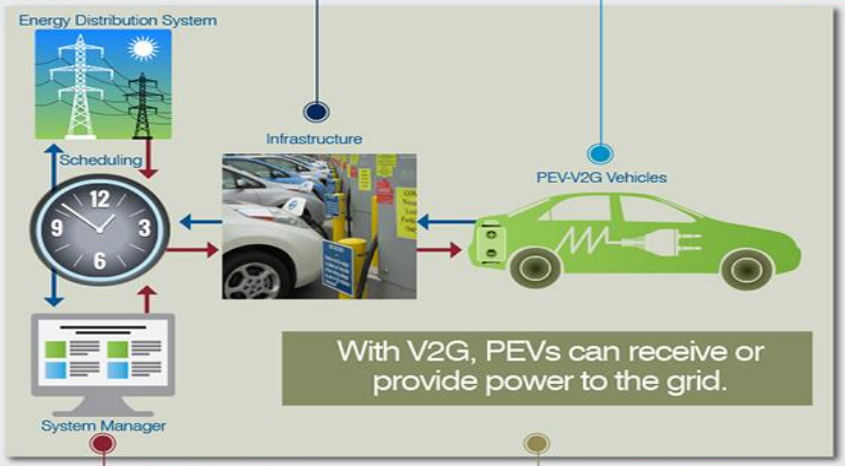
V2G Pilot Locations

- **Selection Benefits:**
  - **Different Services (USAF, Army, and Joint Base installations)**
  - **Different electrical utility territories**
  - **Different installation sizes**
  - **Different climates**
  - **Different vehicle requirements**



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







Energy providers will

PAY

for V2G services – vehicle batteries provide an energy source to stabilize the grid.

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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

Through its V2G services, a military base

REDUCES

its energy costs and greenhouse gas emissions.

CTC Concurrent Technologies Corporation

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What Plug-In Electric Vehicles (PEVs) and Plug-In Hybrid Electric Vehicles (PHEVs) are in the V2G fleet?

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	 Nissan LEAF Sedan	 Ford F-Series Trucks with EVAOS PHEV kits	 VIA Motors VTRUX Van	 Electric Vehicle International (EVI) Range Extended Electric Vehicle (REEV)	 Phoenix Motorcars Electric Shuttle
Range Description 	**PEV** **electric range: 75 miles** **fuel efficiency: 99 MPGe**	**PHEV** **electric range: N/A** **fuel efficiency: 45 MPG****	**PHEV*** **electric range: 31 miles** **fuel efficiency: 38 MPG****	**PHEV*** **electric range: 40 miles** **fuel efficiency: 43 MPG****	**PEV** **electric range: 100 miles** **fuel efficiency: 32 MPGe**
General Purpose Fleet Role 	**23.6 cubic feet cargo capacity**	**1500 to 2800 lbs payload**	**2650 lbs payload (cargo van only)**	**5300 lbs payload**	**116 cubic feet cargo capacity**
	**5 seats**	**3 seat standard cab 6 seats crew cab**	**2 seat cargo 12 seat passenger**	**2 seats**	**visitor transport: 12 passengers + driver**
Battery Capacity 	**24 kWh**	**27 kWh**	**21 kWh**	**54 kWh**	**102 kWh**
# at Locations 					
LAAFB	13	5	9	4	1
Fort Hood	5	14	---	---	---
JB Andrews	4	5	---	---	---
JB MDL	---	8	---	---	---

Miles per gallon (MPG), Miles per gallon equivalent (MPGe), Kilowatt-hours (kWh)
Los Angeles Air Force Base (LAAFB), Joint Base Andrews (JB Andrews), Joint Base McGuire-Dix-Lakehurst (JB MDL)

*Fuel used only when electric range exceeded
**Averaged over 60 miles

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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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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 performance information.

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.



Vehicle to Grid
OB-EVI supplies power stored in vehicle batteries to the grid according to the award signal.



Power Sent from Battery to Grid

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.



Charge Vehicle Battery Discharge Vehicle Battery

Managing fleets & participation in the ancillary services market

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

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

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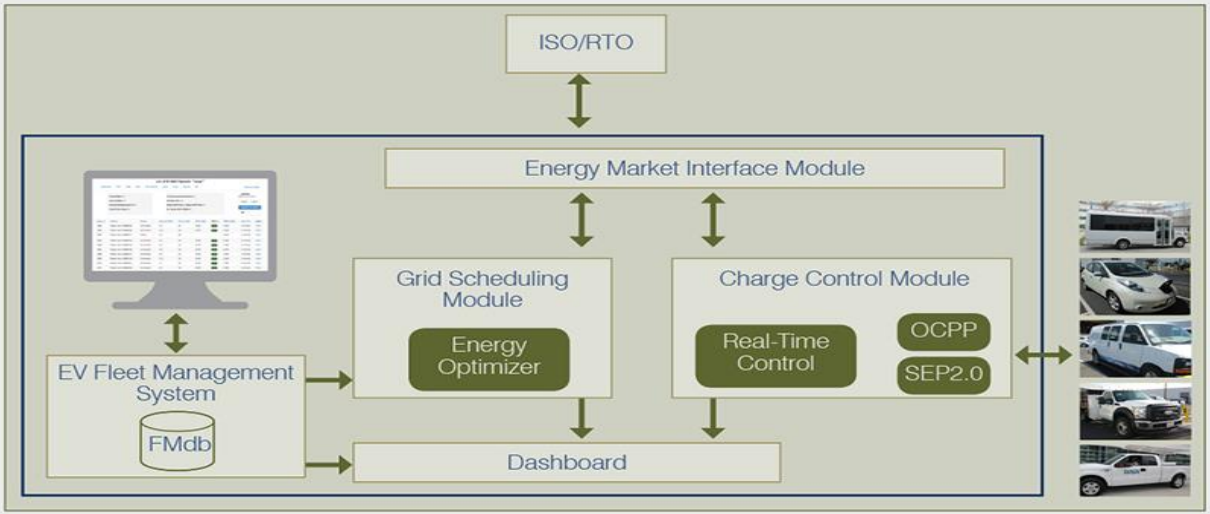
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On Base-Electric Vehicle Infrastructure (OB-EVI)

The software that enables V2G integration

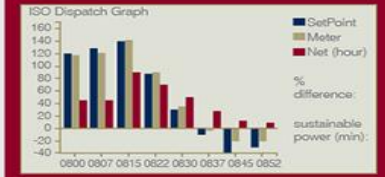
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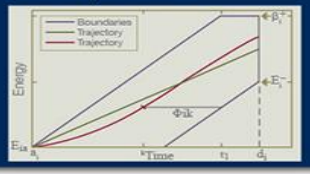
Energy Market Interface Module

- 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

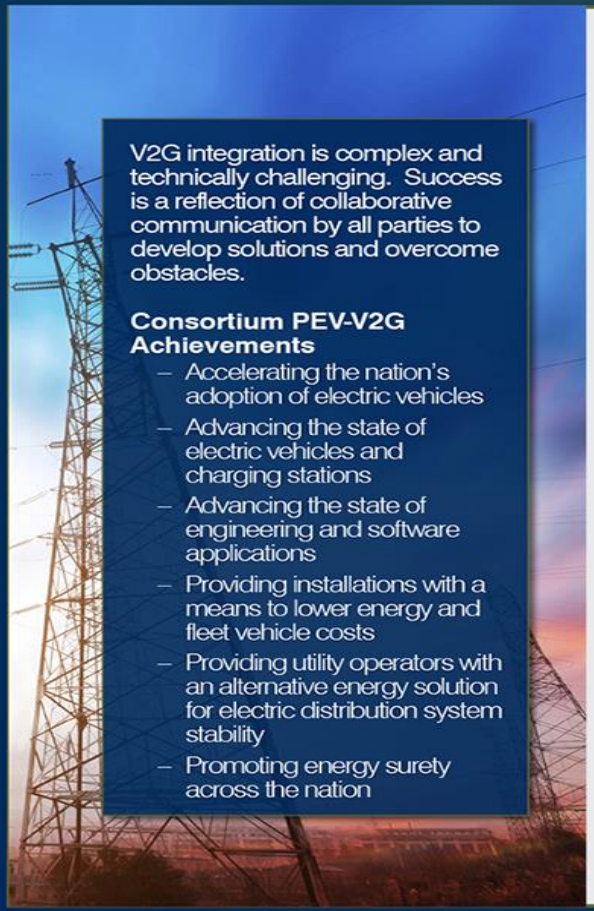
- Day ahead and real-time bidding into energy markets
- Continuous monitoring and re-optimization based on actual vehicle status
- Complies with FERC-ISO rules in each energy market

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

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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

Who are the Public-Private Consortium members deploying V2G technology?

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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 (LAAFB)
- Office of the Secretary of Defense (OSD)
- Secretary of the Air Force Installations, Environment, and Logistics (SAF I/E)
- Secretary of the Army Installations, Energy & Environment (ASA [IE&E])

State Government and National Laboratories

- California Energy Commission (CEC)
- Lawrence Berkeley National Laboratory (LBNL)
- Massachusetts Institute of Technology Lincoln Laboratory (MIT LL)

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.

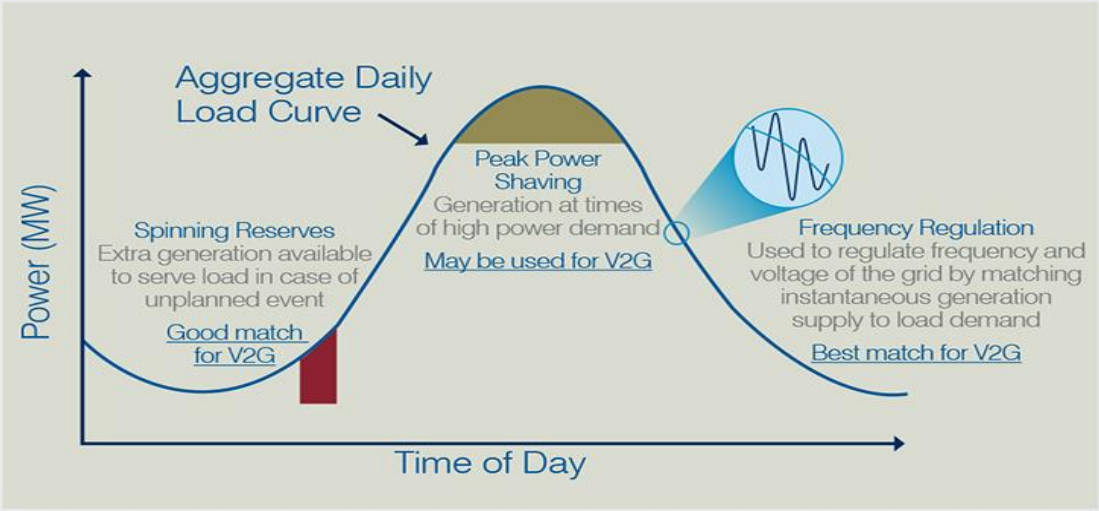
Energy Providers and Regulators

- 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

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



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.

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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

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