Vehicle-to-Grid
Vehicle-to-Building

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SEEDZ Electric Vehicle Infrastructure Workshop
November 6, 2013
Background

Los Angeles Air Force base
- 90,000 m² office complex
- 4 MW peak electrical load

Base vehicle fleet
- 41 mixed-duty vehicles
- to be replaced with PEVs
- dedicated charging station per PEV
Objectives

- Manage PEV fleet dispatch and charging
- Ensure sufficient charge to meet mobility needs (mission critical)
- Charge PEVs under cost-minimizing schedules
- Optimize participation in grid service markets to generate revenue
- Determine extent to which PEV fleet cost gap can be narrowed
- Identify critical loads in one of the buildings
- Run critical loads using the battery power from the fleet
Research Team & Support

Optimization
Grid Integration Group – Berkeley Lab
*Chris Marnay, Nicholas DeForest, Terry Chan, Judy Lai, Jason MacDonald, Michael Stadler*

Fleet Management
Bosch Software Innovations
*Tobias Erdmann, Markus Müller, Andreas Hoheisel, Scott Sabre*

Communication
Akuacom Honeywell
*Ed Koch, Paul Lipkin*

Funding
U.S. Department of Defense
*vehicles, charging stations & construction*
Environmental Security Technology Certification Program
*fleet management, communication and optimization*
California Energy Commission
*vehicles and building integration*
**Ancillary Services**

**Operating Reserves** respond when a contingency event occurs to restore balance.
- respond within 10 minutes
- event duration typically 10-30 minutes
- must be able to sustain output for 30 minutes or award length
- not well suited for energy constrained resources

**Regulation** rectifies small discrepancies between load and 5-minute real time dispatch
- receives an operating point instruction and responds within 4 seconds
- continuous response during the award period
- must be able to sustain output for 1 hour
LA AFB V2G System Architecture

Simple Case – Charging Only

Diagram:
- Dispatcher
- eMobility (fleet mgmt)
- DER-CAM (optimizer)
- Foreencers
- Electricity distribution company
- Base retail meter
- Charging/discharging instructions
- PEV availability
- Estimated energy consumption
- SOC requirements
- PEV charge/discharge schedules
- EVSEs
- PEVs
- L.A. Air Force Base

Simple Case – Charging Only
LA AFB V2G System Architecture

Complex Case – Regulation Bidding

Independent system operator (ISO)

Awards
Settlements

Regulation Bid

Scheduling Coordinator

Awards
Settlements

Regulation bid
Energy schedules
Outage information

DRAS

AGC set point
Awards
Regulation price

Dispatcher

eMobility
(fleet mgmt)

PEV availability
Estimated energy consumed
SOC requirements
Prices
Awards

DER-CAM
(_optimizer)

Forecasters

Electricity distribution company

Base retail meter

ISO PEV meter

Outage information
Regulation bid
Energy bid

Charging/discharging instructions

EVSEs

PEVs

L.A. Air Force Base
LA AFB V2G System Architecture

- Independent system operator (ISO)
  - Awards
  - Settlements
  - Regulation Bid
- Scheduling Coordinator
  - Regulation bid
  - Energy schedules
  - Outage information
- DRAS
  - AGC set point
  - Awards
  - Regulation price
- eMobility (fleet mgmt)
  - PEV availability
  - Estimated energy consumed
  - SOC requirements
  - Prices
  - Awards
- DER-CAM (optimizer)
  - PEV charge/discharge schedules
  - Regulation bids
- Forecasters
  - Outage information
- Dispatcher
  - AGC telemetry and verification
- Electric distribution company
- Base retail meter
- ISO PEV meter
- EVSEs
- PEVs

L.A. Air Force Base
Distributed Energy Resources Customer Adoption Model

Inputs

- Building end-use load data
- Electricity & gas tariff data
- DER technology data
- Site weather data

Outputs

- Optimal DER capacities
- Optimal DER operations schedule

Objectives:

- Minimize total cost
- Minimize CO₂ emissions

- **Investment & Planning:** determines optimal equipment combination and operation based on *historic* load data, weather, and tariffs

- **Operations:** determines optimal week-ahead scheduling for installed equipment and *forecasted* loads, weather and tariffs
Profit on investments is predetermined and spread among expected energy sales.
- The cost of electricity is a pass-through
- Ancillary services costs are a pass-through
Grid Resource Comparisons

Typical grid resources

• Solely dedicated to grid related activities
• Very rarely changes in absolute size
• Few energy constraints
• Fixed location

Electric Vehicle Fleets

• Grid activities are the secondary objective
• The size (both power and energy) rapidly change as vehicles change connection state
• Very energy constrained
• May connect (and increase or decrease energy stored) anywhere
Integration Challenges with CAISO

• CAISO market optimization can not account for missing vehicles or energy consumed while driving → limits awards

• Regulation, though in theory energy neutral, gives control of battery charge/discharge to CAISO (risk of being empty)

Source: caiso.com
Concluding Remarks - Status

• Status:
  – Charging and bidding optimization, grid communications, fleet management and communications between system components is nearly complete
  – Integration challenges
  – First vehicles/charging stations arriving at base this month
  – Real-time charging control and communications, uncertainty analysis, and forecasting tools under development
• Demonstration will tentatively be live in March 2014
Questions?
Incorporating risks

- Tariff demand spikes
- AGC signals depleting batteries
- Uncertainty in schedules
- Battery degradation
Value of Regulation

Market Clearing Prices by Season

**Up Regulation - Winter**

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