Enabling Vehicle Grid Integration (VGI)

New Jersey Retreat on Advancing Vehicle-to-Grid Technologies

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Enabling flexible EV loads is a key transition for low carbon pathways

Transportation is first, new flexible load in pathways portfolio...

...establishing business models for flexible building loads to follow...

...enabling increase in low carbon electricity
The driver comes first

Meeting driver mobility needs is paramount

Driver enrollment in VGI has been a challenge

Grid operators view driver response as uncertain

Don’t think of EV’s as a toaster with wheels
Which VGI services have the highest value?

- Frequency Regulation
- Load Following
- Load Shifting

https://www.powermag.com/getting-bulk-storage-projects-built/?pagenum=3
Load shifting will have the largest value in high renewables systems

Market Values are in 2016 $Million

2018 CPUC IRP (CA 2018-2030 levelized value, 2016 $/kW-yr.)
With increasing renewables, value of VGI will grow over time

+ California is leading, but Northeast is a fast follower

Note that the unmanaged charging baseline is used for calculating the value of providing V1G and V2G
Added value of V2G is significant

- Capacity for grid services is double
- Low daily VMT limits value of managed charging alone
- V2G can provide grid services after battery is full
- V2G can be precisely timed to grid need

2x

Non-Coincident Peak Load

CA Separately metered EVs on TOU Rates

Coincident Peak Load

2017 Load Research Data
Separately Metered EVs

Average Monthly kW

- Non-Coincident Peak Load
- Diversified Peak Load
- Coincident Peak Load

PG&E
SCE
SDG&E
Grid benefits of dynamic rates

$/kW grid benefits of energy storage

Revised TOU Rates

Hourly Dynamic Rates

Modified TOU periods increase grid benefits by average of $16/kW for some customers

Hourly dynamic rates increase grid benefits by average of $35/kW for all customers

Analysis for 2017 and 2018 California Self-Generation (SGIP) Incentive Program
VGI requires unprecedented coordination between power and transportation sectors.

Key Questions for Regulators:

- Enabling viable business models
- Role of regulated utility vs. competitive market
- Attracting market investment

Element Energy:
http://www.zevalliance.org/implementing-smart-charging/
Multiple players between consumer and revenue sources seek a slice of the pie

Source of Value

Enablers

Automaker

EVSP

Aggregator

Utility

- Interface with EV owner
- Optimize EV Charging
- Aggregate loads
- Metering / settlements

Sources of Revenue

Organized Wholesale Electricity Market

Utility Demand Response Program

Utility Tariff

Low Carbon Fuel Standard
Enabling VGI

+ Enable collaboration while protecting sensitive data
  • Avoiding data silos between automakers, ride share companies, EVSPs and utilities

+ Open and interoperable standards
  • Heavy lobbying to pick a standard, but it is too early to do so

+ Increase efficiency and reduce costs
  • Strategies to avoid or minimize need for real-time telemetry and revenue grade meters

+ Where should ‘smartness’ lie?
  • EV, EVSE, Aggregator, Utility DERMS?

Element Energy and Energy and Environmental Economics
http://www.zevalliance.org/implementing-smart-charging/
Appendix
## Advanced rate design for EVs

### E3's Smart Home Model

E3's Smart Home model simulates the customer and utility system benefits of controllable flexible loads under any user defined retail rate price scheme like the FVT including TOU, tiers, subscription charges, and real-time pricing. A 2,500 square foot, 3-bedroom New York specific home is modeled with a generic home energy control device that:

- Sends and receives data signals to/from the electricity grid
- Learns customer preferences and behavior
- Controls electricity use and generation of home appliances

### Examples

- **ConEd & ORU**
  - NY REV Smart Home Demonstration Rates
- **SDG&E**
  - Grid Integration Rate
- **APS**
  - Saver Choice Rates

### Rate Option

<table>
<thead>
<tr>
<th>Solar Roof (75% Usage Offset)</th>
<th>A/C EE 25%</th>
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</thead>
<tbody>
<tr>
<td>Savings</td>
<td>Price Induced Load Shifting</td>
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<tr>
<td>Smart HVAC</td>
<td>Battery Storage</td>
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<tr>
<td>Smart Electric Vehicle</td>
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</table>

### Bill savings

- **Existing Rates**
  - Bill savings (high local T&D value) $/year
  - Bill savings (zero local T&D value) $/year
- **Full Value/Smart Rate**
  - Bill savings (high local T&D value) $/year
  - Bill savings (zero local T&D value) $/year
- **Full Value/Smart Rate + Societal Signal**

### Part 1: Embedded Costs

- **Customer Charge**
  - $/customer
  - $/meter

### Part 2: Embedded Costs

- **Network/Grid Access Charge**
  - kW
  - Monthly kWh

### Part 3: Dynamic Marginal Costs

- **Cost Based Charge/Payment**
  - Coincident kW
  - kWh
Communication Standards

Element Energy
http://www.zevalliance.org/implementing-smart-charging/
### Key functions and roles for enablers along the V1G/V2G value chain

<table>
<thead>
<tr>
<th>Function/Role</th>
<th>OEM</th>
<th>EVSP</th>
<th>Aggregator</th>
<th>Utility</th>
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</thead>
<tbody>
<tr>
<td>Recruit participants</td>
<td>⭐</td>
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<tr>
<td>Provide customer interface</td>
<td>⭐</td>
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<tr>
<td>Forecast customer driving / SOC needs</td>
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<tr>
<td>Manage charging for customer</td>
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<tr>
<td>One-stop shop for demand side flexibility</td>
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<td></td>
</tr>
<tr>
<td>Offer into markets / utility programs</td>
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<td>⭐</td>
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<td>⭐</td>
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<tr>
<td>Provide very accurate energy meter services</td>
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<td>⭐</td>
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<td>⭐</td>
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<tr>
<td>Backhaul, data management, settlements</td>
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<tr>
<td>Install (cost-effective) bidirectional inverter</td>
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<tr>
<td>Enable bidirectional power flow to grid</td>
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#### Primary regulatory barriers

- Current capability
- Potential capability
- Stretch capability
- Competitive advantage

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Energy + Environmental Economics
Potential monetization options for flexible EV load

A) Share Bill Savings

- Actively manage EV charging on dynamic rate to reduce charging costs; charge customer higher default rate, a service fee, or share savings with customer

  **Pro**: direct arrangement with customer and no need for an EVSP or aggregator to get involved

  **Con**: going beyond the home is complex because it would require understanding the fee structure across all EVSE equipment

B) Utility Payments

- Enter into a contract with the utility (or participate in a utility program) providing payments based on grid benefits of managed charging

  **Pro**: monetizes value of providing local network capacity to utility while avoiding complications of wholesale market participation

  **Con**: utility acts as an intermediary between the EV and the market, potentially reducing the amount of value that can be captured

C) Market Payments

- Bid an aggregate EV resource into the wholesale electricity market (e.g. CAISO) and earn payments for energy and capacity from managed charging

  **Pro**: direct access to liquid, transparent market prices with flexibility to not participate

  **Con**: the market has strict rules around minimum size of aggregate resource and accuracy/latency of meter data

Share savings/revenues with drivers
V1G: the PEVs must be charging to provide benefits and they cannot provide services once the battery is full.

V2G: the capacity for grid services is doubled, the dispatch can be precisely timed to coincide with peak loads and the battery can be used for grid services even after the battery is full.
V2G Dispatch - Overgeneration

V1g
Utility Benefit: $0.06

V1g can only provide a limited amount of charge before reaching the SOC upper limit.

EV charges 4.2 kWh

V2g
Utility Benefit: $1.96

V2g is able to discharge to take advantage of mid-day solar overgeneration.

EV charges 33 kWh

Solar overgeneration

Dispatch for EV 1 on May 11, 2030 - Saturday