Vehicle - Grid Integration Initiative

June 25, 2019

Agenda

10:00 - 10:30 - Introduction and Level Setting

10:30 - 11:30 - VGI Value (Bill Boyce, SMUD)

11:30 - 12:30 - Data Needs Revisited (Matthew Tisdale, Gridworks)

12:30- 1:15 - Lunch

Lunch provided by Gridworks

1:15 - 2:30 - Review Gridworks' Revised Framing Document (Matthew Tisdale, Gridworks)

2:30 - 3:00 Wrap Up and Next Steps

3:00 – 5:00 – Networking and Community Building

Location: The Punchdown (1737 Broadway, Oakland, CA)

Initiative Objectives

1. *Identify and assess opportunities in which VGI can create value from multiple market participants' perspectives*

2. *Identify regulatory, labor, or industry market barriers to realizing VGI value creation, and*

3. *Provide recommendations on the market or policy actions needed.*

Initiative Scope

Address the CPUC's Questions:

- *What VGI use cases can provide value now, and how can that value be captured?*
- *What policies need to be changed or adopted to allow additional use cases to be deployed in the future?*
- *How does the value of VGI use cases compare to other storage or DER?*

SMUD
Electric Vehicle
Grid Impacts and Value

June 2019

Summary of Past SMUD Analysis

Study	Description	Year
Original Berkheimer Analysis	Monte Carlo simulation of Distribution Transformer overloads. Team members were Jeff Berkheimer, Dave Brown, Matt Schaedler, Tim Berg, & Bill Boyce. Forecast assumption: 316,000 EVs by 2030	2011
Berkheimer-Tang Analysis	Revised Monte Carlo simulation with updated assumptions and addition of rate sensitivity. Forecast assumption: 140,000 EVs by 2030	2013
Net Revenue Analysis	Modeled impact of financial impact of EV adoption on SMUD's operations. Used distribution cost estimates from Berkheimer-Tang Analysis. Forecast assumption: 140,000 EVs by 2030	2014
EPRI EV HotSpotter Analysis of SMUD	Probabilistic service transformer overload tool baselined against the Berkheimer-Tang analysis. Added sensitivity to clustered adoption. Forecast assumption: 93,000 EVs by 2030	2016
Managed Charging Analysis	Economic modeling of opportunities for avoided wholesale energy costs and distribution impacts through utility-dispatched charging of EVs. Forecast assumption: 94,000 EVs by 2030	2018

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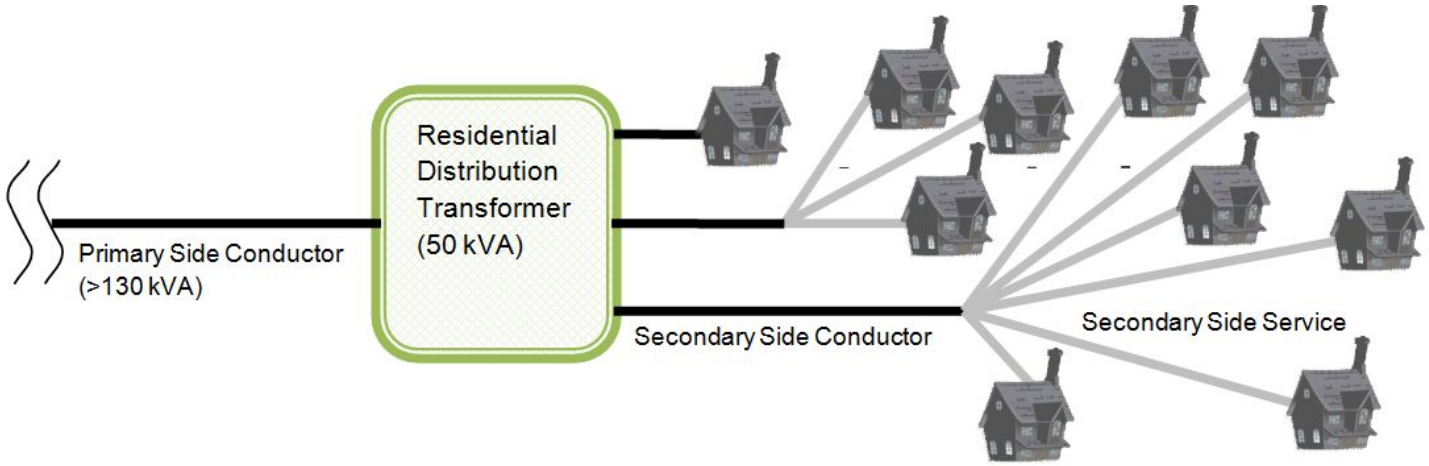
Original Berkheimer Analysis

- **Goal:** Quantify the impact of PEV loads at the residential service transformers
- Used transformer nameplate and associated accounts in GIS



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Assumptions

- Only residential single phase customers were included
- Transformers above 115% or below 10% were not included
- Transformer replacement triggered when loading hit 120%
- Random number generator used to establish addresses for PEV charging locations
- Charging locations were overlaid onto SMUD's existing transformer loading GIS database
- Random number generator uses hybrid database to establish a bias for the first 5 years of market growth. The bias is not captive to the hybrid distribution
- Equal weighting used after year 5.
- 10,000 houses acquired 2 vehicles
  - Only 1 EV at each location charging simultaneously

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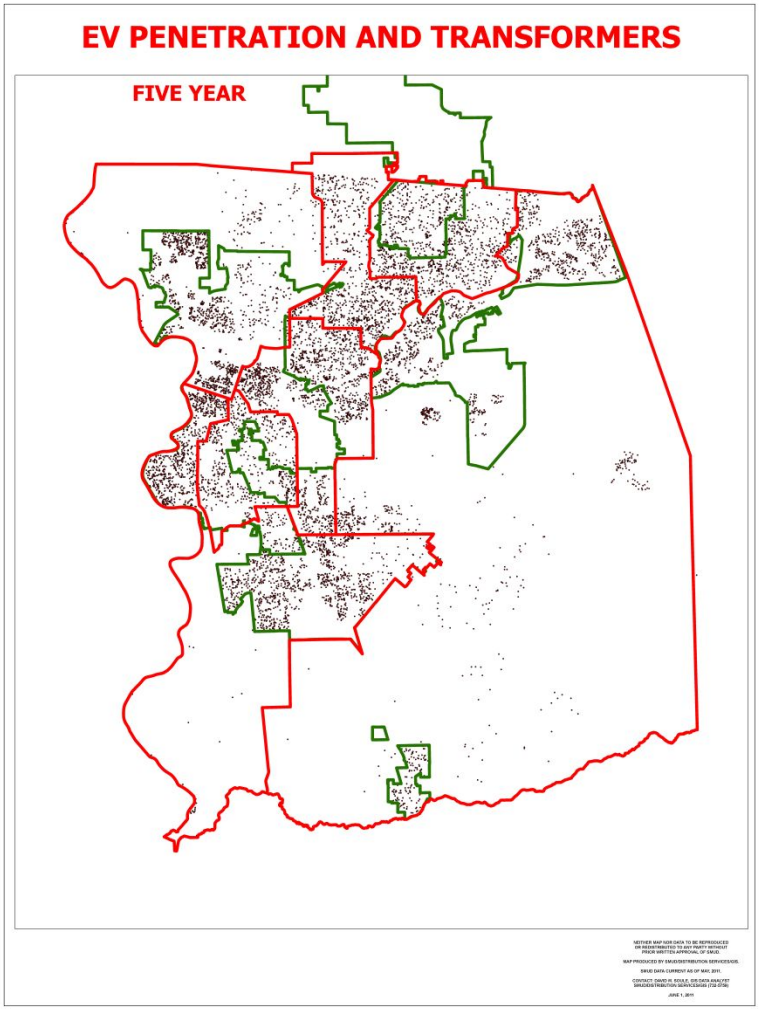
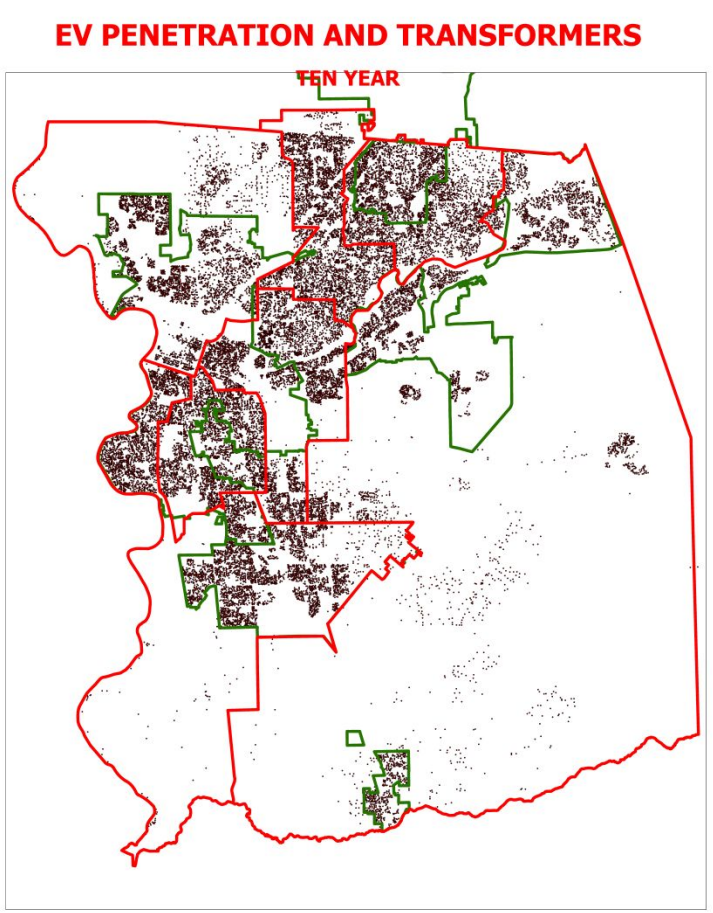
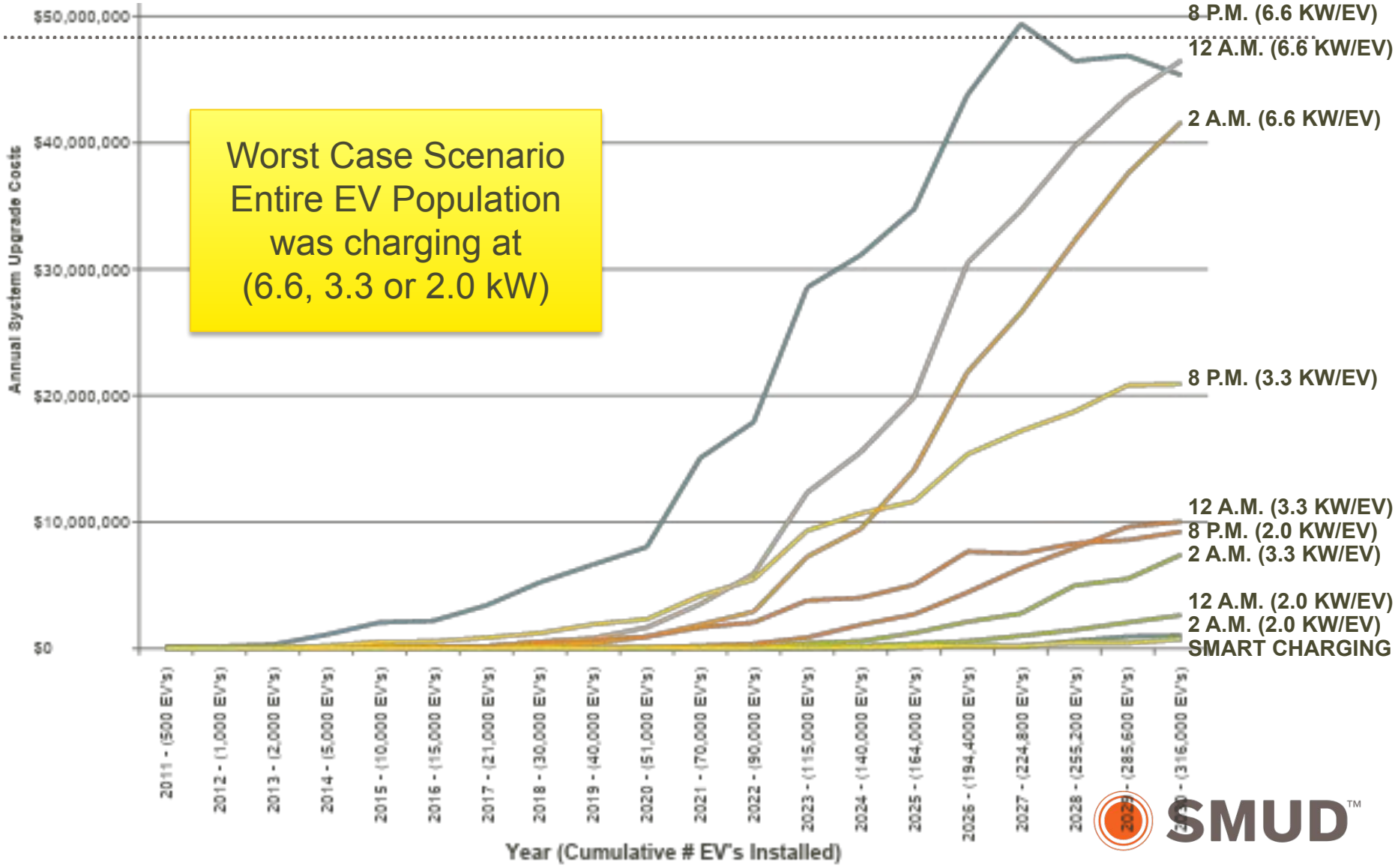
PEV Penetration plotted against SMUD Transformers





Original Berkheimer Analysis: System Upgrade Cost Sensitivity to EV Charging Rate and Time of Day

Assumptions: 100% coincidence charging and 316,000 EVs by 2030



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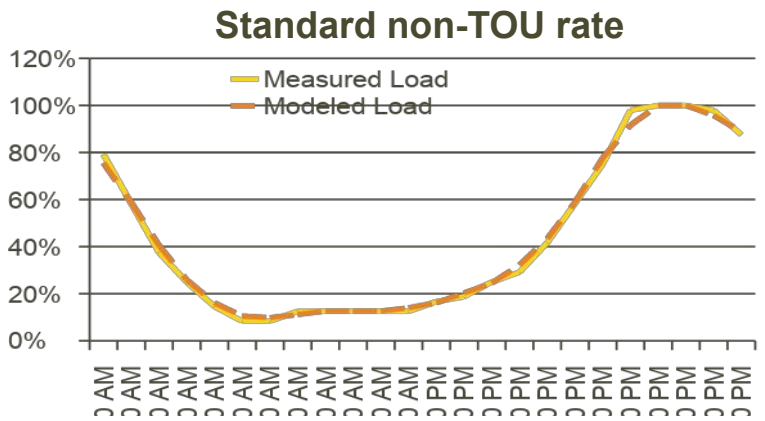
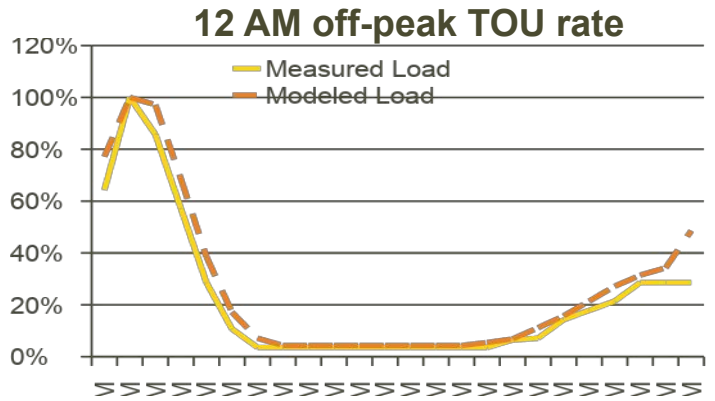
Berkheimer-Tang: Addition of load shapes for more representative coincidence

- Charging rate

Charging Level	Percent PEVs
1.4 kW	41%
3.3 kW	25%
6.6 kW	33%
9.6 kW	0.5%
19.2 kW	0.5%

- Duration
  - 8 kWh/PEV/day
- Start time
  - Data from DOE INL studies
- 3 scenarios
- Average charging is at 3.3kW





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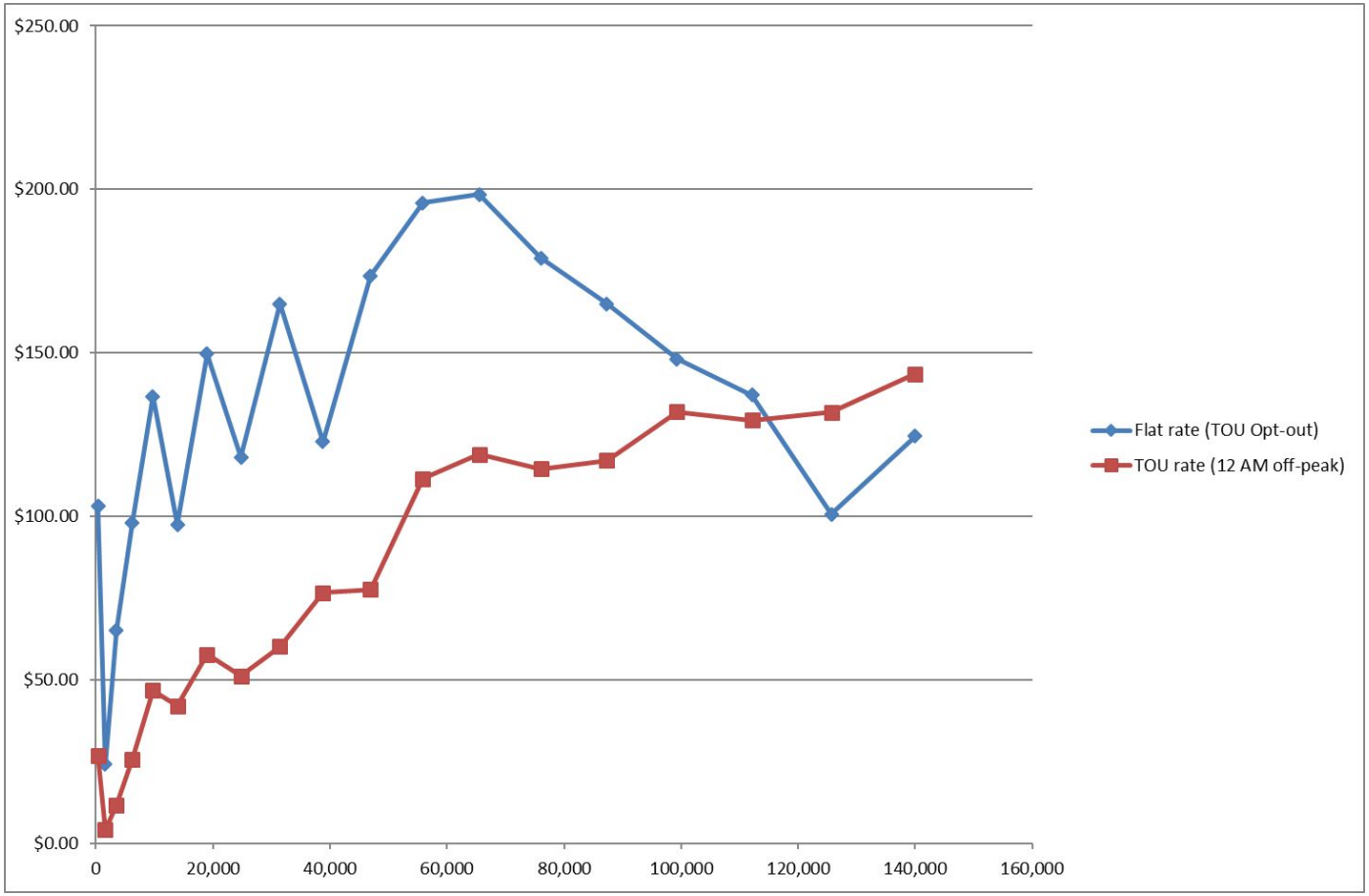
Berkheimer-Tang: Average Distribution System Upgrade Cost per EV



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Berkheimer-Tang: Distribution System Upgrade Cost Sensitivity to Charging Rate

Charge Rate (kW)	Distribution System Cost Per EV (TOU with 12 AM off-peak)
1.4	$0
3.3	$24
6.6	$239
9.6	$577
19.2	$1,588

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EPRI HotSpotter took a different approach to grid impacts for a comparison

- Sensitivity toward location/clustering and service transformer sizing
- Moderate linear sensitivity to adoption rate.
  - More affluent neighborhoods are showing higher EV adoption.
- High sensitivity to transformer nameplate for overload:
  - 25kVA risk = Three times 50kVA risk
  - Lower load diversity on 25kVA for a comparable EV adoption
- Even with clustering, average costs modeled by HotSpotter matched the Berkheimer-Tang results

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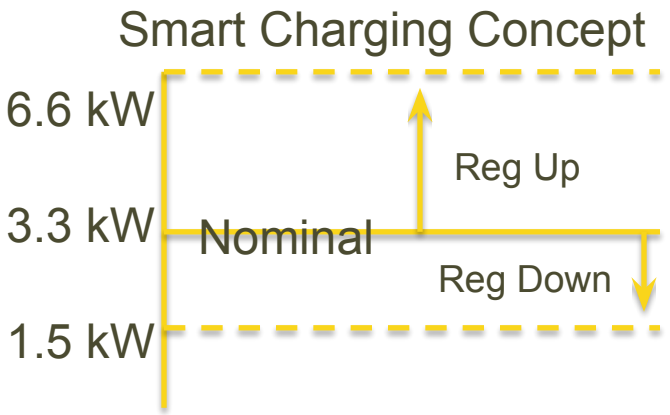
Majority of EV energy business models focus on wholesale regulation service markets

- Regulation service markets are typically higher value
- **However** there are issues with regard to this as a standalone target
  - Ancillary service markets are crowded already
  - All new DER's appear to be targeting these markets as well
  - Technical requirements drive up the communication layer cost
    - ISO metering
    - Minimum threshold requirements (500kW)
    - Communication / control latency
  - Does not require two way energy flow
  - Customers like charging flexibility



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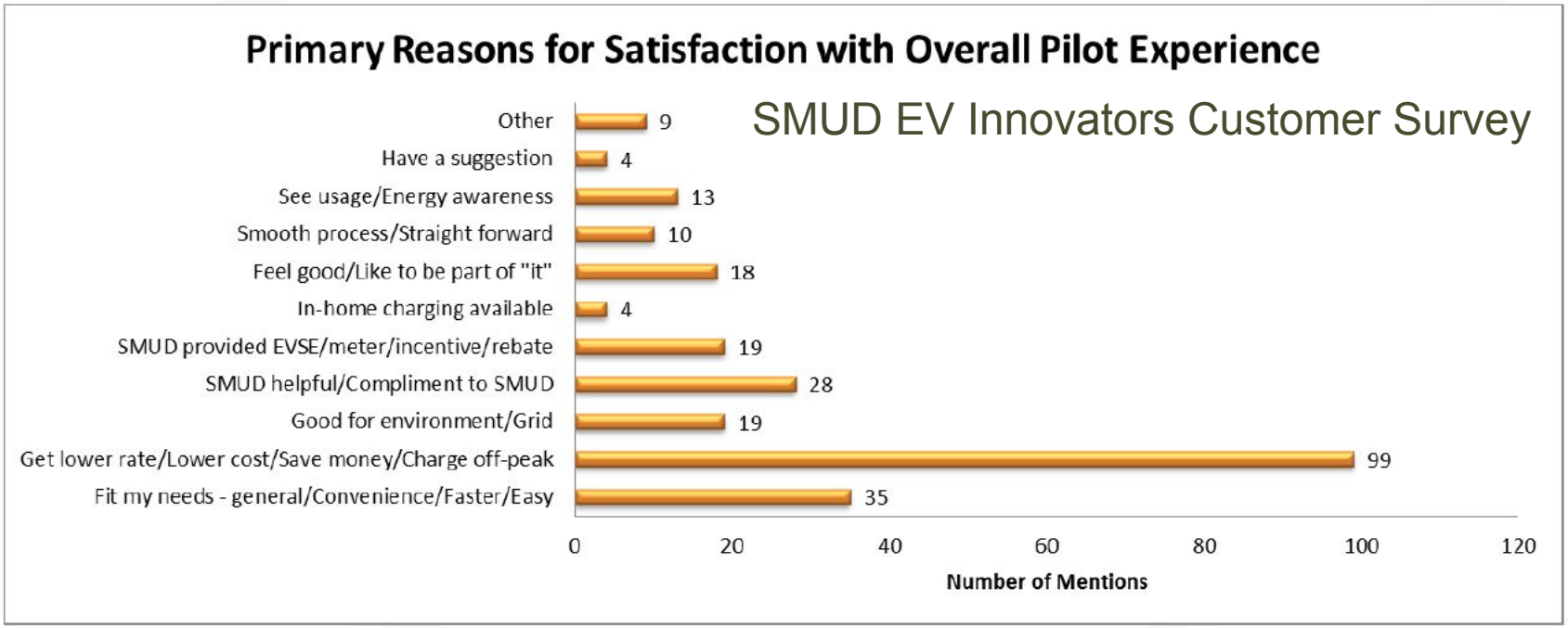
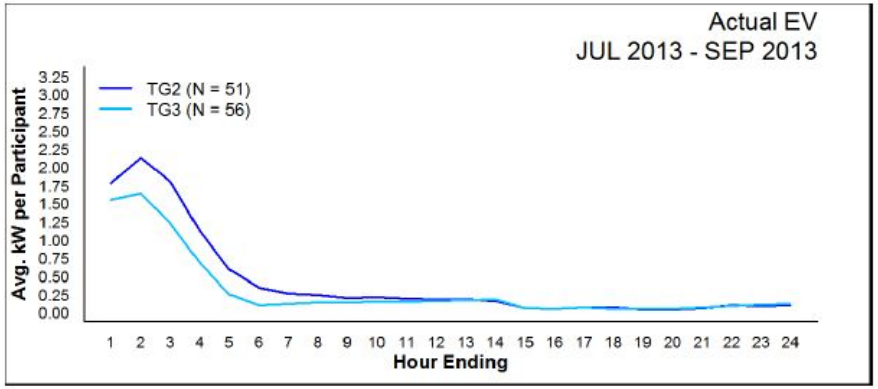
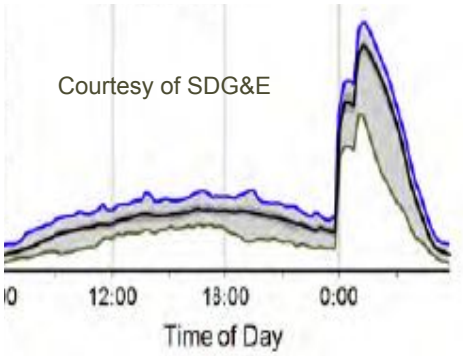
Customers are motivated by saving money







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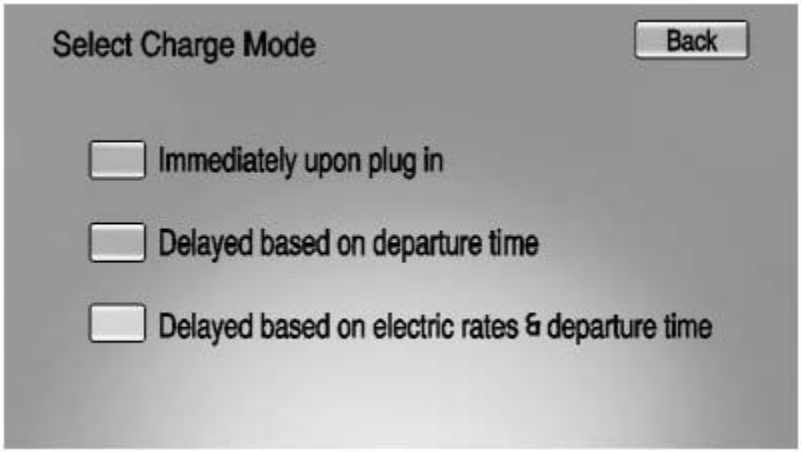
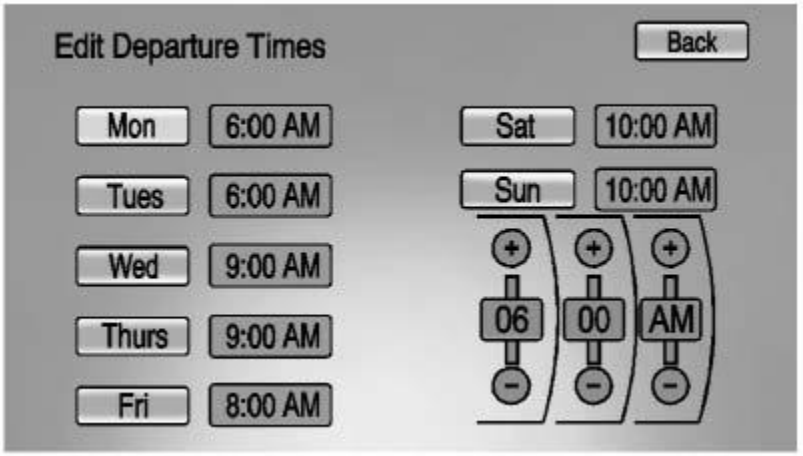
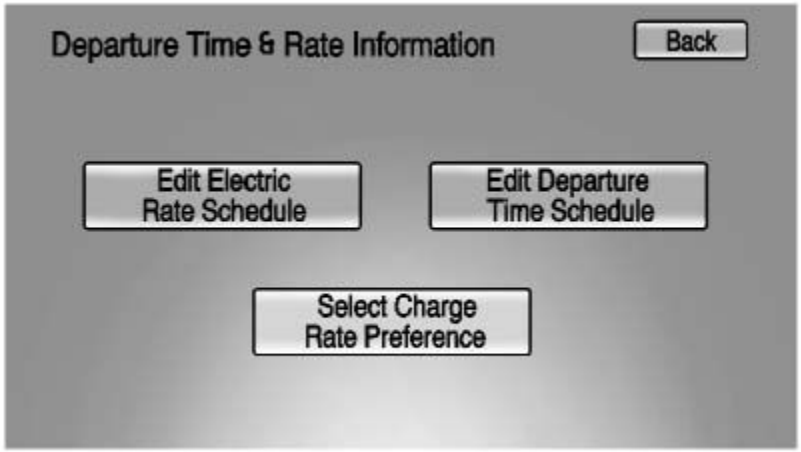
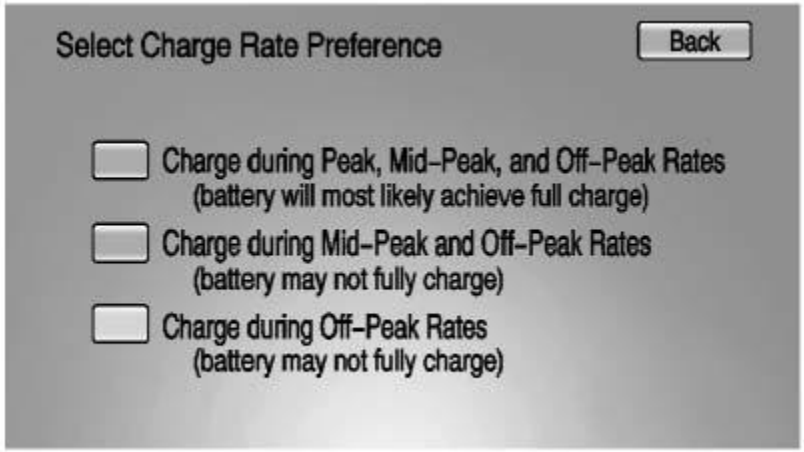
Chevrolet Volt Charge Management Application









2010 Chevrolet Volt Owner's Manual

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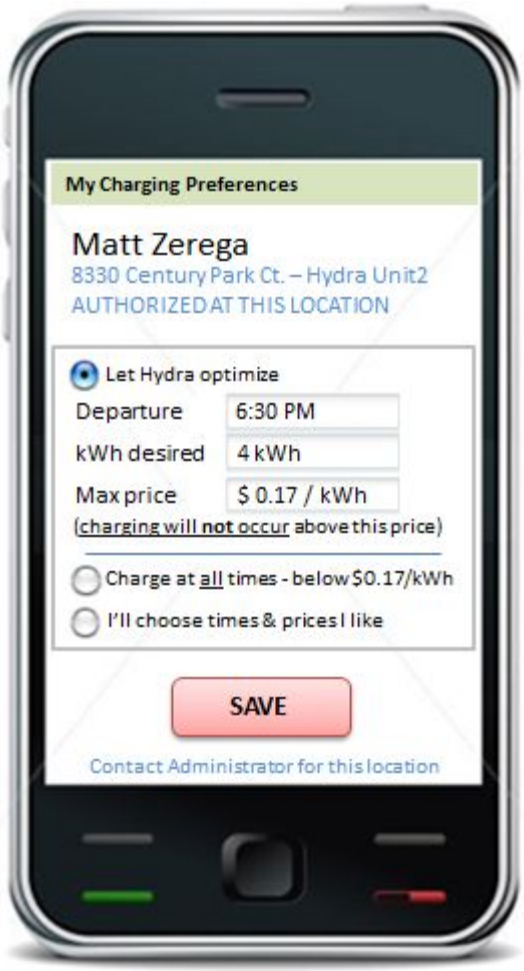
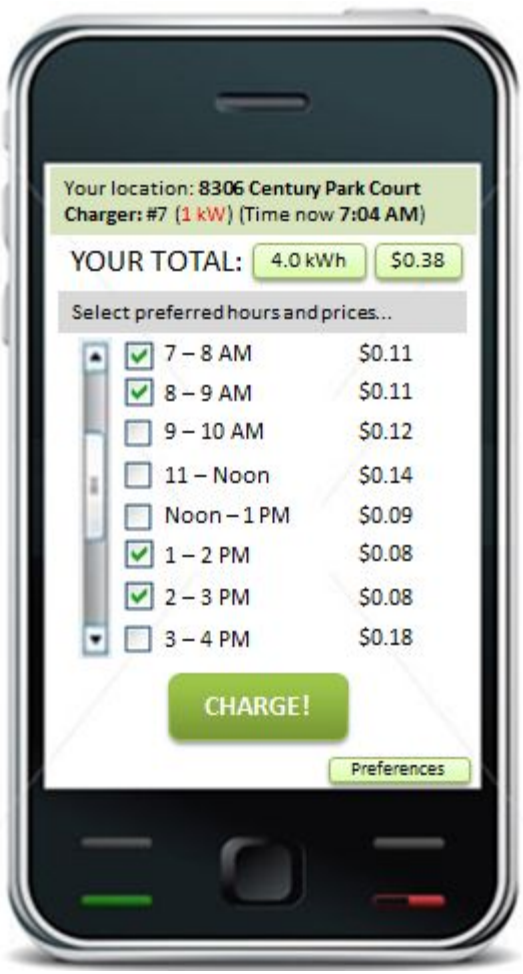
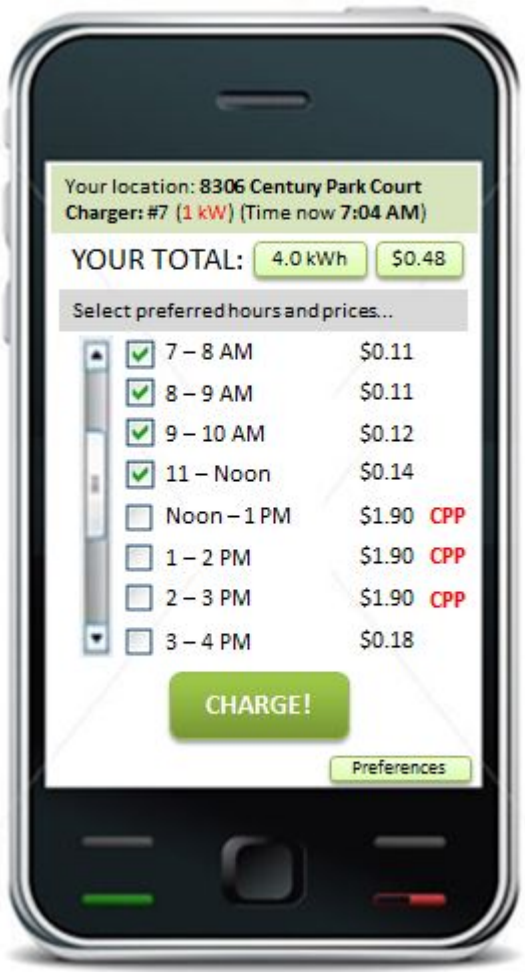
SDG&E Vehicle Grid Integration Rate App







Basic settings – "set & forget"

Advanced settings – choose hourly prices

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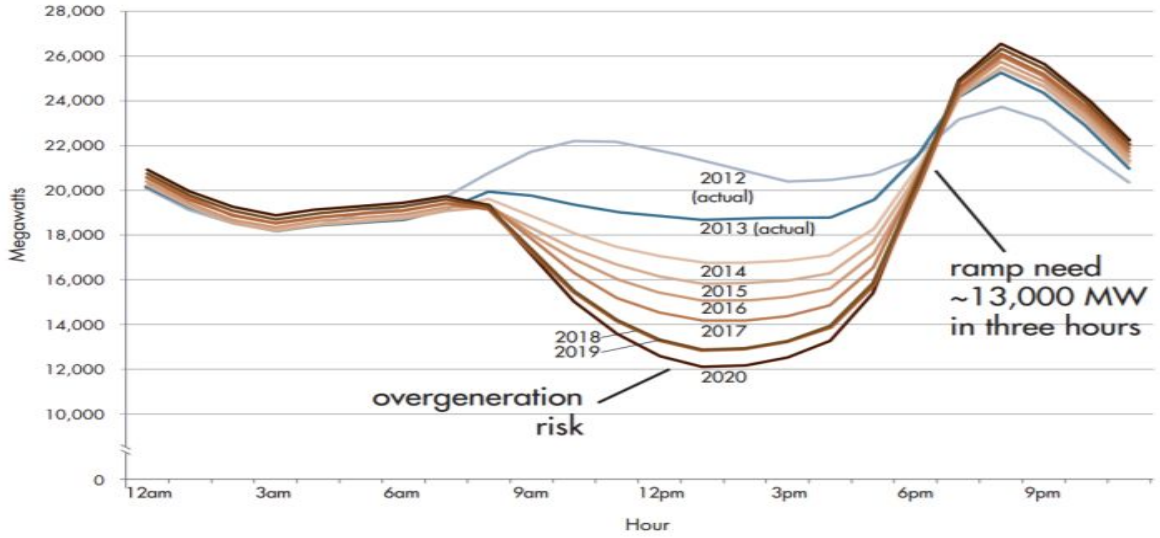
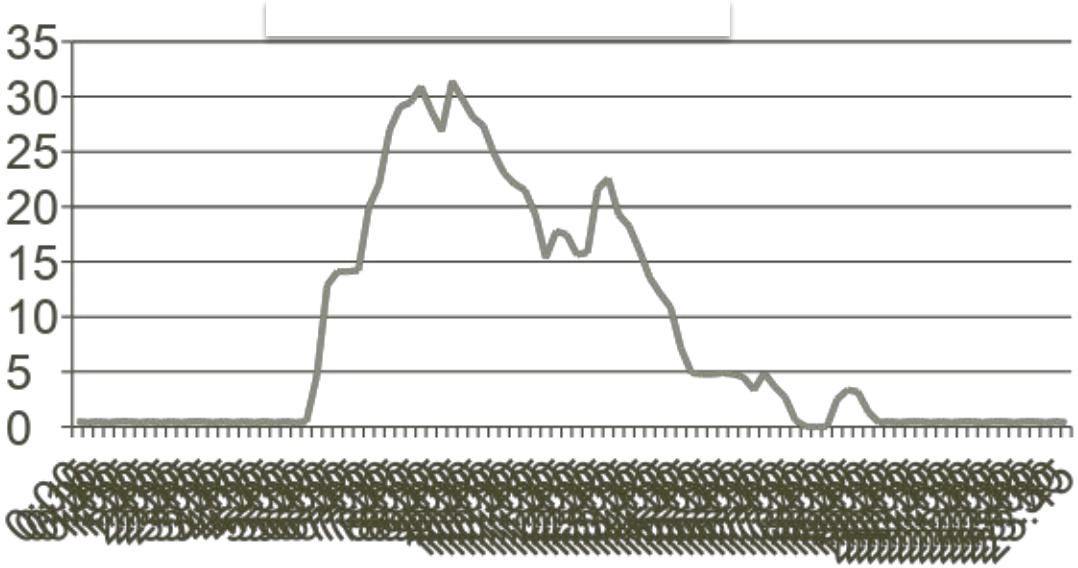
Duck Curve versus workplace charging



Cal-ISO Duck Curve



SMUD Workplace Charging
15 L1's
4 L2's

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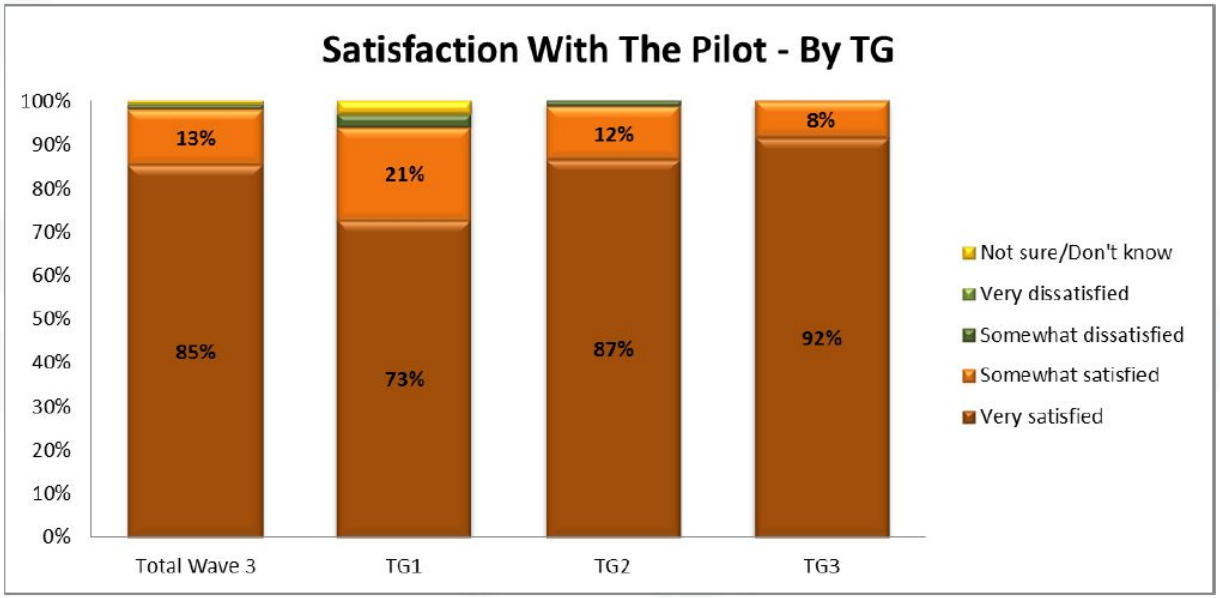
SMUD EV Innovators showed Flexibility



- Critical Peak Pricing R&D Program 15 Days a Year
  - $3.8/kW residential demand charge for charging above 2.0kW on CPP days
  - Day ahead notification
- Results
  - TG1 94% Customer Satisfaction with Whole-house TOU
  - TG2 98% Customer Satisfaction with Customer Control
  - TG3 99+% Customer Satisfaction with Utility Control

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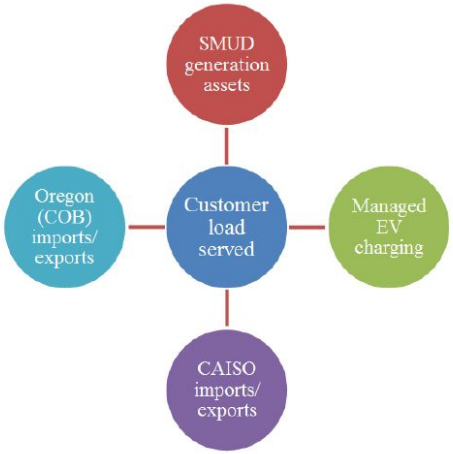
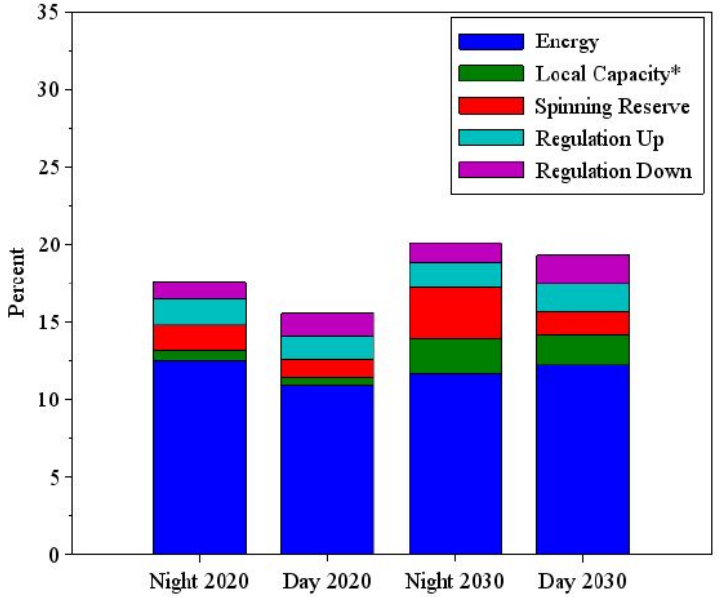
SMUD Value of Managed Charging

IEEE DOI 10.1109/ITEC.2018.8450258





- SMUD case for a vertically integrated utility
- Plexos® Production Cost Model
  - Hourly energy prices over a 24/7/365
  - Assumes 50% Renewables by 2030
  - 44,000 Vehicles (very low)
- Assumptions
  - EV was grid connected at all times
  - 3 modes of charging
    - No-charge (battery full)
    - Charge at Level1
    - Charge at Level 2
  - Guaranteed 3 hours of L2 charging and 3 hours of Level 1 charging to meet normal traction energy demand / vehicle usage
- 15% to 20% value against normal charging costs

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Summary

- Residential EV Grid impacts appear manageable
- Managed / Smart Charging could further reduce impacts and potentially support duck curve mitigation (workplace charging)
- Customers appear to be very flexible with charging behavior to achieve cost savings
- Value from managed charging is modest at current time

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VGI Valuation Data Needs

May Meeting Notes:

- Data needed
  - Reference Loads (baselines)
  - Market prices and curtailment data
  - Underlying power supply
  - Value of low carbon fuels standard credits
  - Vehicle Miles Travelled (VMT) assumptions
  - Customer elasticity
  - Plug-in/plug-out for different customer types
  - Energy needed for mobility for different customer types
- Even, where data exists, sharing it may be a challenge.

VGI Valuation Data Needs

June Sub-Group Meeting Notes:

- Data needs depend on their application -- what specific applications are anticipated?
  - Locational (statewide vs. service territory) and temporal demands follow application

- Available CEC sources (from 19-IEPR-04):
  - 2017 work on Light Duty
  - 2019 work on charging needs for medium- and heavy-duty
  - AB 2127 assessment ongoing

VGI Valuation Data Needs

June Sub-Group Meeting Notes (cont'd):

- Insight into current L1 charging limited
  - Creating a VGI Data Reservoir would be valuable
- Topic also addressed in June 14 DAWG Meeting
- Risk in navigating the complexity

VGI Valuation Data Needs

Exercise:

1. Small Groups
2. Each participants identifies
   a. One data set they have and can share
   b. One data set they wish they had
3. Discuss what applications are potentially served by available data (e.g., insights into elasticity of customer demand inform rate designs)
4. Discuss what applications rely on hard to reach data (e.g., proprietary cost data needed to price services)

Lunch

Review Gridworks (draft) Framing Document

See draft framing document

Definition: where we started

"the many ways in which a vehicle can provide benefits or services to the grid, to society, the EV driver, or parking lot site host by optimizing plug-in electric vehicle (PEV) interaction with the electrical grid…."[1]

[1] "VGI Glossary of Terms" California Public Utilities Commission. http://www.cpuc.ca.gov/vgi/

Where we started (cont'd)

"...VGI includes:

- *active management of electricity (e.g., bi-directional management, such as vehicle-to-grid power flow [also known as V2G];*
- *unidirectional management such as managed charging [also known as V1G]) and/or active management of charging levels by ramping up or down charging; and*
- *passive solutions such as customer response to existing rates, design of improved utility rates (e.g. time-of-use (TOU) charges, demand charges and customer fees), design of the grid to accommodate EVs while reducing grid impacts to the degree possible, and education or incentives to encourage charging technology or charging level (e.g. rebates for lower level charging, modifying current allowance policy).*

What we heard

- 2017 definition is too long, with too many specifics
- Maintain a “mobility first” emphasis to support accelerated electrification of transportation; don’t put the cart (grid services) before the horse (mobility)
- Should complements/fits California’s larger DER definition and framework
- Needs to answer the main question: “Who is it for? Who benefits?”
- Should serve marketing purposes
- Emphasis on EVs as an integral part of the grid, rather than the grid as something that must accommodate EVs
- Careful not to confuse V1G, V2G, charge and discharge
- Don’t get too hung up on the definition…

Gridworks Proposal:

Vehicle - Grid Integration:

VGI is how we drive electric, while driving down cost of and emissions from the electric grid. VGI includes both managed charging and demand-response use cases (V1G), as well as use cases in which vehicle batteries discharge stored power back onto the grid (V2G).

Wrapping Up

Next Steps

- ❑ Written feedback on Gridworks Framing Document by July 12?
- ❑ Gridworks revisions complete by July 26
- ❑ Published week of July 29
- ❑ Joint Agency VGI Working Group begins in August
- ❑ Provide Gridworks Feedback on VGI Initiative through the following survey: https://forms.gle/FRvtrYyKDpU6p3AS6

Thank you!