CEC Project 14-086

"Distribution System Aware Vehicle to Grid Services for Improved Grid Stability and Reliability"

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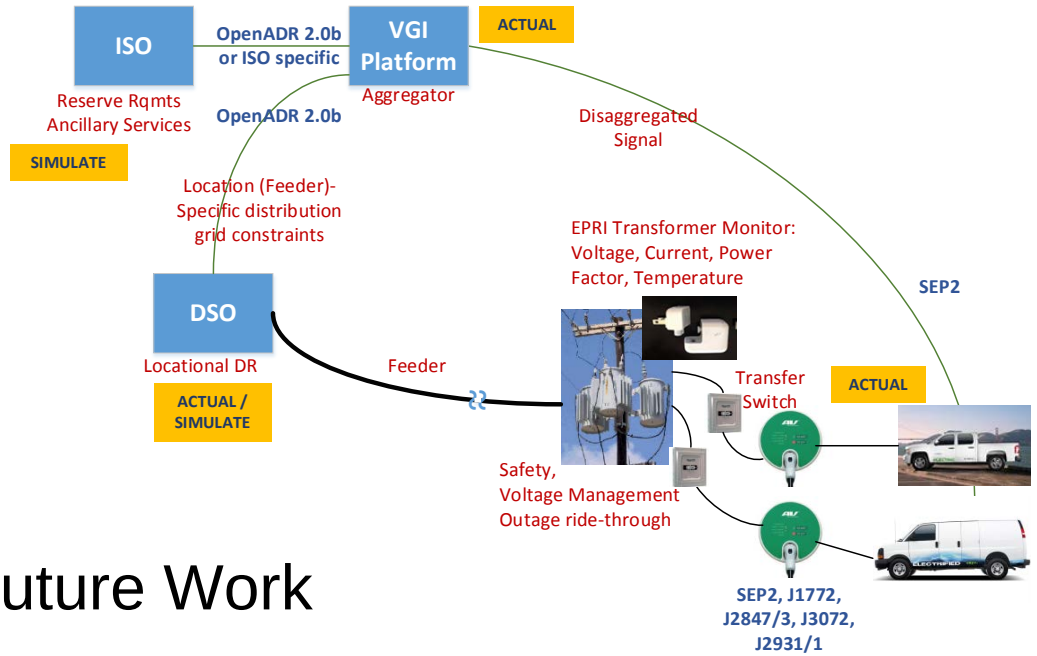
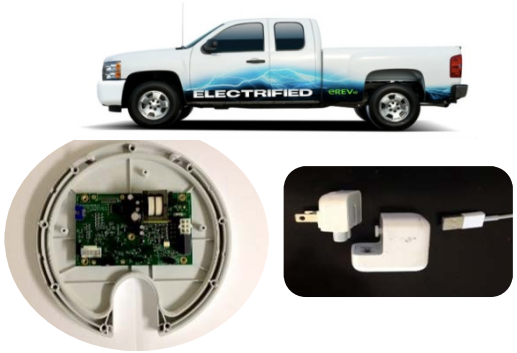
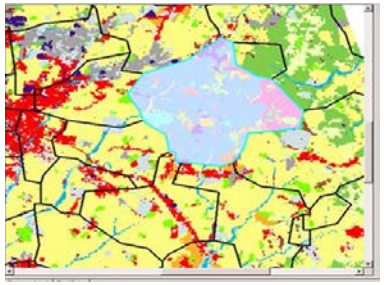
Agenda

- Project Overview
  - Issues and Challenges
- Project Methodology
- Key Questions
- Core Innovations
- Recommendations for Future Work







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Introduction

Plug-in Electric Vehicles application Distributed Energy Resources could deliver substantial benefits due to large numbers expected

- 1.5M PEVs in 2023 charging / discharging at 6-7kW constitutes 10,000 MW of capacity for distribution and ancillary grid services
- 20% of 1.5 million PEVs could provide 2,000 MW capacity at a value of $350 million per year in capacity constrained urban areas (i.e. Los Angeles basin)

Attributes for Vehicle to Grid (V2G) Technology

- Provide energy storage resource for AB2514 Energy Storage Procurement Mandate (1.3GW) and at no capital cost to IOUs
- Provide generation resource for balancing net load effects of intermittent renewable energy ramping - “Duck Curve”
- Provide cost avoidance for ancillary generation capacity and distribution system upgrades deferment
- Mitigate emissions and inefficiencies for maintaining on-line power plant generation for ancillary services

PEVs integrated with V2G systems can improve air quality, reduce grid stress, and increase grid reliability and stability

- Air Quality through increased transportation electrification through incentives
- Grid Stress through acting as Flexible DR or ‘balancing resources’ in aggregated manner
- Grid reliability and stability through provision of ancillary services

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Issues/Challenges

- Inconsistent data communication approaches among Utilities and PEVs
- Lack of situational awareness of the PEVs relative to distribution grid state
- Fragmented technology and standards inhibiting interoperability and preventing inclusion of V2G resources
- Capability for on-vehicle inverters to meet Rule 21 performance and interconnection requirements
  - Certification of PEV inverter system to UL and IEEE requirements
  - Site authentication/authorization requirements due to roaming of PEVs
- OEMs do not see value to end customers
  - Prevents realistic assessment of PEVs as Distributed Energy Resources (DERs) with a path to volume production
- Learnings to date based on controlled experimentation for ancillary services
  - Ancillary services is limited capacity market - minimizes utilization and value of V2G
  - V2G must be demonstrated outside the frequency regulation market to represent a sustainable long-term net benefit for utilities and ratepayers
- Requires dynamic real world distribution grid integration

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Purpose/Key Objectives

Purpose:

- Develop and Implement an end to end V2G communications system to enable real time dispatch of dischargeable PEV energy capacity as a Distributed Resource for DSO and ISO grid services.

Objectives:

- Develop and demonstrate V2G capable PEVs and communication technologies and interfaces based on open standards
- Develop and demonstrate an end to end integrated system that is distribution grid and ISO-aware, safe, interoperable, extensible, and able to offer distribution and ancillary grid services
- Prove technical feasibility and utility value by testing the system under a variety of use cases
- Collect operational data utilizing a data warehouse to correlate system performance with system safety, outage immunity, stability and reliability.
- Validate the cost/benefit for ratepayers and PEV owners
- Transfer technology to relevant stakeholders.

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Project Scope

Innovative Automated Distribution Load Management, Open Standards

- **Use of Open Standards:** SAE J1772, J2836/3, J2847/3, **J3072**, J2931/4, J2931/1, IEEE2030.5 (SEP2), OpenADR 2.0b
- Local transformer real time monitoring, sensing and load management control
- SEP2 based communications feature sets and control algorithms: Load Control from EMS and DSO / ISO to PEVs

Implement and Test Dynamic Use Cases

- Automated transformer management based on localized transformer constraints – residential / fleet environments
- DSO aggregated PEV DR and load management dispatch utilizing local transformer condition information
- ISO ancillary services dispatch (simulated) control communications

Quantify costs and benefits from the customer, utility and societal perspective

- Apply E3's DER Avoided Cost and cost-effectiveness methodology adopted by the CPUC
- E3's REFLEX and GHG Pathways modeling to quantify the value of V2G under high renewable/low carbon scenarios
- EPRI ESVT Extension for V2G services valuation
- OpenDSS: quantify the physical and electrical impacts on the distribution system to ID hotspots for localized DR; Deferred Distribution Upgrade Assessment

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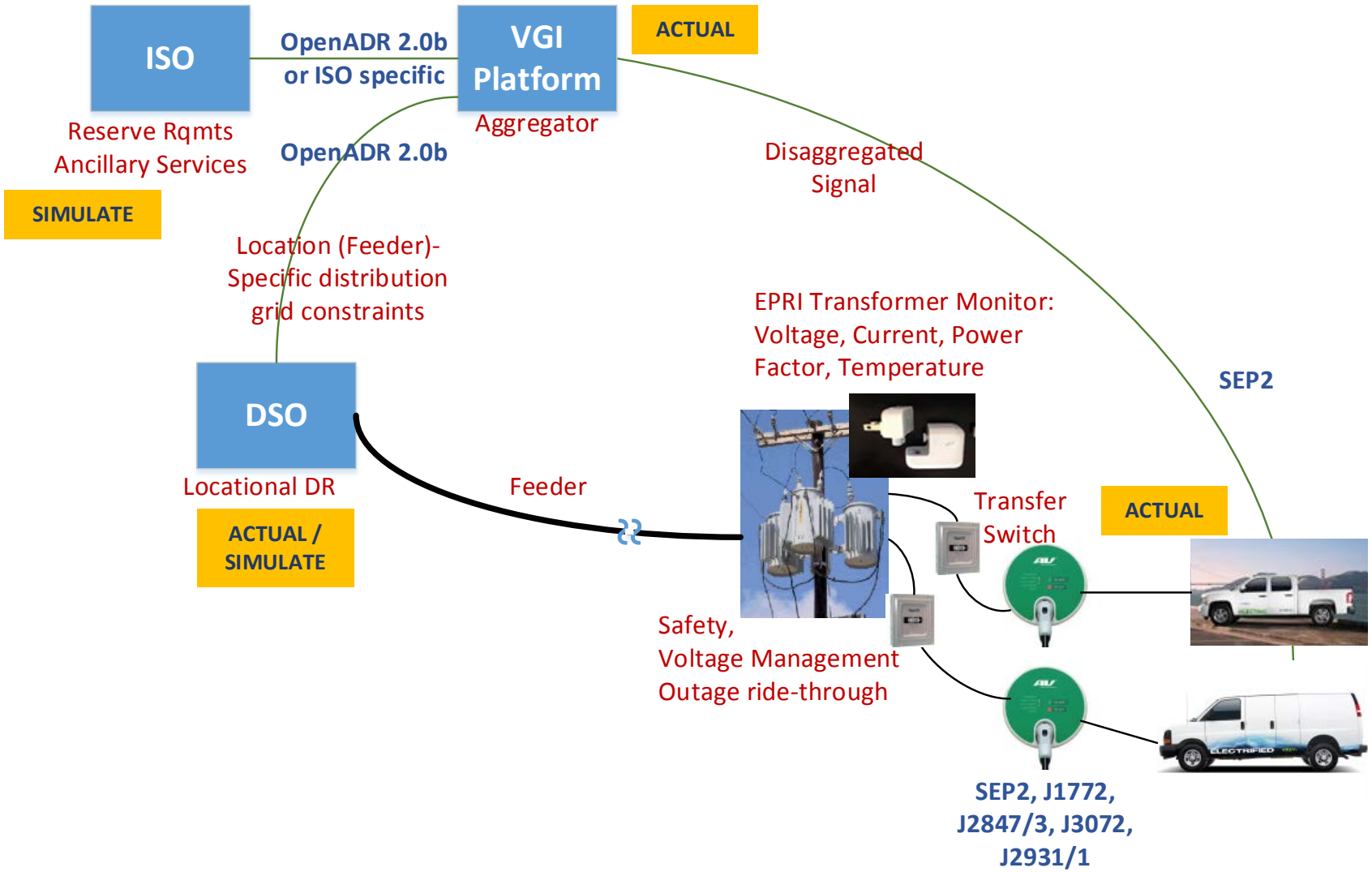
System Layout – Distribution System Aware Vehicle to Grid Services for Improved System Stability and Reliability



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Core Innovations 1/2

V2G equipped PHEVs from VIA Motors

- VIA PHEV with 23.3kW Lion battery pack, 40 mile all electric range, 14.4kW/50A Exportable Power module, bi-directional battery energy flow and SAE CCS fast charging
- Standards-compliant using SEP2 (IEEE 2030.5), SAE J2847/3, J2931/4 and J3072

EVSEs from AeroVironment

- Bidirectional-capable EVSE based on AV's EVSE-RS platform
- Expandable control board providing grid voltage and current measurement, energy metering, and grid frequency; integrates HomePlug GPHY (J2931/4) with SEP2 client and J3072
- SEP2 functions through add in daughter card running SEP 2.0 from Kitu

Energy harvesting transformer sensor

- Transformer-mounted power flow controller that load-manages connected PEVs. Measures voltage, current, phase, power factor, and temperature

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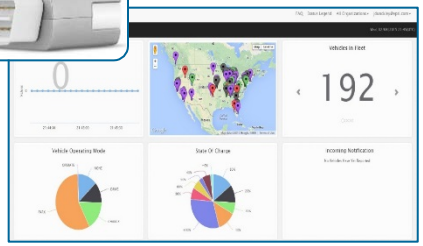
Core Innovations: #2/2

EPRI Multi-Protocol Router

- Enables SAE J2847/1, SEP2 and J2931 connectivity all in one package through on-vehicle communications
- On-vehicle SEP2 client connects with EVSE SEP2 server, upgraded to include J3072 and J2847/3 protocol

GoPoint Technologies DRIVE OBD2 Adapter,

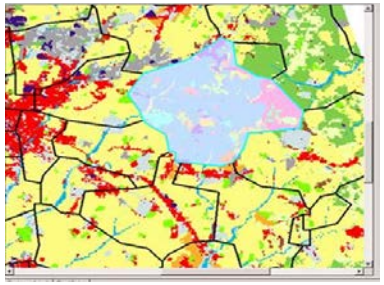
- EPRI Software for Enhanced CAN Data Capture in a commercial device
- Device reads operational raw data
- Streams data over active cellular (3G) connection to the internet to a Cloud server at high bandwidth providing EPRI-managed data warehouse for archival and analysis.



Data Monitor Dashboard

EPRI **OpenDSS**

- Distribution system analysis tool simulates feeder-level congestion
- Valuation of distribution and ISO services for a variety of V2G penetration scenarios, in conjunction with E3 valuation tools.



Distribution System Hot-Spot Prediction

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Challenges and Opportunities

- Challenges
  - Obtaining PEVs with on-board bidirectional Level 2 chargers
  - Coordinated communications and establishment of use cases
  - Systems integration and data acquisition
- Opportunities / Recommendations for Future Work
  - V2G space and value are evolving: Vehicle charging increasingly shifting to DC as more long-range PEVs come to fore
  - **Strongly Recommend** integration of off-board DC bidirectional charging equipment for V2G services because (a) it's simpler to implement than a 'roaming battery' (b) More palatable and practical for OEMs to implement and (c) it is generally associated with vehicles with larger batteries, which are a source of more value
  - **Strongly Recommend** integration of V2H and V2L systems for additional value (or V2G operating as V2H and V2L) because that may be the pathway to V2G long-term

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