Informing VGI Working Group Priorities through EPRI Vehicle-to-Grid Technology Programs

Summary of Key Relevant Findings

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Outline

- Summary of EPRI Research Projects
- Insights and lessons learned from on the following areas:
  - The feasibility of EVs for backup generation when not as part of a Microgrid (Recommendation 5.02 of the VGI Working Group), and to a multi-customer Microgrid (Recommendation 6.07 of the VGI Working Group).
  - The ability of EV~~SE~~ to provide grid services (Recommendation 2.21 of the VGI Working Group)
  - Directional information on the costs of hardware and software technology solutions

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Summary of Recent EPRI Research Projects

2009-2014 – DoE ARRA Funded OEM Programs

- EPRI-GM 'Battery to Grid' Project – Defined Use Cases, Interface Requirements and Develop Models for VGI (Incl V2G) Grid Services
- EPRI-Ford PHEV Demonstration Program – Developed VGI Fleet Value Optimization Tools
- EPRI-FCA – Open Standards-Based Implementation of Managed Charging Algorithms – Foundation for V2G Implementation

2016-2019 EPC 14-086 – Distribution System Constrained V2G Services for Improved Grid Reliability and Stability

- Implemented with FCA and Honda, AC V2G open standards implementation – Transformer Management System →EVSE→PEV Communications
- Value-Added Use Cases, Field Trial Demonstration at UCSD Microgrid
- Provided key data points for EVSA Project led by EVGo/Nuvve and Honda

2017-Present: DE-EE0007792 – Comprehensive Assessment of On-and Off-Board V2G Technology Performance on Battery and the Grid

- Developing SPIN – Smart Power Integrated Node – Technology: Single grid-tied Power-Processing and Control System integrating PV, EV V2G and Storage power and energy management
- Implementing DC V2G with smart inverter functions
- End-to-End System Integration and Test
- Battery cycle life testing with mobility and grid services cycles

2017-Present: EPC 16-054 - Open Vehicle to Building/Microgrid Integration Enabling ZNE and Improved Distribution Grid Services

- SPIN Integration with Microgrid DERMS
- SPIN Standalone Operation with Integrated V2G
- Open Standards / Interoperability Verification for DC V2G

EPRI Focus on Open Standards based AC and DC V2G with Direct OEM Engagement

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Feasibility of EVs for Backup Generation Without a Microgrid

- Two current EPRI programs: DE-EE0007792 and EPC 16-054 verifying it
- Smart Power Integrated Node designed precisely for this purpose
  - Integrates local PV with V2G capable EVs and assists local energy management
  - Fully capable to support local premise during an outage
  - Functions grid-tied or islanded through optional transfer switch
  - Capable of unitary or aggregated grid services while grid-tied
  - PV-integrated operation enables local PV to energize the home and charge EV
- Challenges / Opportunities
  - Results to inform DC V2G standards process
  - Results to inform battery degradation question

EVs Require an Interoperable Interface (e.g., SPIN) for Backup Generation Support

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Feasibility of EVs for Backup Generation as a Part of Multi-Customer Microgrid

- EPC 16-054: Vehicle to BMS and Vehicle-to-Microgrid Integration for ZNE and Distribution Services
  - Defining, implementing and verifying V2G to Microgrid Integration
  - V2G Capable EV treated as a local stationary storage while connected and available
  - Local DERMS / Microgrid Controller sets the dispatch order, with the standby generator being the ‘resource of the last recourse’
  - Testing will confirm feasibility of V2G to Microgrid Integration
- In case of SPIN, it can also serve as a residential microgrid controller, managing local V2G capable EV and PV in coordination with overall energy management of the home appliances

EVs Require Interoperable Interface and Coordinated Operation to serve as Backup Generators in a MIcrogrid

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Ability of EVSEs to Provide Grid Services

- EVs, EV owners and primacy for mobility (and not EVSEs) must be at the center of Grid Services
- EPC 14-086 and EPC 16-054 investigating a variety of use cases featuring full capabilities of V2G capable EVs
  - Scheduled charging for transformer thermal / local circuit capacity constraints
  - PV generation-synchronized charging, locally and based on distribution signaling – *belly of the duck*
  - Peak shaving during critical peak periods through reverse power flow
  - Mitigating peaker demand during ramp-up (*neck of the duck*) through reverse power flow
- EPRI and E3 published a valuation model for grid services

EVs and EV owner decide EV capability and availability. Grid Services Require Local and Wide-Area Situational Awareness

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Directional Information on Cost and Hardware

- Physical equipment requirements known on both the vehicle and EVSE / off-board DC charger
- Costs: Hard and soft costs
  - Hard: Hardware (variable), software (NRE), Installation and Permitting
  - Soft: O&M, Upgrades and obsolescence (must be avoided)
- Standards and Interoperability key to future-proofing the deployed hardware
- Guidelines and templates for interconnection-capable packages and ease of permitting, as well as clear path to value for participants will enable scale, which will bring down per-unit costs

Costs are Quantifiable, At-Scale Implementation Requires a Clear Path to Value to Participants

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