Project Background

Description
9 Nissan and Honda electric vehicles with **bidirectional** (V2G) power flow driving and providing energy storage at the UC San Diego campus

Goals
- Test Honda and Nissan approaches to bidirectional power flow
- Advance inverter technology and standards for electric vehicles
- Identify and test energy storage use cases appropriate for EVs
- Share data and insights to inform VGI Roadmap and other stakeholder processes

Funding
Originally selected to receive an award under PON 14-301 – but funding transitioned to technology fund under NRG settlement with CPUC

Technology Precedents
Builds off of technology developed by NRG, University of Delaware and Honda/ BMW as part of 2013-2014 V2G demonstration with PJM

Builds off of V2G technology developed by Nissan, Princeton Power, and others as part of LA Air Force Base project

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Does V2G Make Sense? An Unusually Polarizing Technology With Lots of Opinions

V2G Doesn't Make Sense

"We've said it many times before, but once more for emphasis -- vehicle to grid is a dumb idea"
- Smart Grid News (4/29/2013)

- Lack of automaker interest
- Negative impact on battery life
- Value of energy storage low compared to value of driving
- What happens when storage is needed, but device is on the road?
- Regulatory issues too complicated
- "V1G" just as good

V2G Makes Sense

"Vehicle-to-grid (V2G) is the banner idea for a larger and more complex challenges involving plug-in vehicles and grid operations"
- Greentechmedia (4/10/2012)

- Honda and Nissan and other OEMs undertaking V2G R&D
- Customer has already "paid for" most or all of energy storage system (battery, enclosure) – potential for radically cheaper form of storage
- Bidirectional energy storage more valuable than "V1G"
- Fundamental inverter technology already developed for other applications

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Why is V2G So Important to California?

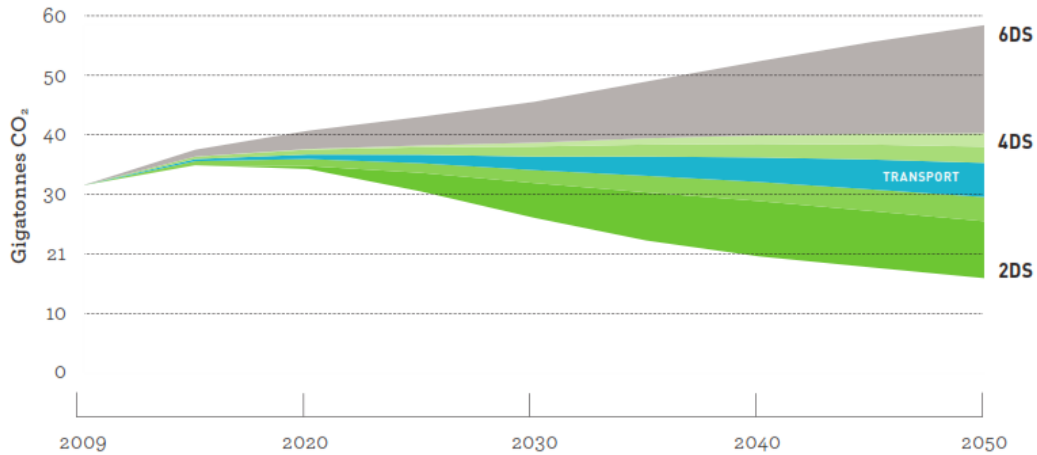
California's 2030 Goal:

50% Renewables and 50% less automotive fuel use

- And **80% less GHGs** by 2050
- Unprecedented change to California's grid
- V2G is a technology that helps enable BOTH goals

Figure 1. Role of Transport in CO_2 Reduction (% = 2050 estimate)

Source: IEA, ETP 2012. NOTE: Sector percentages represent cumulative contributions to emissions reductions relative to the 4DS (4°C Scenario, which is based on proposed policies).



SECTORS

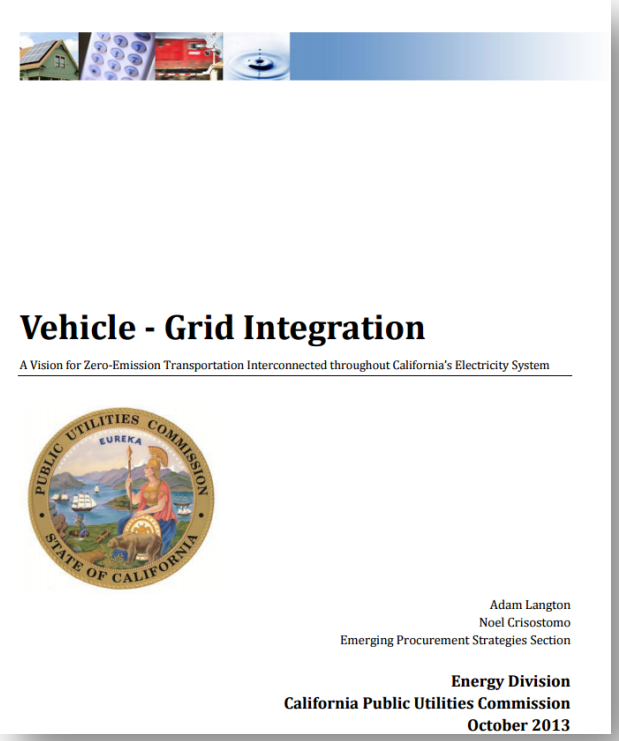
- Power Generation **42%**
- Transport **21%**
- Industry **18%**
- Buildings **12%**
- Other Transformation **7%**
- Additional Emissions **6DS** (6°C Baseline Scenario)

Isn't "V1G" just as good? And much easier?

- The technology for V1G (one-directional power flow) is more readily available, easier to implement and has a number of important use cases
- But V2G – if we can get it right – has advantages:

"Bidirectional capabilities avail a larger capacity and longer duration resource than controlled charging. V1G can only provide grid value during the times that the vehicle is charging...for a typical California residential PEV customer, controlled charging will amount to about 2 hours per day. A vehicle that can discharge its battery to the grid can provide grid services whenever it is plugged-in and able to communicate with the grid."

- CPUC Vehicle Grid Integration Whitepaper



Vehicle - Grid Integration

A Vision for Zero-Emission Transportation Interconnected throughout California's Electricity System

Adam Langton
Noel Crisostomo
Emerging Procurement Strategies Section

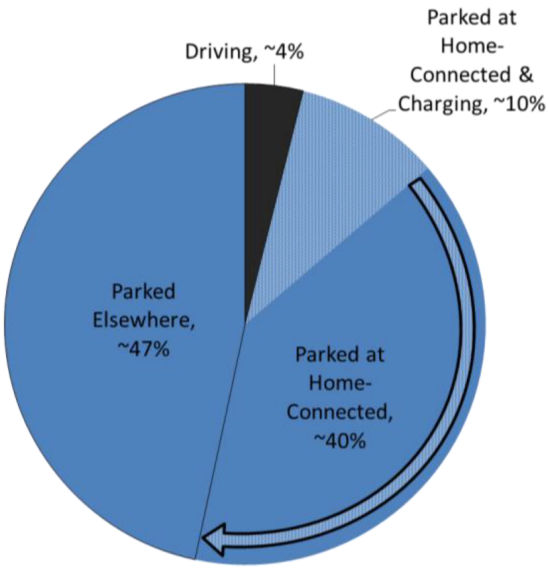
Energy Division
California Public Utilities Commission
October 2013

Benefits of V2G Energy Storage

- **Depends on duration, speed, location and availability of resources**
  - EVs are only driving **4%** of the time

- **System (Bulk) Benefits**
  - Managing duck curve
  - Providing Ancillary Services (AS)

- **Local Issues**
  - Peak shaving
  - Voltage regulation
  - Helps address issues associated with high penetration of DG solar
  - Phase balancing
  - Managing localized distribution constraints
  - Lowering facility upgrade requirements



Estimated percent of time PEVs spend by location and activity.

Source: Vehicle - Grid Integration: A Vision for Zero-Emission Transportation Interconnected throughout California's Electricity System; California Public Utility Commission, March 2014. R.13-11-007. Pg. 5.

- **Rates**
  - Better utilization of existing generation and T&D assets = lower consumer cost per kWh

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Why is the **EV Storage Accelerator** Important?

The project is uniquely positioned to build critically important OEM support for and to answer many vital questions about V2G:

- OEM Involvement
  - **Honda** and **Nissan** are both committed to investing in the project as a way to test technology, use cases, regulatory/codes barriers, and market opportunity for V2G

- Questions the project will address
  - **UL listing** – Will EV-based inverter approaches emerge that meet utility interconnection specs?
  - **Automaker involvement** – will OEMs get comfortable with both market opportunities and battery impact to move forward?
  - **Product value –** Is an energy storage resource valuable if not available 100% of the time (because it is mobile)? Does it provide sufficient value to ratepayers, the system, customers and project developers?

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How do EVs compare to Fixed Storage as a DER?

Important to separate out questions about market for behind-the-meter storage from questions about technology…

- Resource Availability
  - EVs are only driving **4%** of the time, but availability of vehicular storage may not always align with local/system needs, and may require consumer behavioral changes
- Cost
  - How do the benefits provided by V2G compare to the costs of additional battery cycling, adding mobile inverters, bidirectional charging capabilities, and going through full utility interconnection processes?
- Standards & Readiness
  - What additional codes & standards need to be developed or tested in order for V2G technology to gain utility acceptance and clear, timely, and cost effective interconnection?

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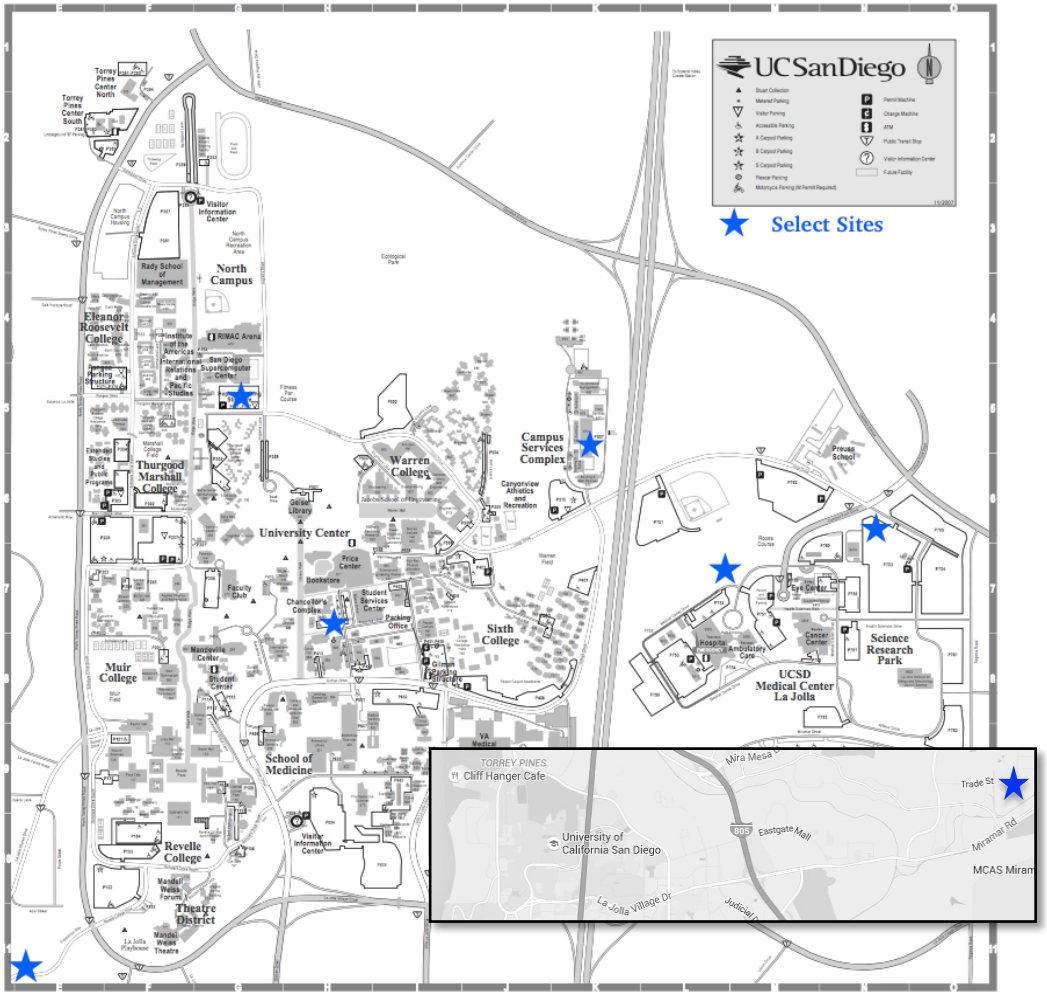
Technical Project Aspects



- **9** Vehicle & L2 EVSE on or near the UCSD campus
- **7** sites on or near the UCSD campus
- **6** Nissan LEAFs using UL listed bi-directional CHAdeMO Princeton Power inverter
- **3** Honda Accord PHEVs utilizing onboard bi-directional vehicle inverter developed jointly by UD and NRG
- **2** Interconnections in SDG&E distribution grid
- Summer 2015 to Summer 2018

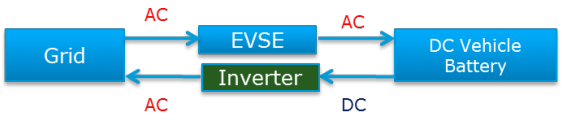
NRG V2G Energy Storage Use Cases to be Studied

Uses	Potential Value	NRG Project Focus	Notes
End-User Benefits (Retail Bill Management, or other end user incentives)	◑ || ◕	✓	Focus on unique end-user incentives to maximize participation
Proxy Demand Response - **Wholesale Energy**	◔		
Non Generator Resource - **Frequency Regulation** - **Spinning Reserves** - **Wholesale Energy**	◑	✓	Most tested DER use case to date; unclear whether NRG project will simulate energy prices only, or also ancillary services
Distribution Services (Deferral, Reliability)	○ || ◕	✓	Goal: method to layer circuit-level volt/VAR support on top of wholesale market signals (which are longer duration)
Capacity (System, Local, Flexible)	◔ ⟹ ◑ 2015 2018		Not studying directly, but anticipation data (i.e. resource availability) will help inform future capacity values

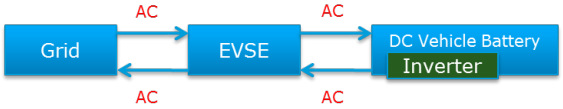
Codes and standards are critical

Relevant Standards

"Offboard" Inverter



"Onboard" Inverter



NEC -
Local code enforcement to NEC 625 and UL 2202 (EVSEs)

- Princeton Power EVSE designed to meet standards

- Vehicles not within code enforcement jurisdiction
- NEC 625.48 (2017) would clarify rules

Anti-Islanding -
Utility requirement for conformance with UL 1741 (that refers to IEEE 1547 standard)

- Princeton Power EVSE designed to meet standards

- Vehicles not ever capable of meeting certain UL 1741 standards (eg. inverter needs to be bolted to ground)
- SAE J3072 passed in May 2015 to conform to IEEE 1547 anti-islanding standards
- The challenge is how to get utilities comfortable with J3072
- 3 Hondas in project meet J3072

Rule 21 -
Emerging requirements in California for smart inverters

- Princeton Power EVSE designed to be adaptable to emerging standards

- Meeting Rule 21 requirements further down the product development path

No major obstacles – product development necessary to lower inverter/EVSE costs

A number of obstacles – project hopes to get first Honda vehicles in front of utilities for anti-islanding testing

NRG V2G Energy Storage Project: Next Steps

- Finalize use cases in coordination with project stakeholders
  In Particular, SDG&E & UCSD for distribution circuit volt/VAR support
- Vet third party and internal technical solutions to test use cases
- Finish EVSE Installations
- Obtain VGI-capable vehicles from Honda and Nissan
- Acquire beta customers for demonstration project
- Apply with SDG&E to interconnect off-campus EVSE location(s)

Collaboration Opportunities

NRG EVgo proposes a technical working group for California's VGI projects

Goal: Provide forum of interaction & problem solving for VGI pilot program shared technical issues

- Compare use cases & value streams under evaluation
- Avoid "reinventing the wheel"
- Discuss common technical issues and range of potential solutions
- Identify shared regulatory barriers and policy recommendations

Proposed First Forum Date: January, 2016

Interested parties should contact Niki De Leon to coordinate details:

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Key Stakeholders

Agencies

California ISO
Shaping a Renewed Future

California Environmental Protection Agency
AIR RESOURCES BOARD

Utilities

PG&E
Pacific Gas and Electric Company

SDGE
A Sempra Energy utility

SOUTHERN CALIFORNIA EDISON
An EDISON INTERNATIONAL® Company

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