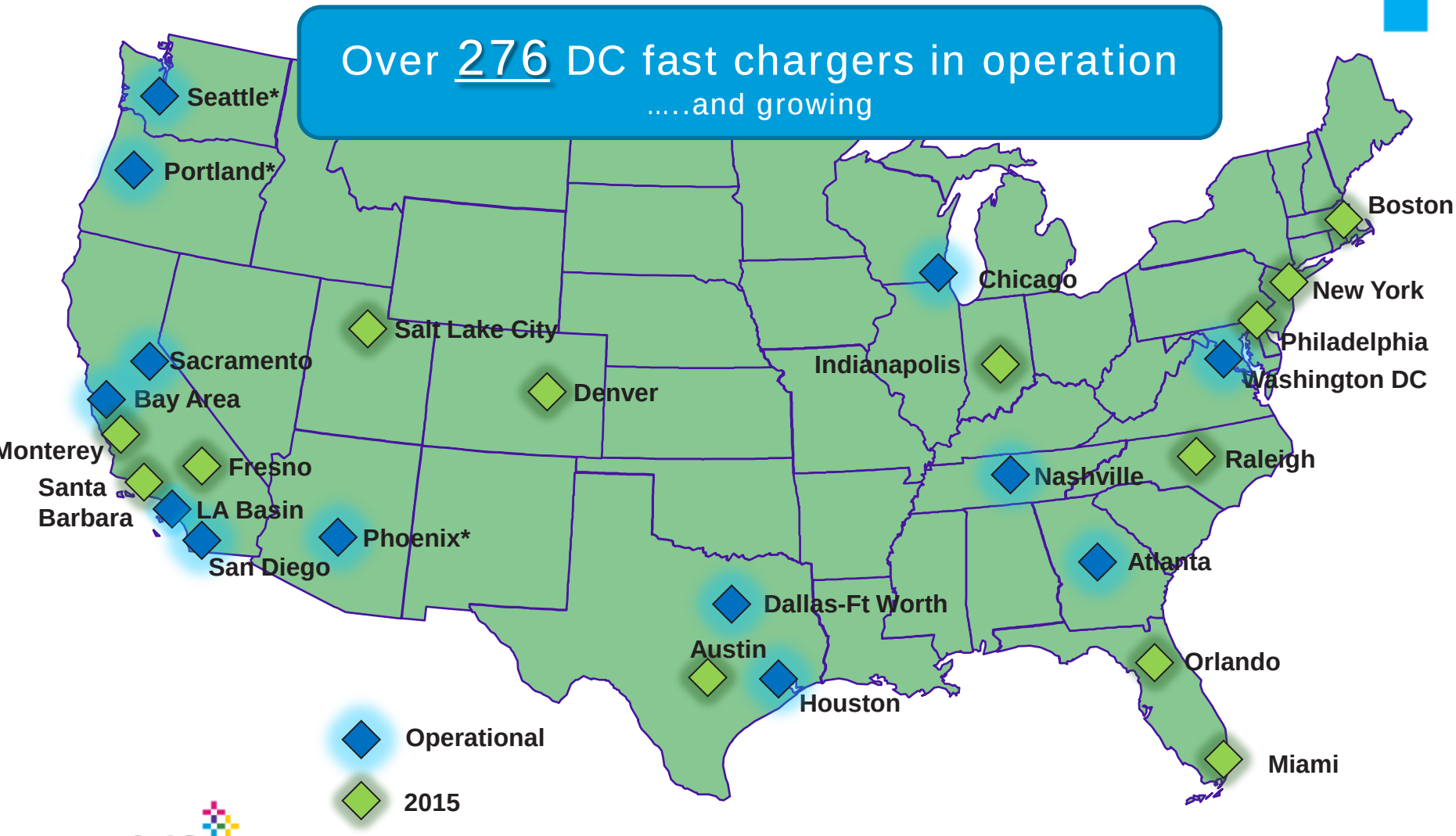
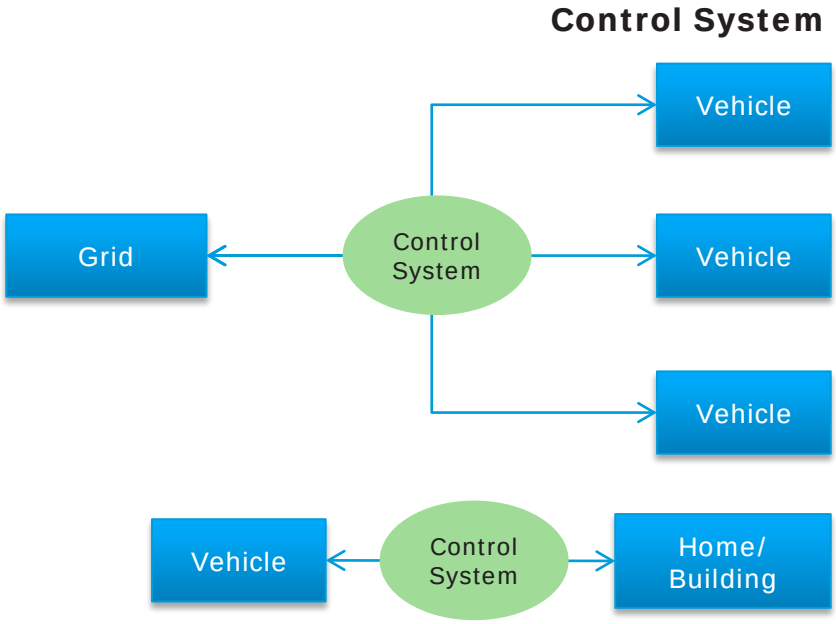
Vehicle to Grid – Getting from Hype to Reality

Scott Fisher, Director, Alternative Energy, NRG Energy
National Town Meeting on Demand Response and Smart Grid

NRG's Main Current Focus in EVs

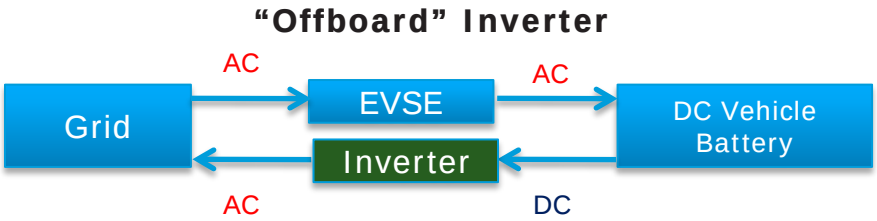


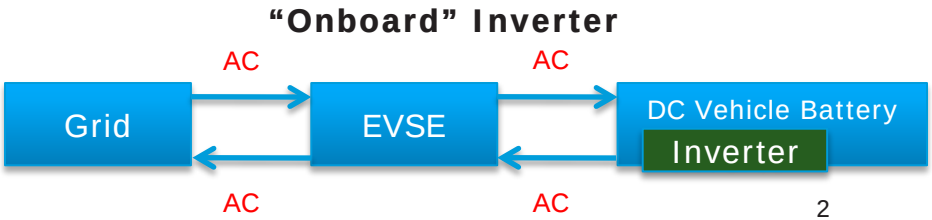
We are also developing vehicle to grid technology – What is V2G?



- Uses vehicles as a behind-the-meter energy storage device
- Power flows to the vehicle and from the vehicle
- Could provide energy storage services to the grid or to a home or building

A key enabling technology is the inverter to take DC power from battery to grid AC power





Does vehicle to grid makes 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

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)

- Growing # of EVs, 1.5 million ZEVs in CA by 2020
- 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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NRG V2G Focus

- V2G is an important enough technology to try to figure out the reality of it – especially given NRG's broader interest in electric vehicle infrastructure
- NRG set up eV2g partnership with U of Delaware to fund programs – whether in partnership with other companies and/or as cost share to grant programs
- In 2013, came online with world's first instance of cars earning revenue as a grid resource in PJM frequency regulation market (15 vehicles @ 100kW)

eV2g

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University of Delaware

- Energy market expertise
- Capital to commercialize technology

- Vehicle control software
- Other enabling technologies

Major Partners

pjm


Los Angeles Times

Electric cars may hold solution for power storage

In a Delaware pilot project, electricity is stored in and retrieved from the batteries of idle vehicles. Car owners would be paid.

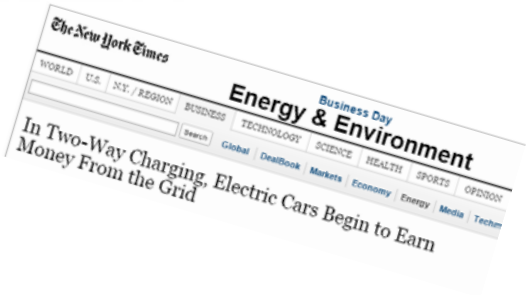
December 29, 2013 | By Evan Halper


THE WALL STREET JOURNAL. U.S.

JOURNAL REPORTS: ENERGY

Electric Vehicles Sell Power Back to the Grid

Delaware Test Fleet Makes Money by Serving as an Electricity Reserve


The New York Times

Business Day

Energy & Environment

In Two-Way Charging, Electric Cars Begin to Earn Money From the Grid

Key V2G Questions

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

- Questions for all behind-the-meter storage technologies in accessing grid
  - Will opportunities emerge to provide value to utility or grid beyond local peak shaving?
  - How to deal with “net metering” type issues – behind the meter storage will be challenged if battery fills with retail power rate and discharges at wholesale rate
- Questions specifically for V2G
  - **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)? Can predictive intelligence partially mitigate?

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Progress Over the Last 12-18 Months

- Previously, lack of public support because of “chicken vs. egg” problem
  - Public agencies previously not supportive of V2G because they had not heard interest from OEMs
  - OEMs didn’t push technology because they needed some pathway on market potential

- But now a number of recent public sector efforts
  - Department of Defense/California Energy Commission (CEC) project at Los Angeles Air Force base
  - At least two recent multi-million dollar CEC funding opportunity for V2G
  - Other recent funding from NYSERDA and NREL
  - California VGI Roadmap

- OEM Interest
  - BMW and Honda R&D collaborations with NRG/UDel
  - Nissan work at Los Angeles AFB and “vehicle-to-home” work in Japan
  - CEC solicitations are noticed

- Standards development
  - SAE J3072 for “Interconnection Requirements for Onboard, Utility-Interactive, Inverter Systems” now drafted – conforms with IEEE 1547 inverter standards

Potential Pathway

Greater EV Sales

- Drives continued OEM interest in investing in EVs

Storage Market Development

- Allows for opportunities for value by supporting the grid, not just building or home

Progress on Basic V2G Technology

- Progress on inverter technology and product development – initially based on vehicle to home market (requires fewer regulatory changes)
- Evaluation of technology on public grants leads to certain V2G specific rules (example, interconnection for mobile inverters)
- Interested automakers continue supporting technology development efforts

V2G gets a legitimate market opportunity to prove itself