Technical Implications of Electric Vehicle (EV) Integration for the Grid, Bulk and Local Distribution

Presentation to the
U.S. Department of Energy
by the IEEE Joint Task Force on QER

U.S. DOE Requested Insights on

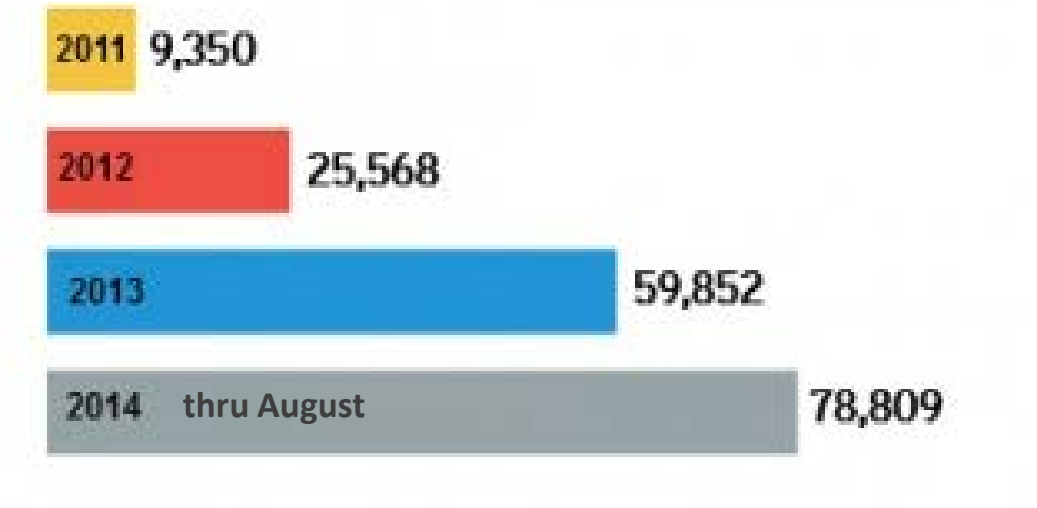
- The technical implications for the grid (bulk and local distribution) of electric vehicle (EV) integration - and the timing you see as necessary to avoid having the grid status slow down any potential progress

Plug-in Electric Vehicles

- **Plug-In Hybrid Electric Vehicles (PHEV)** - similar to conventional HEV except for the ability to charge the battery directly from an electric socket, and a larger battery to enable driving on electricity
- **Extended Range Electric Vehicles (EREV)** - electric drive vehicles with fuel-engine-driven generators capable of recharging their batteries
- **Battery Electric-only Vehicles (BEV)** - all electric drive vehicles with no supplemental engine

Market penetration

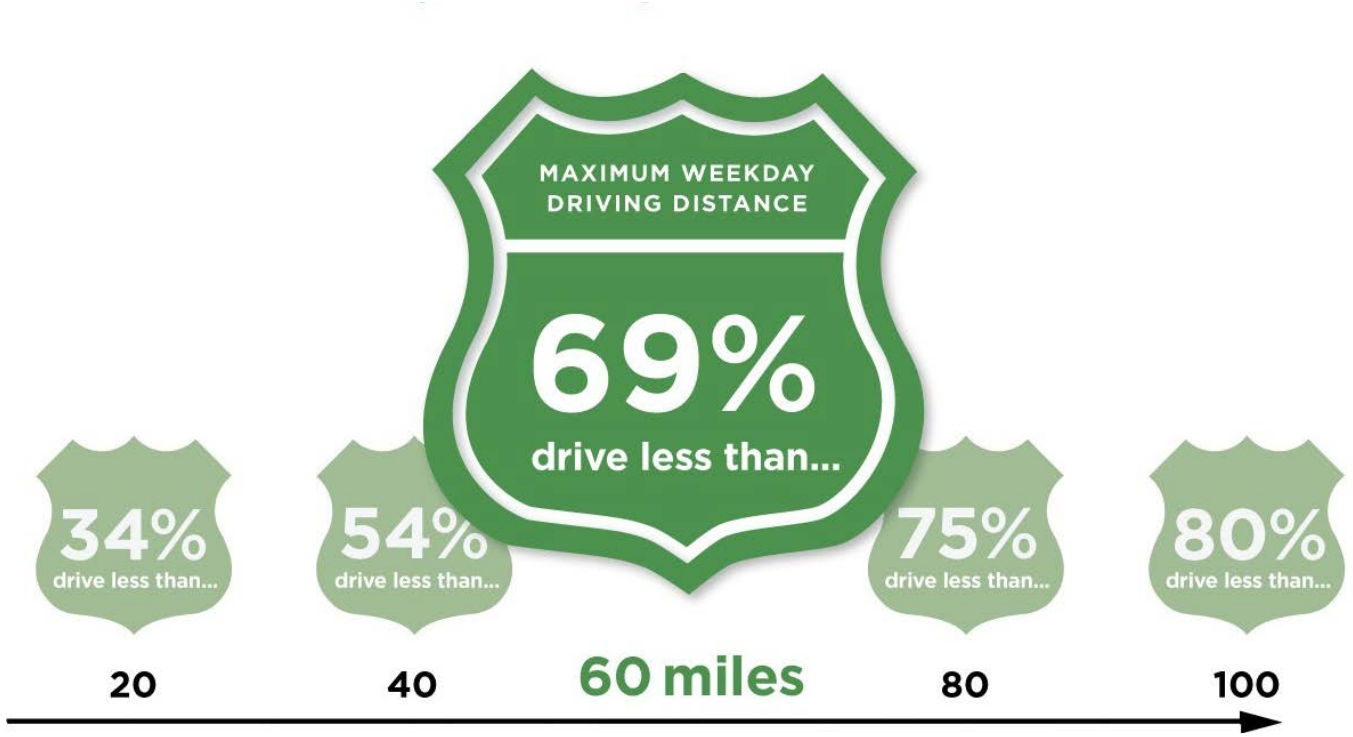
- There are about 250,000 PEVs and 20 models on the road (through August 2014)
- Steady increase in sales year over year



PEV energy use

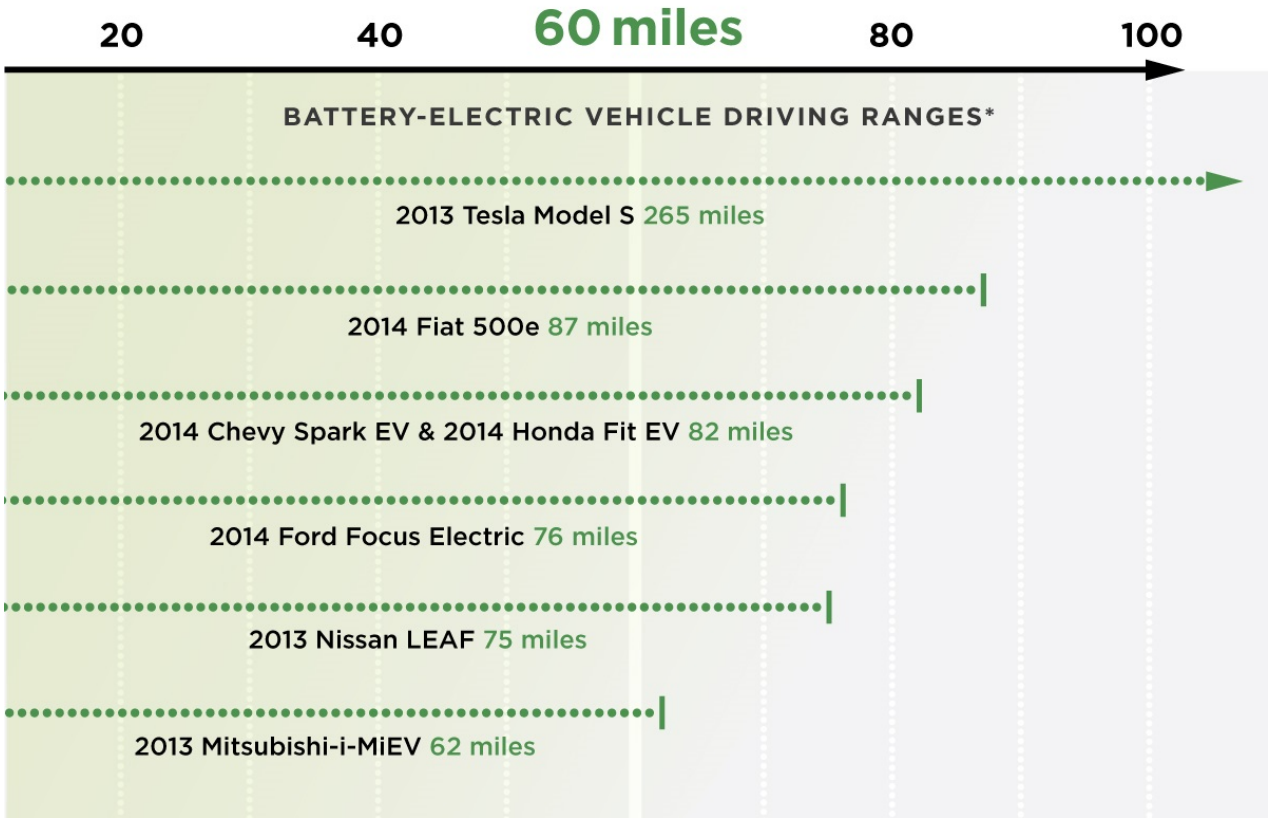
- PHEV/EREV battery is typically below 20 kWh - BEV has a larger battery – 1 to 5 times this size (includes longest-range BEVs, Tesla, with an 85 kWh battery for 250 miles)
- Average use is 5 to 10 kWh/day – much less than the battery size
- This reflects field test findings
  - Majority of miles driven in EV mode were primarily in trip distances of less than 50 miles; and
  - Largest percentage of total distance traveled was for trips of 10 to 20 miles in length.

69% of U.S. drivers drive less than 60 miles on weekdays



Source: "Survey Says: Over 40% of American Drivers Could Use an Electric Vehicle," Union of Concerned Scientists, December 2013 (http://blog.ucsusa.org/survey-says-over-40-of-american-drivers-could-use-an-electric-vehicle-338)

42% of U.S. households could use today's EVs



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Charging demand

- Typical PEV charger power rating
  - Ordinary plug (Level 1) ~1.6 kW
  - 240 V plug (Level 2) 3.3/6.6+ kW
- Data on a mix of Nissan Leaf (BEV) and Chevy Volt (EREV) vehicles using Level 2 chargers
  - Average length of time with vehicle drawing power per charging event is 2.3 hours
  - Average electricity consumed per charging event is 8 kWh AC (at the plug)

Does everyone need a fast charger?

How long does it take to charge the battery for 32 miles?

Level-1 in 8 hours

$300 cord comes with all EVs and outlets exist

Source: Bob Bruninga, IEEE Transportation Committee, http://aprs.org/payin-to-plugin.html

Level-2 in 2 hours

$3,000 installed

Findings: Bulk Power System

- **Generation and transmission systems can handle millions of plug-in electric vehicles**
  - Studies suggest that more than half of the LDVs could be powered by existing generation.
  - Although not a realistic expectation, even electrification of the entire passenger fleet would only add about 10% to U.S. electricity requirements

Findings: Distribution System

- There is a good understanding of **technical issues that may arise on the distribution system**
  - Potential overloads of distribution transformers and circuits,
  - Changes in equipment cooling patterns, or
  - Inability to accommodate high-power charging in older neighborhoods with legacy distribution infrastructure

Recommendations: Infrastructure

- Promote the development of PEV charging infrastructure and its deployment by cities, states, and businesses, and along the interstate highway system with the support of the federal government

Recommendations: Standards

- Fast track standards and research to support higher penetration of PEVs
  - Sizing and implementation guidelines for physical grid equipment
  - Sensors and controls for remote control of charging to better interface with the grid
  - Security of communication
  - Use of the PEV batteries to support electric needs during natural disasters

Recommendations: Research

- Support battery research for transportation focusing on longer range/life and battery chemistries suitable for opportunity charging
- Increase the focus on research to determine
  - Grid sizing to support high penetration of PEV
  - Reduction in losses when charging from roof-top photovoltaics
  - PEV load modeling and forecasting
  - Demographics of PEV locations
- This research will also benefit high penetration of distributed generation

Recommendations: Modeling

- Modeling tools (e.g., based on DOE's GridLAB-D) needed to support:
  - Distribution grid modeling for PEV load forecasting, short term and long-term. The modeling needs to focus on both static and dynamic power flow
  - Integration of demand response and transactive energy into the PEV fleet linking economics with power quality

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