Overview of Electric Vehicle Market Issues in the U.S.

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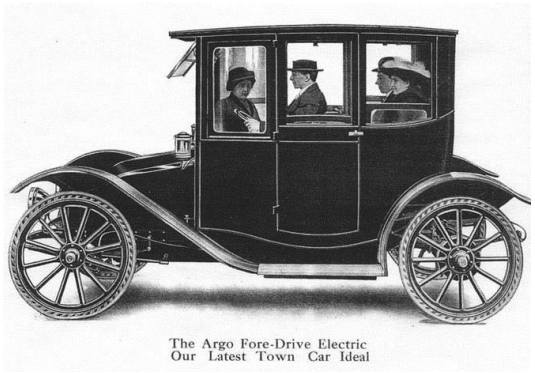
History of EVs in the U.S.

- EVs held at least 30% of the market in 1900
  - EVs disappeared as gasoline became more available and less expensive and gasoline vehicles improved in power, reliability, and cost.
- Small revival during energy crisis in 1970s
- Another revival after initial CA ZEV mandate in early 1990s
  - GM EV1
  - Toyota RAV4 EV



Current U.S. Market Status

EVs and PHEVs in U.S. Market

- Many new vehicle models entering market
  - 2011
    - Two major introductions: Nissan Leaf EV and Chevrolet Volt PHEV
    - Also Tesla Roadster, BMW ActiveE EV and Smart fortwo EV
  - 2012
    - Mitsubishi i EV, Ford Focus EV, Tesla Model S EV, Toyota Prius PHEV, and Fisker Karma PHEV
  - 2013
    - Honda Fit EV, Toyota RAV4 EV, Ford C-Max Energi PHEV, …
- Total sales remain relatively small
  - 0.1% of overall sales in 2011, 0.2-0.3% of sales in 2012

U.S. Refueling Infrastructure

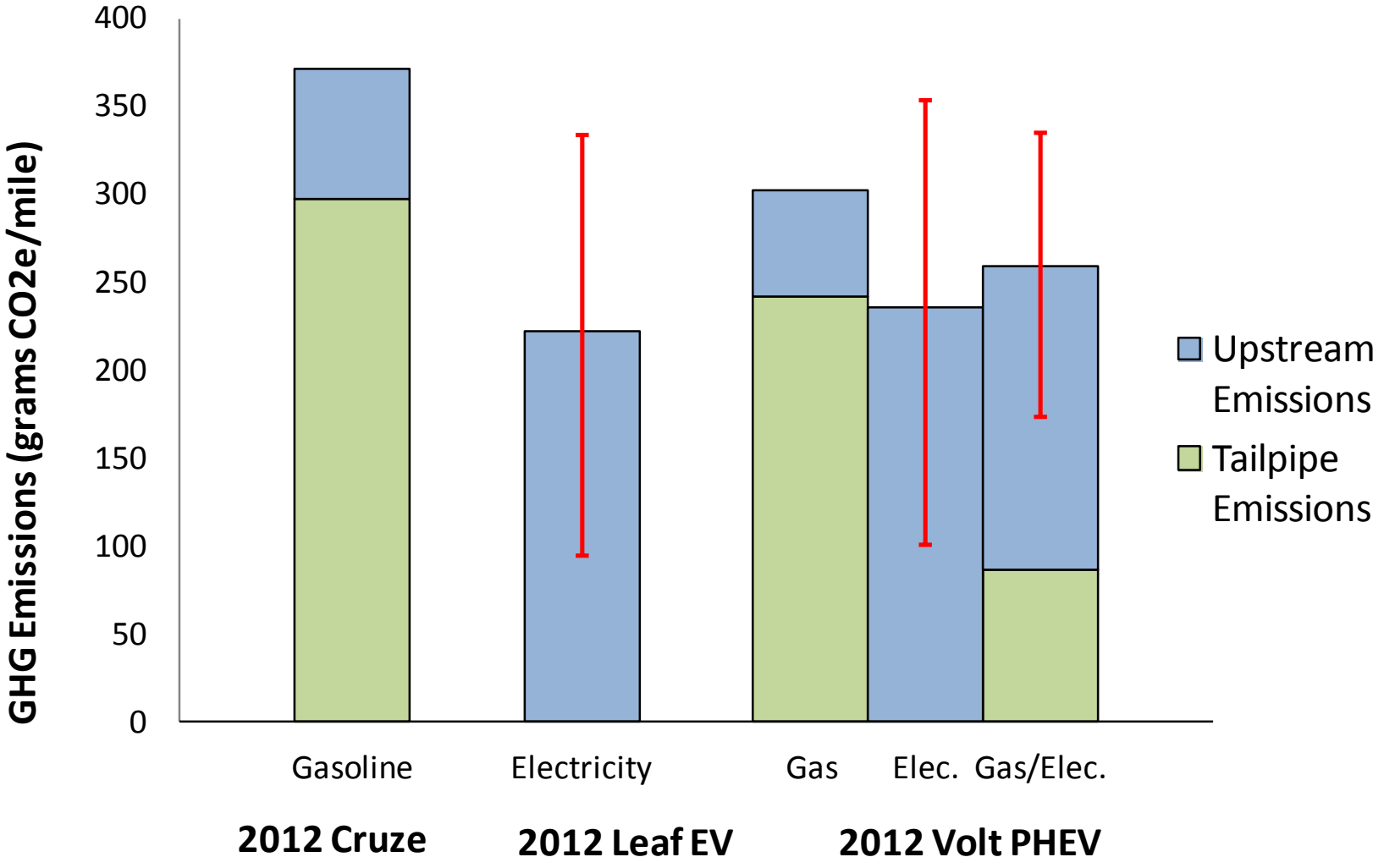
- Home charging
  - Nationwide, 50-60% of all U.S. households have garages
  - 61% of new vehicle buying households in California have access to an electrical outlet within 50 feet of parking location
  - Level 1 (120 v) systems can work for PHEVs
  - Level 2 (240 v) are best for EVs
    - GE WattStation sold to consumers for $1,000 plus installation
- Public charging stations
  - About 4500 public charging stations in U.S.
  - Mostly Level 2 (240 v) systems, a few Level 3 (480 v) systems

Utility Programs in U.S.

- Promoting consumer interest
  - Offering new pricing options
    - Lower rates for nighttime charging
    - Dedicated meters with lower rates for home charging
    - Fixed monthly price for unlimited EV charging at public stations
  - Free or reduced price Level 2 charging stations and home installation
- Evaluating potential impacts on electric grid
  - distribution infrastructure (e.g., transformers)
  - “smart charging” and vehicle-to-grid technology
- Operating EV/PHEV fleets for research purposes
- Collaborating with cities, local governments, and other stakeholders on plug-in vehicle readiness planning

Lifecycle GHG Emissions Performance

(Real world, based on EPA eGRID2012)



U.S. Regulatory Landscape

U.S. Health-Related Emissions Standards

- U.S. (EPA and the California Air Resources Board) was the global pioneer in reducing automotive health-related pollution in the 1970s and 1980s
- EPA "Tier 2" standards now in effect represent 98-99% reductions, relative to 1970, for hydrocarbons, carbon monoxide, and oxides of nitrogen emissions
  - Technologies such as fuel injection and on-board electronic controls have led to cars that are not only cleaner, but better performing and more reliable and durable as well
- EPA considering future "Tier 3" standards that could tighten both vehicle and fuel standards
- Unlikely to have major effect on future EV market

U.S. National Program GHG/CAFE Standards

(www.epa.gov/otaq/climate/regulations.htm)

	MY 2010 Baseline	MY 2016 Standards	MY 2025 Standards
GHG emissions	351 g/mi (218 g/km)	250 g/mi (155 g/km)	163 g/mi (101 g/km)
Fuel economy	25.3 mpg (9.3 L/100 km)	34.1 mpg (6.9 L/100 km)	49.6 mpg (4.7 L/100 km)

U.S. National Program
GHG Compliance Incentives for EV/PHEVs

Timeframe	GHG Emissions Compliance Treatment for Grid Electricity	Compliance Multiplier
2012-2016	Below sales limit: 0 grams/mile Above sales limit: Net upstream	None
2017-2021	0 grams/mile	EV: 2.0 … 1.5 PHEV: 1.6 … 1.3
2022-2025	Below sales limit: 0 grams/mile Above sales limit: Net upstream	None

U.S. National Program
Net Upstream GHG Approach for EVs

- Measure vehicle electricity consumption over EPA city and highway test cycles in watt-hours/mile
- Divide value by 0.935 to reflect transmission losses to reflect electricity needed at the electric powerplant
- Multiply value by 0.534 grams/watt-hour to reflect EPA projection of overall electricity upstream GHG emissions (both powerplant and feedstock) associated with extra electricity demand for EVs/PHEVs in 2030
- Subtract the upstream GHG emissions of a gasoline vehicle with the same footprint meeting its CO_2 target

CAFE Treatment for EVs

- Based on “petroleum equivalency factor” per DOE regulations, reflecting that little or no oil is used in U.S. electricity generation
- CAFE rating = 82,049 Wh/gal divided by electricity consumption in Wh/mile over EPA tests
  - Nissan Leaf uses 238 Wh/mile, so CAFE = 347 miles/gallon

California ZEV Program (www.arb.ca.gov)

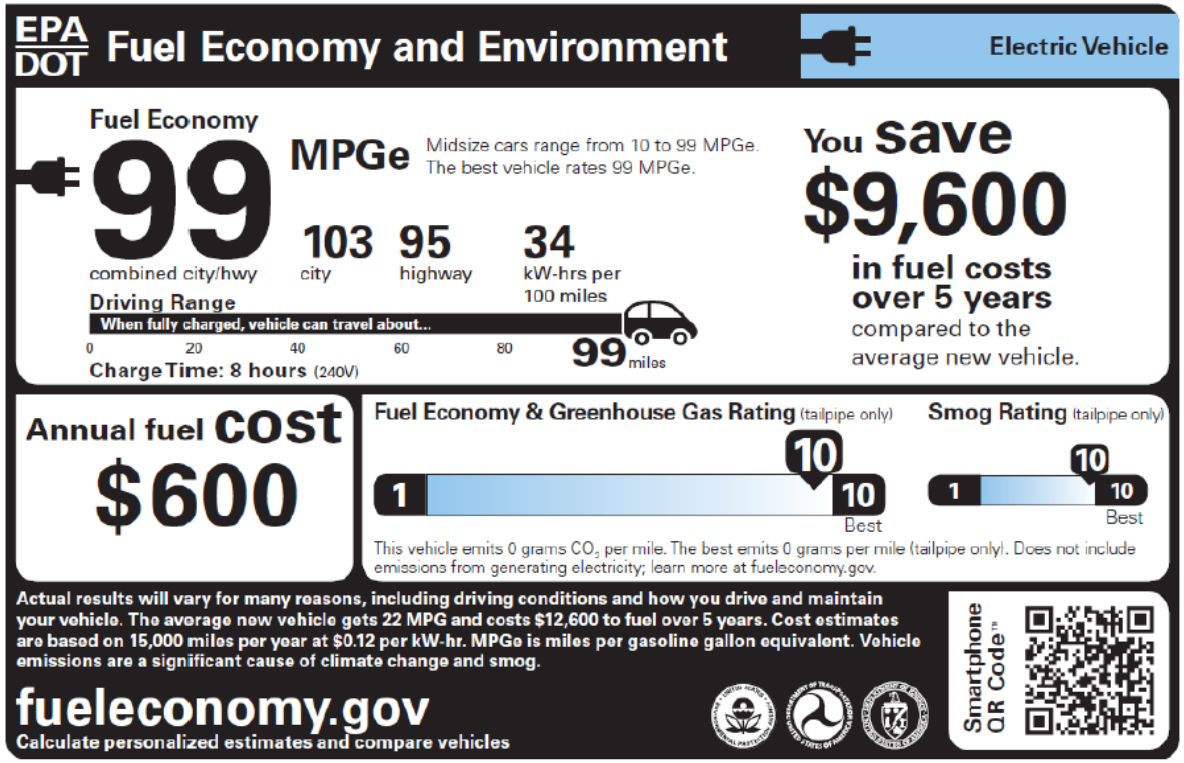
- Originally established in 1990 to require a fraction of sales of advanced technology vehicles with zero or near-zero health-related emissions
  - Mostly met by ultra-low emissions gasoline and hybrid cars
  - Smaller number of EVs, often “Neighborhood EVs”
- Evolving to greater focus on vehicles that use fuels with “zero emission” tailpipe GHG emissions
  - Grid electricity and hydrogen
- Compliance based on credit system reflecting technology, EV range, hydrogen fuel cell storage pressure, etc.
- EPA currently reviewing “waiver” for 2018-2025 that could be met by, for example, 13% EV 100 and 4% PHEV
  - Or fewer fuel cell vehicles, or EVs with longer range

U.S. Fuel Economy & Environment Label

- Starting with model year 2013, all new passenger cars and trucks sold in the United States are required to have the revised fuel economy & environment label
  - The label's metrics and design enable consumers to compare across technologies (gas, diesel, EV, PHEV, FCV, CNG)

Both MPGe & kW-hrs per 100 miles

Range & Charge Time



Highlights how much consumers can save (or spend) in fuel costs compared to average vehicle

Tailpipe CO_2

More information, including upstream GHG emissions estimates, are available on joint DOE-EPA website

U.S. Government Incentives

U.S. DOE Funding to support EVs/PHEVs

- American Recovery and Reinvestment Act of 2009
  - $2 billion in grants for advanced battery manufacturing and recycling & electric drive component manufacturing
  - $400 million for transportation electrification program to install charging infrastructure and purchase EVs/PHEVs for demonstrations—The EV Project
    - 20+ cities
    - Over 8000 Evs and PHEVs
    - 14,000 Level 2 chargers and 300 Level 3 chargers
    - Data at http://avt.inl.gov/evproject.shtml

- Recent Research & Development programs
  - EV Everywhere Grand Challenge, announced March, 2012
    - Goal to enable US companies to develop an EV that is cost competitive with conventional vehicles (payback < 5 years) and has a range that meet s average Americans' needs by 2022
    - Working with industry, academia, state and local governments, and other stakeholders
  - $4 million to develop a wireless charging system for EVs, announced April 2012
  - $43 million for breakthrough energy storage technologies for electric vehicles and the grid
    - through the DOE's Advanced Research Projects Agency-Energy , announced Aug 2012

- Advanced Technology Vehicles Manufacturing Loan Program
  - Loans help fund domestic manufacturing facilities for EVs and batteries (as well as other advanced technology vehicles)
  - $25 billion authorized, $8,4 billion spent so far

U.S. EV/PHEV Tax Credits

- Primary economic incentive to promote consumer interest in EVs/PHEVs
- Federal tax credit
  - $2500 credit for EV/PHEV with battery capacity of 4 kWh
  - Credit increases by $417 for every kWh in excess of 4 kWh
  - Maximum credit of $7500 for battery capacity of 16+ kWh
  - Credit begins to phase down after a manufacturer's cumulative EV/PHEV sales reaches 200,000 units
- Some individual states also offer EV/PHEV tax credits
  - Highest credit is $5000 in Georgia
  - California state incentive ended June 30, 2012

HOV Lane Access in U.S.

- Primary non-economic incentive to promote consumer interest in EVs/PHEVs
- High-occupancy vehicle (HOV) lanes are normally restricted to vehicles carrying a certain minimum number of passengers to encourage car-pooling
- 11 states allow EV and PHEV drivers to use HOV lanes
  - Including California, New York, New Jersey, Florida, Illinois, Virginia, and Maryland
- In some areas, this can be a very powerful incentive

Fuel Road Taxes in U.S.

- U.S. fuel taxes
  - Federal: 18.4 cents per gallon
  - State: vary, but typically average about 30 cents per gallon
- Vehicles that use electricity generally pay no fuel taxes
  - One state, Washington state, has a $100 annual EV tax
- This yields an annual benefit of about $250 relative to a gasoline car that pays fuel taxes, or $2500 over a 10-year period

U.S. Market Drivers and Barriers for EVs

U.S. Market Drivers

- Direct benefits to vehicle owner
  - Fuel prices
    - Much lower
    - Much more predictable
  - Refueling
    - Can do so at home and avoid gasoline stations
  - Reduce personal oil use and carbon emissions
  - No tailpipe/noise may be perceived as more “elegant”
- Collective societal benefits
  - Large carbon savings, especially if electric grid is transformed to low-carbon feedstocks
  - Large oil savings can also reduce oil prices, reduce trade deficit, and keep more dollars in local economies

U. S. Market Barriers

- Much higher vehicle cost, due primarily to batteries
- Vehicle range
  - Lower
  - More variable due to climate and driving behavior
- Inconvenience and flexibility
  - Loss of peak vehicle utility
  - Longer refueling time
  - Greater need for household planning for vehicle use
- Lack of widespread public charging infrastructure
- Consumer reluctance to try very different car technology
- Cost and challenge of transforming electric grid to low-carbon feedstocks

Perspective

- EVs are a “bigger change” than any other alternative vehicle technology option for the U.S. market
- U.S. gov’t has done more to promote EV/PHEVs than other advanced technologies, but sales remain low so far
- It is impossible to predict whether EVs will be successful
  - Plausible that EVs will gain only a very small market share, e.g., as a second or third “city car” for high-income families
  - Plausible that EVs will become a mainstream competitor and the “technology of choice” for those consumers who want to nearly zero out their oil and carbon footprints
- Major determinants of future EV success in U.S.
  - Oil prices
  - Battery innovation and cost
  - Ability to transform U.S. electric grid to low-carbon feedstocks
  - Cultural attitudes toward oil and carbon

Thank You

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