Vehicle Electrification – So How Close are We?

Session 538: Transportation Research Board Annual Meeting

Reid (Rusty) Heffner
Booz Allen Hamilton

Washington, DC
1/12/2010

TRB TRANSPORTATION RESEARCH BOARD
OF THE NATIONAL ACADEMIES

So, How Close Are We?

So, How Close Are We? *It Depends…*

We are very close to having commercially-available grid-connected vehicles in the United States…

	Chevrolet Volt	Toyota Prius PHEV	Fisker Karma PHEV	Ford Focus BEV	Nissan Leaf	Think City EV	Mitsubishi i-Miev
Type	PHEV	PHEV	PHEV	EV	EV	EV	EV
AER	40 mi	12-18 mi	50 mi	100 mi	100 mi	110 mi	100 mi
Price	$40,000	$48,000	$87,900	$45,000	$28,000	$27,000	$47,500
Launch	2010	2012	2011	2011	2012	2011	2010

- This list is representative, but not comprehensive. Several EV models are on the road today in very small volumes (Tesla, BMW, Subaru) either as exotics or in fleet evaluation programs
- Numerous other models are proposed from both major manufacturers (Daimler, Chrysler, VW) and smaller manufacturers (Tesla, Fisker, CODA) although product details and launch dates are less clear

…but planned production volumes are low by automotive standards, and will remain that way for a while

	Chevrolet Volt	Toyota Prius PHEV	Fisker Karma PHEV	Ford Focus BEV	Nissan Leaf	Think City EV	Mitsubishi i-Miev
Type	PHEV	PHEV	PHEV	EV	EV	EV	EV
AER	40 mi	12-18 mi	50 mi	100 mi	100 mi	110 mi	100 mi
Price	$40,000	$48,000	$87,900	$45,000	$28,000	$27,000	$47,500
Launch	2010	2012	2011	2011	2012	2011	2010
Volume	10K/yr(init) 50K/yr(max)	20-30K/yr	8K/yr(init) 15K/yr(max)	10K/yr	100K/yr	3K/yr (init) 20K/yr (max)	5K/yr (init)

- Some points of reference:
  - 2009 light duty sales: 10.5M (“real” market size in 12-15M range?)
  - Highest volume vehicles: Ford F-150 (413,625), Toyota Camry (356,824), Chevrolet Silverado (316,544)

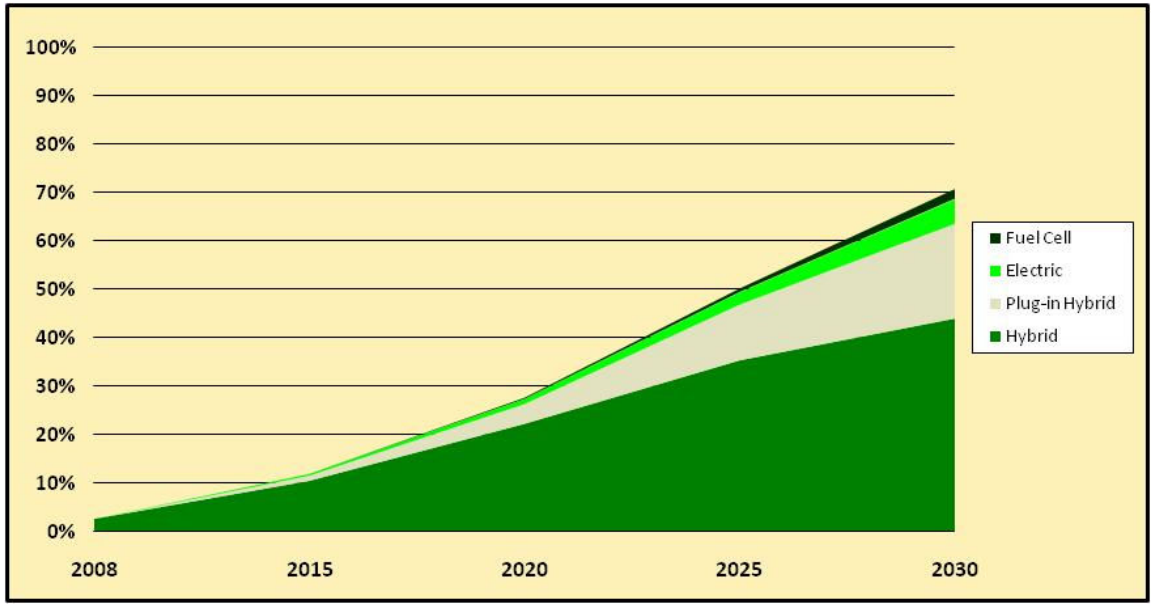
Modest vehicle volumes mean modest battery volumes, particularly when production is spread among numerous suppliers

	Chevrolet Volt	Toyota Prius PHEV	Fisker Karma PHEV	Ford Focus BEV	Nissan Leaf	Think City EV	Mitsubishi i-Miev
Type	PHEV	PHEV	PHEV	EV	EV	EV	EV
AER	40 mi	12-18 mi	50 mi	100 mi	100 mi	110 mi	100 mi
Price	$40,000	$48,000	$87,900	$45,000	$28,000	$27,000	$47,500
Launch	2010	2012	2011	2011	2012	2011	2010
Volume	10K/yr(init) 50K/yr(max)	20-30K/yr	8K/yr(init) 15K/yr(max)	10K/yr	150K/yr	3K/yr (init) 20K/yr (max)	5K/yr (init)
Battery	LG Chem	PEVE	EnerDel	JCS	NEC	EnerDel	GS Yuasa

A likely scenario is that grid-connected vehicles are adopted gradually, attaining 2% market share by 2015 and 30% by 2030

- Grid-connected vehicles account for 1.7% of sales in 2015 (annual sales ~300K units)
- By 2030, 29% of new vehicles are grid-connected vehicles
  - 24M PHEVs in PARC by 2030, between NAS Maximum and Probable Scenarios
- Conventional vehicles still account for ~20% of the 2030 market, and hybrids (grid-independent) account for nearly 50% of all vehicle sales
- Forecast includes:
  - Realistic product development timelines that permit traditional R&D and product testing
  - Battery prices that include profit for OEMs and suppliers (BCG, Heywood) and assume new chemistry post-2020
  - Increasing petroleum prices, but within limits (IEA)

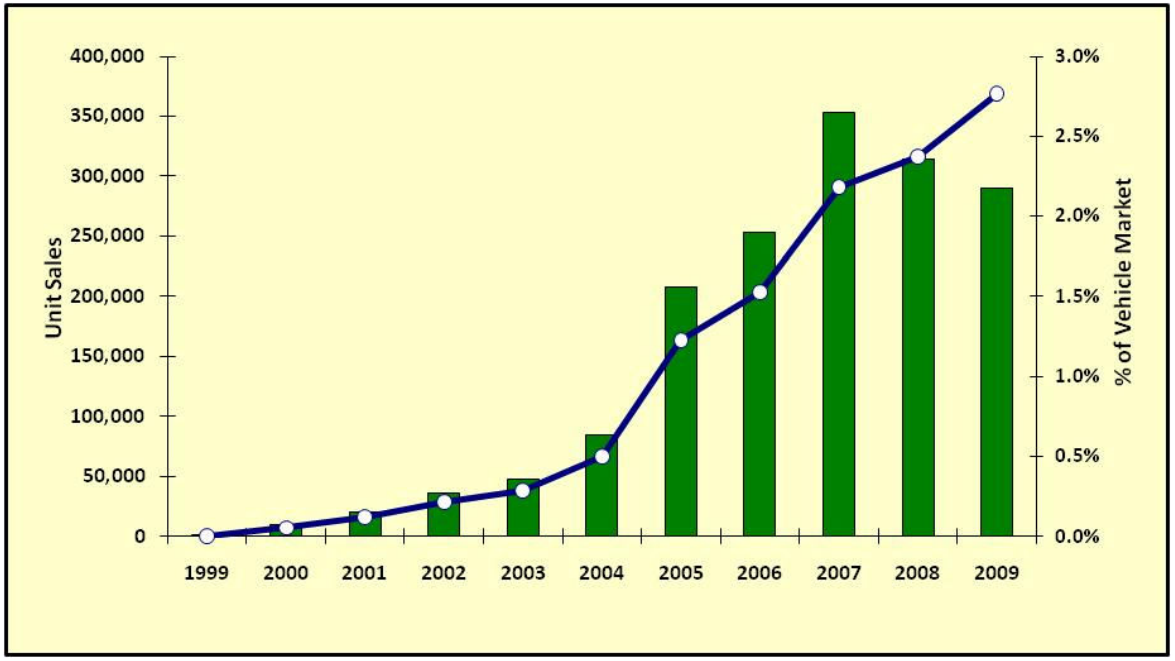
Electric-Drive Vehicle Sales: 2008 - 2030



Source: ***Booz Allen***

If that sounds too pessimistic, consider the historical penetration of hybrid vehicles in the United States

US Hybrid Vehicle Sales: 1999-2009

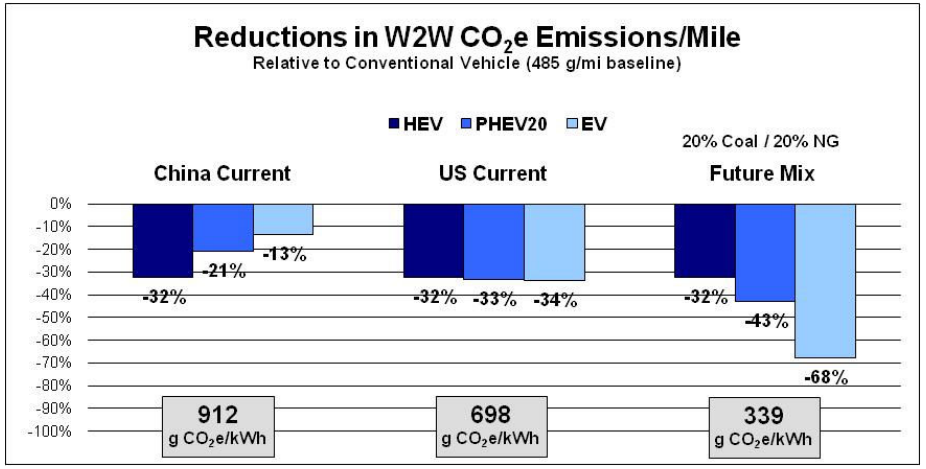


Source: ***Hybridcars Market Dashboard/Booz Allen***

- In the past ten years, US hybrid sales have grown to just under 3% of the light-duty market.
- While individual models like the Toyota Prius have become very popular, in general hybrid technology has yet to "catch on" with mainstream carbuyers.
- Automakers will continue to "raise the bar" in the fuel economy of conventional vehicles (direct injection, turbocharging, twincharging, lightweighting, camless actuation, AMTs, HCCI, etc.)
- PHEVs and EVs must not only compete with conventional vehicles, but also with HEVs, which benefit from advances in li-ion batteries

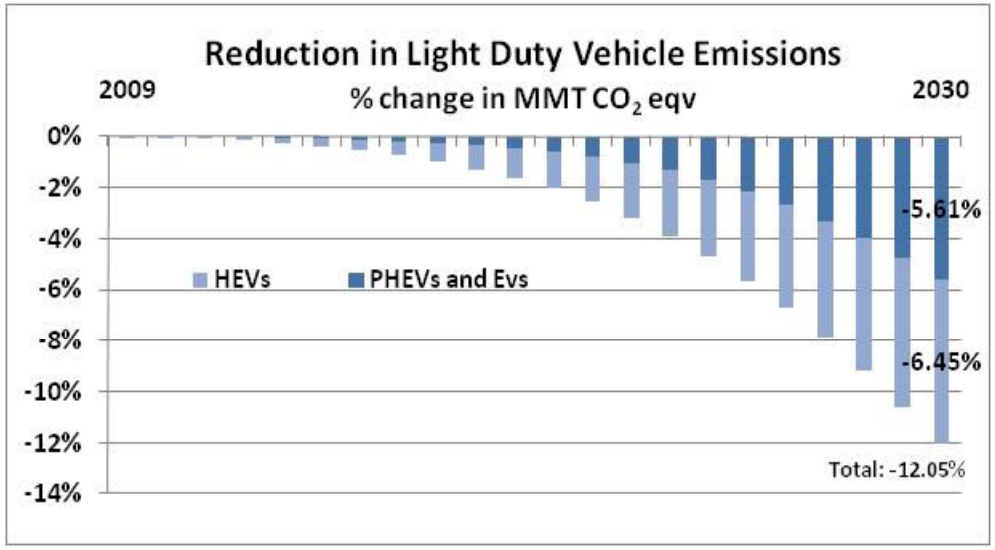
Gradual adoption of PHEVs and EVs isn't necessarily bad news…

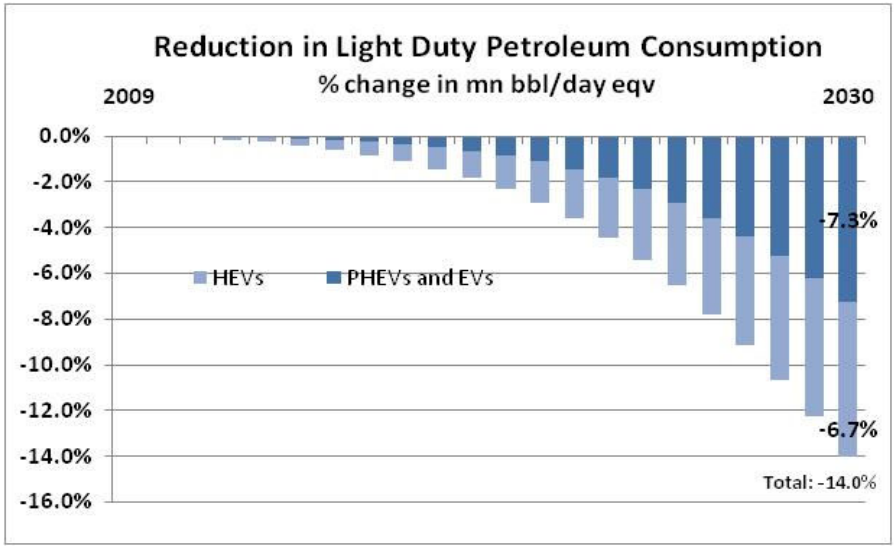
- Consumers have time to learn about the new technology and decide what designs and features best meet their needs (AEP, AER, vehicle size/capacity)
  - ***How much can today's carbuyers really tell us about a vehicle they have never seen or driven?***
- Automakers have time to optimize product designs based on how consumers actually use the vehicles
  - ***What will have the most appeal? PHEV10? PHEV20? PHEV40 (EREV40?) PHEV0 (fully-blended?)***
- Automakers (and others) have a chance to determine best battery ownership strategy
  - ***Can the battery be covered under separate payment and warranty?***
- Utilities have time to "green" the generation mix to maximize CO_2 benefits of PHEVs and EVs
  - ***PHEVs and EVs offer a future pathway to low CO_2 emissions, but current performance varies by region***
- Utilities (and others) have the opportunity to develop charging infrastructure based on real consumer needs
  - ***Is the current emphasis on public charging justified?***



Source: ***US DOE/Booz Allen***

…unless you were hoping for quick reductions in petroleum use and CO_2 emissions





- Big reductions in petroleum use and emissions require major shifts in PARC composition, and the sooner the shifts happen the better
- Turning the PARC is a real challenge – at previous adoption rates, less than half of vehicles on the road in 2030 are electric-drive
- VMT is also likely to continue increasing as it has in the past, although rising fuel prices may help moderate VMT growth

So how do we move closer to large-scale vehicle electrification?

- Advances in energy batteries are essential
  - Reduce EV/PHEV vehicle costs
  - Extend driving range
  - Enable a full set of vehicle types
- Transition to a new chemistry is probably needed
  - ARPA-e Batteries for Electrical Energy Storage in Transportation (BEEST)
  - Funding development of advanced batteries with capabilities well beyond those of lithium-ion intercalaction chemistries
  - Candidates include metal air, lithium-air, lithium-sulfur, and non-lithium intercalation systems
- Would enable a PHEV40 pack for $4K, and a midsized EV200 for $15K

Characteristic	ARPA-e Target
Specific Energy Density (C/3 rate)	200 Wh/kg (pack) 400 Wh/kg (cell)
Volumetric Energy Density (C/3 rate)	300 Wh/L (pack) 600 WH/L (cell)
Cost	<$250 kWh (pack)

So how do we move closer to large-scale vehicle electrification?

- Charging infrastructure matters, but emphasis should be placed on home and workplace charging
  - We have a lot to learn about how PHEV/EV drivers charge their vehicles and what public charging they really need, if any
  - Reducing the cost and complexity of home charging equipment and installation process is a great place to start
- Tax credits and other financial incentives that reduce TCO are useful, although they are probably less effective for early buyers
  - Analysis of HEV buyers showed that vehicle meaning was more significant than the “business case” for most owners
  - We tend to remove federal tax credits before price-sensitive mass market buyers can access them
- Cheap gasoline doesn’t help…

Thank You

Reid (Rusty) Heffner
Booz Allen Hamilton
heffner_reid@bah.com
(703) 377-1149