The EV Everywhere Challenge: Setting the Technical Targets

Jacob Ward, Vehicle Technologies Senior Analyst

August 23, 2012

Campus Center, University of Massachusetts – Boston

Boston, Massachusetts

The EV Everywhere Grand Challenge

A clean energy grand challenge to make electric-powered vehicles as affordable and convenient as gasoline-powered vehicles for the average American family within a decade.

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

arpa·e

U.S. DEPARTMENT OF ENERGY | Office of Science

For "EV Everywhere" Analysis, Three Scenarios

1. **PHEV40** – reduces battery size while removing range issues, but involves the higher cost of two powertrains
2. **AEV100** – minimizes vehicle purchase cost, but introduces range/vehicle use/infrastructure tradeoffs
3. **AEV300** – helps to address range issues, but large battery leads to high vehicle cost

Vehicle-level analysis provides a starting point for setting EV Everywhere technical targets for these vehicles.

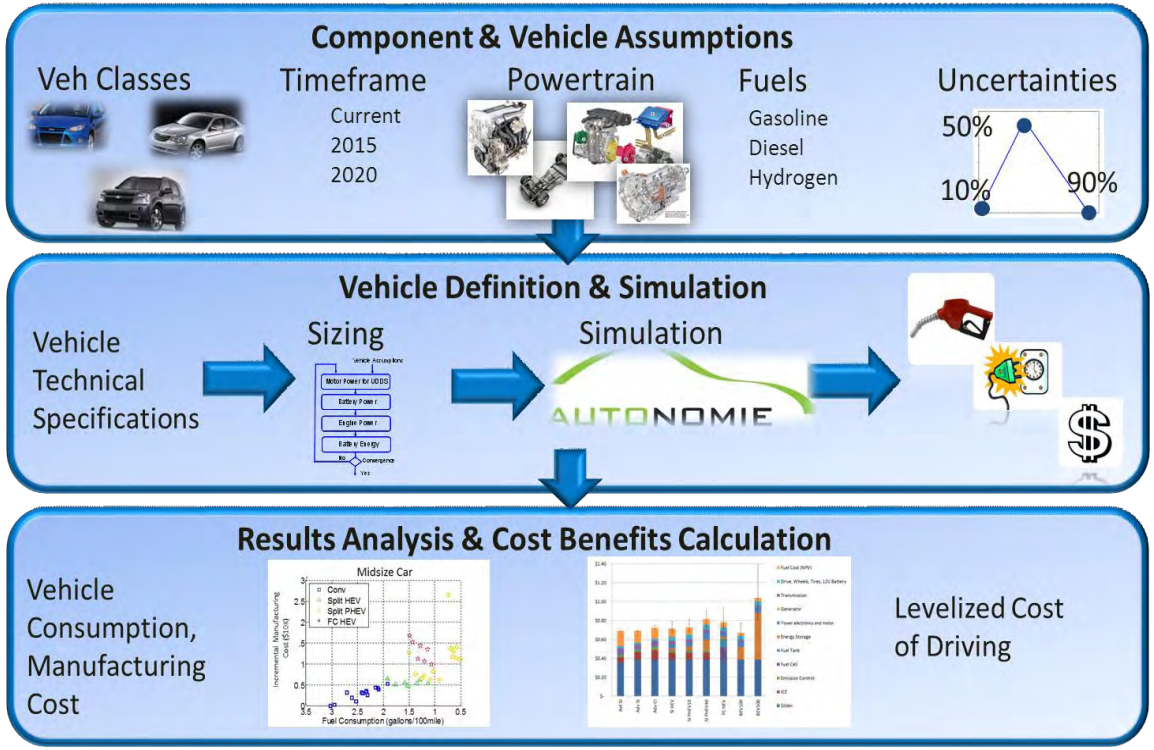
EV Everywhere Vehicle Analysis Process Flow

in three steps…

1. DOE experts **define the bounds of technical possibility** for technology key metrics
   - 90% "low progress" scenario
   - 50% "mid case" scenario
   - 10% "high progress" scenario

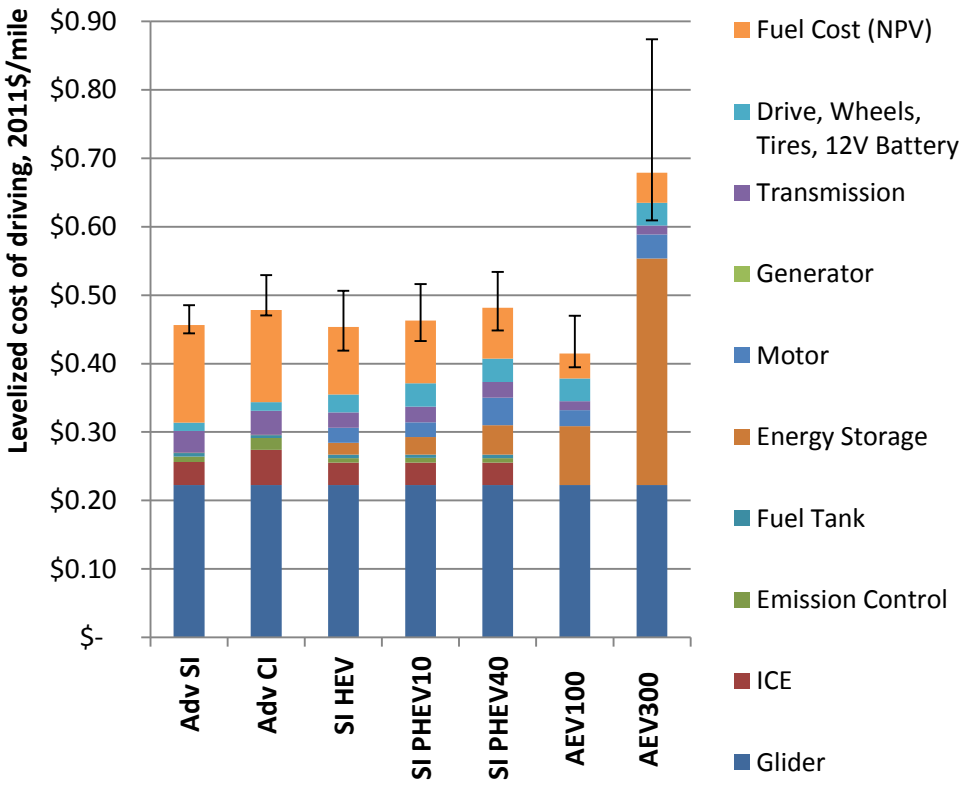
2. **Define virtual vehicles** in Argonne National Lab's *Autonomie* modeling and simulation software

3. **Compare vehicles in a 5-year simple payback framework** within bounds defined by experts



Levelized Cost of Driving (LCD)

vehicle purchase price + fuel expenditure over 5 years, expressed per mile traveled



Using a common LCD metric,

an "average" future cost of purchasing and operating an AEV exceeds that of an ICEV…

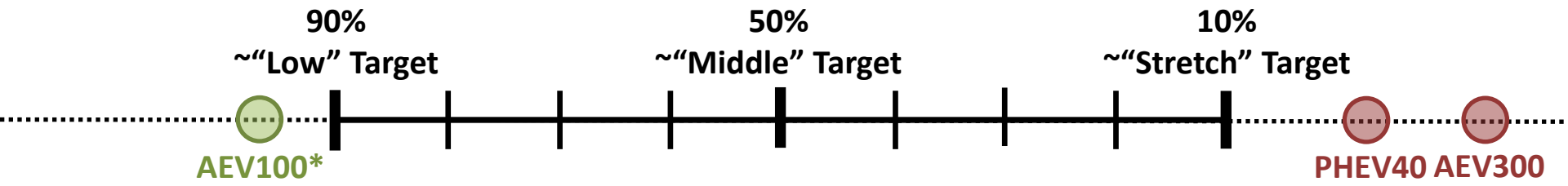
BUT

in a "high-technology" future, AEV LCD can be attractive.

Analysis Assumptions: *2022 midsize vehicle, mid-case technology projection (with high and low technology sensitivities), EIA's AEO11 "High Oil" fuel prices projections for 2022 = {Gasoline $5.12/gal, diesel $4.76/gal, Electricity $4.12/gge), 14.5k miles/year, 5-year analysis period, no discounting, retail markup over manufactured cost = +50%*

Target Implications–

Analysis Subcomponent Inputs		
Battery	$/kWh	125-250
Electric Traction Drive	$/kW	7-13
Lightweighting	% wt	5-29
On-board Charger	$/kW	40-120



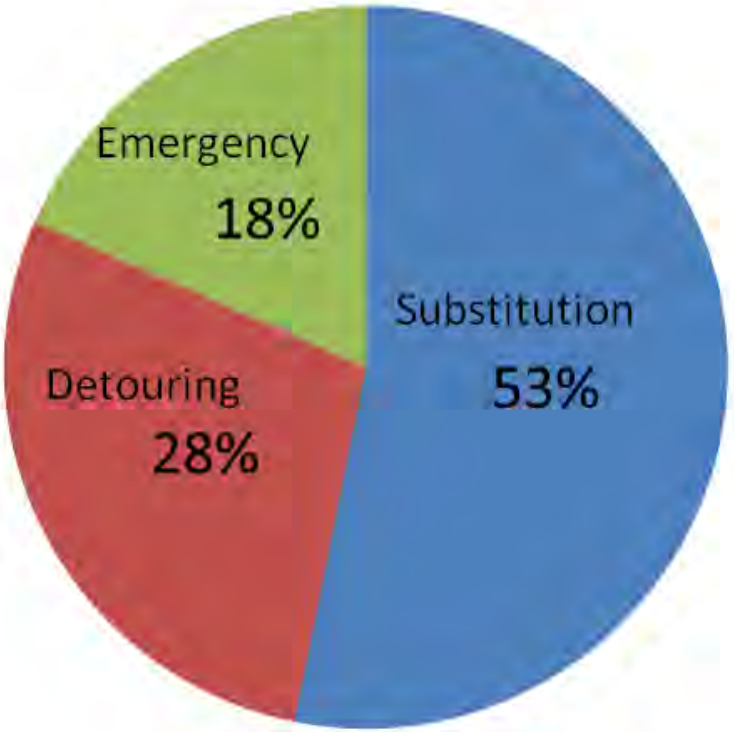
		Current Status	PHEV40	AEV100	AEV300
Battery	$/kWh	~650	190	300	110
Power electronics and motor	$/kW	~20	5	14	4
% Weight Removed	%	n/a	29	3	30
On-board charger	$/kW	~150	35	140	25

[Starting to…] Make Sense of Range Anxiety

$$\text{Range Anxiety Cost} = \sum \text{Costs of} \left(\begin{array}{c} \text{Vehicle Substitution} \\ \text{Emergency Roadside Service} \\ \text{Detouring for Public Charging} \end{array} \right)$$

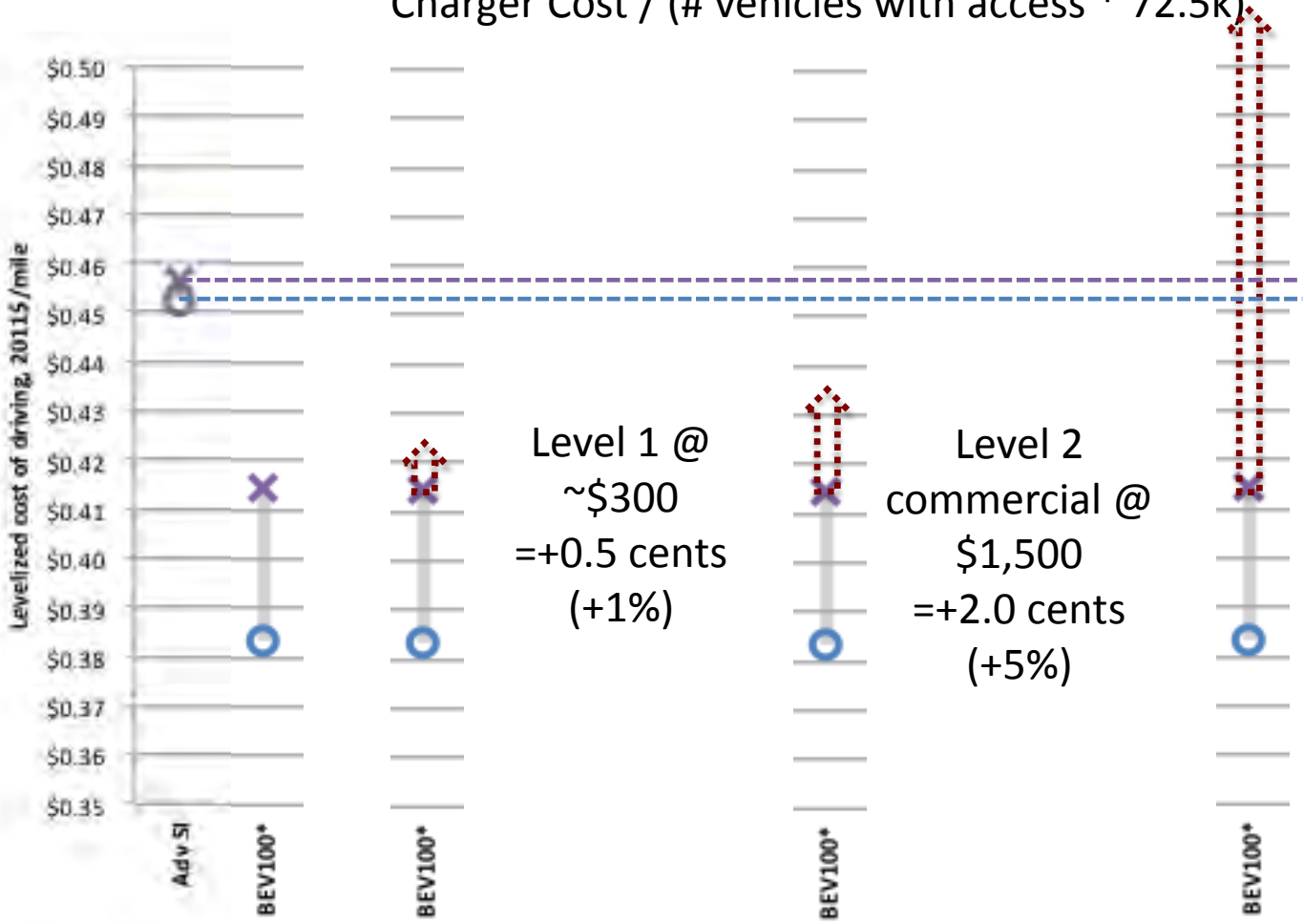
Total RAC
=$1,309/year

Assumptions:
$62 per emergency roadside service call, 0.5% charging accessibility, 100-mile BEV range, public charger power 60kW, 16000 miles driven per year typically at 20 miles per day, 2.5% standard deviation for daily travel distance, 20-mile standard deviation for BEV range, $30 per needed vehicle substitution



Adding Charging Infrastructure to the LCD Equation?

LCD additional cost =
Charger Cost / (# vehicles with access * 72.5k)



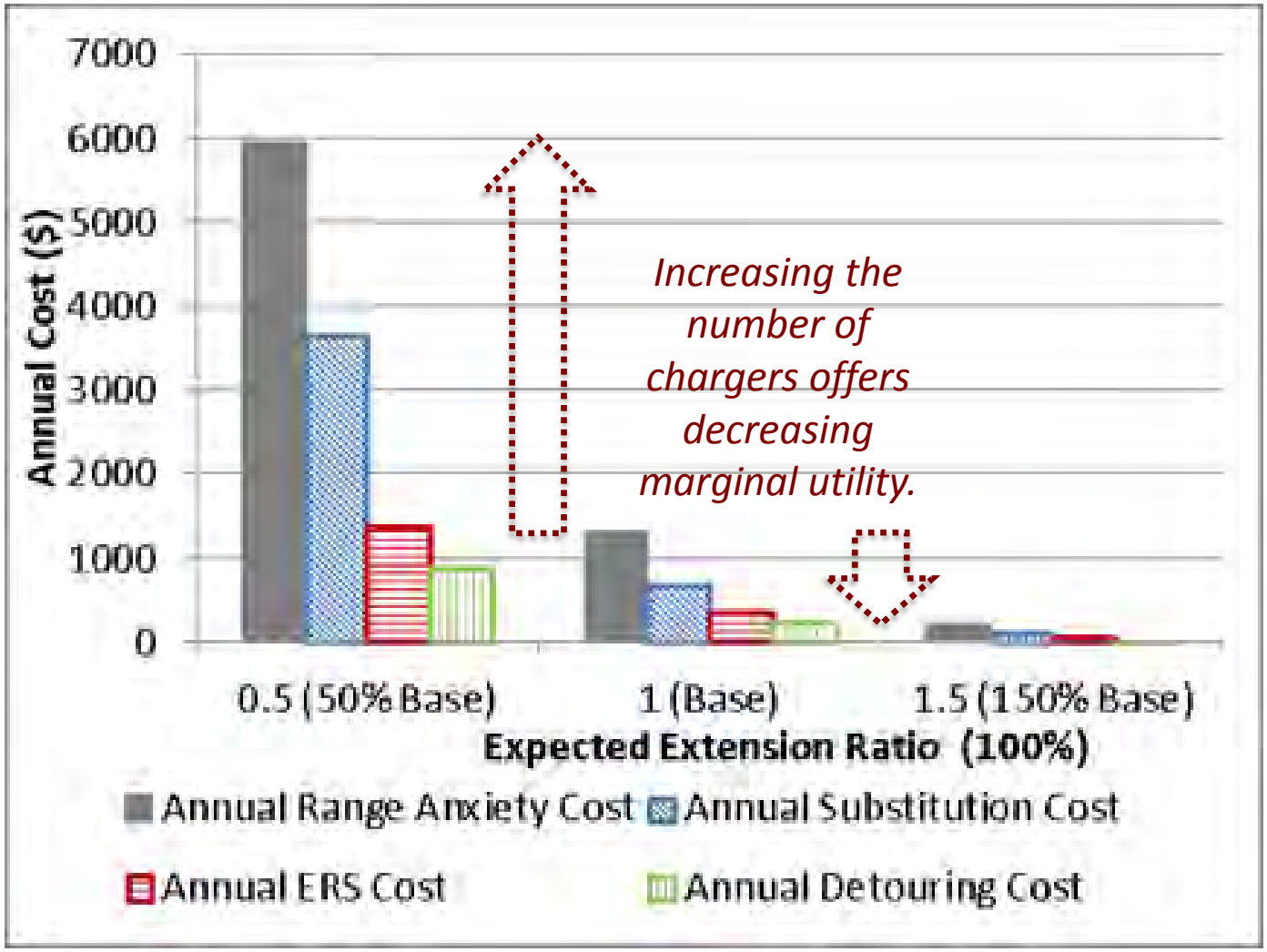
Level 1 @
~$300
=+0.5 cents
(+1%)

Level 2
commercial @
$1,500
=+2.0 cents
(+5%)

DC Fast Charge @
$20,000
=+27.5 cents
(+50%)

…OR divide by 5 vehicles and look cost-competitive against the Adv SI

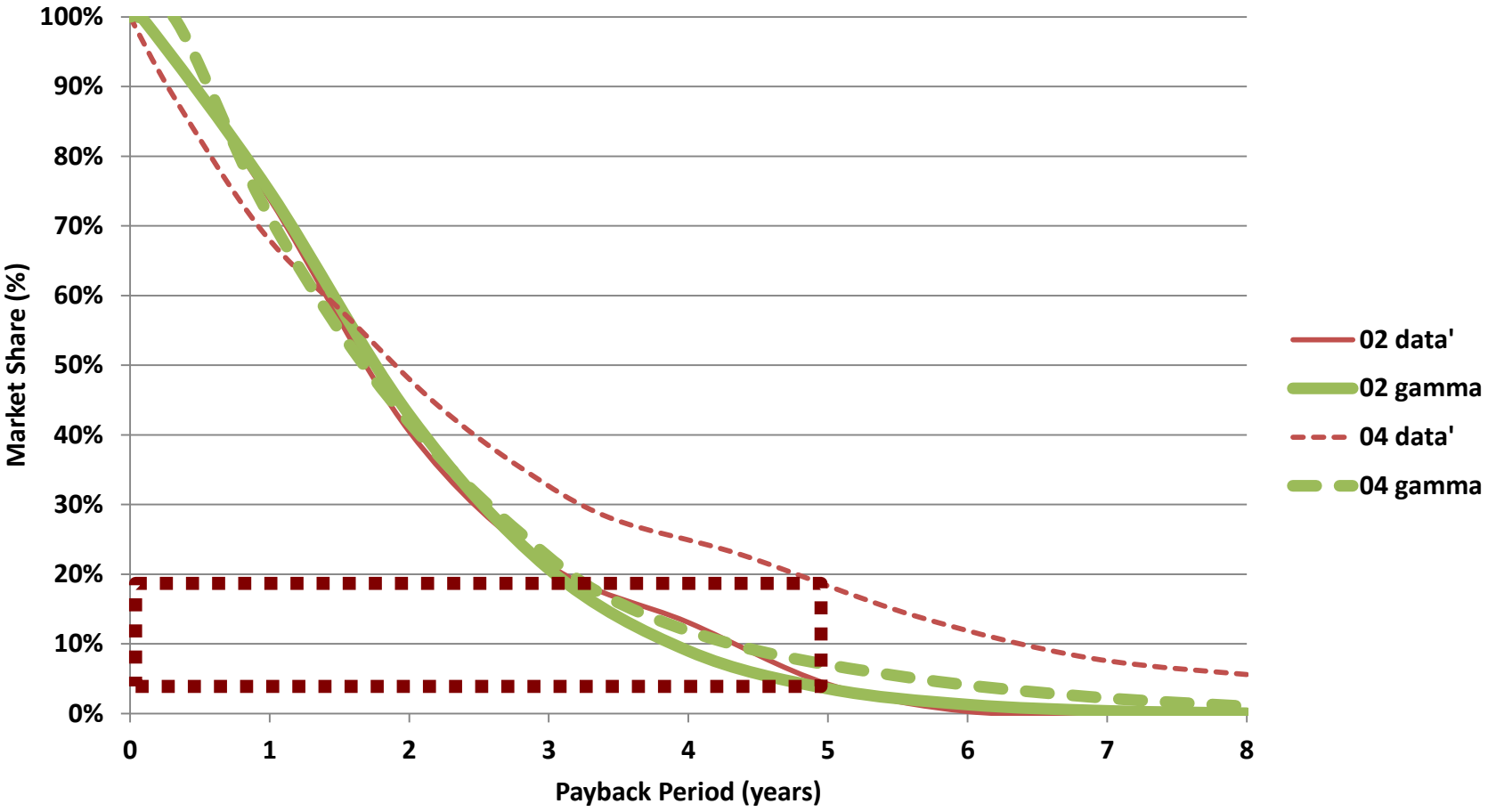
Charging infrastructure's value is relative



More work/public chargers and user-friendlier chargers allow/motivate multiple daily charges, extend ranges and reduce RAC.

Increasing the number of chargers offers decreasing marginal utility.

Payback Periods: Survey Data and Acceptability



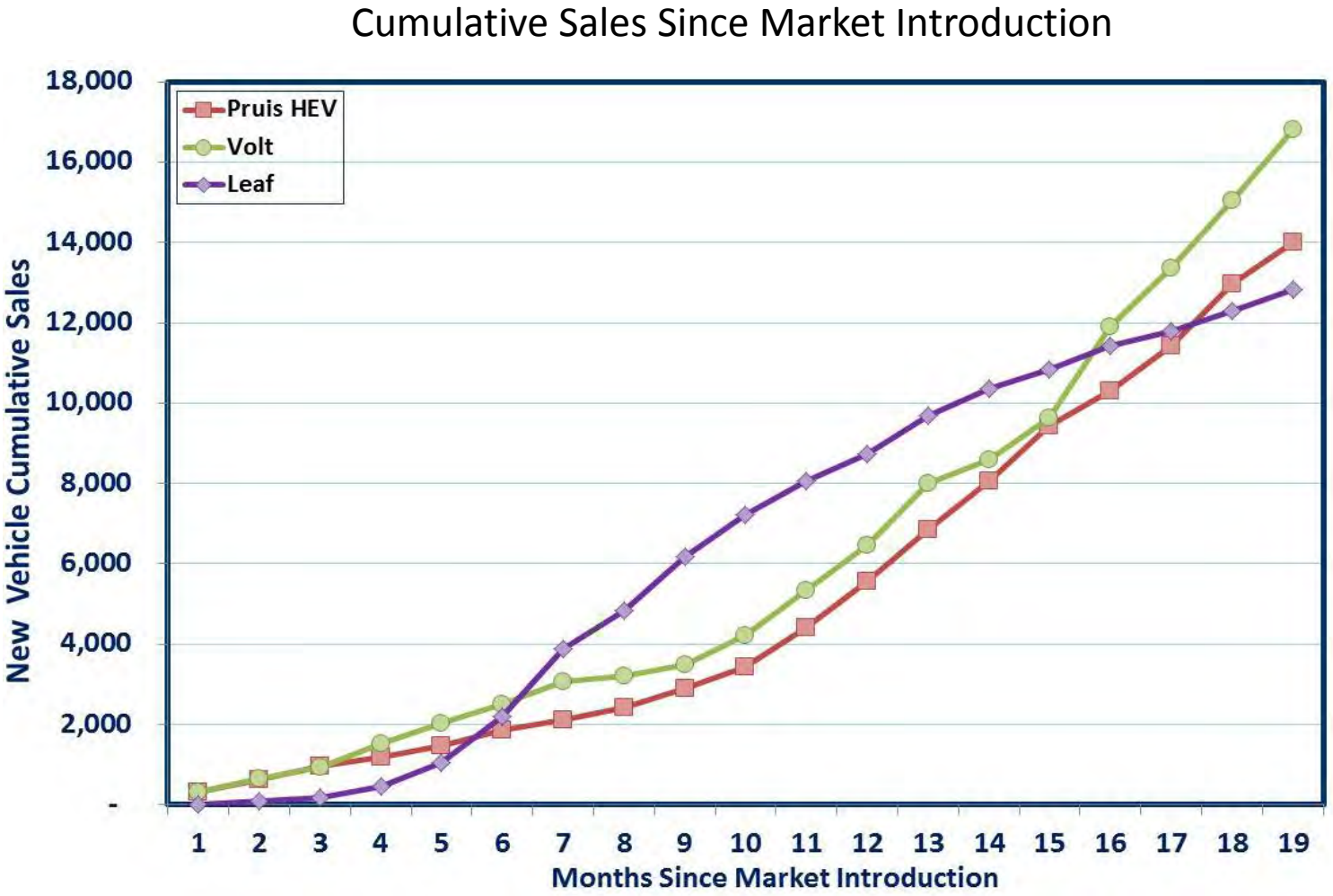
Critical Topic: What is the market potential?

(and how can DOE set appropriate technology targets for these markets?)

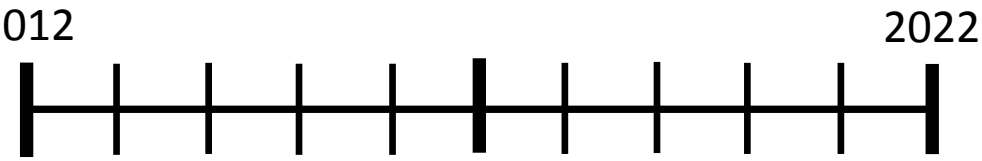
- **Early Adopters**
  - How many? 5 to 15%?
- **Majority consumers**
  - If price is "right"
  - If other features are attractive
- **Fleet managers**
  - In 2009 and 2010, 18 – 23% of new light-duty vehicle sales were to fleets

    (11 – 15% to rental, 5% to commercial, and 2% to government)
- **What technology targets will result in vehicles attractive to various markets?**

Early Sales of Prius HEV, Volt and Leaf



EV Everywhere consumer/charging through 2022



Advanced Batteries	650 $/kWh	→ cost reduction →	110 $/kWh ?
Advanced Electric Traction Drives	20 $/kW	→ cost reduction →	4 $/kW ?
Advanced Lightweighting	--	→ lightweight at reduced cost →	20% ?
Advanced Charging Technologies	~known.	How do we get to 2022?	What's needed by 2022?
Advanced Infrastructure Rollout	~known.	How do we (who?) rollout through 2022?	What does 2022 look like?
Advanced Understanding of Consumer Behavior	?	What do we (who?) study through 2022?	What do we know by 2022?
Advanced Consumer Understanding of EVs	???	How do consumers learn (and who teaches?) through 2022?	What do consumers know by 2022?