

# ACTUAL VERSUS ESTIMATED UTILITY FACTOR OF A LARGE SET OF PRIVATELY OWNED CHEVROLET VOLTS

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SAE World Congress

April 9, 2014

Detroit, MI



U.S. DEPARTMENT OF  
**ENERGY**

# Idaho National Laboratory

## **U.S. Department of Energy (DOE) federal laboratory**

890 square mile site with 4,000 staff

### **Support DOE's strategic goal**

- Increase U.S. energy security and reduce the nation's dependence on foreign oil

### **Multi-program DOE laboratory**

- Nuclear Energy
- Fossil, Biomass, Wind, Geothermal and Hydropower Energy
- Advanced Vehicles and Battery Development
- Homeland Security and Cyber Security



# Utility Factor Definition

- **Utility factor (UF) = Percentage of miles driven in charge depleting (CD) mode**
- **Fleet utility factor (FUF) = estimated UF of group of vehicles with a given charge depleting range ( $R_{CD}$ )**

Equation per SAE J2841:

$$FUF(R_{CD}) = \frac{\sum_{k=1}^N \min(d(k), R_{CD})}{\sum_{k=1}^N d(k)}$$

where  $k$  represents a single vehicle driving day

$d(k)$  is the distance that vehicle traveled in that day

$N$  is the total number of vehicle driving days in the data set

# Utility Factor Definition

- **SAE J2841 presents an FUF curve calculated using conventional vehicle travel behavior data from National Household Transportation Survey (NHTS) 2001, correlated to Commute Atlanta GPS-based travel study**
- **Simplifying assumptions:**
  - Drivers will charge their battery once per day and start the day with a fully charged battery
  - NHTS driving patterns are representative of PHEV driving patterns
  - PHEV's CD range can be represented as a constant value

**The objective of this paper is to compare the estimated J2841 FUF to the actual FUF observed in a large set of privately owned Chevrolet Volts enrolled in The EV Project**

# The EV Project

- **The EV Project was a large-scale plug-in electric vehicle charging infrastructure demonstration**
- **Purpose was to build mature EV charging infrastructure in 17 US regions and study:**
  - Infrastructure deployment process
  - Customer driving and charging behavior
  - Impact on electric grid
- **12,000+ AC level 2 charging units, 100+ DC fast chargers**
- **8,000+ Electric drive vehicles**
- **INL data collection Jan 2011 – Dec 2013**

## Project partners



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# Opportunity to Observe Real-world Usage

- **The EV Project provides the opportunity to determine the real-world UF of a large group of privately owned Chevrolet Volt extended range electric vehicles**
- **Owners of these Volts were PHEV early adopters who chose to participate in The EV Project**
- **Participants consented to allow their vehicle usage to be monitored electronically by OnStar and sent to INL**
- **For this paper, data was analyzed from:**
  - 1,405 privately owned Volts located throughout the United States
  - October 2012 through June 2013

# Size of EV Project Volt Data Sets

- Vehicles were split into two groups by model year, because the 2013 model year (MY) Volt has a higher  $R_{CD}$  than previous model years.

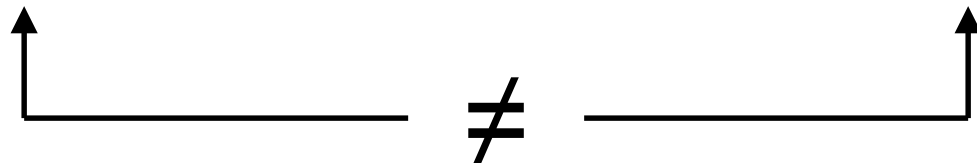
MY	Number (%) of vehicles	Number (%) of vehicle driving days	Total distance driven mi [km] (%)	Number (%) of charging events
2011/2012	787 (56%)	160,035 (70%)	6,477,419 [10,424,415] (70%)	232,120 (70%)
2013	618 (44%)	68,709 (30%)	2,827,140 [4,549,849] (30%)	98,199 (30%)
Total	1,405	228,744	9,304,559 [14,974,265]	330,319

- Many of the MY2013 vehicles were enrolled in The EV Project after the start of the study period, which explains why this group drove and charged less.



# FUF Results

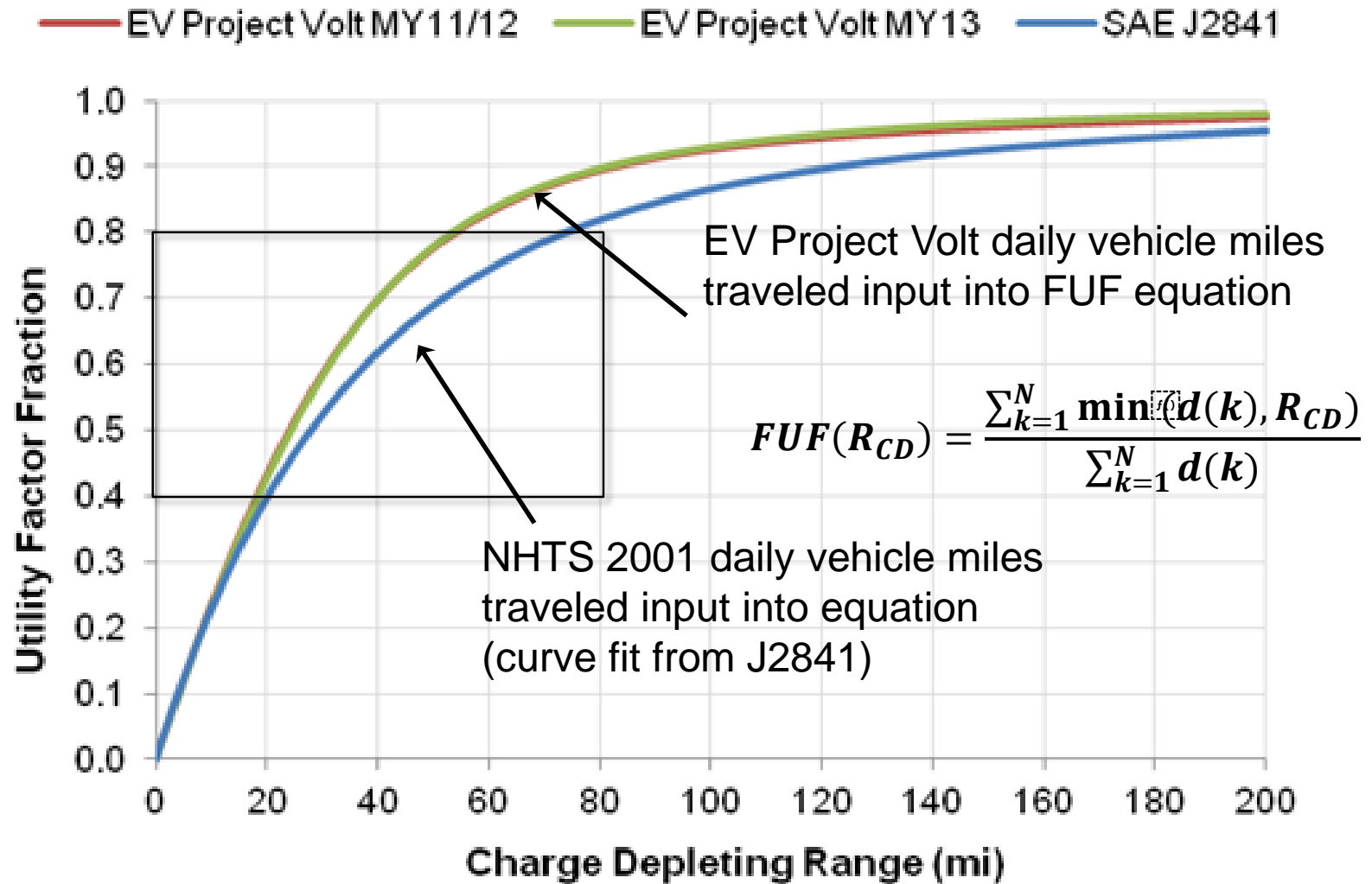
MY	US EPA R <sub>CD</sub> estimates ( mi [km] )	Estimated Volt FUF per J2841	Total distance driven ( mi [km] )	Distance driven in EV mode ( mi [km] )	EV Project Volt actual FUF
2011/2012	35 [56.3]	57%	6,477,419 [10,424,415]	4,689,022 [7,546,264]	72.4%
2013	38 [61.2]	60%	2,827,140 [4,549,849]	2,088,496 [3,361,115]	73.9%



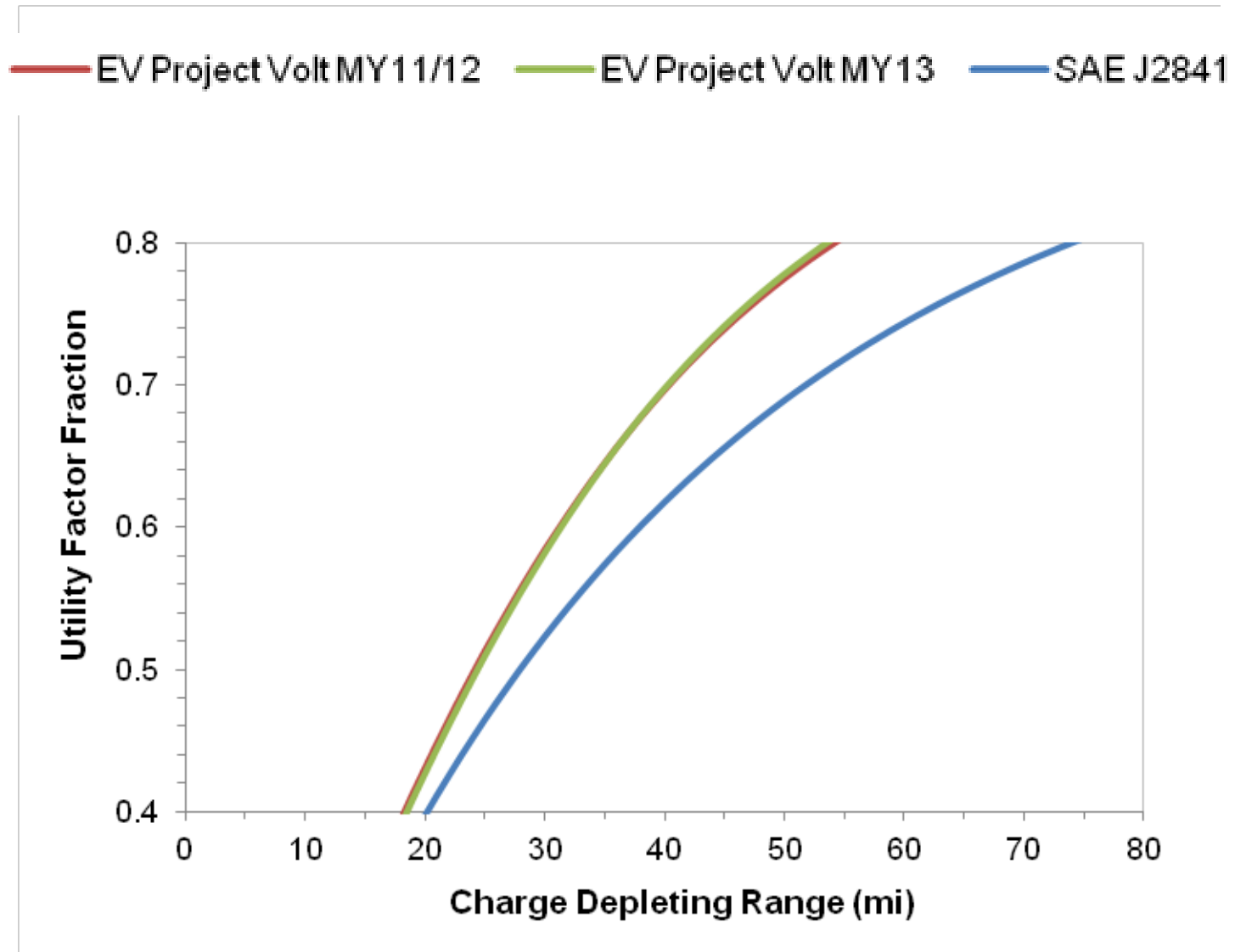
# Examining the Difference between J2841 and EV Project Volt FUFs

- **Three possible causes for the discrepancy between the calculated value of the J2841 FUF and the observed value of the EV Project FUF were investigated:**
  - Difference in driving habits between EV Project drivers and NHTS drivers
  - Difference in charging habits between EV Project drivers and J2841 assumptions
  - Variability between the EPA-rated  $R_{CD}$  and the observed  $R_{CD}$  of EV Project drivers

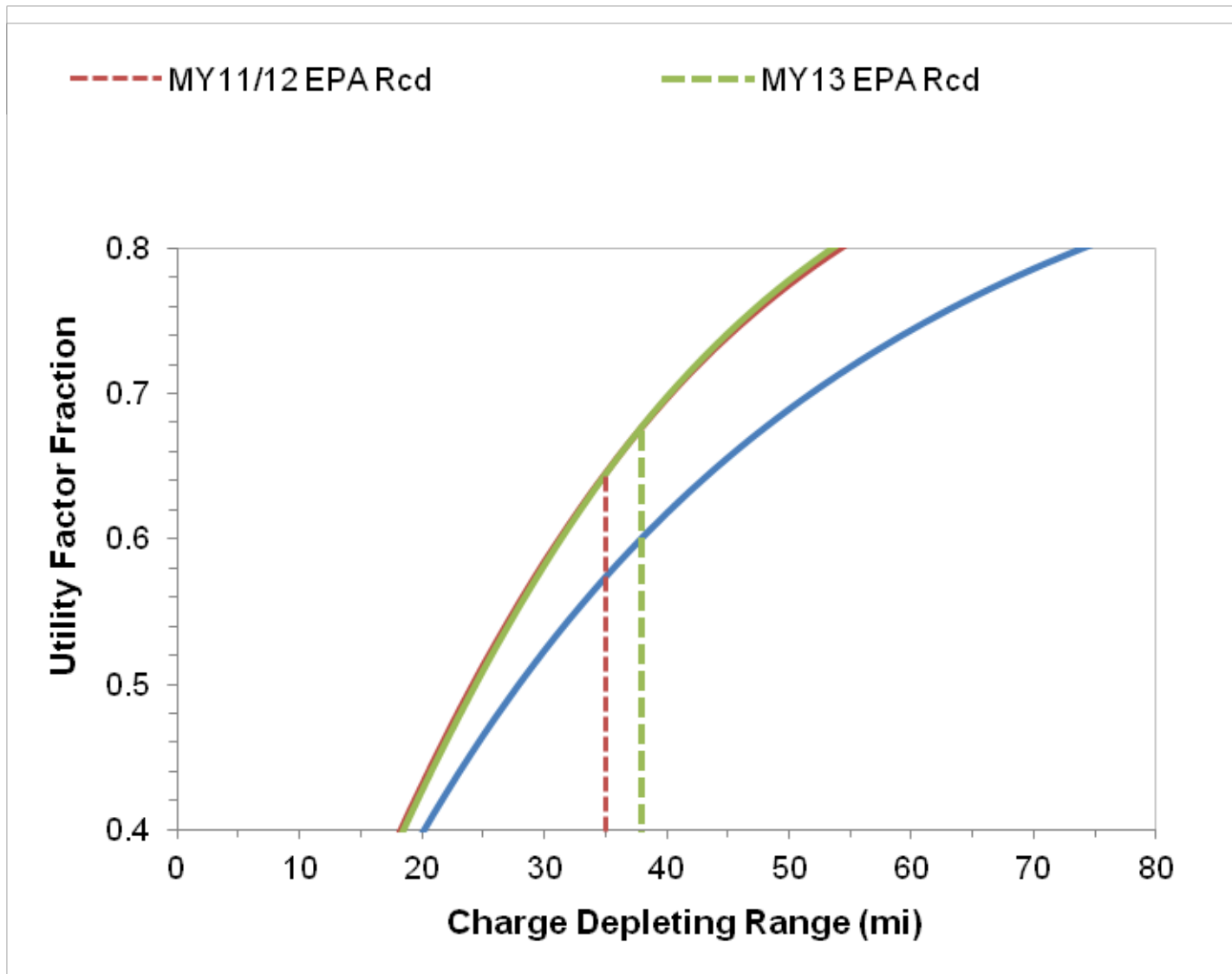
# Estimated and Actual FUF Curves



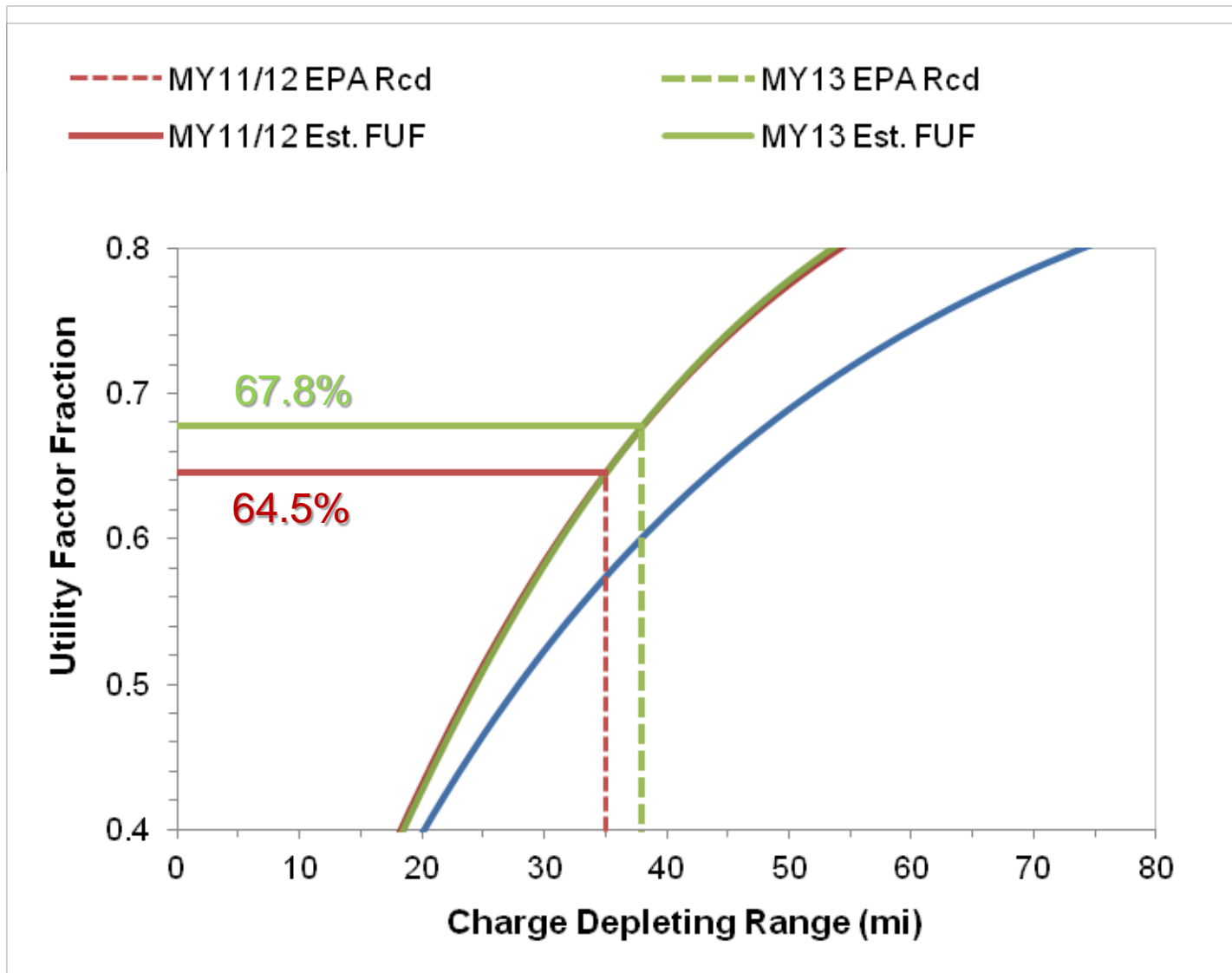
# Estimated and Actual FUF Curves



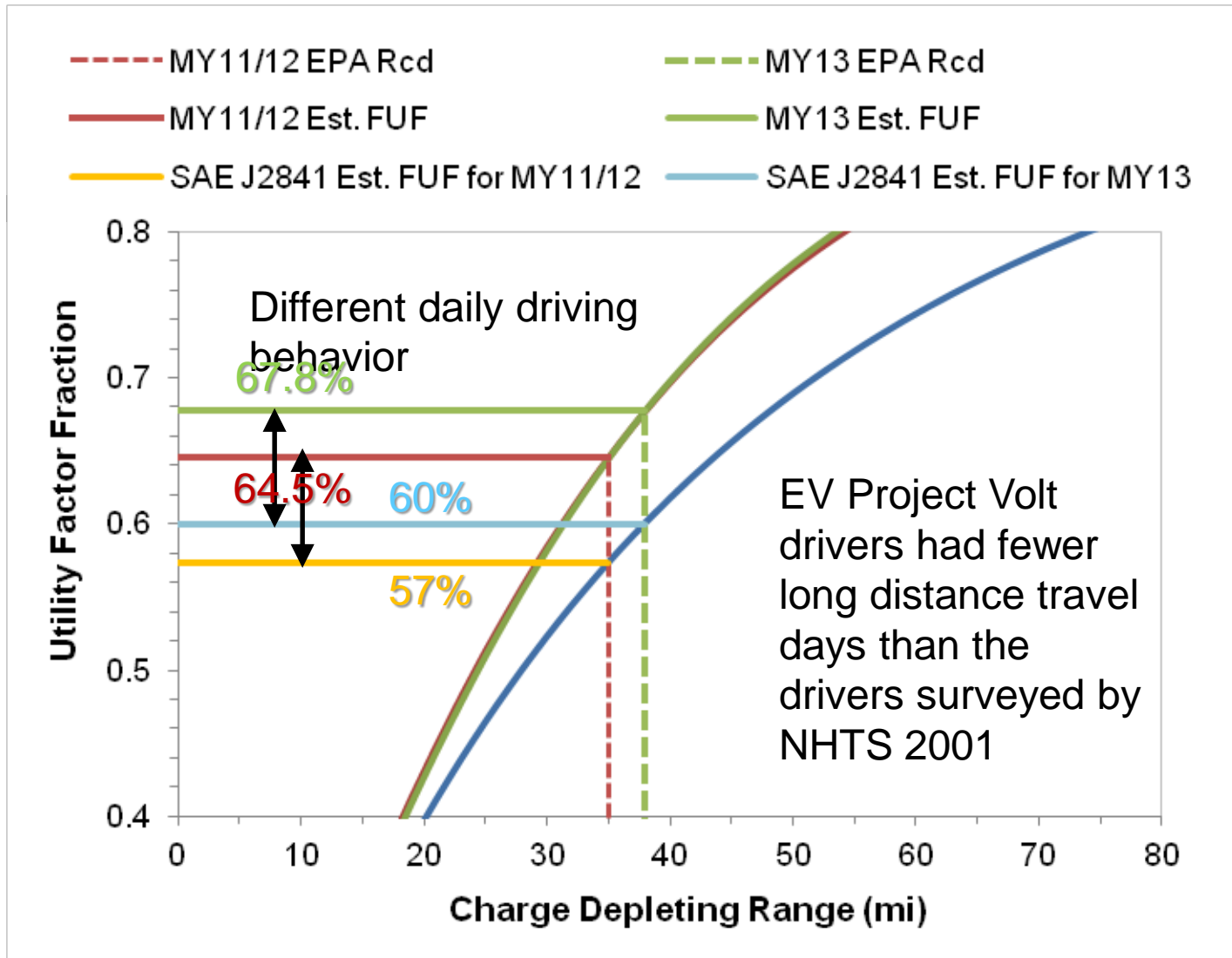
# Estimated and Actual FUF Curves



# Estimated and Actual FUF Curves

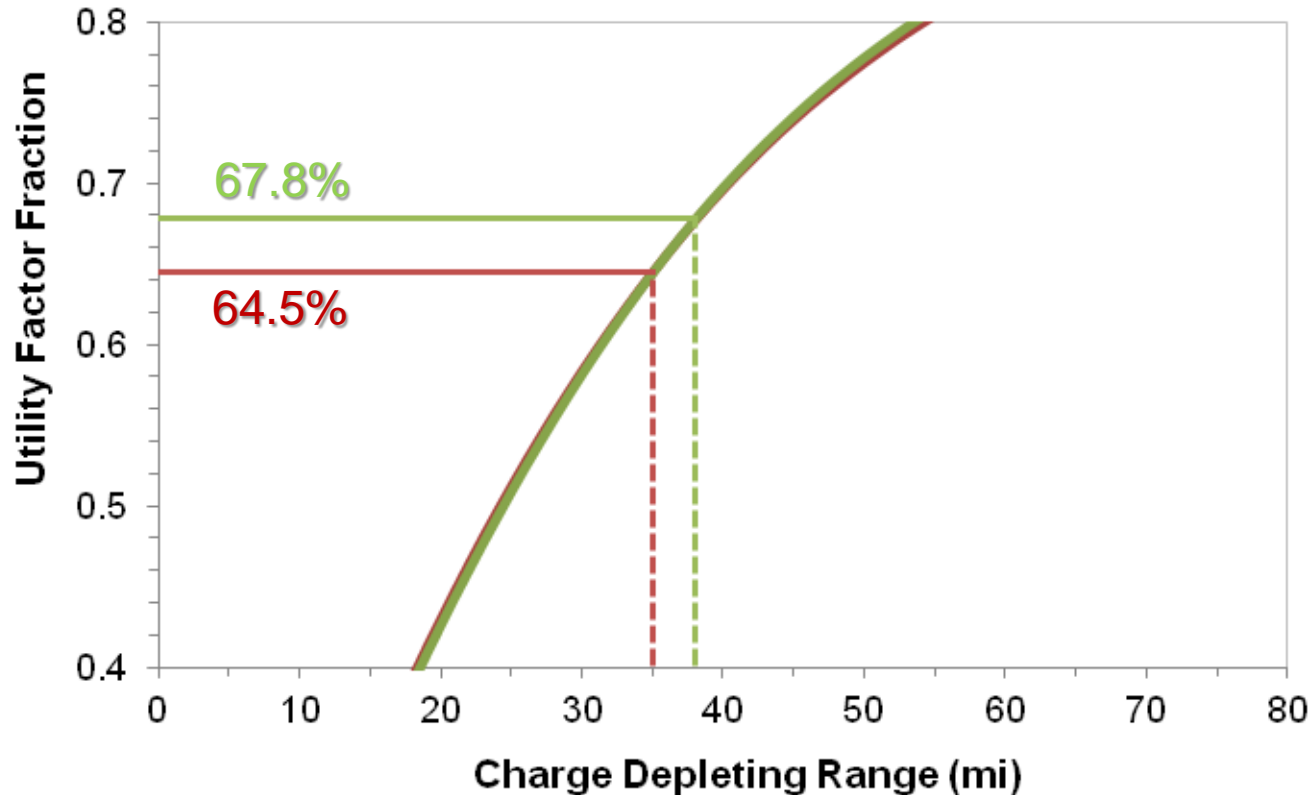


# Estimated and Actual FUF Curves



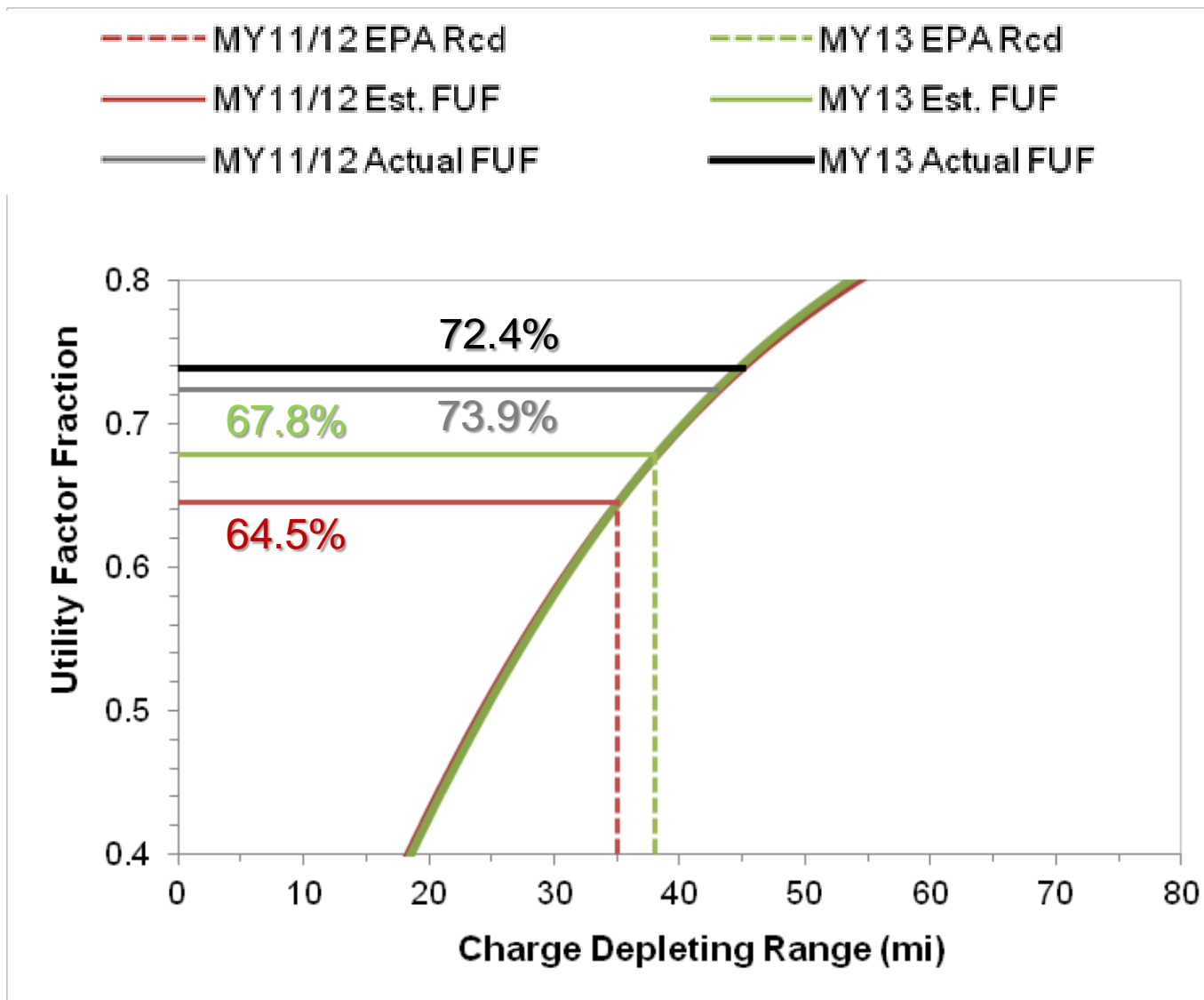
# Estimated and Actual FUF Curves

How does the estimated FUF using actual Volt daily driving data compare to the actual FUF for EV Project Volts?

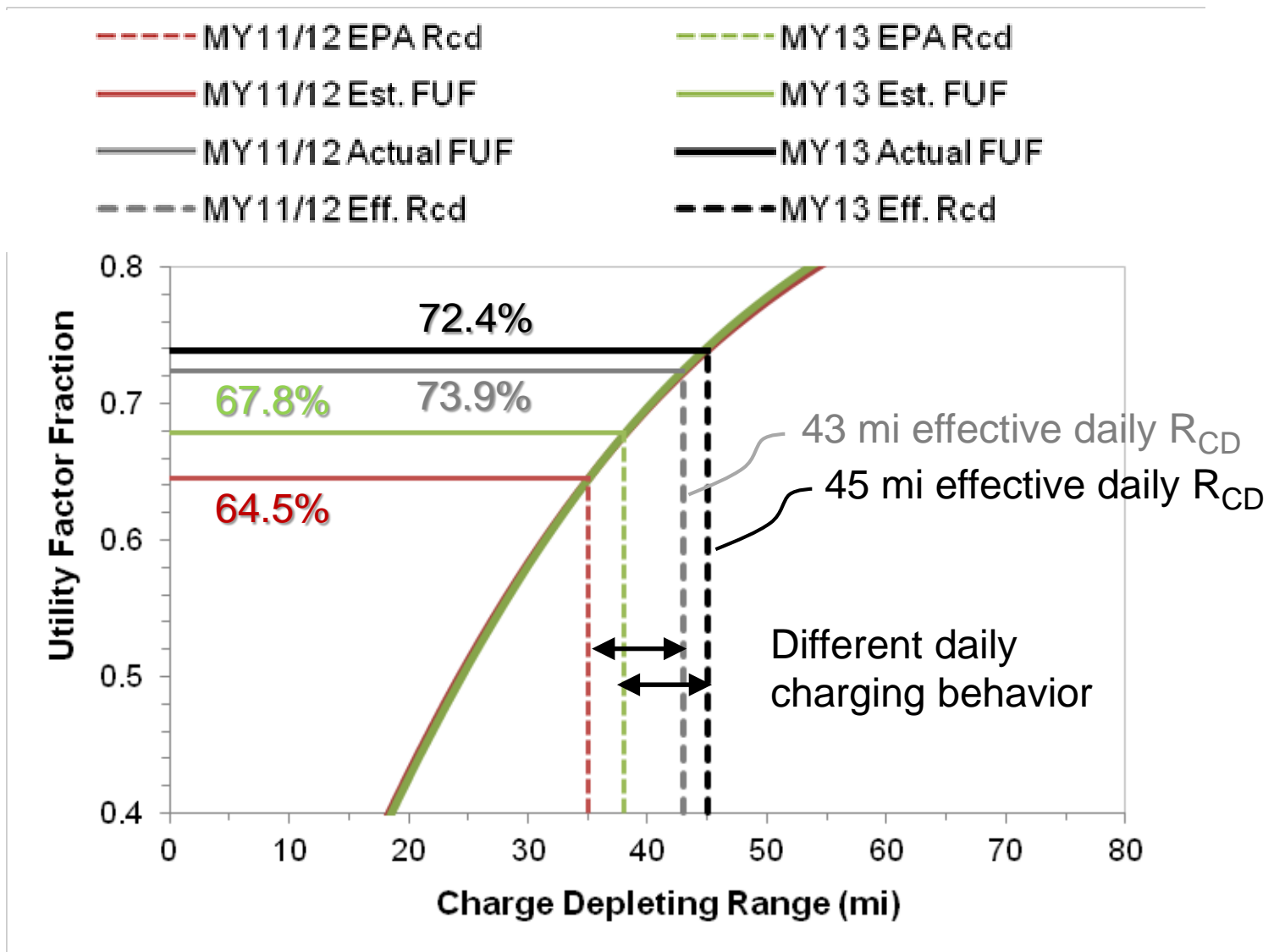




# Estimated and Actual FUF Curves

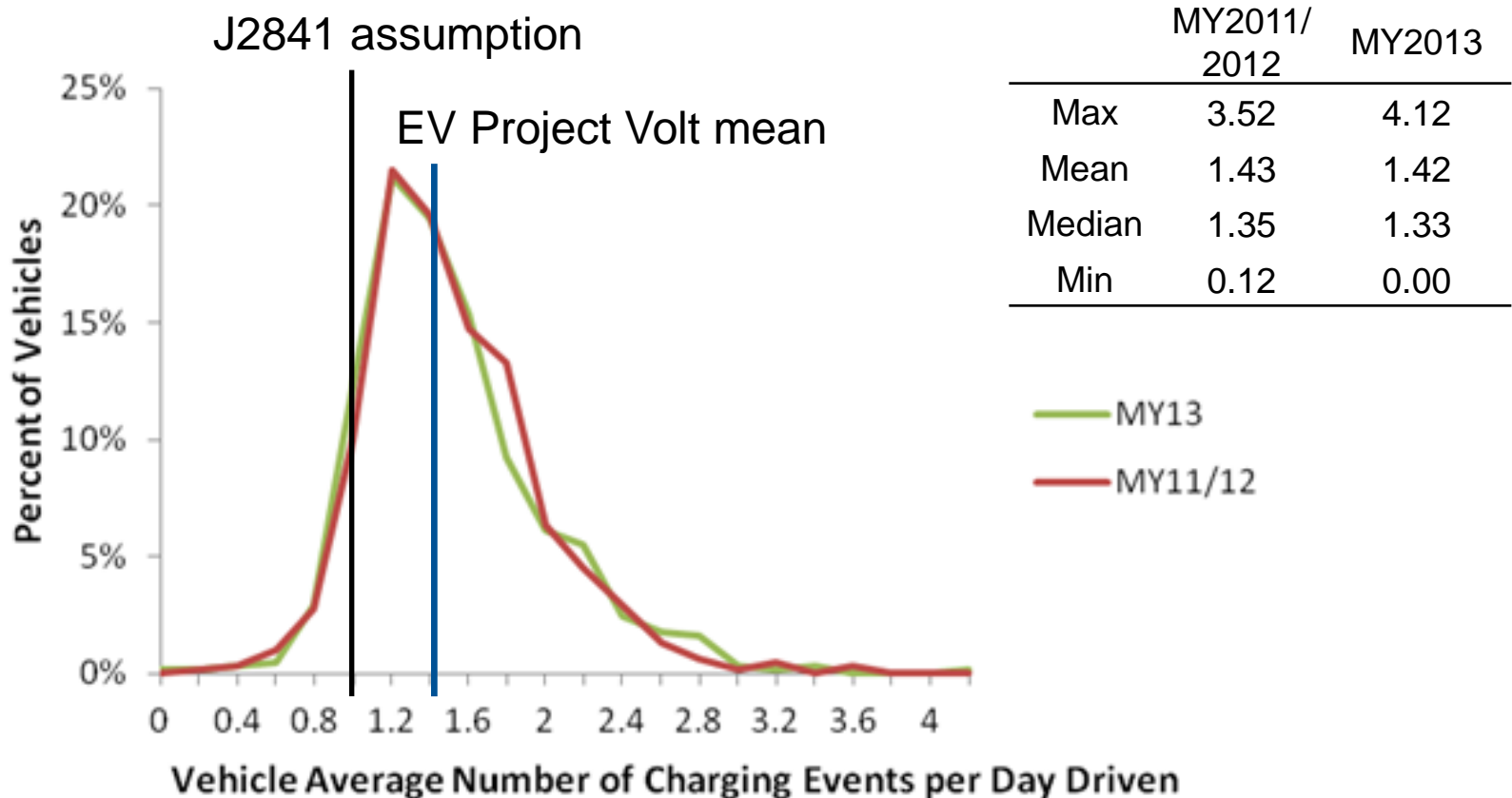


# Estimated and Actual FUF Curves

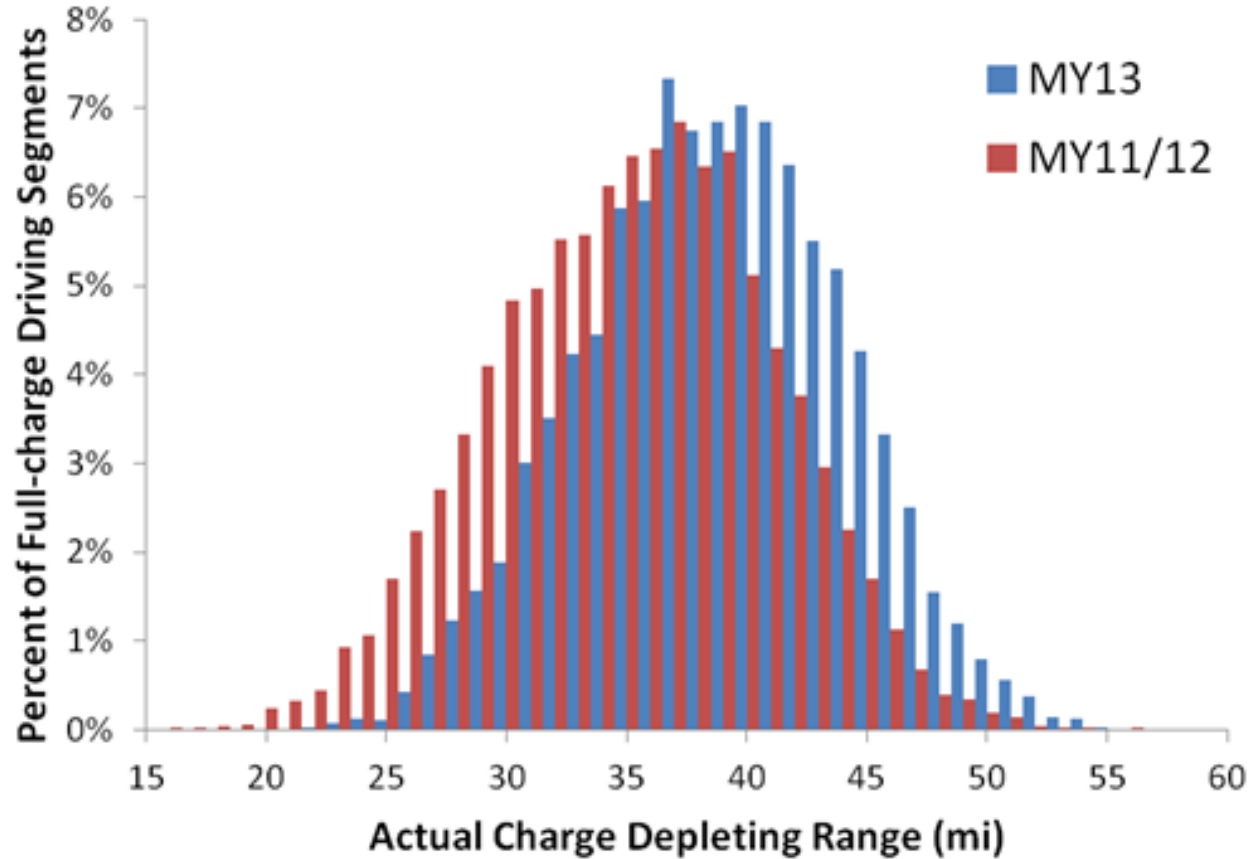


# Charging Frequency

## Distribution of Average Number of Charging Events per Day Driven for each Vehicle



# Distribution of Actual Charge Depleting Range



	MY2011/2012	MY2013
Number of full-charge driving segments	16,296	5,420
Mean	34.7	38.3
Standard deviation	5.7	5.3

# Conclusions

- **In-use data collected from 1,405 EV Project Volts between October 2012 and June 2013 was used to calculate actual FUF**
- **Actual observed FUFs for the MY2011/2012 and MY2013 Volt groups were 72% and 74%, respectively**
- **Using the EPA CD ranges, the method prescribed by SAE J2841 estimates a utility factor of 65% and 68% for the MY2011/2012 and MY2013 Volt groups, respectively**
- **Volt drivers in this study achieved higher percentages of distance traveled in EV mode because their driving habits differed from the NHTS drivers and their charging habits differed from J2841 assumed behavior**
  - EV Project Volts drivers had fewer long distance travel days than the drivers surveyed by NHTS 2001
  - EV Project Volt drivers averaged over 1.4 charging events per day, compared to the once-per-day J2841 assumption

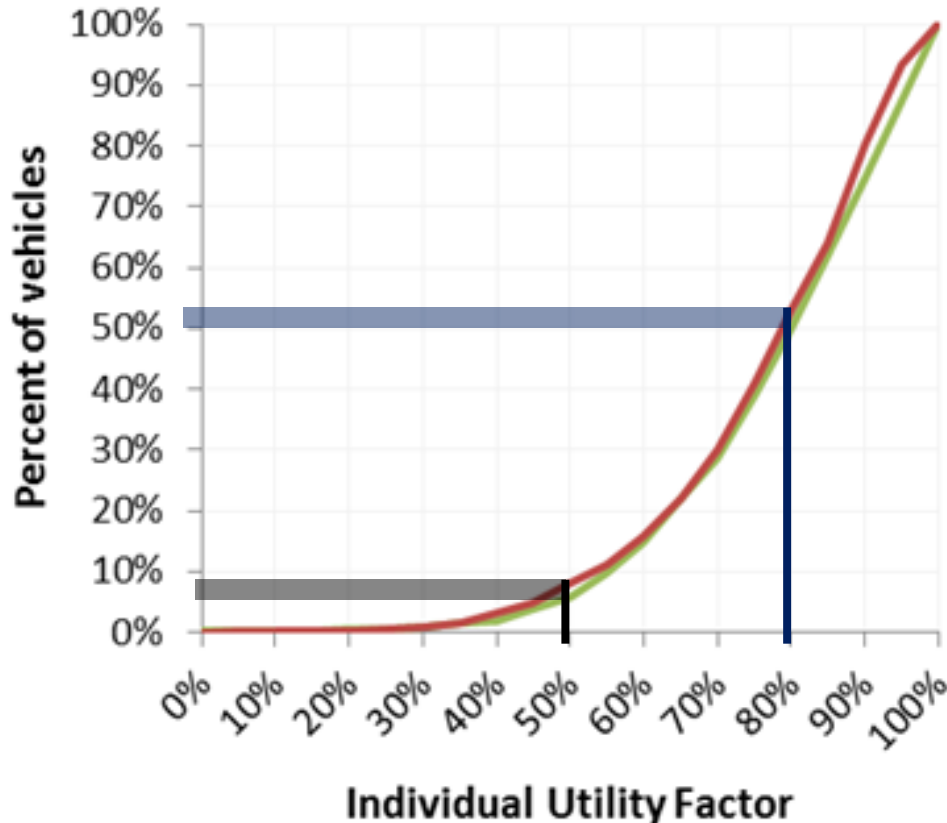
For all EV Project publications, visit

[avt.inl.gov/evproject.shtml](http://avt.inl.gov/evproject.shtml)

**INL's funding for this work comes from  
DOE's Vehicle Technologies Office**

INL/CON-14-30046

# Distribution of Utility Factors for Individual Vehicles



About half of vehicles had more than 80% their miles in EV mode

— MY13  
— MY11/12

Over 90% of vehicles had more than half their miles in EV mode

# Utility Factors for Individual Vehicles

- Individual vehicle utility factors varied widely for the Volts studied
  - Utility factors ranged from 0% to 100%
  - Most vehicles had high UFs
    - over 90% of vehicles drove over half their distance in EV mode
    - 50% of vehicles drove 80% or more of their distance in EV mode –
- This variation was largely due to variation in charging frequency and actual CD range
- Care should be taken to incorporate this variation into calculations when estimating utility factors for individual vehicles or subsets of vehicles