# Characterizing Energy Usage of Chevrolet Volt Versus 

## Speed

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## Introduction

- Range is a key performance metric in EVs $\rightarrow$ Energy usage and battery capacity determine range.
- Various algorithms determine remaining range to inform consumer.
- Many factors affect energy usage of given vehicle.
- Terrain
- Temperature
- Acceleration
- Speed
- Specific energy usage over range of speeds has been determined for 2012 Chevrolet Volt.



## Volt Specifications



## Powertrain

- Traction Motor - 111 kW (149 hp)
- Torque of 370 Nm (273 lb-ft)
- Induction motor
- "Generator" 55 kW
- Permanent Magnet machine
- ICE - 63 kW (84 hp)



## Battery Pack

- 16 kWh Capacity (10.4 kWh useable)
- Typically discharges to $20 \%$ SOC
- Typically charges to $84.71 \%$ SOC
- Total Range of $\sim 65 \%$
- (3.2 kWh - 13.6 kWh $)$
- Lithium manganese spinel chemistry (LG Chem)
- Battery pack consists of 288 Cells ( 3 parallel sets of 96)
- "Fully" Charged Voltage - ~386
- 197 kg ( 435 lb )



## Variability in Energy Usage



Sustech 2013 - August 1, 2013, Portland, OR

## Instantaneous Power



## Instantaneous Power at various Speeds



## Cumulative Energy Use [kWh]



## Experimental Design

- Large quantity of data available through OBD2 (battery voltage, SOC, motor currents, motor RPMs, motor voltages, etc).
- Individual trips were logged at sample rate of $\sim 1 \mathrm{kHz}$ with speed kept constant.
- Test segment was 3.48 mile stretch of road with low elevation change.
- Compromise between low elevation change, reasonable access to charging station, and capability to travel at wide range of speeds.
- Energy efficiency measured for repeated trips in both directions to reduce elevation effect.
- Energy usage calculated based on instantaneous power measurements.


## Elevation profile of tested road segment



Sustech 2013 - August 1, 2013, Portland, OR

## Results: Average Power [ kW ]



Sustech 2013 - August 1, 2013, Portland, OR

## Results: Energy Use [ Wh / mile]



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- Minimum energy usage of $169 \mathrm{~Wh} / \mathrm{mile}$ at 30 mph
- Maximum energy usage of $369 \mathrm{~Wh} / \mathrm{mile}$ at 75 mph
- 65 mph to 60 mph reduces energy consumption by $\sim 8 \%$
- 65 mph to 70 mph increases energy consumption by ~7\%
- 65 mph to 75 mph increases energy consumption by ~22\%



## Results: Efficiency [ miles / kWh ]



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- Minimum efficiency of 2.71 miles/kWh at 75 mph
- Maximum efficiency of 5.98 miles $/ \mathrm{kWh}$ at 30 mph
- Typical range of $35-40$ miles would be seen for a constant speed trip of ~55mph



## Conclusions

- Energy efficiency is a key performance factor in EVs and major contributor to accurate range calculations
- For 2012 Chevy Volt, energy usage on flat terrain ranges from 169 $\mathrm{Wh} / \mathrm{mile}$ at 30 mph to $369 \mathrm{~Wh} / \mathrm{mile}$ at 75 mph
- Energy usage equates to total range expectations from 28 miles to 61 miles, depending on speed travelled (demanding terrain would decrease range)

