<u>Re-Simulation of Carnegie-Mellon PHEV Study</u>

http://www.leapcad.com/Transportation/Re-simulation_CM_PHEV_Study.mcd

Carnegie-Mellon Study: "Impact of battery weight and charging patterns on the economic and environmental benefits of plug-in hybrid vehicles" http://www.cmu.edu/me/ddl/publications/2009-EP-Shiau-Samaras-Hauffe-Michalek-PHEV-Weight-Charging.pdf

<u>Net present value of vehicle lifetime costs per lifetime miles</u> <u>as a function of the distance driven between charges.</u>

Base case assumes Performance 0-60 mph in 10.2 seconds, 12 year 150,000 mile lifetime, +1x structural weight, no battery replacement over the vehicle life, 5% discount rate, 50% SOC swing, no carbon tax, and an average U.S. electricity mix. ICE: Base - \$17,600, mpg = 27



Conclusions For NPV 12 Year Lifetime

20 mi AER Prius is competitive with ICE

40 mi AER Prius is competitive with ICE



40 mi AER Prius is competitive with ICE

60 mi AER Prius is competitive with ICE

2010 Volt @\$700/kWhr Li-Ion Battery Cost

Jon Lauckner, the co-creator of the Chevy Volt and GM's VP of global program management states that the Volt's battery cost is "many hundreds of dollars per kWh" less than \$1000/kWhr. Lets say it is \$700/kWhr. Then the Volt's price minus the battery is \$28,800.

The Volt (136 kW) has higher performance than the 2004 Prius (57 kW) and thus an equivalent ICE for the Volt costs more than for the Prius. A Chevy Malibu with a standard 169-horsepower (126 kW) 2.4L Ecotec DOHC four-cylinder engine that delivers 30 mpg highway, 22 city ('08 EPA) and sells for about \$22,000. We will use this for our Volt ICE comparison. ICE: Base Price - \$22,000, mpg = 27

The Volt is a series hybrid, while the Prius is parallel and consequently their combinations of motor and engine powers are different. The charge depletion efficiency of the Volt is 40 miles/8kWhr or 5 mi/kWhr. The Prius, with a simulated 40 mile AER and a structural weight factor of 1X, has a simulated efficiency of 5.3 mi/kWhr. The charge sustaining efficiency for both the Volt and Prius with a 40 mi AER is about 50 mpg. Most of the added weight for higher AER comes from the battery.



40 mi AER Volt is competitive with ICE

60 mi AER Volt is competitive with ICE

Summary:

Using Li-Ion battery high volume cost projections for 2010 and not current costs, this re-simulation concludes that a PHEV is competitive with an ICE.

Refer to Mathcad Analysis: http://www.leapcad.com/EV/Re-simulation_of_CM_PHEV_Study.pdf