

Re-Simulation of Carnegie-Mellon PHEV Study



[http://www.leapcad.com/Transportation/Re-simulation CM PHEV Study.mcd](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"

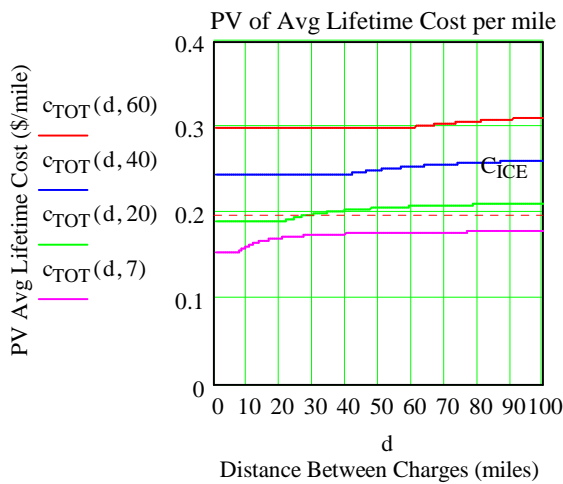
<http://www.cmu.edu/me/ddl/publications/2009-EP-Shiau-Samaras-Hauffe-Michalek-PHEV-Weight-Charging.pdf>

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

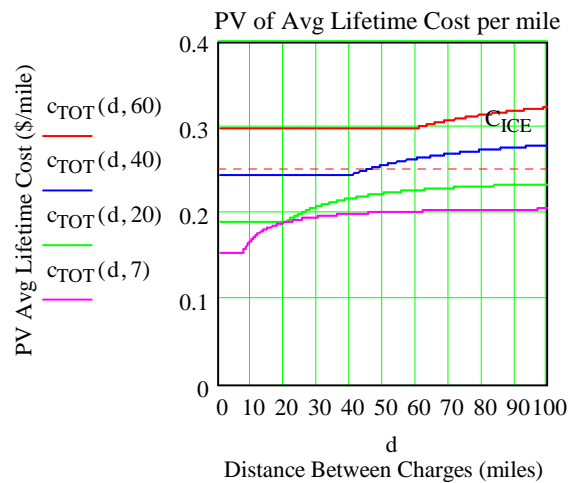
Base case assumes Performance 0-60 mph in 10.2 seconds, 12 year 150,000 mile lifetime, +1x structural weight, no battery replacement over the vehicle life, 5% discount rate, 50% SOC swing, no carbon tax, and an average U.S. electricity mix. ICE: Base - \$17,600, mpg = 27

2004 Prius @\$1000/kWh Li-Ion Battery Cost

C-M Study with Gas @ \$3.00/gal



C-M Study with Gas @ \$5.00/gal



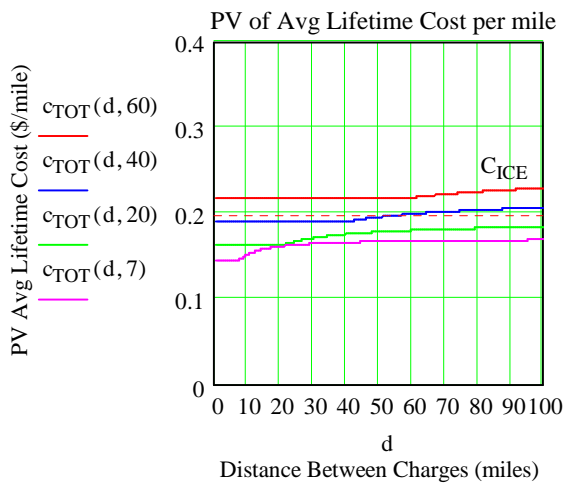
Conclusions For NPV 12 Year Lifetime

20 mi AER Prius is competitive with ICE

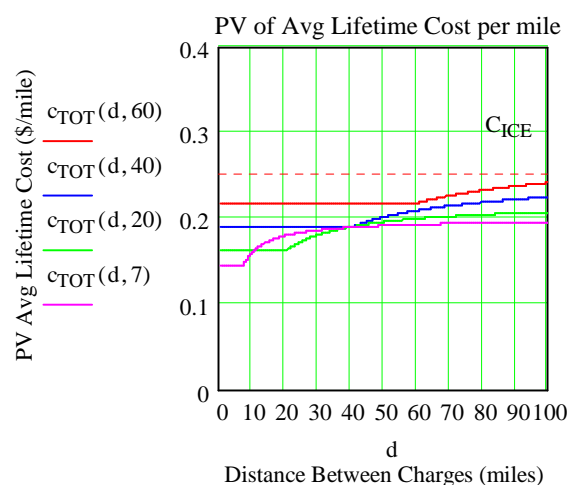
40 mi AER Prius is competitive with ICE

2004 Prius @\$500/kWh Li-Ion Battery Cost

C-M Study with Gas @ \$3.00/gal



C-M Study with Gas @ \$5.00/gal



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.

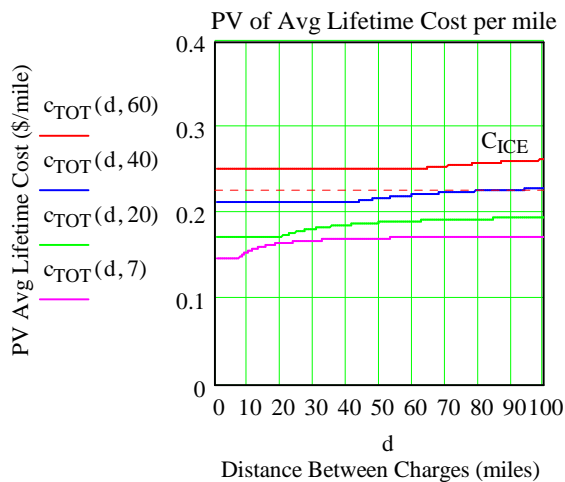
The Volt (136 kW) has higher performance than the 2004 Prius (57 kW) and thus an equivalent ICE for the Volt costs more than for the Prius. A Chevy Malibu with a standard 169-horsepower (126 kW) 2.4L Ecotec DOHC four-cylinder engine that delivers 30 mpg highway, 22 city ('08 EPA) and sells for about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

ICE: Base Price - \$22,000, mpg = 27

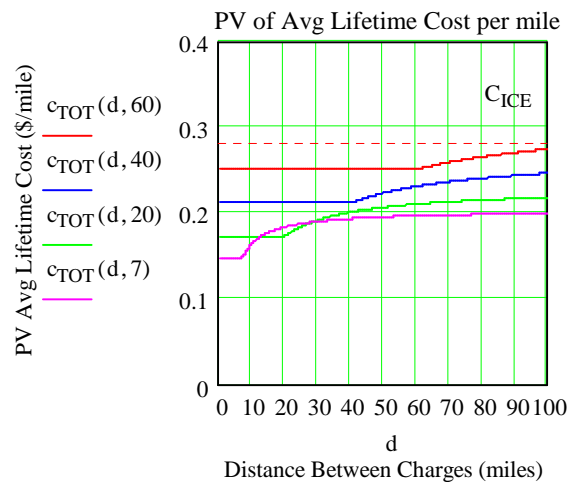
The Volt is a series hybrid, while the Prius is parallel and consequently their combinations of motor and engine powers are different. The charge depletion efficiency of the Volt is 40 miles/8kWhr or 5 mi/kWhr. The Prius, with a simulated 40 mile AER and a structural weight factor of 1X, has a simulated 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.

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

Study with Gas @ \$3.00/gal



Study with Gas @ \$5.00/gal



Conclusions For NPV 12 Year Lifetime

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