Driving a Chevrolet Volt in New Jersey:
Its Economic and Environmental Impact

Nobo Komagata
insi2.org
January 1, 2015 (First written: October 16, 2013)

Would It Really Be Beneficial to Drive a Volt?

In October 2013, I purchased a 2013 Chevrolet Volt (a plug-in hybrid). The main motivation was my strong desire to drive mostly electric while still keeping the ability to run on gasoline. And I love my Volt; so, this essay is certainly biased in many respects. But I will at least be open to and examine critical ideas.

Regarding the economic and environmental impact of a Volt, I thought I had some ideas. However, only after buying and driving it, I paid a closer attention to the details, especially in the context of my driving pattern specifically in my locality, Mercer County, New Jersey. What I found was surprising: the result was very *conditional*. That is, it depends on many factors.

Some Background Information

In December 2008, my wife ditched her beloved 1998 Honda CR-V and purchased a 2009 Toyota Prius. She commutes about 90 miles round trip two to five days a week. The Prius is a gasoline-powered hybrid and its fuel efficiency is about 50 MPG, both the combined EPA figure and our experience. This is about twice better than CR-V and the U.S. average. The Prius is a sort of "parallel" hybrid in the sense that both its electric motor and gasoline engine are engaged often at the same time. This was surely the right choice for her. During the first five years, we drove about 80,000 miles in the Prius. Assuming a typical gasoline price of $3.10 per gallon in New Jersey for this period (http://www.newjerseygasprices.com/), we probably spent about $5,000 on gas. Compared to the CR-V (with its actual MPG value of 25), we must have saved about $5,000 during the same period. The original MSRP of the Prius, which was about $24,000, now appears more like $19,000. If we use the combined EPA figure of 20 MPG for the CR-V, the saving would be almost $7,500. And this is only for the first five years; the car is still running well and the saving would continue.

After getting a Prius, my wife gave her old CR-V to me. I had been driving it until I bought a Volt. It was amazing that after fifteen years of service, the car was still running well with no major repair. But during these five years, my perception about cars has changed drastically. With the real-time MPG monitor on the Prius, I learned how moment-to-moment MPG figures change and realized how I could drive more fuel-efficiently even in a gasoline-powered car. So, I started to practice a "moderate" form of hypermiling in my CR-V. For example, at red lights, I shut off the engine. I also shut off the engine when I can safely cruise in Neutral. The procedure is as follows: shut off the engine with the key turned to the accessory position, shift the gear to Neutral, turn the key to the start position, wait until the car needs to be started, and start the engine by turning the key to the ignition position, then shift the gear to Drive (*Disclaimer: This operation may turn off certain safety mechanisms of an automobile and can be dangerous; I cannot be responsible for any negative consequences following this procedure*). I was also accelerating and braking gently and driving relatively slowly, especially, on an express way (e.g., at 55 MPH instead of the limit 65 MPH). Occasionally, I saw the driver behind me being visibly annoyed and showing mean gestures. Some drivers even passed me on a no-passing local street. I felt that the biggest obstacle to hypermiling is other, more aggressive drivers. In order not to interfere with other drivers, I tried to drive on multiple-lane roads, where available, so that other drivers can pass me easily. While the combined MPG figure (EPA) of 1998 Honda CR-V is about 20, I was able to achieve about 25 MPG during this period.

Even with this kind of effort, the MPG figure of a CR-V (and most other cars) is still half that of a Prius. I even got to a point that I didn't want to drive the CR-V any more (or any other typical gasoline-powered car for that matter). As my CR-V aged, I started to think about my next car. In terms of MPG, Prius is still the gold standard. And, I wanted a car at least as good as Prius in terms of the MPG figure.

Also during the past five years, our Prius let me experience the sense of driving completely electric. That is, when the condition is good, the Prius can run entirely on electricity for a few miles. It is so quiet and pleasant. I became confident that it is technically quite practical to go electric. I often tried to drive as much as possible in this mode in the Prius; but the car would soon switch back to the normal gasoline-powered hybrid mode. While I felt so good driving electric, I was often frustrated by the inability to stay in that mode much longer, even when there still is some battery capacity left. I wanted to drive electric much more than that.

For the few years before buying my Volt, I have been comparing Toyota Prius Plug-In, Nissan Leaf, and Chevrolet Volt. At first, I was attracted to Prius Plug-In as I became familiar with the high fuel efficiency and reliability of our Prius. But the electric mode of Prius Plug-In would last only for eleven miles, which would be insufficient for my driving pattern, including a 40-mile route for volunteering. Beside, I was able to tell that even within this electric range, Prius Plug-In would automatically start the engine occasionally. So, I felt Prius Plug-In would not really satisfy my needs.

Leaf was very attractive because it is completely electric and practical. In addition, the price was reduced by $5,000 or so in 2013; it also comes with the NJ state sales tax exemption (which can amount to $2,000 or more). But I was still not entirely comfortable going completely electric. There are still not enough charging stations in our area. I also imagined rare occasions when my wife needs to drive another car to work or I need to rescue her at work beyond the Leaf's range. In addition, I was still hesitant to install a 240v charger at home. One more factor was its availability. When I was actually considering a purchase, no Leaf was available at a local dealer, especially the least expensive version I was interested in.

Until the summer of 2013, the Volt had been far more expensive than the other two. Then, during the summer of 2013, GM reduced the price by $5,000. Then, I became serious about the Volt. The Volt is a plug-in hybrid and can drive about 40 miles (estimate) in the purely electric mode and after that, gasoline-powered engine will work mainly as a generator, still mostly driving the car with its electric motor (extended-range mode). So, it is a sort of "series" hybrid, distinct from Prius and Prius Plug-In, which are "parallel." In truth, it would also run in a series-parallel mode as well, directly connecting the engine with the drive axle. When the Volt is in the extended-range mode, its fuel economy is expected to be between 30 and 40 MPG and it requires premium gasoline. Of course, I don't like this MPG figure and the use of premium gasoline, but I figured I wouldn't need much of it any way because I would be driving within 40 miles most of the time. To fully charge the battery, it would require about ten hours with a regular household power (120v - 12A). The combination of the 40-mile electric range and 10-hour charging on 120v seemed to strike a good balance for me.

I now drive my Volt for volunteer work, including senior people transportation two days a week, and some other local trips. On weekends, we use the Volt for trips up to about 50 miles and the Prius for longer ones.

The Economic Impact of Driving a Volt

Now, I discuss the economic aspects of driving a Volt, especially in comparison to Prius. First, here are a rough estimate of the initial costs of our two cars (as of October, 2013). The other two candidates mentioned earlier have also been included for comparison purposes.

Model	**2009 Prius**	**2013 Volt**		**2013 Leaf**	**2013 Prius Plug-In**
	II	Basic		S	Basic
MSRP (approx.)	$24,000.00	$40,000.00		$29,000.00	$33,000.00
NJ sales tax	$1,680.00	$2,800.00			$2,310.00
Price with NJ sales tax	$25,680.00	$42,800.00		$29,000.00	$35,310.00
Manufacturer rebate		*-$5,000.00*			
Federal tax credit		*-$7,500.00*		*-$7,500.00*	*-$2,500.00*
Charging station (240v)				$2,000.00	
Hypothetical final cost	$25,680.00	$30,300.00		$23,500.00	$32,810.00

These do *not* include discounts, trade-ins, various fees/costs involved in the purchase, insurance, and any interests/costs associated with financing. In addition, the Federal tax credit here is the *maximum* figure for the specific tax year and if the tax amount is less than that, the credit will be limited to that amount. Toward the end of 2013, GM increased the Volt rebate to $7,000 and a local dealer reduced the priced up to $10,000 near the end of 2014. If I had waited longer, the cost calculations below would be somewhat different.

If the maximum tax benefit is applicable, the difference between the costs of our two cars is somewhere between $4,000 and $5,000. So, roughly speaking, if we can offset this difference within a specific period, the initial cost difference would be justified. Since how long one would drive is entirely conditional, this kind of justification needs to be case by case. Since many calculations found on the web are based on various assumptions, we need to be careful about their applicability to our own cases. If you want to adjust the data in this essay to your own specifics, there is an Excel file available on-line (http://nobo.komagata.net/pub/Komagata13-Volt.xls).

As an example, I present a hypothetical scenario based on my own case. Since I have been driving my Volt only for a relatively short time, my analysis is still in a preliminary stage. First, here is the driving cost estimate for the Prius as the base line. If the cost of gasoline is at $3.00/gallon (2014 median) and the fuel efficiency is 50 MPG, the cost of driving a mile on gas would be 6.00 cents. Since the gas price dropped substantially to about $2.50/gallon toward the end of 2014, this may appear too high. But the gas price is always lower during the winter months and has never consistently decreased over the past ten years. So, I will use this figure for the present purposes.

Next, here are some basic information for analyzing the driving cost for the Volt. For our area, the Residential Service (RS) rate of our utility company, PSEG, for the majority of our consumption (based on our bill, except for the small amount billed with a slightly lower rate) is 17.5 cents/kWh (6.6 cents for "delivery" and 10.9 cents for "supply"). This seems very high compared to what I saw earlier on the Internet (e.g., 10 cents/kWh). I also checked alternative energy companies for a better rate, which could replace only the "supply" part of the bill. Only a few alternative companies offer rates lower than our PSEG rate, but not substantially lower. Another point to consider would be switching from the RS to the Residential Load Management (RLM) rate, which involves different peak and off-peak rates. However, it is not clear if our household would benefit from such a move, without a careful analysis of the entire household. Since the RLM rate has a higher peak cost and a lower off-peak cost compared to the RS rate, the usage of certain appliances during the peak time could increase the overall cost.

The Volt's battery capacity is 16.5 kWh. To sustain the life of battery, only 10.8 kWh of it is being used for driving. From what I read on-line, a full single charge would consume about 14kWh. This, I assume, would include temperature management. Then, the *practical* charging efficiency seems to be about 77%. I also read that Volt's charging efficiency is about 90%, but I believe that this does not include auxiliary functions such as temperature management. A full charge cost would then be about $2.45. This is much higher than I saw on some on-line articles (e.g., $1.75). This seems to reflect relatively high cost of electricity in the area. But once I started to monitor the actual electricity consumption, I realized that the cost per charge does not mean much.

Initially, I was hoping that I could rely on the OnStar information for record keeping. However, after a few months of observing, I realized that OnStar information is not so accurate. While the mileage information is only slightly off (but not radically), the charging information was occasionally completely wrong. I also checked the Volt Stats! data (http://www.voltstats.net/). The information seems accurate. But neither OnStar nor Volt Stats! seem to include the mileage and gas usage during ERDTT (discussed later) and forced Engine Maintenance. So, in January 2014, I started to use the vehicle data (odometer/trip meter and gas consumption) and the reading from a Kill-A-Watt (at the 120V outlet). Here is the relevant information for the entire year of 2014 (available in the above-mentioned Excel file).

					Electricity rate						0.175	$/kWh					
Month	Gas▸	Odome▸	Total ▸	Gas n▸	Gas ▸	Kill A▸	EV mi▸	EV %	Gas ▸	Electri▸	Combi▸	Comb▸	Electr▸	Ga▸	EV	Range▸	
	Prem▸	Odomet▸		Sum o▸	Sum ▸										Hi	Me▸	Lo
	$	mi	mi	mi	gal	kWh	mi	%	$	$	$	$/mi	$/mi	mi/▸	mi	mi	mi
2014-01	3.60	1,876	547	24.0	1.12	199	523	95.6%	4.03	34.83	38.86	0.0710	0.0666	21	44	42	40
2014-02	3.60	2,282	406	15.1	0.43	138	391	96.3%	1.56	24.15	25.71	0.0634	0.0618	35	47	44	41
2014-03	3.60	2,862	580	0.0	0.00	190	580	100.0%	0.00	33.25	33.25	0.0573	0.0573		52	49	45
2014-04	3.80	3,237	375	3.6	0.13	99	371	99.0%	0.49	17.41	17.90	0.0477	0.0469	28	55	52	48
2014-05	3.80	3,791	554	0.0	0.00	135	554	100.0%	0.00	23.63	23.63	0.0426	0.0426		57	55	53
2014-06	3.80	4,260	469	11.3	0.20	110	458	97.6%	0.76	19.25	20.01	0.0427	0.0421	57	60	58	56
2014-07	3.70	4,367	107	0.4	0.03	35	107	99.6%	0.11	6.18	6.29	0.0588	0.0580	13	59	58	57
2014-08	3.50	5,050	683	271.8	6.81	95	411	60.2%	23.84	16.60	40.44	0.0592	0.0404	40	60	59	57
2014-09	3.50	5,505	455	0.0	0.00	119	455	100.0%	0.00	20.83	20.83	0.0458	0.0458		60	59	57
2014-10	3.10	6,001	496	5.1	0.16	123	491	99.0%	0.50	21.53	22.02	0.0444	0.0438	32	58	56	54
2014-11	3.00	6,427	426	0.5	0.03	144	426	99.9%	0.09	25.20	25.29	0.0594	0.0592	17	55	50	45
2014-12	2.80	6,839	412	26.2	0.66	133	386	93.6%	1.85	23.28	25.12	0.0610	0.0603	40	47	45	42
Total			5,510	358.0	9.57	1521	5,152	93.5%	33.23	266.12	299.35						
Averag▸	3.48		459	29.8	0.80	127	429		2.77	22.18	24.95	0.0543	0.0517	37	55	52	50

During 2014, I drove 5,510 miles and consumed 1,521 kWh of electricity and 9.57 gallons of gasoline. The vehicle was driven 93.5% of the time with electricity. The total energy cost was about $300. The driving cost (including both electric and gasoline consumption) was 0.543 cents/mile. The MPG figure when driving in the gasoline-hybrid (or charge-sustained) mode was 37, which was exactly expected. The median estimated range per charge was 52 miles, which is greater than the estimated 40 miles. This reflects my driving pattern, i.e., a sort of moderate hypermiling. I often drive even on a highway at 50 MPH where the speed limit is 65 MPH. I think that driving faster than 50 MPH is a waste of energy (spending the energy for pushing the wind) and thus don't do it unless there is a reason. During the summer, I was able to drive more than 60 miles on a single charge.

Now, let us compare Volt and Prius. I would most likely drive my Volt about 5,000 miles a year, i.e., 25,000 miles for the first five years. Using the cost of 5.34 cents/mile for the Volt, the energy cost would be $1,358 for that period. On the other hand, with 6.00 cents/mile, the gasoline cost for a Prius would be $1,500 for the same period. There is not much difference. Thus, I would say that **in *my* case, the energy cost of driving a Volt is comparable to that of driving a Prius**. In other words, **it would be impossible for *me* to recover the initial cost difference of a Volt**. Here, the critical figure for this comparison is the estimated gasoline price at $3.00/gallon. At about $2.70/gallon, the numbers would break even and at a lower figure, Prius would be more cost effective. In any case, the difference would still be a couple of hundred dollars for the five-year duration and that would not make a significance for the comparison purposes.

What about if we were in another locality where the cost of electricity is 10 cents/kWh and drove 134,000 miles in 10 years (at the same gas price of $3.00/gallon)? Then, the cost of driving a Volt would be about $3,300 less than that of a Prius. Even under such an optimally hypothetical condition, the initial cost difference ($4,000 to $5,000) will not be justified. That is, it is not realistic to expect any cost benefit over Prius. Of course, in any case, the driving cost of my Volt would still be much lower than that of my old CR-V.

Next, here are some additional details. First, the driving cost depends on the outside temperature, just like a gasoline-powered vehicle. However, there are two reasons. One is associated with propulsion and the other, climate control. The former aspect is more or less analogous to gasoline-powered vehicles. The latter is different. Since I am used to ride a recumbent tricycle in cold and hot weather, I don't really need much heat or A/C when I drive alone. However, I still use these for other passengers, especially when I volunteer to transport senior people. So, depending on the temperature, a substantial part of the electricity consumption went to climate control. If one thinks that it is a pity that electric cars consume battery power to heat the cabin, I would say the following. It is quite wasteful for gasoline-powered cars to lose energy in the form of heat, *all the time*.

Another point is that I did not intend to use gasoline even during the coldest months of January and February. Most of the gas use during these months was due to "Engine Running due to Temperature" (ERDTT). Even though I set the threshold temperature at 15F, there were several days below that. To avoid this condition, various techniques are being discussed on gm-volt.com. I have tried some of them, but since it would happen only a small number of days in my area, I felt that it is something I can bear. Some other occasions for the gas use were when I drove more than the EV range. During those trips, I used the "hold" mode. I think this is a nice feature as I have a better control over how (not) to use gas. For example, it is possible to use the hold mode on a highway to save the battery and use the normal mode when driving locally.

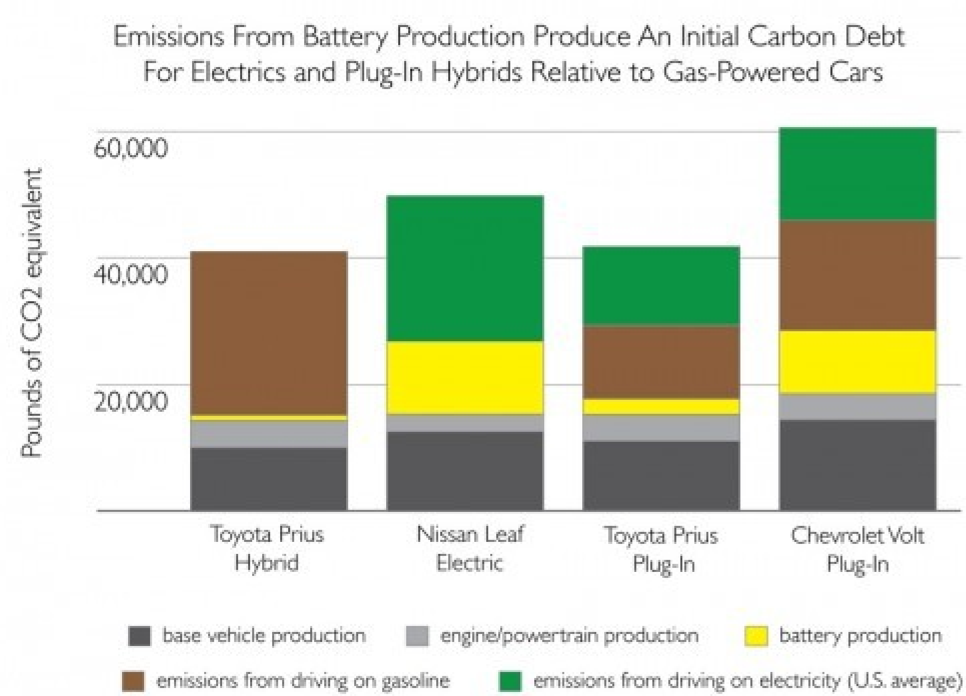
As can be seen in the table above, the largest amount of gas use was in August 2014. This was due to Volt's built-in mechanism to consume stale fuel. My car must have been filled in August 2013 and the vehicle recognized that the original gasoline was more than one year old. Since I was driving mostly electrically, I still had 3/4 of the gas tank still filled. At that point, I was forced to drive in the gasoline-hybrid mode and that certainly affected the EV percentage and other data. If August 2014 is excluded, the EV ratio would be about 98%.

Environmental Impact: Based on Climate Central's Report

How about the environmental impact of driving a Volt in our area, especially in comparison to a Prius? We mainly rely on the information in *A Roadmap to Climate-Friendly Cars: 2013* by Climate Central since this seems to be one of the most recent and most comprehensive analyses on this topic.

According to the report, if we consider the life cycle of various cars over 50,000 miles (about 10 years of driving in my case), it would be more environmentally friendly *in New Jersey* to drive a Prius than a Volt. In fact, Prius was listed No. 6 and Volt was listed No. 18 under the report's condition. There is no specific emission figures for the vehicles in the rankings. Under the same condition, but using the U.S. average grid emission (i.e., not specifically for New Jersey), the green-house gas emission of a Prius is 0.83 lbs. $C0_2$ e/mile and that of a Volt is 1.15 lbs. $C0_2$ e/mile. A Volt is 39% worse than a Prius. This was rather surprising.

This report is comprehensive in a sense that it includes not only the driving emission but also the emission involved in the vehicle *manufacturing* process. Due to the large size of the battery, the Volt and the Leaf are said to be responsible for a large amount of emission during the manufacturing process, even before they are delivered. A relevant figure in the report (taken from the on-line version of the report; Figure 6 in the print version lacks the column for the Prius Plug-In) is included below.



The main contributing factor during the production is the emission associated with Leaf's and Volt's battery production, as shown in the yellow bands (third from the bottom) in the figure. As for Volt, its relatively heavy weight also contributes to its larger base vehicle production emission, shown in the dark gray band (the bottom). As a result, in order to offset this initial deficit, both the purely electric Leaf and "true" plug-in hybrid like Volt with a substantial battery size would need to drive a long distance with much less driving emission.

Before proceeding, here are some caveats. As one of the on-line comment on the report points out, the report basically relies on a *single* set of production emission studies. The studies use a model based on various assumptions. Thus, it is difficult to verify the validity of this particular model. It would be more desirable if we were able to compare multiple different models. So, we need to regard the report as such.

Next, the report is accompanied with the web page title, "Hybrids Better for Climate than Leaf, Tesla in Most States." This seems to be the message and the tone which the report is trying to convey. People who don't like electric cars would love to quote this statement. Personally, I do not think this statement is a responsible way to present very *conditional* data in the report. This relatively negative attitude toward electric cars is also associated with this report and the previous version's (*A Roadmap to Climate-Friendly* Cars, 2012) unfair treatment of plug-in hybrid driving pattern (especially true for the Volt), as will be discussed below.

Furthermore, although the report acknowledges that the grid is rapidly becoming cleaner (even for the short duration between 2010 and 2012), the report uses the 2012 figure for long-term analyses into the future. This is very unrealistic and in a sense irresponsible. We need to be more forward-looking and be ready for the availability of cleaner energy. In this connection, the report seems to be sidestepping the real problem. That is, we should not adjust ourselves backward; we should improve on it. Although the reports touches upon this point, the tone of the report could actually dampen the effort of many drivers who try to make the best use of currently available cars.

Although this is not directly related to the discussion here, I would also like to point out potential problems with nuclear power. Even though considered clean in the report in terms of carbon emission, some of the problems with nuclear power can be environmentally disastrous, albeit in a different way.

At this point, let us discuss some more specific problems associated with the report. First, the above figure is based on the driving emission of the U.S. average, not that of a particular state. Due to the cleaner grid, the electric driving emission in New Jersey is much lower than that of the U.S. average. Thus, the green bands for the Leaf and the Volt would be thinner and the column heights for these vehicles would be lower as well. Then, this figure in its current form presents an unfair picture for the Volt and the Leaf as driven in New Jersey and other relatively clean states.

Second, the analysis in the report is based on the following driving pattern for *all* plug-in hybrids: 50% driven in the electric and 50% driven in the gasoline-hybrid mode. This is completely unrealistic. With its 40-mile electric range, many Volt drivers would drive mostly in the electric mode. In fact, according to the web site Volt Stats! (http://www.voltstats.net/), which uses the real-time data from GM's OnStar service, the registered users of the web site on average drive electric about 74%; the median value is about 80%. In my case, I intend to drive my Volt mostly on battery (97.8% electric during Janauary-April 2014). Then, the life-cycle emission of a Volt would be more like that of a Leaf (actually slightly more due to its higher production emission and slightly higher driving emission, both mainly reflecting its heavier weight). On the other hand, Prius Plug-In drivers can drive electric only for eleven miles; it is entirely unlikely that they can drive 50% solely on battery. So, this assumption puts the Volt in an unfairly disadvantaged position and the Prius Plug-In in an unfairly advantageous position. It would be more realistic to view a Volt like a Leaf and a Prius Plug-In like a (non plug-in) Prius. Since this unrealistic assumption is used throughout the report, most of the assessments involving these two vehicles seem rather misleading. Thus, the report not only sets the tone against electric and "true" plug-in hybrid cars, but also substantially downgrades the benefits of true plug-in hybrids.

Then, it seems that *my* Volt (driven almost entirely on battery) is more comparable to a Leaf, except for the following two points. Note that I'm still using the data from the report, even though this may not be accurate. First, the production emmision of a Volt is higher than that of a Leaf by about 7% (estimated from the above figure). Second, the driving emission of a Volt is higher than that of a Leaf by about 6% (Volt: 0.36 kWh/mile vs. Leaf 0.34 kWh/mile, Table A1 in the 2012 version of the same report). So, where a Leaf has much smaller emission than a Prius, a Volt would be comparable to a Leaf in that particular area.

According to the report, New Jersey is ranked seventh in terms of grid emission. In New Jersey, then, 100,000 miles of life-cycle emission of a Leaf is 26.6 Tons CO_2 e and that of Prius is 33.7 Tons CO_2 e (Table 4). That is, a Leaf would be about 21% better than a Prius. Since a Volt is only about 6% worse than a Leaf, it would still be much better than a Prius. For 50,000 miles (10 years of driving for me) of life-cycle emission of a Leaf is still better than a Prius. Although there is no numeric data, a Volt would be at least comparable to a Prius. Thus, **my interpretation of the report is that a Volt is actually no worse than a Prius in terms of the total life-cycle emission based on my driving pattern in our area**.

Environmenal Impact: Data from PSEG's Web Site

However, the story does not end here. As I checked one of PSEG's web pages (http://www.pseg.com/info/environment/envirolabel.jsp), I realized that their energy source is much more fossil fuel-dependent than the data in the report (next page/below): about 25% coal and 21% natural gas.

Environmental Information for Basic Generation Service, PSE&G

Electricity supplied from June 1, 2012 – May 31, 2013

Electricity can be generated in a number of ways with different impacts on the environment. The standardized environmental information shown below allows you to compare this electricity product with electricity products offered by other electric suppliers.

Energy Source

PSE&G relied on these energy resources to provide this electricity product.

Coal	24.93%
Gas	20.88%
Hydroelectric (large)	0.04%
Nuclear	43.49%
Oil	0.22%
Renewable energy	
Captured Methane Gas	1.36%
Fuel Cells	0%
Geothermal	0%
Hydroelectric (small)	0.30%
Solar	0.78%
Solid Waste	2.20%
Wind	5.76%
Wood or other biomass	0.04%
Total	100%

Renewable energy sources subtotal: 10.44%

This web page is for 2012-2013 and thus does not seem obsolete. However, this page was found only through Google search but does not seem to be linked from any other "current" pages on the site. I wonder why this is so. The difference between this web page and the report could be explained if other utility companies in New Jersey, e.g., Atlantic Electric, JCP&L, Orange Rockland Electric, are much less fossil-fuel dependant and the other companies are offseting the numbers from PSEG. For example, Atlantic Electric might be heavily dependant on the nuclear power from Oyster Creek Nuclear Generation Station. Or, as another web page of PSEG (http://www.pseg.com/family/power/fossil/responsiblecoal/index.jsp) argues, their coal-based power plants in Hudson and Mercer Counties are much cleaner than most other coal-based plants in the country. Unfortunately, I have no further information to discuss this issue. So, if PSEG's web page is accurate, the environmental impact of electric cars in our area, which is dependent on PSEG, would be significantly different. Now, let us examine the consequence of the energy source distribution as shown on that web page. This pattern is more like that of South Carolina or Virginia (Figure 3 of the report). In these states, a Prius would generate about the same or slightly lower life-cycle emission than a Leaf for both the 50,000 and 100,000-mile cases. A Volt (in the electric mode) would be about 6% worse than a Leaf. So, if we follow PSEG's web site (for energy source distribution) and the report (for other data except for the driving pattern), my Volt would have slightly more life-cycle emission than a Prius in our area. If this is the case, driving a Volt would not be any better than the best gasoline-powered cars. But is it really the case? Is there any deeper meaning in life-cycle emission?

What Really Matters

At this point, let us shift our point of view. We now consider the responsibilities of the automobile industry, utility companies, and consumers *separately*.

First, let us examine the production of the entire automobile population. In 2011, almost 60 million cars were produced (http://www.worldometers.info/cars/). Considering the *actual* production data about the Volt (about 30,000) (General Motors, 2013) and the production *capacity* of Leaf (250,000) (Cole, 2013), both in 2012, we can estimate that there are no more than 300,000 (probably much fewer) electric and true plug-in hybrid vehicles (with relatively high production emission). The percentage of these cars to all the vehicles would be less than 0.5%. Even if the production emission is 80% higher for these cars (estimate from the production emission figure), the overall impact would be less than 0.4% increase in the total production emission. It would be much more significant to re-examine and improve the manufacturing process of gasoline-powered vehicles, where 1% improvement for each vehicle would translate into 1% improvement overall.

The development of electric and true plug-in hybrid vehicles would certainly improve the diversity of the future offerings. Since we know that fossil fuel will not last forever, this is surely a vital point. It would be too late to start investing in electric and true plug-in hybrid cars only after running out of fossil fuel. And the total production emission of electric and true hybrid cars appears to be almost negligible, compared to that of an enormous number of gasoline-powered vehicles. Then, I believe that the automobile industry is (at least minimally) meeting their responsibility to diverse the offerings without substantially increasing the overall production emission. Of course, I would personally like to see more diversity with less production emission. But I think that the automobile industry has at least started to respond to the needs of today and tomorrow.

As for utility companies, we have already noted that the report has acknowledged their effort and results. That is, even between 2010 and 2012, there has been a noticeable improvement in the distribution of the energy sources. Although this trend in the U.S. may be offset by the increased use of fossil fuel in other countries, somebody must lead the world to save the global environment. Again, I would give at least some credit to the utility companies. Of course, I hope they will try harder.

Finally, what about our responsibility as a consumer? My opinion is that we should minimize the emission where we can *individually* contribute. Of course, it is very important for us to pressure the automobile industry and the utility companies to improve their environmental positions. But what we can do immediately and directly is to minimize emission, especially *in the form of driving emission*. For example, it would be better not to drive a car and use an alternative form of transportation, such as bicycle and public transportation, if that is at all possible. It would be better to drive as little as possible, even though the production emission may not be offset by not driving a sufficiently long distance. Thus, as a driver, regardless of the production emission, we should minimize our driving and thus minimize the *total* emission as much as possible. In this respect, I think that Climate Central's report is misleading.

Once the automobile manufacturers produce vehicles and the utility companies are set to provide electricity, we must make a good decision based on the available options. **Among the vehicles already manufactured and available to us, it would be better to choose vehicles with lower driving emission** (as in the report, this certainly depends on where we live). **Once we own a vehicle, it would be better to minimize its use**.

Next, I will consider my own case. I think we made good choices to have purchased a Prius and a Volt, whose production emission have already been accounted for. When we choose a car to drive on weekend, what we need to think about is the driving emission. Even if we use the data from the PSEG web page, comparable to the data for Arizona or Pennsylvania (not cleaner New Jersey) of the report, a Volt (driven electric), being about 6% worse than a Leaf, would still be better than a Prius in terms of driving emission only (*not* the life-cycle emission as discussed earlier). Even in a state like Texas, where the grid is less environmentally-friendly and at about the U.S. average, a Volt (driven electric about 90% of the time) would be better than a Prius, as also shown in a case report (Lamb, 2012). So, it would make more sense to drive the Volt for trips up to about 40 miles and the Prius for longer trips.

Thus, in my opinion, **when we consider buying and driving a car, life-cycle emission is basically irrelevant**. **Our true goal would be to reduce the total emission involved in manufacturing and operating all the vehicles**.

Concluding Remark

Under the condition I drive my Volt, it appears that it does not have substantial economic benefit compared to a Prius. However, considering a perspective different from Climate Central's report, it makes sense *for me* to drive a Volt in the electric mode; that is, environmentally speaking, a Volt is better than a Prius for me. Whether this applies to other drivers would depend on many conditions. Thus, the conclusion may be different. But in any case, both Prius and Volt are always better than an average car in terms of emission.

The initial cost of a Volt is surely high; probably too high. However, if one shares my view, a Volt can still be a very attractive choice. What I like most about my Volt is the sense of direct control of energy through its "battery pedal." Here are some metaphors I considered. Driving an electric car (or a true plug-in hybrid) may be like using a touch-tone telephone when rotary phones are everywhere. While both can dial a phone number, we have much better sense of how our fingers control each phone call. Or, driving an electric car may be like holding a baby with bare hands, not with garden gloves. We can feel the source of energy much more directly and pleasantly. After getting used to an electric car, a gasoline-powered car (even a Prius) seems like a steam locomotive. I am a kind of guy who prefers a hand reel mower (http://www2.fiskars.com/Gardening-and-Yard-Care/Products/StaySharp-Reel-Mowers) to a gasoline-powered mower and, for a short distance, riding a trike (http://nobo.komagata.net/hpv.php) to driving. So, my Volt made a perfect sense as an introduction to electric cars. Would I be interested in the second generation Volt (from the 2016 model)? Sure.

References

Cole, J. (2013). *Nissan LEAF Production Starts At 3rd Assembly Plant In Sunderland, UK (Factory Video)*. Retrieved from http://insideevs.com/nissan-leaf-production-starts-at-3rd-assembly-plant-in-sunderland-uk-factory-video/ on October 11, 2013.

General Motors. (2013). *2013 Chevrolet Volt Boosts EV Range to 38 Miles*. Retrieved from http://media.gm.com/media/us/en/gm/news.detail.html/content/Pages/news/us/en/2012/Jun/0607_volt.html on October 17, 2013

General Motors. (2013). *U.S. Car and Truck Production*. Retrieved from http://media.gm.com/dld/content/Pages/news/us/en/2013/Jan/gmsales/jcr%3acontent/rightpar/sectioncontainer/par/download_0/file.res/Production-by-Plant-December-2012-NA.pdf on October 12, 2013.

Lamb, E. (2012). *Are Chevy Volts Really Cheaper and Cleaner? A Case Study*. Retrieved from http://blogs.scientificamerican.com/observations/2012/09/21/are-chevy-volts-really-cheaper/ on October 12, 2013.

Larson, E. D., & Kenward, A (2012). *A Roadmap to Climate-Friendly Cars*. Retrieved from http://www.climatecentral.org/news/climate-friendly-cars on October 9, 2013.

NewJerseyGasPrices.com. (2013). *Historical Price Charts*. Retrieved from http://www.newjerseygasprices.com/ on October 9, 2013.

PSEG. (2013). *Responsible Coal*. Retrieved from http://www.pseg.com/family/power/fossil/responsiblecoal/index.jsp on October 13, 2013.

PSEG. (2013). *Where Your Energy Comes From*. Retrieved from http://www.pseg.com/info/environment/envirolabel.jsp on October 9, 2013.

Thomas, D. (2011). *A Winter in the Chevy Volt*. Retrieved from http://blogs.cars.com/kickingtires/2011/04/a-winter-in-the-chevy-volt.html on October 12, 2013.

Volt Stats! (2013). Retrieved from http://www.voltstats.net/ on October 9, 2013.

Worldometers. (2013). *Cars produced in the world - sources and methods*. Retrieved from http://www.worldometers.info/cars/ on October 11, 2013.

Yawitz, D, Kenward, A, & Larson, E. D. (2013). *A Roadmap to Climate-Friendly Cars: 2013*. Retrieved from http://www.climatecentral.org/news/a-roadmap-to-climate-friendly-cars-2013-16318 on October 9, 2013.