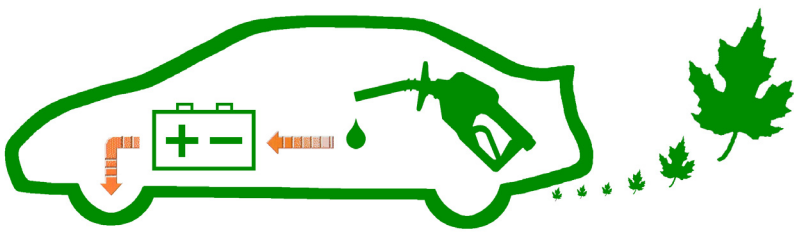
Understanding Hybrids

Back in the early 1990's, the need to develop an entirely new automotive technology which was much cleaner and more efficient became apparent. In 1993, efforts to achieve that began in both the United States and Japan, but with unbalanced political and economic support. That proved to be a rather a significant motivator. It also caused a radically different approach to the research. In 1997, the first Prius was sold in Japan. It was a shock to the competition, who didn't even have prototypes available yet. By late 2000, the sale of an upgraded Prius began in the United States. That marked the end of the effort to compete. Instead, they mocked the technology calling it only a "stop gap" solution. Now in 2006, those same automakers are scrambling to make up all that lost time… as well as repair their tarnished reputations.

Prius is the undisputed champion of that race to achieve those emission & consumption goals. The technology it utilizes is now being rolled out to other type of vehicles, sharing the benefits of that research & development investment… which is proving to have been a very wise choice. And by the time those other automakers finally have a comparable hybrid available at a quantity & price to compete with, Toyota will have a 10-year lead for consumer acceptance and real-world data.

The purpose of this document is to help clarify that trouble the automotive industry is now struggling to deal with, from a perspective of the media... who often incorrectly portrays the success of Prius and the technology it uses due to not completely understanding it.

The lack of a table-of-contents is intentional. Promoting the acknowledgement of all aspects of the hybrid ownership experience should be strongly encouraged in all venues. For this document, that means having to carefully examine each page. Hopefully, that effort will reveal a topic you were unaware of, rather than just allowing the jump to a section you are already somewhat familiar with.



Emission Ratings

Far too often, attention is focused solely on "global warming" emissions (**CO2** = carbon dioxide). The "smog related" type of emissions are usually forgotten… especially when comparing traditional vehicles to hybrids. This is unfortunate, since the hybrids are almost always dramatically cleaner with respect to preventing smog (**NOx** = nitrous oxides, **CO** = carbon monoxide, **NMOG** = non-methane organic gases, **HCHO** = formaldehyde, **PM** = particulate matter).

The following are the emission rating categories, as defined by CARB: (more info at http://www.arb.ca.gov)

ULEV Ultra Low Emission Vehicle

50% cleaner than the average new 2003 model year vehicle; rated for 100,000 miles

SULEV Super Ultra Low Emission Vehicle

90% cleaner than the average new 2003 model year vehicle; rated for 120,000 miles

PZEV Partial Zero Emission Vehicle

Meets SULEV tailpipe emission standards; eliminates evaporative emissions; rated for 150,000 miles

AT-PZEV Advanced Technology - Partial Zero Emission Vehicle

Meets SULEV tailpipe emission standards; eliminates evaporative emissions; rated for 150,000 miles; includes advanced technology components

Hybrid Types

Mild This isn't actually a hybrid, since no propulsion power whatsoever is provided by an electric motor. The system is simply just a traditional engine with a starter and battery that are extra large, giving it the ability to save some gas when the vehicle is not in motion. That's it.

available as this type: *Chevy Silverado*

Assist This type of hybrid directly bonds an electric motor directly to a traditional engine. The design allows for some propulsion to be provided through the use of electricity; however, the RPM of both the motor & engine are always identical due to the connection the share. This limits the power & charging abilities. The electrical strategy is referred to as a "passive".

available as this type: *Honda Civic & Accord, Saturn Vue*

Full Unlike the "assist", this type of hybrid has an additional electric motor as well as a power-split-device. The setup dramatically increases flexibility while at the same time eliminates the need for a manual or automatic transmission. Only the "full" hybrid has the ability to propel the vehicle exclusively using an electric motor without the engine moving at all. Only the "full" hybrid can create & consume of electricity simultaneously, which allows recharging of the battery-pack even while climbing up a hill and the ability to take advantage of electric motor torque without even using the battery-pack. The electrical strategy is referred to as a "persistent".

available as this type: *Toyota Prius & Camry & Highlander, Lexus RX400h, Ford Escape*

Hybrid Configurations

A common assumption is that the current hybrids available are limited to that particular configuration only. That couldn't be further from the truth. Engine size, as well as type, can be changed… just like with traditional vehicles. Later on, automakers could provide a size & type option, allowing you choose how much emphasis should be placed on efficiency. The same is true for the battery-pack too.

Full Hybrid – City Operation

Just like most people assume, the "full" hybrid does indeed heavily favor the use of electricity in city conditions. With the HSD hybrids (such as Prius), you have the ability to drive up to 42 MPH without the engine in motion… even with the A/C running. So, if you have to deal with quite a bit of stop & slow driving (like a daily commute on a very congested highway), this design type will deliver excellent efficiency… unlike any other type of hybrid or traditional vehicle.

Full Hybrid – Suburb Operation

This often forgotten type of driving is the ideal for a "full" hybrid. Truly remarkable efficiency, even better than city, achieved from suburb conditions is due to the fact that this mode of operation can be sustained for many hours. With fewer stops and faster speeds, the system takes advantage of having two electric motors, one for generating & regenerating electricity and the other for providing thrust. So the battery-pack is never depleted. An ample supply of electricity is always available.

A "full" hybrid (like Prius) generates electricity 100 percent of the time the gas engine provides power. It is a misconception that electricity primarily comes from regenerative braking. In reality, brakes only contribute a very small amount compared to what the generator motor creates. This persistent nature seems counter-intuitive, until you discover it is what allows the engine to run at a more efficient state than it would with a traditional vehicle. The RPM remains relatively constant, with the flow of electricity fluctuating instead. This is a significant benefit frequently overlooked.

Full Hybrid – Highway Operation

The belief that the electric motor isn't used much at very high speeds is quite incorrect. Unfortunately, far too many people think that and draw the conclusion that a "full" hybrid won't provide much of an efficiency gain for highway driving. That simply is not true. There is quite a bit of opportunity for better MPG than a traditional vehicle.

First, consider the gas engine itself. Most "full" hybrids utilize an Atkinson-Miller pumping cycle, rather than Otto. The difference is substantial. Less gas is used, but there is a penalty of less power being available. However, the hybrid design includes an electric motor to contribute power. So that penalty is cancelled out. In addition to that, the hybrid engine is smaller than that in a traditional vehicle. And because so little horsepower is needed to sustain a high-speed cruise anyway, even less gas is used since there is less engine to feed.

Second, the contributions of power from the electric motor are dramatically faster and for much short durations than most people realize. While driving along the highway, it is normal for a Prius owner to notice (on the Multi-Display) the flow of electricity change 10 to 20 times per minutes. So even the slightest incline or decline of the road can be taken advantage of, efficiency opportunities lost by traditional vehicles.

Lastly, the negative effect on efficiency from acceleration is greatly reduced by the hybrid system. An electric motor is much more efficient under high demand conditions than an engine. This feature is anytime you accelerate, especially when merging.

Remembering the Past

Did you know that emission reduction equipment and less polluting mechanical operation both have a penalty of causing reduced efficiency? Most people don't. So when they quote MPG data from the past, they don't take into account that the much dirtier older vehicle naturally had a efficiency advantage. (More is definitely not better in that situation.) Those vehicles of the past were significantly slower & smaller than they are now too. Don't let data of that nature mislead you either. Just look at how much larger & faster Camry is today, compared to when it was available several generations ago. They may both be known as "Camry", but they are very different vehicles. Don't forget that the newer models are quite a bit safer as well.

Cost Analysis – MPG

MPG data must take into account a wide variety of driving conditions, to properly reflect what owners can actuall expect. Only long-term real-world measurement can do that. Brief samplings are never appropriate for drawing conclusions with.

Lots of real-world data is available for manual transmission diesel vehicles, a popular choice for comparisons to Prius. Since over 90 percent of the consumers in the United States prefer automatic transmissions, which are not as efficient as a manual, using that data is very misleading. The automatic diesel gets lower MPG.

Winter cold causes MPG to be reduced in both hybrids and traditional vehicles. The switch to winter-formula gas also causes lower MPG. So when data is collected, knowing when is absolutely critical. Most people have no idea that their efficiency cycles higher and lower throughout the year due to those factors.

When gathering MPG data, verify that the tire-pressure and oil-levels for each vehicle are correct. Tires too soft and overfilled oil will cause an efficiency reduction.

Cost Analysis – Emissions

A very common problem for hybrids is the fact that no monetary value is placed on the significantly cleaner emissions. That is an irrefutable indication that the cost analysis was not objective. That benefit simply cannot be ignored. At minimum, at least a small amount of money should be allocated to this improvement over most new traditional vehicles available. Since people are willing to spend a little extra for a better stereo system or better tires, why isn't there any value accredited toward the better emissions? After all, small contributions to the environment are a common practice in other industries.

Cost Analysis – Vehicle Class

Please, don't ever compare an economy-class vehicle to a hybrid. The purpose of the "economy" design is to deliver a very affordable vehicle, inexpensive to both purchase and fuel. The purpose of the hybrid design is to deliver the same vehicle you would have purchased anyway, yet be less expensive to fuel. So the only sincere type of cost analysis is one that goes to great lengths to compare *ALL* aspects of the vehicle, not just MPG. The best example of this is an equally equipped Camry being compared to a Camry-Hybrid. In other words, all but the propulsion system should be the same. That means most of the Prius comparisons have not been objective, since even the base-model of Prius is much better loaded with non-efficiency features.

Cost Analysis – Safety

If the point of safety is to not have an accident in the first place, why do so many people focus only on the crash tests? The answer is surprisingly simple, though by no means obvious. In the past, the only measurements commonly published were crash tests results. But recently that changed, there are now measurements available for rollover resistance too. In other words, the topic of "*accident avoidance*" is finally getting attention.

Think about how a smaller, more nibble vehicle has the ability to maneuver around an obstacle in an emergency. The response is much more effective than a monster-size vehicle can provide. But knowing that would harm sales of those once popular guzzlers. Fortunately, consumer priorities are now changing. Avoidance features like ABS (Anti-Lock Braking System) and VSC (Vehicle Stability Control) are rising in popularity; however, they are not taken into account when a hybrid like Prius is compared to a traditional vehicle like Echo. That is an inappropriate cost analysis omission.

Cost Analysis – Sound

At least a small amount of value should be placed on the quietness of the "full" hybrid system as part of a comprehensive cost analysis. That fact that the engine will remain motionless at times and the fact that brushless electric motors are silent makes a hybrid like Prius extremely quiet. This is a luxury feature, often overlooked. It can also serve as a safety benefit, since noisy children and people speaking on cell-phones are sometimes not attentive enough to notice traditional vehicles. With a hybrid so quiet, the driver is more likely to notice them.

Cost Analysis – Feel

An extremely common misunderstanding among reviewers of Prius is that the hybrid felt slow. That feeling is the result of the device that allows the gas engine and two electric motors to interact, a Planetary-CVT. It is used in place of a transmission. But since the components within are permanently engaged and there are no gears, the feel is extraordinarily smooth. So if you don't look at the speedometer, you get a false impression that the vehicle is not accelerating quickly. Those purchasing luxury vehicles seek out that type of smoothness. So when a cost analysis is performed, that hybrid benefit should be accounted for.

Cost Analysis – Long-Term Considerations

Since when is taking the price of gas today a smart approach for the cost analysis of a vehicle? Countless media reports have though, and all of them from before 2005 are now grossly incorrect. The price increased dramatically since then, so all of that negative press about hybrid being cost-effective was wrong. You have to take the entire lifetime of a vehicle in consideration. That means a minimum of 9 years. Thinking the price won't ever increase by 2015 is totally unrealistic.

"Full" hybrids like Prius offer an unexpected benefit that is rarely ever included when talking about the long-term. Even though the battery-pack was designed to last the entire lifetime of the vehicle, some owners may later consider an aftermarket upgrade. An option to increase performance on that magnitude is impossible for a traditional vehicle to compete with. Just imagine how much more powerful and less expensive the battery-packs could be years from now. After all, the computer industry is absolutely desperate for a better battery, so they are investing fortunes into research to develop one. That effort, along with what the automotive industry is investing in, should make it a reality someday. "Full" hybrid owners will be able to take advantage of that, long after their original purchase.

Cost Analysis – Saving Gas

How come when someone chooses an automatic transmission they don't expect there to be a savings? They gladly accept the lower efficiency compared to a manual transmission for the sake of not having to shift gears themselves. That is worth paying for. Why isn't saving gas? Using less gas is an undeniable benefit to both the environment and our national security. Why do some people insist that consumers are not willing to contribute even a small amount of money toward those causes, by instead wanting to get that entire cost of the hybrid option back from spending less at the pump?

The ever-increasing demand for oil is causing supply shortages. Hurricanes and political instability is making the supply problem even worse. That has contributed significantly to the high gas prices.

Myth – Accelerate Slowly

To the surprise of many, you don't have to accelerate slowly to achieve great efficiency in a hybrid like Prius. In fact, if you do, the resulting MPG will actually be lower than just driving normally. This is counter-intuitive, not at all the impression given from observing consumption screen on the Multi-Display. Yet, it is true. When you accelerate quicker ("brisk" is best), the faster running engine causes the generator motor to create lots of electricity… as you can observe on the energy-monitor screen. This feeds the other motor for thrust and recharges the battery-pack at the same. The result later, after that electricity is finally used, is a MPG higher than if you had just accelerated slowly.

Myth – Plugging is Needed

It's hard to believe that some consumers still think that all hybrids require a plug to recharge their battery-pack. They don't. Regardless of the type, each has the ability to drive its entire lifetime without ever being plugged into an electrical outlet. A few prototype models do offer a plug, but even with them it is not necessary to use it. Through the use of both regenerative braking and recharging via the gas engine, enough electricity is created to always keep the battery-pack from ever being depleted entirely.

Myth – Battery-Pack Replacement

This should never be necessary. The system is designed to carefully protect the battery-pack, preventing the charge-level from ever dropping below the mid-range minimum (40 percent). The "full" hybrids are especially persistent about this, generally keeping the level much higher (close to 70 percent). It's how the "lifetime" claim can be made.

Deep discharges (almost completely empty) are what shorten the life of a battery. People often allow that to happen with their rechargeable devices, which is why they end up having to do a replacement later. They don't realize that not allowing that will save them money. Automaker do, so they made sure the hybrids would behave accordingly.

Myth – Accident Danger

When the air-bags deploy, both the supply of fuel and electricity are automatically severed. In fact, you cannot just drive away afterward without manually first pressing a button in the back of the vehicle to re-engage the supply. That button is proof that accident safety was carefully considered when the hybrids were designed. Additional proof is the appearance and location of the wires. They are no where near any of the doors. The brightly-colored orange wires are underneath the floor in the center. Rescue workers can cut through any door or even a window-area without any fear of coming in connect with them.

Myth – EPA Estimates

Most people are under the impression that those large numeric values displayed on the window-sticker represent the MPG that the vehicle will actually deliver in real-world driving conditions. That belief is a serious misconception, one which has misled countless consumers.

Reading the fine-print on the window-sticker, you'll notice those values are just the average of a widespread efficiency range. The reason for this is that the tests performed to measure efficiency are not actually representative of how people really drive a vehicle. They are nothing but standardized maneuvers designed to provide a basis of comparison among other vehicles within the same size classification. That's it. They were never intended to be used for MPG calculations.