http://mb-soft.com/index.html

This was created in 2006 & updated in 2011 by C. Johnson, Theoretical Physicist, Physics Degree from Univ of Chicago. A lot of his predictions have come true by 2018.

Electric Cars

Battery-Powered, Hybrid Cars and Hydrogen-Powered Vehicles

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- The **IDEA** of electric-powered vehicles is an attractive one. It is a concept which has been pursued for over a hundred years. Unfortunately, as of yet, it is not remotely practical or economically beneficial.

- Battery-powered vehicles (and future Hydrogen-powered vehicles) consume no fossil fuel during driving and they produce extremely little pollution.

- However, batteries contain no energy of their own and they must be CHARGED in order to contain any energy. Similarly, Hydrogen does not exist naturally and must be extracted from other chemicals, such as from water by electrolysis.

- **There is a scientific Law called the Conservation of Energy, which is also called the First Law of Thermodynamics.**

- If someone claims to have tremendous increase in gas mileage due to some concept such as being a Hybrid, they must explain WHERE the additional energy allegedly comes from! A hybrid vehicle is one where gasoline must be burned to power an engine to drive alternators to charge batteries to drive motors attached to the wheels, and to claim that this arrangement somehow has magical results, is simply not logical because at some point, gasoline has to get burned up to provide ALL the energy used! People talk about Hybrids as though they magically create extra energy, NEW energy, which simply cannot happen by the laws of science! Below, we discuss the advantages and disadvantages of Hybrids, to see just how significant

an advance they actually are, and more importantly, WHY. **They DO have some advantages,** but those advantages are not quite as spectacular as people seem to think!

- Except in the case of hybrids, where gasoline is burned to charge the batteries, in other words, **Electric vehicles and future Hydrogen-powered vehicles, this all results in SOME OTHER source of energy to be required to have to provide all the energy that either batteries or hydrogen could later release. Currently, that energy is always electricity, and for EVs that electricity always comes from the electric power distribution grid.**

  A real problem exists in that the US generates 51% of its electricity by burning coal in distant powerplants. That coal is a fossil fuel which releases 2.93 pound of carbon dioxide and other pollutants into the atmosphere from each pound of coal burned, which turns out to be in rather large quantities. Unfortunately, all electric power plants (coal-powered, nuclear-powered, petroleum-powered or natural-gas-powered) are all only around 32% efficient. Then the Power Grid has many additional losses which drops the delivered electricity to our houses to around 13% of the energy that was in the coal. **Each kiloWatt-hour of electricity that you use at your house required around two pounds of coal to have been burned and therefore around 5.86 pounds of carbon dioxide sent into the atmosphere.** This is NOT a "personal opinion" but a group of well confirmed facts. As a scientist and as a human, I LOVE the idea of the possibility of future electric vehicles, possibly powered by sunlight or wind-power. So none of this is described to be mean-spirited to EVs or hybrids, but instead simply to provide HONESTY to the people who spend a lot of money to buy such vehicles. So in case you personally decide that these statements are wrong, wrong, wrong, then go to your local Public Library and either confirm or deny these statements being true. There is no need to send nasty notes to me, because I would LOVE to be able to say wonderful things about both EVs and Hybrids, and that may someday be possible!

- **Such an EV or hydrogen-fuel-cell-powered vehicle might SEEM "Green" if the charging is not considered, but charging from conventional electricity supplies causes these vehicles to be far WORSE than the gasoline engines they replace!** We will see below that the Chevy Volt contains a battery-pack that requires 16

kiloWatt-hours of electricity to fully recharge it. Because of the way that wires and battery chargers and batteries work, this process needs around 32 kWh of house electricity (through your meter) to be used to provide the 16 kWh of electricity that can get stored in the Volt battery pack. Note that this means that around (32 * 2 or) 64 pounds of coal had to get burned at that distant powerplant to produce that amount of electricity and that therefore 64 * 2.93 or **around 185 pounds of carbon dioxide is necessarily released into the atmosphere (at that electric powerplant) each time a Chevy Volt battery pack is re-charged!** For comparison sake, that is more than **ten** gallons of burned gasoline releases into the atmosphere.

- **Everyone seems willing to ignore this factor because it occurs at a distant electric powerplant where we do not see it happening!**

- Due to these various issues, a darkly humorous situation arises! We certainly know that when a gallon of gasoline is burned in any vehicle, 18.3 pounds of carbon dioxide is released into the atmosphere (standard thermodynamics) (to travel maybe 30 miles on that one gallon of gasoline). Everyone is upset at that number. But the TOTAL effect of electric vehicles is actually FAR worse, causing at least 150 pounds or 185 pounds of carbon dioxide to have to be released into the atmosphere instead of 18.3 pounds!

  The promotional information for the Chevy Volt say that the car can go around 30 miles before the gasoline engine having to start, meaning fully discharging the battery-pack. We just found (with all the complete calculations presented below) that the distant electric powerplant will release more than 150 pounds of carbon dioxide into the atmosphere (to go that 30 miles) so the original **gasoline engine (boo, hiss) which releases 18.3 pounds of carbon dioxide is replaced by an electric vehicle which SEEMS absolutely GREEN but which actually causes at least 150 pounds of carbon dioxide to be released from coal!** **Someone needs to explain to me how that represents being GREEN!**

- The electricity used in Hybrids is created by an alternator driven by a gasoline engine, using gasoline to do it. (as discussed below). Think about this! Instead of burning gasoline in the engine to turn the wheels directly, the gasoline is burned in the engine to turn an alternator to produce electricity which is then put into batteries,

where it is then later used to send to electric motors, which then turn the wheels. Now, if all those mechanisms and processes were perfectly efficient, fine, there would be no disadvantage of the complicated sequence, but they all have efficiencies which are well below 100%! Adding in lots of extra processes is NOT really beneficial! **The very fact that the SAME gasoline is the initial source of chemical energy, and the SAME mechanical turning of the wheels is the final goal,** makes this all somewhat bizarre. However, Hybrids DO have one real advantage, in that the gasoline engine can run at essentially constant speed. Normal driving involves the engine running at very different speeds, from idling to flat out, and the Physical laws do not permit devices to have excellent efficiency over such wide ranges of speed. It is amusing that you will hear people tell you a hundred different reasons of why they think Hybrids are spectacularly more efficient than gasoline engines, and they are virtually all totally wrong! Just the fact that a gasoline engine has to run in either case should be a clue. IF it can always run at whatever speed where it has maximum efficiency, fine, there can be a real advantage. That is rarely the case in what those "experts" describe!

And manufacturers and even the EPA seem willing to ONLY evaluate Hybrids WHILE the batteries are fully charged and are discharging, where they then can claim really impressive mileage figures. I guess that is not ABSOLUTE deception of potential buyers, but it certainly seems pretty close. Look carefully at TV commercials. The commercials USED TO say ACTUAL TESTED RESULTS numbers done BY the EPA (for both highway and city driving). It is quite different today! The commercials now all refer to ESTIMATES, and interestingly, the EPA did NOT come up with those numbers. If you look into this matter, you will find that THE MANUFACTURER PROVIDED THE EPA with the estimate number! And NO ONE SEEMS TO HAVE EVER CHECKED THEIR HONESTY! It appears that today, the EPA TRUSTS the manufacturers to provide accurate numbers! Really amazing! I used to see TV commercials which claimed that hybrids were ESTIMATED as having 125 mpg mileage, and more commonly, numbers around 60 mpg or 70 mpg. Maybe someone complained, as most TV commercials for hybrids now seem to claim around 40 mpg. But even that might change as a Federal Judge recently awarded a woman driver a significant monetary award for

having been mislead into believing she would get very high gas mileage from the hybrid she had specifically bought for that reason. Apparently, she did a great job of documenting all the gasoline she bought where the Judge accepted her numbers of actually having gotten mileage in the 30s range of mpg. THAT is the first really honest and credible number I have yet seen regarding hybrid performance. (A related overlooked aspect is that hybrid vehicles tend to have rather small and low-powered engines and where the vehicles are also fairly small and light, where such vehicles get better gas mileage simply because of having less Aerodynamic Drag and Tire Drag!)

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In general, web-pages tend to be composed by people who consider themselves to be 'EXPERTS'. They often have no greater claim to being an 'expert' than their own opinion of themselves! They rarely seem to have the appropriate College Degree that might support such a claim, and they are rarely considered to be an expert by the thousands of people who DO have such College Degrees. In any case, this then seems to inspire the 'expert' to make many ASSUMPTIONS which are not actually based on any solid science or facts, and to express their own PERSONAL OPINIONS which they then present as being actual facts.

The presentations in this Domain are rather different from that, in generally being based on universally respected texts, such as the *Handbook of Chemistry and Physics* and *Mark's Standard Handbook for Mechanical Engineers*, and the author of these pages received a Degree in Theoretical Nuclear Physics from the University of Chicago. You might therefore notice some significant differences in the presentations in this Domain. These presentations tend to drive many visitors crazy by extensive equations and mathematics that support statements made in the text of a presentation. These presentations also tend to include a LOT of the logic and documentation for the statements made.

We see this as extremely important, to enable our visitors to recognize the difference between the actual Scientific Method and what is commonly claimed to be science. Our hope is that some young people might choose to pursue careers in science (or Technology) and we want to make sure they can tell the difference, regarding having a productive and successful career in a scientific field.

This presentation was first placed on the Internet in April 2006.

First, it will be WONDERFUL if and when battery-powered vehicles and/or hydrogen fuel-cell-powered vehicles become economically practical. Neither seems very likely during the next thirty or probably fifty years, until and unless some great breakthroughs are found in energy production. Maybe YOU might come up with such a concept some day, but in order to do that, you FIRST need to completely understand the many subjects mentioned and discussed here.

For the record, in the year 1900, there were around 2300 automobiles that were registered in Boston, Chicago and New York City. Only 400 of them were gasoline-powered, while 800 were electric (battery-powered) and 1170 were steam-powered! Electric cars are NOT a recent invention! In 1899, an electric car set a speed record of 66 mph, which few modern electric cars could match! Most electric cars of that time could go about 50 miles before their many batteries needed to be re-charged, and most had top speeds of around 30 mph. Electric cars were manufactured in significant quantites in the US until about 1930.

It IS true that millions of really smart people come up with wonderfully innovative ideas regarding a thousand aspects of the energy situation. Some are dumb ideas, but many are brilliant. IF there were only a few thousand of us humans around, then those ideas would be able to provide excellent solutions to all of our problems! Unfortunately, there are a LOT of us!

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We see very impressive demonstrations for Reporters of all sorts of ideas. The demos work! The real purpose for the majority of those demos is NOT to show a sellable product. The inventor had spent a good deal of money to create that demo, with the specific point of trying to inspire INVESTORS to see an impressive demo and immediately want to give them a wheelbarrow full of money to improve the concept! Have you noticed how FEW of those magical breakthroughs that you have seen promoted in nightly news have ever actually become products? That is mostly because any investor who has billions to invest also has advisors who are VERY careful about what they give their money for, and if the advisors do not see it actually becoming what the (dream-filled) inventor claims it can or will, it disappears and a DIFFERENT idea gets the public's fancy for a while.

It is certainly true that electric motors have some tremendous efficiency advantages over the common 21% (thermal) efficiency of most cars on the road with internal combustion engines! But, unfortunately, the REST of the picture involves devices and technologies which are not as efficient as the electric motors themselves, specifically the batteries and the methods of charging them.

Sadly, "battery-powered vehicles" and future Hydrogen-powered vehicles, will likely NOT be the wonderful "energy solution" that people think they will be! At least not for twenty or thirty or fifty years. People think they are "really efficient" because of no exhaust, etc. **That's true, IF**

you only consider the car itself! (This also applies to the electric operational aspects of hybrid cars.)

People, including the so-called experts, seem to be overlooking a central concept! **A battery does not MAKE any electricity, it merely stores it.** However much energy or work or power you want to get OUT of a battery, must first get put INTO the battery! This is simply stating a long-known fact in science called the Conservation of Energy (also called the First Law of Thermodynamics)! In other words, batteries are not FUEL like petroleum or natural gas or coal. They actually have no fuel at all, and are instead simply STORAGE devices. Hydrogen is actually much the same, as there is no existing supply of hydrogen gas; it must be produced, such as by the electrolysis of water (which requires a LOT of electricity again, very similar to the battery situation). ALL promotional displays show performance with fully-charged batteries to impress everyone, and they often show a "simplicity" of plugging the car into house electricity, but they neglect to note just how much electricity that car is going to suck out of the house wiring! We will calculate that below.

Added note, August 14, 2010: A television interview on a program called First Business just provided the FIRST glimpse of honest information regarding battery powered vehicles that I have seen admitted to the public! The expert admitted that only about 7 miles added range occurs for each hour of re-charging in a home garage from a 120 volt, 20 ampere electrical outlet. Around here, electricity costs around 15 cents per kiloWatt-hour (nearly half of which is often Delivery fees, assorted taxes and other fees). Therefore, in one hour, of using 120 * 20 or 2400 Watts, or 2.4 kW, the electric meter reading increases by 2.4 kWh. At 15 cents per kWh cost, that means that about 36 cents gets added to the house electric bill each hour. This is to get seven added miles of range. Some simple math shows that to get 70 miles of range, the electric bill increases by $3.60. That is NOT that much better than the cost of gasoline for a similar small vehicle that can get 40 mpg!

Certainly, some people WILL buy $40,000 SMALL electric cars like the highly promoted GM Volt. Will those owners still be thrilled to have limited acceleration and moderate top speed and still have to be paying nearly as much for electricity as they did for gasoline? Some will, of course, but I suspect that many will not.

(Another added note, early in 2012: General Motors has announced that they are shutting down the production of Chevy Volts and laying off many workers because there is so little demand for the very expensive Volt vehicle. Sure, wealthy people will still buy them as a way to brag about having state-of-the-art toys, but it is hard to see many wealthy people be willing to spend much time actually in such a tiny vehicle!)

There is actually a far darker aspect of electric-vehicles, that make them downright a rather dumb idea! Owners brag about being GREEN when spending a lot of money for such a vehicle. In a darkly amusing way, they are not! We briefly mentioned this above, that the DISTANT ELECTRIC POWERPLANT that made the electricity you receive at your house, probably burns coal to make that electricity. We provide the numbers here, which you can confirm, that electric vehicles are MANY TIMES LESS GREEN than gasoline vehicles are! Sort of funny, eh? People who drive electric vehicles (indirectly) cause distant electric powerplants to generate

and release at least SEVEN TIMES AS MUCH carbon dioxide into the atmosplere. And yet the owners are always ignorant of the fact that they are NOT remotely GREEN in driving such a vehicle!

The same expert pointed out on that TV interview that hybrid vehicles have been aggressively sold for more than ten years already, and still only 3% of vehicles on the road are hybrids. I think he was suggesting the same as this presentation has long indicated: IF Hybrids really had the magical advantages that salespeople have always claimed, shouldn't they then have nearly taken over the entire market by now?

There is so much political insistence on battery-powered vehicles and hybrids and future hydrogen-powered vehicles, that leaders have chosen to intentionally mislead the public! It might not be actually illegal to ignore negative aspects of products that are sold, but it certainly seems unethical!

Watch the TV commercials for the Chevy Volt electric car. They bragged that it would be able to go 40 miles (later reduced to 30 miles because they found they can't provide the 40) before ever needing its included gasoline engine to start up to recharge the batteries. They ONLY ever talk about starting out with FULLY CHARGED batteries, and about discharging them to provide the power to move the vehicle that 40 (30) miles. They NEVER mention the necessary fact that EXTERNAL power has to be provided from somewhere to re-charge the batteries! In fact, in interviews, the Executives of General Motors showed amazing attitudes and apparent lack of knowledge regarding the central subjects! **It was NOT an Engineer that dreamed up the Volt, but an Executive with NO expertise in the needed areas! He simply THOUGHT that since most drivers drive less than 40 miles in each round trip, he THOUGHT it would be a great idea to create a vehicle that could go 40 miles without needing any fuel!** His interviews seemed to sound like he believed in the Tooth Fairy to re-charge those batteries, and that the ONLY thing GM needed to still do was to improve the performance of the batteries! The GM top executive even described their advanced battery packs as having 16 kiloWatts of capacity. Apparently, no GM Engineer ever told him that CAPACITY (or energy) can only be described in kiloWatt-HOURS, which is a unit of energy. To describe ANY battery as having a CAPACITY of 16 kiloWatts is simply meaningless and a statement that shows ignorance of basic facts. (For their information, KiloWatts describes POWER, which is the RATE at which electricity or other energy can be put into or taken out of a battery or used!) These are "facts" upon which GM is intending to base the entire survival of their company??? Wow!

But their commercials are like all others for electric/battery-powered vehicles and also hybrids, an IMPLIED assumption of that Tooth Fairy to re-charge the batteries when no one is looking! As if FREE energy and power can somehow be available by some hocus-pocus.

There is another REALLY important fact that the Volt spokesmen never mention! In YOUR car, you only push your battery hard for a few seconds each day, to start it, and other than that, the engine and alternator provides most of the electricity for your lights and everything else. **STILL, every three or four years, YOU HAVE TO BUY A NEW BATTERY!** In electric cars, the technology is too complex to allow you to get in there and replace just one or two batteries that might fail! When ANY of the thousands of component batteries fails, your car will be dead until

YOU BUY a new $8,000 battery pack for it! **Very few people in the industry expect owners to be able to go more than three years before having to replace the battery pack! So set aside an additional $8,000 for a replacement battery pack,** and hundreds more for the GM Technicians to install it, every two or three years! As long as you do not KNOW about these sorts of details, the overall concept looks attractive, doesn't it? But do you really want to spend $40,000 to buy a rather small car, and then have to be expecting to pay $8,000 more for replacement batteries every two or three years? (The Tesla battery pack contains 2300 individual batteries, all very exotic and not really very well tested regarding long lifetimes under heavy usage. Can we expect that GM will be straight with us about their lack of knowledge on how long their Volt's battery pack will last? I wish we could but I have doubts, especially since they have avoided saying much about their batteries at all, except when they brag how far the little car will go on their battery pack. And even that, a constant insistence of 40 miles was discovered to only actually provide around 28 miles in their actual vehicles! And so GM has made hundreds of tiny aerodynamic tweaks to the Volt's body, to try to improve the reality to be closer to what their claims had been! Still, all those billions they have spent on promotion of the Volt will be wasted when the first news reports occur where someone with a Volt either was in an accident where the battery pack exploded or caught fire, or that any of the thousands of component battery cells fails and the owner finds himself expected to pay GM $8,000 for a replacement battery pack. Think about this! WHERE ELSE can that owner go than to give GM $8,000? Or have a lawn ornament that looks like a little car?)

Another fact to be considered is that GM has admitted that it does and will cost them around $40,000 to build a Volt which they feel they can sell for $40,000. **NO PROFIT!** And they expect to make their company stable with that sort of thinking?

There is another important fact that is always presented in a very misleading way!

Peak Power Rating vs. Average Power Rating

You may drive a car which was advertised as having a 495 horsepower (370 kW) engine, and that may have even affected whether you bought that specific car. That engine rating can be called a PEAK POWER RATING, being the greatest amount of power that it is capable of producing. When creating that enormous amount of power, it is realistic to expect to get around one or two MPG gas mileage. But for AVERAGE driving on an Interstate Highway, your engine only produces around 40 horsepower (30 kW), during which you may get 25 miles per gallon gas mileage. This AVERAGE situation is a far more accurate description of what YOU CAN ACTUALLY EXPECT, such as regarding gas mileage. Both situations are true, but they are extremely different. One is a situation which sounds very impressive, but which you will likely NEVER actually experience, except possibly rarely for a second or two at a stoplight! The other is a situation which you may experience every day of driving! IF you were only given ONE of the numbers, which would you consider more important to know?

Whenever electricity ratings are given for alternative energy devices, they seem to always be PEAK

POWER RATINGS, meaning the greatest amount of electricity or power which can be created. That is entirely different than ratings for AVERAGE USAGE CONDITIONS, which would be realistic numbers of amounts of electricity or power which might NORMALLY be expected to be provided. The discussion and calculations included here will indicate that OFTEN the realistically expectable amounts of electricity or power is only around ONE-TENTH that of the PEAK POWER RATINGS. But no one bothers to mention this important fact! So advertising makes claims of spectacular performance numbers for photovoltaic solar-electric panels, and for solar roof panels, and for electric vehicles, and for Hybrid vehicles, and for windmill-electricity-generation, and even for FUTURE giant windmills and hydrogen as a fuel. They invariably state PEAK POWER RATINGS, like that 495 horsepower engine in the car, numbers that may be technically true but are extremely misleading. A TV commercial could easily be aired that stated a true fact that a Corvette has a MAXIMUM SPEED of over 160 mph, but that statement would be rather misleading, as essentially no Corvette drivers would ever be able to confirm that fact!

Fuel Mileage Claims and Horsepower Claims

The big V-8 engines used to be tested by the government and the ratings of 390 V-8 engines used to often be around 220 horsepower, and only engines with exotic camshafts and other tweaking were ever described as much more than that. Such engines were in vehicles which weighed more than 4,000 pounds, even up to about 5,600 pounds for the big Cadillacs of the late 1950s, and as a result, they tended to get average gas mileage of maybe 12 miles per gallon. But gasoline was then very cheap (on sale it was sometimes 17 cents per gallon in the 1960s!) so no one cared about poor mileage. During the 1960s, so-called Economy cars were sold because some people became concerned about environmental issues, etc. Such vehicles tended to have four-cylinder engines of around 150 cubic inch displacement, but since the vehicles was much lighter, often around 2500 pounds, they were only moderately wimpy as to performance, and they were tested by the government to have gas mileage of as much as 20 mpg.

The buying public is fickle and by the late 1960s, a number of Muscle-cars were sold, then in the 1970s, Economy was again popular, and so forth. But an interesting detail was that the Political power of the giant auto manufacturers got the government to change the formulas regarding calculating horsepower. The engines did not really change, but engines that had been officially Rated at 200 horsepower suddenly became rated at maybe 270 horsepower! A Physicist does not like it when politicians do such things, but everyone in America now thought they were getting much more powerful engines in their cars! A change which WAS made was in lightening the vehicles, where cars which previously weighed around 4,000 pounds now often weighed around 3,500 pounds. The effect of that was to have the car have significantly higher acceleration from stop lights! NIT because of additional power, but instead because of Newton's Laws and F = m * a! Reduce the weight (mass) a lot and the same Force (Power) can create more Acceleration.

Later still, the government stopped doing any testing, and they decided to TRUST the vehicle manufacturers to determine horsepower ratings and gas mileage numbers, which then became

called ESTIMATES in all advertising.

Granted that there HAVE been many incremental improvements in engine design in recent decades, but the Laws of Physics still apply!

Modern (2012) advertising tends to brag about Mileage Estimates of 30 mpg or even 40 mpg. But in extremely fine print, they note that the engine they are describing is 1.2 liters (72 cubic inches) or 1.6 liters (96 cubic inches) or 2.0 liters (120 cubic inches). The giant 350 cid or 427 cid engines sucked down the gasoline, while engines which are 1/6 as big in piston displacement CAN get much higher gas mileage. But there are unspoken details. The impressive numbers of 30 mpg or 40 mpg ARE possible, but only if you drive in a very restrained manner! Those new (tiny) engines ARE able to wind out to impressively high REVS, where they can sound like a Dentist's Drill, where they might create the horsepower claimed, but under those conditions, the gas mileage is far lower. No free lunch!

So the LANGUAGE is now rather different than it used to be. A giant V-8 engine running at 1600 rpm made a throaty growl and had impressive available torque for acceleration, even for a 4,000 pound car. A modern 2.0 liter (120 cubic inches) four cylinder engine running at 2,500 rpm makes a lawn-mower sound but also has extra torque for accelerating a 2,200 pound car. Are they the same? Not to me! But the point here is that evaluating big old V-8s and tiny new four-cylinder engines involves two rather different languages, even though the Physics is still the same. With the tiny modern engines, IF you run it at some specific rpm, you CAN get impressive mileage, but no advertising ever mentions that fact. The giant old V-8s had such large pistons that they were not very fussy regarding any precise engine speed, even without computer control. The point here is that in order that manufacturers not get sued too much regarding false advertising, they find the ideal situation to be able to achieve the very best fuel efficiency that particular engine could ever achieve. And they do other test runs where the engine produces the absolute maximum horsepower, again for advertising purposes.

It all makes me wish for the days when the government used to actually do the testing on cars and engines, where the numbers created were not BY the manufacturers themselves. But I guess those days are long gone, and manufacturers are now free to be 'optimistic' about the performace of their products.

It is necessary for us all to recognize something the first Law of Thermodynamics taught us, that energy cannot be either created or destroyed. If anyone ever tries to tell you something where MORE energy appears than there originally was, there is something very wrong! Essentially, whenever you hear of anything that sounds fishy, it really makes sense to try to confirm or deny the statement. So when commercials or spokespeople make claims that seem outrageous, check them out if you can! This presentation is intended to help provide you with the background to do just that!

We might also briefly look at some very basic Engineering involved (for which we provide the equations and calculations both late in this page and in the one on Physics of the Automotive Engine). Unless you have an 80-mph tailwind, when you travel down a highway, you must push

air out of the way, which is called Aerodynamic Drag. It is dependent on the shape and size of the vehicle and also the speed, and at 60 mph, it is rare that it is below 100 pounds of drag force. (My aerodynamic Corvettes have around 117 pounds Air Drag at 60 mph). There is also Tire Drag, which is partly due to friction with the road but more due to the flexing of the sidewalls of the tires each time they rotate. This is difficult to get below about 30 pounds for a normal car. (My Corvettes have around 48 pounds Tire Drag [at 60 mph].)

So at the very best we can expect, an economy-sized vehicle is likely to have a total drag of around 100 + 30 or 130 pounds (Corvette = 117 + 48 = 165 pounds) Total Drag. This number gets multiplied by the speed (in feet per second, here 88) to get 11,440 ft-lb/second (Corvette = 14,520 ft-lb/sec). One horsepower is 550 ft-lb/second, so this is 20.8 horsepower (Corvette = 26.4 hp) of ACTUAL power used to move the vehicle (at 60 mph). A horsepower is equal to 746 Watts, so can say that 15,500 Watts of power (Corvette = 19,700 Watts) MUST be used to ACTUALLY MOVE that vehicle at that 60 mph speed. To travel 40 miles at 60 mph on an Interstate Highway, that requires 2/3 hour. Therefore, the economy-sized vehicle would USE UP 2/3 hr * 15,500 Watts or 10.3 kWh of energy (Corvette = 13.1 kWh) for that 40-mile trip. When anyone tells you that they can get highway speeds with virtually no power usage, you can see such claims simply defy the laws of nature and science! (These numbers are ACTUAL REQUIRED USAGE, and since all mechanical and electrical devices have losses, the actual energy needed from batteries is necessarily higher. You can see that IF that GM Exec had properly described the 16 kWh energy storage capacity of the proposed Volt battery pack, it would be about right for a COMPACT car. It would NOT be enough for even a very aerodynamic larger car like a Corvette, which would require around 20 kWh of battery storage for that CONSTANT-SPEED 40-mile trip at 60 mph!)

It is important to note that we have not even mentioned any motors or mechanisms at all! All we have calculated here is the ACTUAL power loss that is REQUIRED to move a vehicle, and all of which then turns into heating of the air and of the tires and of the roadway.

Any actual motor, whether gasoline or electric or even a fuel cell, also has LOSSES in its operation, so the ACTUAL amount of power that must be created and provided must be higher than we just calculated. Again, confirming that GM Engineers had properly understood that they would need to design a battery-pack with around 16 kWh storage capacity for their proposed 40-mile range.

You will certainly notice that virtually all demos of electric vehicles are done at SLOW SPEED. You now know why! At half the speed (30 mph) the Aerodynamic Drag is only 1/4 as much (25 lb Air Drag) plus the Tire Drag (still 30 lb) or 55 lb Total Drag, which is about 40% of the Total Drag at 60 mph, and it is then only necessary to provide far less electricity to make it perform as Reporters are expecting to see. Makes for very impressive demonstrations, but they are therefore somewhat deceptive in the process.

In any case, when you see people on TV claiming highway speeds and ridiculously little electricity used, the first likelihood is that they have never yet actually done it, and they are simply trying to get some media attention so that rich people would give them money! But if they DID do a high-speed demo, try to find out if it was only one mile or whether it was the sort

of trip that you have come to expect! **Be observant, and ask questions!** This presentation is intended to give you some facts to work with on that!

Oh, if GM is ever able to actually mass-produce the Volt, and if they decided to be even more deceptive, there IS a way to LEGALLY CLAIM a spectacular range! If they charged a Volt's batteries to contain their 16 kWh, and take that vehicle out to one of their Test Tracks, and have an Independent Observer Certify what is done, they could drive that Volt at 3 mph! Why? At 3 mph, the Aerodynamic Drag is only 1/400 of the 60 mph drag we just calculated above, (proportional to the SQUARE of the velocity) or 0.25 pound! Tire Drag turns out to be the greatest loss at really low speeds, but if the tires are filled to 90 PSI pressure, even that can be reduced to maybe 1 pound, so the Total Vehicle Drag would be 1.25 pounds! As before, we multiply this by the velocity (4.5 ft/sec) to get 5.6 ft-lb/sec, which is around 0.01 horsepower, or 7.6 Watts! The vehicle could drive for 2100 hours before discharging the 16 kWh of the batteries! (That is around three continuous months of driving at 3 mph!) The Volt therefore might be able to travel 2100 hr * 3 mph or 6300 miles on one charge of the batteries! **Do you see how incredibly deceptive such a claim would be, even though it could be Certified by an Independent Observer?** As long as they never bothered to mention that they did the test at 3 mph, the claim would LOOK spectacular! And not even be a lie! Unfortunately, many manufacturers of energy-related products do such sorts of things, which makes their solar or wind devices or vehicles appear to be spectacular achievements, and they cannot even be sued for false advertising. It IS DECEPTIVE advertising, but that is allowed in modern society!

Looking at Hybrids First

People who are buying hybrids today seem willing to disbelieve a basic law of science, the Conservation of Energy! When the public is told that a vehicle will go vastly farther on the same amount of gasoline, THINK about this! The electric motor which can move the car "without requiring any gasoline" is somewhat of a deception! Yes, at that moment, it can. But the energy that the electric motor needs to use up necessarily came from batteries that are installed in the vehicle. Those batteries needed to be CHARGED to have the needed electricity. Where do they get that electricity? In an amusing example of circular logic, in most Hybrids it comes from alternators which are driven by the very same GASOLINE-POWERED ENGINE in the vehicle that is implied as being so terrible!

It is as though people believe that just because this is a complicated sequence, that somehow EXTRA ENERGY IS SOMEHOW MAGICALLY CREATED! No, it isn't! Newton and Joule would clearly be disappointed that so many people seem to actually think that they can get and use up MORE energy than was originally in the gasoline!

As an example, we might look at a popular Hybrid vehicle, the Ford Escape Hybrid (SUV). It is heavily advertised as having an ESTIMATED 34 MPG average fuel efficiency, as though the EPA had measured that number. However, when that number is carefully researched, it turns out to be a MANUFACTURER'S ESTIMATE! No one other than Ford has apparently confirmed or denied that number! Let's look at it here!

First, we need to calculate the vehicle Drag, as was done above. The Tire Drag at 60 mph is around 4000 pounds (vehicle plus driver plus gasoline) times 1.8% or 72 pounds. The Frontal Area is approximately 28 square feet, it being 71.1" wide and 68.0" tall. The shape of the vehicle is somewhat blocky, which suggests a coefficient of drag (C_D) of around 0.6 This would give an Aerodynamic Drag at 60 mph of around 28 * 0.6 * 18.6 or 312 pounds. The total vehicle Drag for that SUV vehicle would therefore be about 384 pounds. Note that is more than double the total vehicle Drag of my Corvette!

The POWER needed to keep a vehicle going at a constant speed down a highway is exactly proportional to the total vehicle Drag. In this example, where the Corvette only needs to produce around 26.4 horsepower at 60 mph, this Ford Escape Hybrid has to produce a constant 61.5 hp (that is, 384 * 88 / 550) (46 kW). This is the actual power which must be provided to the wheels, and the many mechanical parts all have inefficiencies which require even greater needed power. It is a confirmation of the facts this far in that Ford includes a 94 horsepower (70 kW) synchronous motor in that vehicle, so that it is able to power the vehicle at normal highway speeds. We will momentarily see that it would be incredibly wasteful to actually do that!

So even being kind in overlooking all the other mechanical losses in this vehicle's mechanisms, we certainly need to create the 61.5 horsepower which must be given to the drive wheels to overcome the total vehicle Drag. We can convert that 61.5 horsepower to another form, 46 kiloWatts, or another, 156 KBtu/hr.

The electricity must be CREATED by the gasoline engine driving an alternator (which CANNOT create 46 kW of electricity, so the vehicle CANNOT drive at highway speeds using only electricity, because the engine and alternator have no way of re-charging the batteries fast enough with that level of electricity usage). The actual alternator installed in such vehicles is generally only able to re-charge the batteries at a rate where a maximum of around 40 mph can be maintained for a long time on electric, hybrid power.

Since the GASOLINE ENGINE must run to re-charge the batteries, and we know that even at ideal conditions, gasoline engines cannot have greater than around 25% overall thermal efficiency (mostly due to exhaust and cooling system heat losses) we can now calculate the likely MPG of this Escape Hybrid at the 60 mph highway speed. Twenty-five percent overall efficiency means that the gasoline engine must consume gasoline at the rate of 156 KBtu/hr/25% or 624 KBtu/hr. A gallon of gasoline contains around 126 KBtu of energy. This means that our Ford Escape Hybrid must necessarily use up 624/126 or around 5 gallons of gasoline in an hour of driving at 60 mph. Since it would travel a total of 60 miles in that hour, that indicates that 60/5 or 12 MPG might be realistically expected!

This has NOTHING to do with anything other than the large SIZE of the vehicle and its BOXY SHAPE, and the fact that the gasoline engine which MUST drive the alternator to re-charge the batteries cannot have an overall efficiency of greater than around 25%.

Isn't that interesting?

Now, IF the vehicle is driven at LOWER SPEEDS, the fuel efficiency performance is MUCH

better! If we did the same calculations for 30 mph, the Drag is only around 1/4 as great and our hour drive (of 30 miles) would only require around 1.25 gallon of gasoline to recharge the batteries, and the fuel economy at 30 mph would increase drastically up to 24 MPG.

For decades, people who have driven large boxy vehicles have KNOWN that they get dreadful fuel economy! I personally drove a 1989 GMC nine-passenger Van, and quickly realized why they installed a 40-gallon gas tank in it! **On the highway, about 10 MPG was about as good as I could hope for.** Again, that was due to the large size and boxy shape of the Van (enormous aerodynamic drag), things that could not be avoided.

So, as long as the gasoline engine must run to drive alternators to re-charge the batteries in a Hybrid, the facts described here cannot be bypassed!

So HOW did Ford come up with their own ESTIMATE of 34 MPG for their Escape Hybrid (which they advertise incredibly aggressively as though it is a reliable number!)? Well, it could have been easy, as long as they were willing to BEND one rule. They certainly STARTED OUT with fully charged batteries! And then, as long as they allowed the batteries to discharge during a "test run", they actually could have created pretty much any MPG rating they might have wanted! The point being, the batteries were certainly totally discharged at the end of such testing, in order to be able to show a 34 MPG (ESTIMATE) fuel efficiency. But twisting the rules further, they could just as easily have shown 50 MPG or 1,000 MPG! My guess is that they felt that 34 MPG was high enough to seem competitively impressive but low enough to not cause doubts about credibility.

SUCH PROPER TESTS MUST REQUIRE that the batteries end up in the same condition they started at in order to have any actual real usefulness. Otherwise, they simply provide numbers that are total deceptions! And ALL the manufacturers seem to do that! And, for some reason, our Government seems willing to allow them to do this deception to the public! I find that disgusting!

People deserve HONESTY when asked to commit to large amounts of money for a product!

The FIRST STEP in the hybrid process is that GASOLINE IS BURNED (absolutely normally) TO POWER THE GASOLINE-POWERED ENGINE! Even if all the following processes were perfectly efficient (and they are not), the BEST that could therefore be accomplished would be to do AS WELL AS the gasoline engine by using the electric motor! But the fan belts, alternators, charging the batteries, discharging the batteries, the electric motor and the gears in its drive train, are all less than perfectly efficient. But the basic operation of any internal combustion engine involves losing large amounts of heat out the exhaust pipe and from the cooling system, and those losses are the primary reason why most modern vehicle engines have only around 21% overall efficiency. (Around 1970, that number was rarely as high as 15% overall efficiency, so great improvements HAVE occurred! But they are still impressively bad!) A major advantage of a Hybrid system is that it can allow the gasoline engine to run at a constant speed in charging the batteries, where the efficiency can be maximized up to around 25%. (In laboratories, the best experimental gasoline engines can operate at around 29% overall efficiency.)

The very fact that the gasoline engine MUST run by burning gasoline in order to charge

the batteries, to provide ALL the electricity the batteries will ever contain and which will ever be used to move the vehicle, means that "burning gasoline" is NOT avoided at all! In fact, it is critically important to the operation of all current hybrids. It is just SEPARATED from actually directly powering the vehicle, so the advertising spin can make it seem like it has no connection at all!

Hybrids DO have a significant advantage though. Normal driving requires a gasoline engine to run at many different speeds, and its efficiency is highest only at certain engine speeds. So Hybrid manufacturers have tested their engines and found the exact best RPM for efficiency, and they have the vehicle computer make sure the engine runs at exactly that speed when it is charging the batteries.

It seems necessary to address here the sorts of subjects that many hundreds of people have dreamed up, and sent me e-mails describing their exciting insights! One very popular idea is where they think that they could mount a windmill on top of their car, and that the high speed of the wind when going down the expressway could generate huge amounts of electricity. Without any mathematical calculations or any Engineering background, many absolutely insist that they have found THE SOLUTION, where they would PRODUCE MORE ELECTRICITY than the car would need to drive down that expressway! I can see why that seems so extremely attractive to so many people, but it is disappointing that they had not paid much attention in High School science classes! They are claiming that the first Law of Thermodynamics was wrong! They think they can use up a LITTLE energy to move the car, and then use that resulting motion of the car to not only get the benefit of that motion, but ALSO collect a LOT of EXTRA energy/electricity in the process! Many hundreds of people have gotten very nasty to me when I have tried to explain to them that what they think will happen, cannot happen! In fact, the reason is quite obvious. It is too bad that they cannot do the calculations regarding energy flow rates! Their giant windmill on the top of their car would cause massive amounts of air turbulence, which is aerodynamic drag. The very PRESENCE of their windmill would cause the total vehicle aerodynamic drag to be far higher, meaning the motor driving the car has to create far MORE power than would otherwise have been necessary just to move the car. The EXTRA power that then is used up by that motor is then the SOURCE of the power which has to provide all the wasted power in all that turbulence and added drag, and also for any power that they could possibly hope to generate.

So, yes, if they put their giant windmill on top of their car, and then drove at 60 mph down the highway, they probably COULD produce maybe 746 watts of electricity (selected here because it is equal to one horsepower), BUT they would likely require the vehicle's gasoline engine driving the car to have to constantly produce an additional TWENTY OR FIFTY HORSEPOWER by burning up gasoline! Their idea would need to constantly USE UP maybe 20 or 50 horsepower, in order to produce ONE horsepower worth of electricity! (I pass on doing that!)

Huge numbers of people seem to think they get magical results from hybrid vehicles in essentially the same way! The way the advertising is worded does not technically lie, but it certainly provides PARTIAL TRUTHS that the advertisers know that most people will

ASSUME has the magical characteristics that they know will sell their vehicles!

It only LOOKS like there is extra (free) power, during the time when the batteries are discharging to power the car! But then at the time the gasoline motor has to produce EXTRA power to drive the alternators to re-charge the batteries, ALL of that power has to be put back into the batteries, much of the benefit gets used up. Just like the first Law of Thermodynamics says!

Hybrids DO have some advantages!

However, most of the benefits can actually be duplicated with standard gasoline-powered vehicles! We will examine the benefits of hybrids now, along with what some other drivers do to accomplish much the same benefits in conventional vehicles.

- The biggest benefit of Hybrids has already been mentioned, that the (gasoline) engine can be run at the exact speed where it operates most efficiently. This benefit really depends on your style of driving, and can be from negligible to significant.
- At stop lights, a Hybrid or Electric Vehicle does not need to have an engine running, so it is not wasting power doing nothing. However, the Hybrid or EV DOES still need to be using up SOME electricity. The brake lights are definitely on, using up a little power. If it is night, then a lot of other lights are also on. If it is a hot summer day, an air conditioner might be running, which uses a HUGE amount of power, so much that the electric system of a Hybrid might not be able to provide it and the gasoline engine might need to be running anyway!

  Instead of keeping the gasoline engine running when stopped at stop lights or in heavy traffic, there are some drivers who have long shut the gasoline engine off! That duplicates one of the largest actual advantages of hybrids, where the gasoline engine is not running when the vehicle is stopped! That behavior causes more wear and tear on the starter system, but that is generally minimal.

- Another advantage is to allow the car to COAST as much as possible. Most States make it illegal to take a car out of gear to coast, but if that were allowed, the other major advantage of hybrids can actually be provided in gasoline-powered cars! It is interesting that Laws exist that say it is ILLEGAL to coast in a gasoline-powered vehicle but that it is perfectly legal to coast in a hybrid or an EV!
- This last has a variation which IS definitely an advantage of hybrids that gasoline-powered cars cannot duplicate, that of Regenerative Braking. The electric motor in a hybrid can act as an alternator when the car is slowing down. It is possible to install a system generally called Regenerative Braking which can create a load on the vehicle drive by causing the motor to act as an alternator to put some electricity back in the batteries. The Kinetic energy of motion of the vehicle is therefore (partially) converted into electrical energy to put back in the batteries, to partially re-charge them.

  Standard cars use up that Kinetic energy of motion of the vehicle by heating up brake discs and brake pads (which is 100% total waste of energy, converting the motion of the vehicle into (wasted) heat energy which is then radiated and convected into the air which

the vehicle is passing.)

The commercials for Hybrids are not even very honest about this matter! Regenerative Braking turns out NOT to be a very efficient operation! It has been used for many decades in Urban Commuter Rail passenger trains. Those trains are constantly stopping and then aggressively accelerating, only to soon stop again, over and over. That is the ideal application for Regenerative Braking. However, even there, only around 30% of the motion energy is recovered. Those systems have a great advantage over Hybrid vehicles in that they can rapidly transfer really huge amounts of electricity back into the electrical supply system of that railroad.

In a hybrid or EV, the amount of electricity which can be captured and converted is tremendously limited by the ratings of the motor/ alternator and the wiring and the control system. In fact, Hybrids CANNOT use Regenerative Braking at highway speeds because of that (there is too much power that would need to pass through the electrical components), and they therefore must have conventional friction disk brake systems which are therefore nearly always used for highway speed driving. Regenerative Braking also stops working at very low speeds (where they cannot create the necessary braking effect on the vehicle), where friction brakes are again necessary. Essentially, if a vehicle is expected to be USUALLY be used in stop-go driving, the Regenerative Braking can be very beneficial. But for vehicles which are commonly on open roads or Interstates, it is essentially of no value at all! The result of all this is that NO ONE seems to have ever actually done scientifically valid testing regarding how effective Regenerative Braking is on Hybrid vehicles in "normal driving"! But there is every indication that only a MAXIMUM of around 15% recovery can be expected in stop-go driving and less than 5% for generally highway driving.

This implies that the CAFE MPG rating of any vehicle should be no greater than around 15% higher IF it is measured during stop-and-go driving (and more if long stop-lights are also added in), but only maybe a 5% improvement for open road and highway driving. That would only mean one or two MPG improvement over identical gasoline-engine vehicles! **It seems that ALL advertising for Hybrids describes ESTIMATES for MPG which are far higher than this. Can't the government find the time to ACTUALLY test them to find ACTUAL MPG ratings?** This reasoning suggests that IF the government CAFE testing (1) required the batteries to be at the same level of charge at the end of a test procedure as at the start; and (2) a highway driving program was used, then the Hybrid mileage CANNOT be much over ONE MPG better than a previous identical vehicle! If (2) is a stop-and-go urban program, including a lot of long stop-lights, MAYBE a 5 MPG benefit might be had.

It also seems to indicate that the vehicle testing for Hybrids must be done for the single situation where they have the greatest benefit, stop-and-go driving. That seems to imply that the government testing has gotten into bed with the Hybrid concept, to make them appear more impressive than their actual performance is likely to be. An average driver certainly does SOME stop-and-go driving, but also does some highway driving. Our government certainly has all the data needed to set up SUITABLE test procedures,

instead of which seem intent on making Hybrids appear bigger than life.

NOTICE that most of the benefits seen really have NOTHING to do with the fact that it is a Hybrid! In fact, if it were not for Regenerative Braking and the fact that no motor activity is needed during long red lights, ALL Hybrids NECESSARILY would have WORSE mileage than a gasoline-powered vehicle would! (Because the gasoline-powered vehicle DIRECTLY drives the vehicle, while the Hybrid uses that same gasoline engine to drive alternators, which charge batteries, which later discharge to power the electric drive motor, which drives the vehicle, a LOT of additional sources of losses along the line!) (This conclusion is somewhat dependent on the driving style of the driver, and certain drivers WOULD have a Hybrid perform better, but other drivers would have the Hybrid do worse that the standard gasoline engine it replaced.)

Yes, a Hybrid or EV captures SOME kinetic braking energy and uses that to partially recharge the batteries, which is a good thing. And a Hybrid can have computer control of the gasoline engine to cause it to run at a most efficient RPM, instead of the wide range of engine speeds which occurs in normal vehicles, many of which are at speeds that have lower efficiency.

The point here is that all the massive publicity of Hybrids is centered on performance WHILE THE BATTERIES ARE DISCHARGING. And the performance can then appear quite impressive.

But because of what the first Law of Thermodynamics taught us, if we evaluate the whole situation after HAVING FULLY RECHARGED THE BATTERIES, the benefits of hybrids are actually rather minimal. If similar hybrids and gasoline-powered vehicles of similar size and shape would travel side by side, whether in traffic or on the highway, and if the driver of the gasoline powered vehicles shut their engines off at stop lights and coasted as was possible, the actual benefit of using a hybrid calculates to be around 1 mpg improvement, and certainly less than 2 mpg, on the highway, and only slightly better than that in stop-and-go driving. That benefit is nearly entirely due to the effects of Regenerative Braking! I am aware that all manufacturers of hybrids advertise very impressive ESTIMATED GAS MILEAGES, which they must be allowed to be confirming while their batteries are discharging. It would defy what the first Law of Thermodynamics knows to be true to be otherwise!

You will also NOT ever see any adverting where an electric car or a hybrid is running very far at night, when all the lights are on. That heavy electrical load pretty much eliminates any benefit whatever of trying to use battery power, since the batteries would quickly discharge UNLESS THE GASOLINE ENGINE WAS RUNNING. (Remember that day when you forgot and left your lights on when you went into a store for a few hours? And the battery was dead when you got back to the car? Think about it!)

You will also never see any advertising where an electric or Hybrid vehicle is running on a very hot day where the air conditioner must be on. In a conventional car, the air conditioner consumes around 6 to 7 horsepower of engine power. (This is again due to long-known scientific laws regarding the amounts of energy needed to accomplish the cooling and dehumidifying of air

conditioning, the Carnot Cycle limits on efficiency, and the Conservation of Energy.) You probably have noticed that when you switch the air conditioner on in any normal vehicle, the engine idle speed immediately jumps up from around 550 rpm to around 850 rpm, so that the engine can then create enough power to keep running to avoid stalling AND to also provide those extra horsepower needed for the air conditioning.

The US government has decided to provide billions of dollars to manufacturers to finance the development of Hybrids and hydrogen-powered (fuel cell) vehicles. Otherwise, it would seem to be really weird to think that private profit-motivated companies would invest billions of their own dollars, to develop vehicles such as Hybrids, which are already starting to disappoint many purchasers. They were BOUGHT based on those amazing claims in commercials, but the ATTITUDES of owners soon become based on their actual experiences. Yes, some drivers will do primarily low-speed, stop-and-go driving, and will make rather gentle stops, which allows the regenerative braking to be much more effective at saving energy, and they might do fewer rabbit-starts from stoplights, so they will have SOME benefit they see. Such drivers might even be satisfied with what they get from a Hybrid. However, they also just spent a lot of (extra) money on a Hybrid, and they really do not want to be considered a fool by their neighbors and friends, so they have a motivation to only say positive things!

But still, how many Hybrids can be sold before the public realizes that the benefits are FAR smaller than all the hype seems to indicate? A million of them? But the vehicle manufacturers probably do not see an additional downside. IF the public comes to believe that THIS manufacturer's Hybrids were not even close to what they were presented as being, will the public then look to THIS same manufacturer for a BETTER future solution? Would anyone believe any future claims made by THIS manufacturer?

We MUST therefore add in the consideration of the "household electricity" that regularly will need to get put INTO the batteries! (This will be done below) **This is noting that vehicles powered by batteries or by hydrogen do NOT actually have any "fuel" on board in a conventional sense.** In both cases, OTHER energy sources (specifically electricity) are simply "stored" in the batteries or in the Hydrogen. There is actually such a small amount of storage possible that even Hydrogen-powered vehicles should be thought of as "being essentially weird batteries!"

The current hybrid vehicles that are promoted so aggressively have very similar issues. Current hybrids do not plug in to an electric outlet, but they get the electricity to recharge their batteries from the GASOLINE used by the engine of the vehicle! No one even seems to admit that! They lead the public into believing that when the vehicle is on battery power, it is FREE energy! Nothing could be further from the truth! **In fact, hybrid manufacturers seem to all be indicating that they intend to make their future hybrids be powered by electricity provided from a house! It seems to me that is somewhat of an admission that the initial design of hybrids was not a success!** Hybrid vehicles DO have some advantages over standard vehicles, but they tend to be rather small in effect, and therefore only moderately increase the vehicle efficiency (noted above). Repeating, most hybrid vehicles have Regenerative Braking, where instead of heating up brake pads with the energy removed from the kinetic energy (motion) of

the vehicle, much of that energy is captured by Braking Alternators (actually the electric motors themselves), so the batteries can re-capture some of the electricity in that way. And where gasoline engines generally remain running at idle at stop lights, using gasoline, battery power does not use any then, as the motor is not being powered. (with the exception of if the air conditioning is running or the headlights are on, where the gasoline motor may need to turn on for those needs.)

It is certainly true that the American public seems willing to fall for every imaginable commercial and promotion that promises them incredible wealth or products for free. It has always amazed me that people really believe that companies are willing to spend hundreds of thousands of dollars in making persuasive advertising, and more hundreds of thousands of dollars every time they are aired on TV or cable, just in order to GIVE the viewers things for free! **Companies are apparently viewed as amazingly generous!** But the reality is that they EXIST for the specific function of MAKING THEMSELVES MONEY! No commercial or advertising ever admits that, and as long as viewers are willing to believe that they are such wonderfully generous companies to give ME things for free, it must be working, else the companies would stop making and airing those very expensive promotions and commercials!

General Motors might be given some slack for trying to find ways to keep its company from going bankrupt, but is it ethically right for their new (mid-2008) commercials for their FUTURE Chevy Volt car (maybe five or ten years, but they claim 2010) to be saying "go forty miles before even needing to use any gasoline." Yes, that will technically be true, BUT ONLY DURING THE TIME WHEN ITS BATTERIES ARE DISCHARGING! At some point, the batteries would need to be re-charged, which necessarily takes a LOT of energy! But the fact that such comments by manufacturers seem to IMPLY "totally free energy is created" causes the public to have extremely incorrect ideas of what to actually expect.

Even reporters riding in Hybrid cars joyously talk about "getting 100 or 1000 miles per gallon or more" while on battery power. That is MOMENTARILY technically true, but such comments simply indicate the ignorance of such reporters! They apparently not only buy into the "totally FREE power when on batteries" but they SPREAD such thinking to the public. How could viewers believe anything different when reporters say things like that? **There is NOT any free lunch here!**

Point: To get a specific amount of "motive power" from a vehicle, an even **larger** amount of (electrical) energy had to be used to either charge the batteries or to separate the Hydrogen from water. (Because there are NO processes that operate at perfect 100% efficiency, and charging batteries, storing electricity in batteries, and removing power from batteries each have significant losses which cannot be eliminated.) **THERE is where a big hurdle is!**

Most people also don't realize the amount of electricity that is needed. And no commercials or salespeople seem willing to ever tell potential customers of expensive products about this little detail!

I happen to own a golf cart and its charger. After an 18-hole round, it fully re-charges in around 8 hours. Doesn't sound bad! The charger draws 9 amps of electricity at 120 volts, or around 1080

watts of electricity. It is true that a kitchen toaster draws more, at around 1500 watts, but imagine a toaster running for eight hours straight! And that is just for a few miles of traveling on a golf course at rather low speeds. Getting the picture?

By the way, people who do not own golf carts do not realize this, but in charging at 1080 watts for 8 hours, I use around 8.7 kWh (1.08 * 8) for a round of golf. Even at fifteen-cent per kWh electricity, that 5-mile drive at low speed around a golf course costs over a dollar ($1.30)! I realize that a golf-cart, and especially an older one like mine, is not the most efficient of electric vehicles. **Still, to see that just to travel (three rounds of golf) a total of 15 miles at the 5 mph of a golf cart, requires more than $3 of electricity, I have to say I see a $3 gallon of gasoline a LOT more convenient!** Especially when that gallon of gasoline can get a far heavier (3 times) small car to travel 30 miles (twice as far) at 60 mph (twelve times as fast!

Note: If in the future, efficient ways of getting electricity from sunlight or wind or other non-fossil and non-nuclear sources develops, the concepts of battery-power and hydrogen-power MAY become practical. The public seems to commonly believe that can be next week! But the reality is probably closer to 50 years! For now, **all the energy that will get put into car batteries will come from conventional fossil-fuel or nuclear-fuel sources.** It just doesn't look like it! This is noting that (commonly available) existing photovoltaic cell technology only is around 7% efficient regarding electricity made as compared to the solar energy that hits the cell. Each square foot of solar energy near noon on a perfectly clear hot summer day can have around 100 watts in it, so a square foot of solar collectors can provide around 7 watts (7% of 100 watts per square foot is 7 watts/sf) for those couple hours around noon.

(This 7% figure is for the most economical technology of solar cells, which is based on Cadmium Sulfide. There ARE higher efficient technologies which exist, such as those based on Gallium Arsenide, but they are far more expensive and not within the price range of most people. There are even more expensive technologies that are based on silicon semiconductor technologies, which require a [metal] silicon ingot to be sliced so thin that sunlight can pass through it, which is extremely expensive to do! (Try to imagine aluminum foil so thin that you could see through it!) So higher efficiencies exist in solar cells, which are reported in media stories, but they are currently far too expensive for broad use. This all results in MOST commonly available solar cells being Cadmium Sulfide, and therefore around 7% efficient.)

NOTE: It has been quite amusing that several dozen people have e-mailed truly vicious notes to me, claiming that I have some sort of animosity toward these technologies where I MADE UP numbers that were not complimentary. Some of those writers were even aware that my Degree was in Nuclear Physics from the University of Chicago, and still they made the most nasty of insinuations about me and my character and my intelligence. Actually, I personally would LOVE any such technology to actually be anywhere near as worthwhile as the promotional advertising always implies. But as a Research Scientist, I have an overwhelming responsibility to the truth and to accurate facts and reasoning. This presentation is intended to neither be a commercial for or an attack on any such

technology, but rather simply an accurate presentation of the facts as known by a Research Physicist.

For the record, there are THOUSANDS of resources that give the numbers for the amount of solar energy which arrives. A good Public Library should have a copy of a set of the (US govt financed) ASHRAE Handbooks, which ALL heating and cooling Engineers use for their primary source of information. ABOVE the Earth's atmosphere, the amount of solar radiation coming toward the Earth is called the Solar Constant, and it is around 1,373 Watts per square meter. Roughly 1/3 of the radiation from the sun immediately reflects back off to outer space (called the Albedo of Earth) which results in around 893 Watts / square meter (average) actually getting to the Earth's surface. Since a square meter is around 10.76 square feet, that means that around **83 Watts per square foot can be expected**. It turns out that there are some circumstances of weather where that amount can be a little higher than that, perfectly clear skies, around noon, near June 21, and with an active tracking system so the panels always exactly face the sun, so I used the GENEROUS figure of 100 Watts per square foot!

So it is rather humorous for uneducated people who know four-letter words to be trying to insult me for using 100 Watts per square foot as though it was some MINIMAL value! Instead, it is a circumstance that RARELY actually occurs, except in deserts! (Such cheap shots from uneducated people are why virtually all other Physicists choose to never communicate with the public. I can see why, and yet I still put up with such treatment just because I believe the public deserves to have some source of information which is reliably true.)

Regarding the cited 7% efficiency of solar panels: As noted above, there ARE some panels which have recently been tested in laboratories to be of much higher efficiency than I cite here. However, they are very exotic and a hundred times more expensive than the (Cadmium Sulfide) PV cells that are generally available to the public. If you have millions to spend, you could buy PV panels that are of 15% or higher efficiency! However, the CURRENT reality is that the panels still commonly available are generally only around 7% efficient. It will be great if and when technology advances to a point where reasonably priced PV panels might be 15% efficient. There ARE an assortment of possible breakthroughs which might enable that, but probably not for at least five or ten years.

CUSTOMERS have no easy way of confirming or denying information claimed by manufacturers. So if advertising would say "35% efficiency", customers would not question it! And the manufacturers KNOW that! In fact, customers tend to believe nearly everything they see on TV or read in the newspaper, based on an assumption that if they were lies, the government would somehow jump on the perpetrators! So the manufacturers and advertisers seem to feel wide freedom to be "optimistic" with their promotional claims! They know that, if in a laboratory, under absolutely perfect conditions, they could achieve a test result of XX% efficiency, they will probably never be sued over such a claim! As a Research Physicist, I tend to be in environments where more restrained information is discussed (where honesty and accuracy are paramount), and I do not recall hearing many references above 7% in such discussions, except regarding FUTURE technologies.

The calculations presented here are therefore based on an optimistic situation of 100 Watts per

square foot solar radiation, and even that gives such low electricity production (using the 7% figure that is commonly accepted in science), that even if that were doubled up to 15%, the total production of electricity still does not become even moderate. Actually, it would make a lot more sense to simply buy twice as many of the cheaper 7% panels than to pay more than ten or more times as much for actual 15% panels! Unless you really like to spend money or you are intent on impressing the neighbors!

The official ASHRAE charts show that for a south-facing area of solar panels, on December 21, at 10am or 2pm, the incoming solar is only around 61 watts per square foot, and at 9am or 3pm, it is only around 46 watts per square foot. Multiply these numbers by 0.07 to get the amount of electricity that south-facing Cadmium Sulfide PV panels can produce. These numbers are not even close to the glowing statements made by salesmen of solar PV panels!

If YOU happen to be one of those people who knows four-letter words, you are free to believe all the impressive things that PV manufacturers and their salespeople will tell you to sell you their products. All I would note that at ANY time other than exactly noon, on any other than a perfectly clear day, you are not likely to get the spectacular performance that they managed to get in their laboratory! But you will not actually have all the advanced equipment necessary to MEASURE that, so then "just believe them!"

The amount of incoming sunlight is much less in the morning or afternoon, as just noted above. And much less on days that are not perfectly clear. If you check with the US Weather Bureau, you will find that the Winter Clearness Ratio is surprisingly low! For Chicago, near where I am, it is published as 34% clearness! Yes, there are OCCASIONAL really clear, really sunny days. But there are also a lot of days that are partially or completely overcast. The performance of PV panels is dependent on a LOT of different effects!

Given all this information, it is possible to mathematically Integrate all the sunlight that can be converted into electricity for an entire day. We have already said around 7 watts/sf at noon, and dropping off fairly rapidly in both morning and afternoon. It is well established that on a perfectly sunny SUMMER day, the many hours of sun and the relatively high altitude of the sun CAN produce around 35 watt-hours/sf in the entire day (for a fixed, south-facing collector panel, tilted at the best angle). In winter, the fewer hours of sunlight and lower altitude of the sun reduces this to a little over 20 watt-hours/sf/day. IF the solar panels were mounted on mechanisms where they could move to always more directly face the Sun during the day (called tracking collectors), these numbers can rise to about 50 and 30 watt-hours/sf/day.

(The salespeople for solar products ONLY mention the noon/perfectly sunny scenario, when their products perform best.) Did you notice that just my golf cart charger requires 1080 watts, and for 8 hours. About 8,640 watt-hours. **To recharge MY golf-cart from solar PV panels, around 250 square feet of PV panels (8,640 watt-hours / 35 watt-hours/sf) would be needed ASSUMING that each day remains really perfectly clear and sunny, but those are good golf days where the cart would be needed!** Just how many square feet of solar collectors do you intend to buy??? **No one seems to have noticed that there is NO ONE who uses solar energy to (completely) re-charge their golf cart!** And the highly-promoted high-tech wind energy is generally available so far away from where it is needed, that massive losses of any

made electricity occur in the very long transmission lines. (The STANDARD ENGINEERING DESIGN for really high voltage powerlines plans for about a 10% loss of the electricity in every 60-mile stretch of a long run.) It WOULD be possible to install a $20,000 windmill (WECS) (wind energy conversion system) to use windpower to re-charge the golf cart, but would that really make economical sense?

Yes, it would/will be wonderful if and when such technologies develop, but there is no reason to think they are anywhere near. Maybe in 50 or 100 years, solar-to-electric might be practical on a large scale. I suspect that then ALL electricity will be LOCALLY generated, and electric companies might then no be involved any more. Wind probably will never be on any large scale, because IF really large amounts of energy is removed from a region's winds, the weather patterns downwind will get all fouled up as a consequence, causing unknown weather surprises. We may see whether this turns out to be a problem if and when T. Boone Pickens builds the 2,500 giant wind turbines that he intends to install in north Texas. If it all works as he intends, the AVERAGE WINDSPEED for downwind cities will be several miles per hour slower than has naturally been the case. What might be the consequences of that? No one knows! We will see!

People also do not realize how large a personal (WECS) wind-powered electricity alternator would need to be. My WIND POWER presentation fully discusses that, and notes that all those old farm windmills were around 10 feet in diameter, all to capture around 1/4 horsepower to pump water. One-fourth horsepower is around 185 watts. The result is that even a fairly large 10-foot diameter wind turbine can rarely produce more than around 90 watts of electricity to be put into batteries (during normal winds), except for brief times when strong storms create faster winds. To re-charge my golf-cart after a single round of golf, using such a wind-charger would likely take around 100 hours (at 90 watts rate). Or, more realistically, since golfers would never wait five days to be able to go golfing, around FIVE such windmill setups (of 10-foot diameter rotors) would be required just to keep my golf-cart re-charged! NOT nearly as attractive as the promoters always say!

Assuming that the Chevy Volt some day exists, we can estimate the amount and cost of electricity it would need, IF it were re-charged from house electricity. Because of the inefficiencies of battery chargers and wires and batteries, it generally takes around twice as much INPUT electricity as the amount of electricity that actually finally winds up in the batteries themselves. So, to recharge the 16 kWh of electricity used up in the Volt's vaunted 40 (now 30) miles without any gasoline, around 32 kWh of house electricity would be required. CURRENT electricity costs in much of the US is now around 15 cents per kWh (nearly half of which is often Delivery fees and assorted taxes). This then indicates that around $4.80 of house electric bills will be added each time the Volt needs to re-charge after that 40 miles of driving. MANY current gasoline-powered (little) cars comparable to the Volt get around 30 miles per gallon of gasoline. Say that gasoline costs $3.60 per gallon. Then 1.33 gallons of gasoline would cost $4.80 and it would enable the (rather small) vehicle to travel 40 miles.

Their WORDS regarding concepts like the Volt are very impressive, but, sadly, there is little reality behind them!

People do not seem aware of how many PV panels or how huge a wind turbine would be needed

to produce any significant amount of electricity. They have HEARD partial-truths from people who knew that the public would add in assumptions to get to BELIEVING the impressive things they want people to believe!

Therefore, these comments are based on the realistic expectation of getting the electricity from conventional sources. People who have never done the math often insist that they will buy a few solar cells to provide the electricity or put up a windmill. Admirable thoughts, to be sure. But look at the numbers below, regarding the massive amounts of electricity needed to replace just a single gallon of gasoline! Have you ever seen your electric meter spinning wildly when your central air conditioner kicks in? Or whined about summer electric bills as a result? Imagine that happening constantly for a ten-hour period, just to replace a single gallon of gasoline. And anyone who actually thinks they are going to get THAT MUCH electricity from a few solar cells or a backyard windmill? Interesting! It is logical that the public is not yet familiar with this stuff, but shouldn't the politicians who spend billions of our tax dollars on this stuff know more of the facts? Did you know that every Congressman and Senator has a staff of around 400 people (all of whom we pay for); doesn't it seem reasonable that we should expect that at least ONE of all those 22,000 people would actually look into facts before spending fortunes of our taxpayer money? Shouldn't the people who are actually designing and building such concepts be aware that there is no logical future, except for a brief time as a novelty? Who is doing the thinking? (Sorry for the philosophical tangent, but I never like it when the American public is mislead, which seems to happen all the time these days!) Of course, those companies expect to make many millions of dollars in profits if just the government decides to give them a few billion for research! They have great incentive to tremendously exaggerate the facts! And no one seems to ever check their credibility! IS this some sort of statement regarding the American Educational System, where even political leaders seem to generally be ignorant of many very important facts?

OK. I realize that these comments regarding the possible supply of electricity are extremely dark. They are NOT due to any personal attitude, but instead, brutally accurate facts and logic, as all Physicists necessarily honor! **I would LOVE to be announcing some impressive source of electricity.** If the usage was minimal, sure, ANY of those different ideas would be great! But the central problem is that we use electricity at astounding rates! Coal mines all over the US are constantly digging coal as fast as they can and sending that coal on mile-long trains of railroad hopper cars, to electric power plants, all to produce only HALF the electricity we constantly use today! The idea that a few tower windmills will suddenly provide phenomenal amounts of electricity to replace all of that, or that some solar panels out in a desert field will, is a wonderful dream, but absolutely beyond any reality at all! People are so desperate to learn of "solutions" that they are willing to jump at ANY idea that anyone mentions on TV! Hey, maybe alien spacecraft can show up and hook into our powerplants and supply our electricity, right? Are you holding your breath?

There is also an additional 800-pound gorilla in this room. **A few really huge Corporations INSIST on HAVING CONTROL of the supply of electricity and other resources (in order to be guaranteed of billions of dollars of profits that they lust for.)** It is NOT accidental that

tower windmills are so enormous that ONLY such giant Corporations can afford to be building and operating hundreds of them (along with wonderful financial benefits that the government gives those Corporations for pursuing such things!) You probably are NEVER going to see ANYONE building a 300-foot diameter windmill that costs at least $20 million, in addition to the constant maintenance and repair costs for the 800 moving parts in it, because it is simply FOOLISH for anyone to build or install such a device. Even if it IS claimed to be ABLE of creating 3 megaWatts of electricity! Partly, that is because the ACTUAL AVERAGE production of tower-windmill created electricity is generally only around 1/10 of that or 0.3 megaWatts. That means that only around $45 worth of electricity is being produced each (average) hour! Are YOU interested in spending $20 million or more, and having endless repair costs as well, just to save $45 each hour? Right! Any good Accountant can see and show that such systems will likely take at least 400 years before they Amortize themselves (pay for their own construction and maintenance costs) before they could ever actually show productive performance of making electricity!

The people who promote such things never bother to actually inform anyone else of "certain details"! It was amusing that several years ago, southern California was investing many millions of dollars to get a bunch of tower windmills built in North Dakota. The investors believed (or were told) that they would simply send the electricity that 2,000 miles to southern California to be used! A "detail" that was left out was that when the Power Grid is designed, an extremely common Engineering aspect is that in any 60-mile run of the high-tension lines, only 90% of the electricity comes out the other end. The other 10% gets radiated as heat from the hot wires carrying a lot of electric current, very similar to your kitchen toaster. Since a 2,000-mile set of wires from North Dakota to southern California involves about 33 of those 60-mile segments, the electricity which would get through the whole thing is 0.9^{33} or 0.0309. A little over THREE PERCENT of the electricity would actually arrive in southern California! The rest (97%) would simply heat the air up around those 2,000 miles of wires!

Amusing, huh? Some more discussion of our Power Grid is below, but you get the point. Not EXACTLY like the promoters had described! All THEY cared about is that Investors would give them money!

OK. Being realistic, as a Physicist, I DO see a couple of REALISTIC possibilities for large amounts of electricity. (1) There are currently hundreds of different research projects under way which involve growing algae. That is because they ABSORB SOLAR ENERGY in the process of growing. And they grow FAST, and they are not very fussy! However, there IS one discouraging aspect to that approach, and that is the fact that the process of Photosynthesis (by which plants grow) is only around ONE PERCENT EFFICIENT regarding the solar energy arriving! Still, it is definitely worth the research projects, and I suspect it IS a credible solution for decent amounts of electricity. There is ANOTHER aspect which I am not pleased about! Due to the low overall efficiency of electricity production, the algae-based operations are necessarily huge beyond imagination, hundreds of acres of greenhoused space, meaning that ONLY GIANT CORPORATIONS can build and operate them. That means that they would STILL have extreme control over all the people regarding supplies of basic needs.

It seems that the wild enthusiasm that Ethanol was going to be "the total energy solution for the

future" has faded. (Although, astoundingly enough, the Federal Government in 2012 is STILL subsidizing millions of acres of American farmland where Agri-biz mega-farmers are making millions in profits in STILL pursuing that very foolish concept. Taxpayer money flows like water, I guess!

And I think that people are starting to realize that Fuel Cells that might be affordable and practical for vehicle propulsion are probably still 50 or more years in the future. And battery power had a brief public excitement recently, as it had earlier done during the 1980s. Tower windmills are starting to be seen as only around 1/10 the devices they were promoted as being. So the "breakthrough of the month" lately is algae. As with all the others, it is pretty easy to set up an impressive demo of a few minutes' usage for a few reporters, which gets the public excited about the latest fad energy supply. But like all the others, algae has some major obstacles to overcome. And like all the others, the biggest of the obstacles is the SCALE of our needs.

Yes, with a few million dollars of equipment, it IS possible to grow algae and then extract either hydrogen gas or power directly. But the unspoken detail is that the amounts of equipment which would actually be needed would be comparable with the surface area of the Earth! Do you know how large an acre is? Imagine growing algae in ponds all year, where greenhouse heating will be needed much of the year. But that acre receives around 22,000 kiloWatt-hours of sunlight on a nice sunny day. But the algae, like virtually all other plants, can only absorb certain colors of that incoming sunlight and there are many other losses, where the overall conversion efficiency is generally only around 1%. That means that the full acre of algae farming will only capture about 220 kWh per day as glucose.

The known chemical processes to extract hydrogen from that are generally no better than around 50% efficient, so at best, we could hope to capture around 110 kWh of energy per sunny day per acre. In comparison, one gallon of gasoline contains around 37 kWh of energy in it. So all the equipment and that full acre of algae farming, at best, might someday be able to produce energy comparable to about three gallons of gasoline! The people doing the demos today are merely getting the public excited so that the government will fund billions of dollars into their hands for future research, which will guarantee their personal employment and prosperity.

No one ever seems to be in a position to cast an analytical eye upon such things! Whenever some spokesperson announces that they have found the ultimate solution to all energy crises, everyone seems to immediately accept all claims made, without reservation! Wow! The brief and crude calculations just presented suggest the BEST production from that acre of algae. On days that were overcast or during winter when heating power was required to preserve the algae from cold, far less can be expected. However, clearly, no spokesperson is going to admit that the FUTURE CAPABILITY may be three gallons equivalent of gasoline per acre of algae per sunny day! Even if gasoline rises to a thousand dollars per gallon, it would have to be cheaper than energy from such an algae farm.

Yes, there will be many claims of breakthroughs, each of which will guarantee funding for some new business venture! And there will be spectacular claims made all the time. But isn't the proof in the pudding? Not in any prior claims about how perfect the pudding will be? And the sad part is that there really is no free lunch available. Everyone WANTS TO BELIEVE that some

magical source of massive amounts of energy will allow all people to continue to be as wasteful as we Americans have learned to be for decades. The fact that the public has so little understanding of such matters makes it very easy for some slippery person to deceive a lot of people. If you are very familiar with Hydrogen then you probably have heard of Brown's Gas. A guy who had never had any science education, and not much education at all, declared himself to have a Doctorate Degree, around 30 years ago, and he started telling people that he had discovered the ultimate energy solution, which he called Brown's Gas (after himself). He claimed that his gas was a combination of Hydrogen gas and Oxygen gas, together! His claims were so convincing that he got many people to give him large amounts of money. As a result, he was convicted of cheating people many times and would up spending most of his life in various prisons! But even though his claims were immediately known as false, and all his convictions, there are STILL people today actively promoting that silly concept! I am sure that the web-sites trick a lot of people into sending money in, so I guess it accomplishes their goal of getting rich! It's just that the concept has no value whatever, and it is simply a scam to cheat people.

I feel that there is another credible possibility for providing a lot of electricity. A COMMUNITY-BASED wind generation system, designed to provide around 1,000 homes with all their electricity, and BUILT AND OWNED AND RUN LOCALLY. It's installed cost is around 1/10 that of tower windmills, and they have better performance data. Where all authorities agree that tower windmills will cause electricity costs to RISE, this approach should be able to make them DROP, or at least stay the same. A link to this Practical Large-Scale Wind-Generated Electricity even shows where each town might HIRE around 100 LOCAL RESIDENTS to build their system, thereby helping the community out in yet an additional way!

Back to the central topic, electric-powered vehicles!

Tracking the Energy, Assuming Future Vehicles are Charged From Home Electricity

Currently, 51% of all the electricity available in the US is produced by burning coal in electric power plants. Around another 20% is produced by burning natural gas, which turns out to be relatively similar in analysis. We will examine coal here, since it provides more than half of our electricity.

Two pounds of coal has roughly 28,000 Btu of chemical energy in it. Any reference textbook says that. When those two pounds are burned in an electric powerplant, steam is made, which drives turbines at high speed, alternators are turned, and electricity is made. When everything operates well, all that turns out to be generally around 30% efficient, meaning that 30% of the chemical energy that started out in the coal has become actual electricity. (The other 70% all becomes various forms of heat, much of it being thrown away through Cooling Towers, and all of which contributes toward environmental problems, effects on weather patterns and Global Warming related issues). Now we have around 8400 Btus (30% of 28,000) of remaining energy,

now as electricity, which means that our two pounds of coal burned have now resulted in a little over two kilowatt-hours (2.46 kWh). (It turns out that nuclear power is slightly better, at around 32% efficiency, and petroleum and natural gas turbines tend to be around 28% or 29%, but all are essentially the same general efficiency, around 30%.) That electricity then has to travel long distances through many transformers and the power grid and local wires to get to your house. If you lived right next door to a power plant, it would be fine, but for average Americans, it turns out that around 60% of the electricity put into those wires and transformers never gets to the customers at the other end! It is partially wasted because the wires become hot because of all the electrical current flowing through them, and they act a lot like giant toaster wires! (Every 60-mile long run of High Tension lines is DESIGNED to lose about 10% of the electricity in this way, which is why electric powerplants are always built NEAR the cities they are to serve.) An even larger loss is due to the fact that power companies must ALWAYS generate and supply more electricity that is actually used, for the situation where a lot of people all decide to make toast at the same instant, or they all turn on air conditioners at the same time.

We therefore have the actual situation where just the remaining 40% of the 8400 Btus (2.46 kWh) of electricity sent into the power grid, which is therefore around 3360 Btus (or 0.98 kWh) (which is about 13% of the energy that started out in the coal itself).

(People have ripped into me for many years regarding this statement, that 60% of the electricity put INTO the power-grid at the power plants, is LOST, and that only 40% of the electricity makes it through the power-grid. So it is refreshing to see that IBM has started running TV commercials in Jan 2009 that start off announcing that "more than half" of electricity is lost in the power-grid! Maybe people will be willing to believe IBM about such statements!)

People are therefore not generally aware that **only around 13% (that is, 40% through the power grid of the 30% of the coal's energy actually converted to electricity, or 0.4 * 0.3 or around 13%) of the chemical energy burned in the coal in the (distant) power plant is actually available as electricity in your house!** (The rest, the other 87% all winds up being various forms of heat, all contributing to heating up of the atmosphere and therefore is totally wasted!) **So, (with some more simple math) for every TWO pounds of coal burned at the powerplant, your house electrical outlets then receive around 1 kWh of electrical power.** Around 65% of that can actually get put in the batteries, due to efficiencies of battery chargers and batteries. So those two pounds of burned coal now result in around 0.64 kWh of electricity actually being put into the batteries. Of the energy STORED in the batteries, the efficiencies of batteries, motors and gear trains are such that around 2/3 of that energy is (generally) eventually available at the wheels as motive power. The motors used are generally of nicely higher efficiency, usually in the 90% range. But getting the electricity out of the batteries is not particularly efficient. (Remember that our analysis started with the [28,000 Btus of] chemical energy that was produced when two pounds of coal was burned!) and we finally wind up with around 0.42 kWh (1,450 Btus) of energy given to rotate the wheels of the vehicle.

Sadly, only around 1/20 of the energy that was in the coal actually becomes useful power to drive the battery-powered vehicle or hybrid. The other 95% of that initially available chemical energy in the coal had all BEEN TOTALLY WASTED!

We are still tracking the energy that began as two pounds of coal, and which arrived at your house as one kilowatt-hour of electricity. The 0.42 kWh of PRODUCTIVE ENERGY is the same as 420 watt-hours, or, for a 14-volt automotive battery, around 30 ampere-hours of actual usable power (14 * 31 = 430). The 420 watt-hours is also equal to around 0.56 horsepower for an hour. Now, this might sound like a lot, but remember that the 28,000 Btus in the two pounds of coal resulted in this amount. Not nearly as attractive as the EV salespeople say!

(If this analysis is done for the 16 kWh battery-pack that the Chevy Volt hopes to use, it shows that 46 pounds of coal will need to be burned up each time that battery-pack needs to be re-charged.) (14,000 * 46 / 3.412 * 0.13 * 0.65 = 15.9 kWh) And that sends around (46 * 2.93 pounds of carbon dioxide per pound of coal burned) 135 pounds of carbon dioxide into the atmosphere. Compare that to the 18.3 pounds of carbon dioxide sent into the atmosphere from each gallon of gasoline that is burned. GREEN??? Not even close!

This is for the situation for batteries. Current technologies regarding producing Hydrogen and then recovering it are actually worse, although they are expected to get comparable to the battery situation some day.

In contrast, a gallon of gasoline has around 126,000 Btu of energy in it, of which a modern car converts around 21% into motive power, so there results around 26,000 Btu of motive power. **POINT: Around 33 pounds of coal (with 500,000 Btu of chemical energy in it) must actually get burned to provide the electricity such that a battery-powered car can do the equivalent to a single gallon of gasoline!** (14,000 * 33 * 0.13 * 0.65 * 0.67 = 26,000) (This is a VERY "losing proposition"!)

That amount of electricity that needs to go INTO the batteries in the car (to be equivalent to that ONE gallon of gasoline) is therefore the 0.64 kWh per two pounds of coal times 16.5, or around 10,600 watt-hours of electricity. That is a LOT of electricity! Say you will have 10 hours at night for the batteries to recharge. That means that you would have to have about 1,000 watts of power constantly feeding the batteries. For the 14 volt circuitry of standard batteries, that would mean that around 75 amperes of charging electricity would constantly be needed. (NOT the 6 amperes of a good battery charger!) (This huge charging current might actually cause the batteries to explode, unless they are a special and more expensive Deep-Discharge type of battery!) (Batteries in golf-carts and electric vehicles are generally wired in series to increase the voltage and reduce the amount of current needed.)

This "equivalent to one gallon of gasoline" would actually require about ten standard car batteries. Modern batteries generally have an energy capacity of around 80 ampere-hours, which at 12 volts would be around 960 watt-hours or about 1 kWh. (About 16 standard car batteries would do for the Volt discussed above, except for the standard batteries being both large and heavy!) We just calculated that one gallon of gasoline equivalent would require around 10.5 kWhs of electricity, meaning around 10 standard batteries. (You might be starting to see just WHY gasoline had become so universally used for vehicle fuel! It is an extremely compact source of a LOT of energy!)

Even the house wiring involved might be in question! We are talking about a REALLY

impressive battery charger, of course, akin to 12 conventional battery chargers used together, which requires about 16,000 watt-hours of input electricity. Over our ten hours, we are therefore talking about needing 1,600 watts of electricity constantly coming in to your house to supply your battery charger. Your house electrical service is sufficient for this need, but close! If at 120 volts, a constant 14 amperes of house electricity would be needed, where normal house circuits are either 15 amp or 20 amp if heavy duty. This probably means you could get by with providing ONE gallon equivalent of gasoline in a ten hour night, but you would probably need the specialized wiring like was installed for your air conditioner to charge much more. Two-gallons-equivalent in a night would which uses roughly the same amount of electricity that a central air conditioner would take, except constantly and not cycling like an air conditioner does, through a special 240 volt wiring made especially for the air conditioner. Herein could be a problem, because most houses were built with 100-ampere electrical service If the A/C is running and this battery charger and some other electrical devices, you might get close to the full capacity of the house wiring! The existing house wiring, and even the transformers up on the utility poles, are barely big enough and could overheat at that constant heavy ten-hour load!

No one seems to have noticed that ALL of the hype is based on a FAMILY HAVING ONE (very small) vehicle! Duh! If there would be even TWO vehicles that needed to be recharged, serious concerns about the electrical wiring of the house start to appear! Hasn't anyone noticed that ALL American families have lots of vehicles?

We can use a golf-cart again for comparison. Even there, a LOT of electricity is needed to recharge it after a round! Where a normal battery charger can charge at 6 amperes (at 14 volts) for around 80 watts, the charger I got with my golf cart charges at the rate of around 800 watts, ten times as much. (It USES about 1080 watts of house electricity for this.) During an overnight re-charge of 12 hours, that is around 10,000 watt-hours or 10 kWh of electricity that was provided for the batteries. By the way, my golf cart has four large heavy-duty, (expensive!) deep-discharge batteries, which each can contain around 2.5 kWh instead of the 1 kWh mentioned above for standard batteries.

For a golf-cart that can generate around 4 horsepower (3 kW), if it is actually running for around two hours of the three hours of a round of golf, that uses up 4 * 746 * 2 or 5900 watt-hours or 5.9 kWh, which is realistically what the efficiency of the batteries, motor and gear train are capable of providing. Golf carts need special "deep-discharge" batteries because they tend to be so tapped out from such a round. Note that the cart only travels maybe 5 miles total, and at just a few miles per hour, and it still needs around 10 kWh (or, we will soon see, at 15 cents per kWh, over a dollar's worth) of electricity to do that. Now, consider if you want that golf-cart to be far heavier, and to move much faster and much farther. See where that 16.5 kWh (for one-gallon-equivalent) we discussed above is actually very realistic? They don't make gasoline-powered golf-carts, but they would use up around 1/2 gallon of gasoline, or again over a dollar's worth today) for a round of golf.

Cost of the Electricity

We haven't even yet considered the cost of all that electricity! When you think about a constant 10-hour long consumption of about as much electricity as your central air conditioner uses, you probably start to

get the picture. But say you are in a location where electricity has an overall cost of 15 cents per kilowatt-hour. We are needing to use up 16.5 kilowatt-hours (to equal the vehicle performance of a single gallon of gasoline, remember), so that is 16.5 * 15 or $2.50 of electricity added to your house electric bill, for the equivalent to ONE gallon of gasoline! It does not initially APPEAR to cost anything, and the car merrily scoots around on its battery power. **But if and when an owner realizes that they also have to spend at least $2.50 in extra electricity for each gallon of gas not used, much of the financial argument goes away!**

We can mention the future Chevy Volt again. The battery pack is described as having a capacity of 16 kWh. Even if it could be re-charged with perfect efficiency (which is not physically possible) , and if electricity costs 15 cents per kWh, that represents $2.40 of electricity. (General Motors claims $1.80, under the assumption that the electric power companies would give special deals to such users of large amounts of electricity). But the charger and the batteries are NOT perfectly efficient, and at least $3.00, and as discussed above, more likely $4.80, of house electricity would be required to recharge the Volt after their claimed 40 mile (now 30 mile) distance. Aren't there many existing small cars which get 30 miles on one gallon of $3 gasoline? In other words, are they actually expecting to see actual SAVINGS for owners? To buy a Volt and then have to buy $4.80 of electricity to re-charge the batteries to provide 30 miles of driving, or to simply buy a far cheaper little compact gasoline-powered car to then have to pay $3.50 per gallon of gasoline to go the same distance? The public seems willing to see some sort of logic in this? Particularly since the Volt has an approximate $40,000 price tag for that small and relatively low performance vehicle? This is all noting that GM has admitted that it costs them about $40,000 to build each Volt (apparently not even counting the millions they want to spend on advertising and Executive pay and for profits to dealers), it seems rather clear that GM will have no realistic way to lower the sale price of the Volt for the foreseeable future.

Does this sound like the description of a dead cow? How can ANYONE see any rosy future for the Volt or other electric vehicles in view of these cold and hard facts?

As to that low-performance statement: Say that the (initial claimed) 40-mile trip was made at a constant 40 mph, so it took exactly one hour. That would mean that the 16 kWh of electrical energy would be used up in one hour, in other words, at a rate of 16 kW. A standard conversion ratio is that 0.746 kW is equal to 1 horsepower. This means that the Volt would be consuming electricity at the rate of around 21 horsepower! This would only be true if everything in the vehicle operated at perfect efficiency, since we are talking about the rate at which power is being removed from the batteries! Realistically, figure the actual power of a Volt to be a little less than that 21 horsepower, maybe around 18 horsepower. People who now lust for vehicles advertised as having 475 horsepower or 525 horsepower (355 to 390 kW) gasoline engines; are THEY going to be interested in spending $35,000 for a vehicle that has performance characteristics based on around 18 horsepower from electrical power? Some will, but it seems very likely that many will not. How could such vehicles ever actually become broadly popular? At least the Tesla sports car has an electric motor that can (briefly) produce 248 horsepower, to satisfy such drivers who might have its $120,000 price tag.

For the record, our associated web-pages which describe the Physics of Automotive Engines and the Physics of Vehicles provides the analysis of Aeronautical Drag and Tire Drag for any given

vehicle and for any given speed, and those calculations confirm that a rather small vehicle like the Volt generally requires around 16 or 18 horsepower for constant speed cruising along a highway. That set of calculations also shows that a somewhat larger Corvette, at a somewhat higher speed of 60 mph, can require as much as 40 horsepower for constant-speed highway cruising. So these numbers are NOT speculations but are all based on solid scientific facts and simple calculations, which YOU can reproduce if you wish.

Again, as long as politicians and the salespeople and promoters only talk about the cars themselves, and neglect where the electricity or Hydrogen comes from, battery powered and Fuel-Cell powered cars can seem very attractive. But when the "full story" will eventually get examined, **they are a really, really, really bad idea, regarding any large-scale usage!** Until and unless massive amounts of "free electricity" becomes available, which seems doubtful for a long time!

You are encouraged to do research to confirm what is described above. It is all true. Did you notice the "worst part" of what is described above? I'm not even talking about the fact that you would wind up paying for at least $2.50 of house electricity to replace each $3 gallon of gasoline! It is in the carbon dioxide that is necessarily released from that distant electric powerplant to generate the electricity that is needed and used.

I am inserting a new paragraph in here in January 2012. Some years ago, a woman bought a small hybrid car because the salesperson and the manufacturer's promotions claimed that she would get 40 mpg and even 50 mpg. She apparently carefully documented her fuel consumption over several years and never came close to what was claimed! So she filed a Lawsuit, and a Judge just awarded her around $12,000 as a settlement, which the Judge said is the amount she had overpaid for gasoline over what the alleged MPG figures indicated. In other words, a Judge confirmed that at least that one woman had been seriously misled regarding MPG claims, where he felt the manufacturer was required to pay up for the misleading information. It seems like a moment of sanity in an otherwise insane world!

Global Warming - Carbon Dioxide Issues

In refining a gallon of gasoline, yes, significant energy is used up, although I have never been able to get a reliable figure. But certainly well under 500,000 Btu of refining energy, mostly in the fractionalization tower, is required to form the gallon (126,000 Btu) of gasoline.

If we **Replace all cars with battery-powered vehicles, we saw above that we would then NEED to burn 33 pounds of coal or use nearly 500,000 Btu of coal chemical energy to produce the equivalent effect of every gallon of gasoline.** This is worse, regarding resource energy wastage, than the vehicles that are currently on the roads! (Yes, the energy is used up in a distant place, and maybe it seems possible to be able to be ignored, but that is still a really bad idea!) And, also, virtually everything that does not contribute to the "motive power" winds up as

wasted heat energy.

When those 33 pounds of coal were burned to create the needed electricity to duplicate the benefits of one gallon of gasoline, carbon dioxide is also released into the atmosphere. The carbon content is around 80% of what bituminous coal is, or 26.5 pounds here. In Thermodynamics, it is fairly simple to determine the amount of carbon dioxide that is created when it is oxidized. The amounts of carbon and oxygen have to be in a molal relationship of one to two. That means the weight relationship has to be 12 (the atomic weight of carbon) to (12 + 16 + 16 or 44) (the atomic weight of the molecule of CO2. **This means that** 44/12 or 3.67 times the weight of carbon dioxide is created, or in this case, **97 pounds, of carbon-dioxide would get released in this process (at the powerplant), to produce and provide the electricity needed to replace one gallon of gasoline.**

When a gallon of gasoline is burned in an automobile, it is much less. A gallon of gasoline weighs around 6 pounds, and it is about 83% carbon. That means that it contains nearly exactly 5 pounds of carbon in the gallon. Again using the 3.67 multiplier, we can see that only around 18.3 pounds of carbon-dioxide is released (directly from the vehicle's exhaust pipe).

This means that Global Warming then would occur around 5.5 times as fast as now, by using electric powered vehicles! (97 / 18 pounds of CO_2 released per gallon-equivalent). **If millions of people started driving battery-powered or Hydrogen-powered vehicles, it would therefore be a far WORSE environmental disaster than now, causing Global Warming to become MANY TIMES faster than it already is!**

Isn't that something?

Something that is promoted as attractive as battery-powered cars, or Hydrogen-powered vehicles, being the worst imaginable long-term effect on the climate? Presented as the GREENEST of all possible ideas? It is because the people who want to SELL such things never emphasize such "downsides" and politicians will jump on board anything that the public sees as "interesting"! So our government will certainly pour billions of our dollars into research on battery-powered vehicles (and then Hydrogen-powered vehicles), but it will eventually be seen as a VERY bad idea. I hope you saw why the same reasoning applies to Hydrogen, as the electricity needed to dissociate water to provide the Hydrogen has the same powerplant source!

It does not appear that Reporters yet know enough to ask about how long the battery charging takes or how much electricity is needed.

There actually ARE suitable uses for battery-powered or hydrogen-powered vehicles. Golf carts are a wonderful application. A 500-pound vehicle can travel the five miles of a golf course, at a few miles per hour, and they charge overnight (with VERY heavy-duty battery chargers!) Those standard golf carts use up a LOT of electricity, several kilowatt-hours, during a round of golf. It seems that no Reporter has ever visited a golf course to look at the impressive wiring that had to be installed for them to re-charge their many golf carts after rounds of golf. People should visit golf courses to look at all that in order to better

comprehend the scale of the electricity that is needed, and THAT is all just for rather small, light carts that only travel fairly slowly and only a few miles!

If a vehicle is to be required to travel ten times as far as a golf cart, it will obviously require ten times the electricity from the charger, essentially ten times the charging current. If the vehicle is to travel faster than a few miles per hour, there are new losses due to wind resistance (aerodynamic drag) and tire resistance, meaning even a lot more electricity.

Yes, battery technology figures to continue to improve in the future. So do Fuel-Cells, especially since our Government is spending many billions of our tax dollars to finance that research! **But since batteries (or Fuel-cells) do not actually HAVE any power of their own,** you really wind up dealing with the issue of how many hundred amperes of electricity you can charge the batteries with. And, more significantly, WHERE that electricity is going to come from! Advertising makes it seem that a simple extension cord is all that is necessary to re-charge electric vehicles, and that any Motel or standard electrical outlet will provide it. It may be interesting to see the reaction of Motel owners who have their room electrical circuit breakers kicking out, and their electric bills jumping by many hundred dollars each month!

In upcoming years, it seems certain that the proponents who keep insisting on battery-powered cars will move to much higher voltage batteries, mostly so they can avoid having to use inch-thick wires to charge them! So 100-volt or even 1000-volt batteries may be presented as some "breakthrough" in the future. But it won't reduce the load on your house wiring system or on your pocketbook! It would only be to simplify a minor problem regarding the thickness of needed wires.

In all three cases, Hybrids, battery-powered and hydrogen-powered, vehicles APPEAR to be really efficient and really "green" as long as only the vehicle is considered, and it is simply assumed that a Fairy Queen charges the batteries or provides the Hydrogen! So the public figures to keep believing what they are told in why they should want to buy them! And politicians will certainly see this popularity and they will give many, many billions of our tax dollars to companies that convince them that they have the latest breakthroughs.

But the people who intend to sell millions of such vehicles must already be aware that owners will not enjoy paying an extra $2.50 or more in electricity to replace every $3 gallon of gasoline, especially when it also (indirectly) causes such MASSIVE increases in atmospheric heating, carbon-dioxide, global warming, pollution, etc. Yes, early owners will not know of such things, but they are certainly going to quickly find out! How could millions of such vehicles then ever get sold? People talk, especially when they have complaints! It seems a real mystery that any manufacturers could really believe that millions of such vehicles will be sold.

The grisliest aspect of all this, as I see it, is that the distant coal-fired electric powerplant will need to be creating around six times as much carbon dioxide into the atmosphere as the gallon of gasoline being replaced would have created. In a bizarre result, it turns out that it will be FAR GREENER to simply keep burning gasoline, than to start massively using battery-powered

vehicles or later, hydrogen-powered. UNTIL, some day in the distant future, maybe 50 years(?) when PV (photovoltaic) technology has progressed to a point where electricity can be generated LOCALLY. (The giant electric power utility companies will NOT like that!)

Unfortunately, modern science and technology probably cannot provide those solutions that people will expect and need. (at least for several decades) At some point, the public will finally realize that the petroleum and natural gas that we are using up at wild rates really DID take hundreds of millions of years to form, collecting and storing the Sun's energy from all those years in those fuels. We are currently using up those fossil fuels at nearly a MILLION TIMES as fast as Nature first formed them or can now replace them!

In case you are not familiar with the numbers, each year, we Americans use up over 20,000,000,000,000 cubic feet of natural gas, just for energy (and even more gets used to make plastic materials such as garbage bags). We Americans also use up over 1,800,000,000,000 pounds of petroleum every year. (I guess I could be generous and use the smaller number of 280,000,000,000 gallons, or 7,000,000,000 barrels of crude oil.) Of course, we also use up massive amounts of petroleum to make nearly everything that is plastic, along with countless other products! I have to think that, 30 years from now, when the world has virtually no petroleum or natural gas left, people will be astounded that WE were so stupid as to make disposable plastic wrappers for every single product, which all immediately gets thrown away! WE are not going to come across as very intelligent, just 30 years from now!

Yes, America has a lot of coal, the largest known supplies anywhere in the world! So we might have the chance to maintain industry and business, as long as we are all willing to deal with the coal-fired factories, trains, and home furnaces. But there does NOT figure to be anything to replace the oil and gas that we are merrily using up (as though we have infinite sources).

There are people who talk about "processing and refining" oil shale deposits under Canada, but those processes require USING UP huge amounts of petroleum to power the equipment! Others talk about doing similar things to "biomass" to create methane or methanol or ethanol or some other simple fuels, but again, those processes require massive amounts of energy usage. Some CAN be done in reasonable ways, such as causing a standard compost pile to decompose without sufficient oxygen (anaerobically) which generally creates a good deal of methane gas.

Actually, I suspect that the ONLY real hope of vehicles beyond around 20 years from now is that they somehow run on coal! NOT like the early Stanley Steamer cars, but something sophisticated. Maybe some pyrolization process rather than actual burning. But all research is now in batteries and hydrogen, as they have captured the public's and Congress' interest. And in using up at least 1/3 of America's food crop production to provide corn to be converted into Ethanol, an even more stupid idea! I really think that some day, research into somehow using coal as vehicle fuel will become necessary!

In a peculiar aspect of God's sense of humor (I think), even though we humans do not have the self-restraint to control or stop Global Warming, and as people will certainly be killing each other for the very last barrels of oil, the "forever supplies" of those fuels are all going to run out within just one or two decades. I was terrified to read official US government and oil industry

publications that indicated that the US CURRENTLY has only around FOUR YEARS SUPPLY of petroleum left (if we did not have any imports) and around EIGHT YEARS SUPPLY of natural gas left (again, without imports), and that all the forty-some Uranium mines that used to operate in the US all closed in the early 1990s when they ran out of Uranium to mine!

The politicians will therefore actually be saved from having to make such "hard decisions" (which might reduce the profits of their friends who run the giant companies). Instead, they will have to face far worse decisions, as to how to keep people from freezing in winter, and how to finance farm production to feed everyone, without any fuels or chemical fertilizers! And how to deal with food shortages and far higher food prices in grocery stores directly resulting from these peculiar directions of driving the American future.

In only ten years, it seems possible that a gallon of gasoline might cost $100 or even $1000. How much driving do you expect to do then?

The "Ethanol adventure" of using 1/5 of the total farm crop production of 2006 for conversion to Ethanol, which provided only around 2% of the vehicle fuels we used in 2006, is simply endangering our near-term food supplies. News reports are already (April 2007) discussing higher milk, bread, beef, and many other food prices in our grocery stores, as a result of the massive focus on producing Ethanol. But some weather problem is bound to occur. Where we used to have massive over-production of nearly all crops, our government has planted the seeds of a true food-supply disaster, which could happen any year now. In 2008, it is expected that the amount of America's TOTAL crop production which will go to making Ethanol will be 1/3 of everything grown! It is as if we are totally crazy, or that we do not even give any thought to what might be a consequence next week or next month or next year! It really is amazing!

What are called Hybrid vehicles are promoted and sold everywhere already, cars that include both a gasoline-powered engine and a battery-powered electric motor. The promotions for them are unbelievably misleading to the public! **They totally ignore all that electricity needed to charge the batteries, but then use the charged batteries to help it get very high fuel-efficiency numbers!** People are buying such vehicles (which cost a premium because of their having to include two entirely separate sources of power) greatly because they are told they are GREEN and that they see those very impressive mileage ESTIMATE numbers. Those are both very clearly pure lies! As to the GREEN part, we discussed above that the electric powerplant where any plug-in electricity was made necessarily produces around six times as much carbon dioxide and heat loss as a gallon of gasoline produces directly. But most (current) Hybrids do not plug in, and simply re-charge their own batteries by burning the gasoline in the engine in the vehicle. Not exactly GREEN, since the ACTUAL source of the power is from the very same gasoline! As to the mileage figures, well, without recognizing that at least $2.50 of bought house electricity (for a plug-in) is needed to replace each equivalent gallon of gasoline (eliminating most actual savings), there are a LOT of other details that no one bothers to tell customers! Such as driving a Hybrid or battery-powered car at night consumes far more electricity for all the lights! Far less battery power is left to actually move the vehicle! And no one seems to mention that the battery-mode operation commonly provides only roughly 10 horsepower maximum for the (small and light) vehicle, meaning

only low speeds and rather poor performance. And this deception is INTENTIONAL! TV ads (early 2008) for a Hybrid vehicle that has a 470 horsepower gasoline engine makes it seem that an owner can have his cake and eat it too! A driver who buys a car because it has a 470 horsepower engine is NEVER going to be satisfied with the performance during a 10-horsepower or so battery-powered mode of operation! There are many other drawbacks as well.

But even the Government seems to have participated in this deception! In the tests for the Federal CAFE (fuel efficiency) tests, they do not consider the state of charge or discharge of the batteries! **So when manufacturers show up with fully charged batteries, the vehicle can appear to get impressive mileage ratings, much of which occurs because the vehicle is discharging the batteries!** Those tests should immediately be changed into requiring that the batteries END with an equal charge to what they had when they arrived! Otherwise, the impressive numbers given to Hybrid vehicles are incredibly misleading and far higher than should be the case with fair testing. But then, I suppose that if Hybrids would only show a few MPG improvement over conventional vehicles, and it was learned that all that electric power all came from burning the very same gasoline in the very same engine, very few customers would then want to buy Hybrids! I suppose that Government Accountants would tell Politicians that that would hurt the economy, so they must have decided to play along with this deception. Sort of like the amazing situation where tobacco farmers make fortunes in providing tobacco for the cigarettes that kill 350,000 Americans every year, all with many years of government approvals! Ain't that all something?

Amazingly, GM and Ford are now displaying battery-powered cars for their ideas of the future. Maybe they are unfamiliar with the simple logic of the ideas presented in this article! Considering that both of those Corporations are losing billions of dollars every year lately, one would think that they would spend their research dollars on something that might enable them to remain in business! But I guess that is what hundred-million-dollar-per-year Executives are paid for, to think about such silly things! I sort of wonder if they actually feel any responsibility toward actually preserving their companies?

The specific point of this Essay, though, is smaller! It is merely to show that the Battery-powered or Hybrid cars and Hydrogen-powered vehicles that all Americans are already pinning their futures on, are certainly going to fall far short of expectations, because of a simple and basic assumption which happens to be wrong! **The Hydrogen or the electricity to charge batteries is NOT a natural resource but instead has to be somehow made, and in both cases, they are energy intensive processes.** The first Law of Thermodynamics describes the Conservation of Energy. Whatever amount of energy you have to start with, you cannot end up with more than that, and in fact, due to many losses, you ALWAYS wind up with less than you started with, with the other part generally becoming wasted heat energy.

SO, when you are all excited about going to a car dealership to buy a battery-powered electric car, or a Hydrogen-powered fuel-cell vehicle (or a Hybrid), try to remember these things! The salesperson is not going to tell them to you!

The advertising presentation of the popular Hybrid cars is rather misleading. Their performance is not what American drivers have come to expect from all the hype, and their consumption of electricity (and therefore increases in electric bills) comes as a great surprise to owners (for plug-in cars). For the Hybrids that make their own electricity by burning gasoline in their own engines, the plus/minus is much harder to see, but the net effect is that such cars really have VERY minimal advantage over conventional vehicles. Maybe a few percent improvement, but nowhere close to the miraculous results that advertising has caused the American public to expect of such vehicles. Fortunately, they can still just buy gasoline, and drive an under-powered car, to avoid looking like having gotten "took!" **Not even counting the fact that automotive batteries tend to only last a few years, so owners have THAT cost to look forward to as well.**

Another stupid-brilliant idea is manufacturing and selling vehicles that will only run on what is called E-85, meaning 85% Ethanol fuel. Again, if there were unlimited supplies of Ethanol, that might make sense. But when America used up one-fifth of all its farm crop production to provide only around 2% of the amount of fuel (2006) that American drivers use up each year, it indicates scary thinking, or lack thereof. By the time the auto manufacturers fully perfect cars that they will be able to sell to run on E-85, and by the time there are enough service stations that even carry E-85 for such drivers, it is certain that some overwhelming crisis will occur (probably in a weather problem and severe shortages of food for Americans), where sanity might again briefly appear and the massive effort toward Ethanol will very suddenly end. For the few people who may wind up buying E-85 vehicles, they will merely wind up having something that might someday go into a museum, something like what happened to the Edsel automobile!

It is really sad that even supposed Regulatory Agencies of the Government have participated in this hype. A car that has a conventional engine, is likely to get the gas mileage that has long been known, somewhat UNDER what the EPA estimates say! But regarding Hybrids, they seem to have just considered the battery-powered miles to be "free" (because no gasoline is used) and they have listed some Hybrids as having 60 miles per gallon fuel efficiency. That is technically true, if you totally ignore the cost of all that electricity needed as calculated above (and just let the batteries discharge during those tests)! If they wanted to go even farther, they could set up a really short test procedure where ONLY the batteries were even used, and then they could let the manufacturers advertise "1000 MPG" or "1,000,000 MPG" or more! For plug-in vehicles, the person's home electric bill would go off the charts, but they do not seem to see any reason to consider issues beyond the car and engine that they are then testing!

Many people rely in the articles in Wikipedia, and elsewhere on the Internet, to be absolutely and unquestionably true and precisely accurate. Up to about four years ago (2005) that was essentially true. But the Wikipedia concept allows ANYONE to edit any presentation. Where the early entries were (nearly) all provided by actual Researchers and Scholars, many of the Wikipedia presentations have now become contaminated by editing by uneducated people. It is mentioned here because I just noticed that the Wiki presentation on CNG (Compressed Natural Gas) contains an interesting problem! Near the very start, a Researcher states the true fact that burning natural gas causes INCREASED pollution of a specific type, called NO_x (nitrous oxides). But a later section that had been edited states that burning natural gas

causes REDUCED NO_x pollution! The same presentation claims both sides of that coin! (The first statement is the true one). The point here is just that one must be very careful regarding the source of any information provided, and Wikipedia never mentions the original authors or all those that edited it. How can anyone know whether the current text is correct or not? Trust Wiki staff to monitor their billions of web-pages, having complete Engineering education to understand all the nuances of every article?

Added Information, Tesla Sports Car

There is an extremely heavily promoted new vehicle being presented in the news in 2007. The Tesla Sports Car certainly can show impressive acceleration. And much of the data presented in their web-site is compatible with Physics. However, the media reports often present some information that simply violates the laws of Physics! It would be wonderful if such things were possible, even in a $120,000 car.

The Tesla seems to have another major hurdle that seems to be overlooked, at least in America! In early 2009, they are describing manufacturing several Teslas every week and that they are all already sold (at that high price tag). **Who can be buying them?** Aside from the extreme price tag and the poor economy, which will certainly continue for a number of years, there is an even more important problem. **The Tesla cannot possibly get License Plates in any US State! All the cars on the road had to pass an enormous number of safety tests and requirements by the US government, in order to be allowed to be Licensed in the US.** The Tesla has no possible way of passing many of them. For example, there are many collision requirements, but the Tesla would fail many of those, such as the very low front end going UNDERNEATH any car or truck ahead of it! (Many foreign cars have been disapproved for this reason in the past.) Are there "side impact air bags" or even the standard steering wheel impact air bag and the one for the passenger? Tesla has never mentioned any of them. Can a Tesla withstand a rollover, without the roof collapsing? The US government has always required PROOF of such things before allowing any vehicles on any highway, in other words, to be able to have License Plates. So who is buying the Teslas that are now being manufactured and sold? Clearly, movie stars and other celebrities are buying many of them, people who do not really need to actually drive them. Or who could have them trucked into Mexico to be able to legally drive. But vehicles such as the Tesla face many more difficulties than the promotional stories seem to imply!

Unfortunately, Tesla clearly has done the common "spin" that spokespeople seem to all use today to deceive the public. THAT is really sad. Especially since this particular product actually can probably provide pretty impressive performance. Why is it always seen as necessary to be deceptive today?

Much of their claims can be confirmed by Physics from their published specifications of their early test vehicles. Using information from their own web-site:

First, there is a small-print, very faint, and very hard to read Disclaimer at the bottom of their web-pages that notes that their vehicles have not yet passed government safety testing, and they say that their specifications might change as a result of that. (By the way, since they have not yet passed government safety tests, they are not yet street legal in any State and

could therefore not yet be licensed! And unless the government allows bending a lot of laws that apply to all other cars, they may NEVER be allowed to sell Teslas in the US. And it is hard to imagine Tesla building some of those very expensive cars to allow the government to destroy them in accident testing, for example to make sure that the enormous battery pack could not catch fire or explode in an accident.)

- First, they say that the car can produce an absolute maximum of 185 kW of electrical power. Since 746 Watts is equal to 1 horsepower, this is equal to 185/0.746 or 248 horsepower. They state in the same sentence that that is equal to 248 peak horsepower. That is fine.
- They show a graph where the available torque is basically constant over a wide range of motor speeds (which is fine), and the same graph also shows the horsepower curve that is linear, rising from 0 horsepower at 300 rpm and rising to that maximum of about 248 horsepower at maximum speed. That is also fine, and in good agreement with science.

That information can be mathematically Integrated to determine the actual acceleration, when one also knows the vehicle weight. The web-site gives the vehicle total weight as being 2,500 pounds.

We can first calculate some more things that DO agree with their claims, to show that at least those claims are credible. Let's consider their vehicle top speed. The streamlined shape of the vehicle certainly has a Coefficient of Drag of around 0.3. The total frontal area of the vehicle is around 18 square feet. The claim is that the top speed is 120 mph, which is the same as 176 feet/second. We can simply calculate the total aerodynamic drag from this information (and the average density of air (around one slug mass per 420 cubic feet). It is $0.3 * 18 * 176^2 / 420$ or around 398 pounds of aerodynamic drag. There is also tire drag which is around another 45 pounds for that vehicle weight. The total vehicle drag is therefore around 443 pounds (at that speed). If we just multiply this drag force by the velocity (176) and divide by 550 to convert it to horsepower, we get 142 actual horsepower as being needed. Given that they indicate that their motor efficiency is around 85% to 90%, and there are mechanical efficiencies of the tires and wheels, this is in fairly good agreement with the roughly 180 horsepower claimed available from their graph at 13,000 rpm (times that efficiency factor). This confirms that the expected top speed is likely to be around what they claim. Fine here.

Let's look at their acceleration claim, of zero-to-sixty in around four seconds (which is impressively fast). They certainly did that demonstration in what they call first gear, which has a total gear ratio (and therefore torque multiplication) of 14.3. It is easy to see from this ratio that the motor would be turning at close to its maximum revs at 60 mph, so first gear might have been provided simply to be able to show off with this impressive zero-to-sixty acceleration. In any case, they provide a torque curve for their motor, which suggests that it would produce an average of around 160 ft-lbs of torque through this whole sequence. Multiplying this by the total gear ratio gives around 2300 ft-lb of torque, which becomes around 1900 pounds of thrust after considering the various mechanical losses. We have the aerodynamic drag of around 40 pounds average and the tire drag of another 40 pounds to subtract, so we have around 1820 net pounds of thrust available for acceleration. We divide this by the vehicle weight of 2500 pounds to get 0.73 to get the g-force acceleration. This is roughly 16 mph/second acceleration, or around four seconds

to get from zero to sixty. This confirms that in their first gear, the acceleration they describe is realistic.

There is actually another factor involved here, regarding a flywheel effect of the motor rotor itself having to accelerate as well. Without knowing the Rotational Inertia (I) of that armature and rotor, it is not possible to calculate the reduction which must occur in this vehicle acceleration, but it must certainly be slightly less than calculated above. In other words, slightly over 4 seconds for zero-to-sixty is then realistic.

The acceleration claim also tells us something else about the Tesla! It has absolutely nothing to do with the matters at hand here, but it still seems worth noting. The acceleration they describe, of zero-to-sixty-in-around-four-seconds, means that the average acceleration is therefore around 0.73G (as indicated above.) On a dry and clean roadway, the best static coefficient of friction is around 1.0. This means that the 1820 pounds of thrust for acceleration must necessarily require roughly that amount of weight on the driving wheels, or around 1800 pounds. If one axle of a 2,500 pound car has 1,800 pounds on it, the other axle has only 700 pounds. This would be an incredibly dangerous vehicle to drive on any curvy roads, if it has that extreme of a weight-distribution. For an actual Licensed highway vehicle, it could not possibly pass road safety tests with such an extreme weight-distribution. Maybe it will be modified before any get onto the road. Which also would mean that the acceleration performance would necessarily have to be slightly less. This limitation has to do with the grip of the tires to the road and the weight pressing down on those wheels. (It is interesting all the things that Physics can tell us about any mechanism!) (They might also have used extremely sticky tires for such runs, where less vehicle weight would then have to be on the driving axle.)

So the actual mechanical performance of their car is impressive. Again, much of that is because it is a rather small car that is very aerodynamic. Still, impressive.

- However, when we get to the charging of the batteries, their claims seem extremely outrageous. They claim that after driving 100 miles (presumably at highway speed) it only takes two hours to recharge the batteries, and by simply plugging it in.

  If we do an aerodynamic drag analysis for 60 mph (similar to the 120 mph calculations shown above), we can see that the total vehicle drag is around 100 pounds aero plus 45 pounds tires or 145 pounds total drag. As above, this calculates to 23 horsepower being constantly needed, to overcome the drag factors to maintain a constant 60 mph speed. To drive 100 miles at that (constant) speed takes 1.66 hours, or 38.7 horsepower-hours of energy. This is the same as around 29 kilowatt-hours of energy. However, getting electricity out of batteries is not a perfectly efficient process, and they acknowledge that their motor ranges from 90% to 80% efficient. To charge this amount in a two hour period therefore requires charging at a rate of well over 15,000 watts. Their charger circuits cannot have perfect efficiency so certainly around 18,000 watts of household electricity would be needed.

  If this were simply "plugged in" to a standard outlet, it would require 160 amperes at 110

volts! But standard household outlets are only rated at 15 amperes and even heavy duty ones are only rated at 20 amperes! They are talking about so much electricity that at least 6 or 8 standard outlets would be needed to provide enough power! In fact, the very special wiring that was put in your house for your central air conditioner might not be enough to provide the 80 amperes at 220 volts that would apparently be needed to charge a Tesla in the two hours as described.

We note that the Tesla battery-pack includes around 2,300 very high power density batteries. Each one only needs to charge or discharge by around a total of 12 watt-hours (12 * 2,300 is around 29,000 watt-hours that we calculated above).

In this area, their promotion is extremely misleading. It cannot simply be plugged in as they imply. Very heavy duty special house wiring is required to be able to do that massive charging.

From generally known evidence regarding charging batteries extremely fast like that, the internal structure of the (tiny) batteries often suffers and the battery lifetime might therefore suffer. They don't mention what the cost of replacing their battery pack is, but it certainly would be expensive. A moderately similar experimental electric car recently shown to the press has such an exotic battery pack that replacing it would cost over $300,000! Obviously, the Tesla battery pack is not that exotic or expensive, but it clearly would be a significant expense if and when it needs to be replaced, possibly after two or three years.

A Tesla spokesperson was on TV talking about this after the above text was written. **The battery pack would apparently currently cost around $9,000 to replace,** but she pointed out that battery technology is constantly improving and that cost might drop. She also said that the battery pack lifetime is currently at least two years. It was refreshing to see an honest and open answer to such a question.

HERE is the downside of the Tesla!

Similarly, as discussed much earlier about battery-powered vehicles, the COST of that electricity can be significant. Using Tesla's numbers and this analysis, we are talking about needing to charge around 29 kWh actually into the batteries (in those two hours, after that 100-mile constant-moderate-speed drive). And that due to the efficiencies of chargers, this necessarily requires at least 35 kWh (and probably more likely, around 60 kWh) of actual house electricity. If electricity is charged at conventional rates of around 15 cents per kWh (including substantial parts of that cost for Delivery charges and assorted taxes), this is around $5.25 (or $9.00) for the electricity for that hundred miles. Granted that this is less than or comparable to the cost of gasoline in any vehicle to go that distance (such as two-and-a-half gallons of gasoline at $3.60/gallon, and getting 40 mpg mileage in a small car) , but it is still considerably more (around triple or more) what they claim the electricity cost would be.

However, it turns out that due to the rather light vehicle weight of the Tesla, and the very

small size and aerodynamic shape, it turns out that calculations show that a conventional gasoline engine in the Tesla would likely have only used up around two gallons of gasoline for that hundred-mile trip, so a Tesla with a gasoline engine might get 50 MPG, simply due to its size, weight and shape!

- But finally, the worst part of such an interesting vehicle is that problem described above regarding the amount of coal that would need to be burned at that remote electric powerplant to provide that much electricity. With the Tesla numbers and this 100 mile trip example, the calculations presented far above show that around 65 pounds of coal would have to be burned in that unseen electric powerplant, **which would send around 240 pounds of carbon dioxide into the atmosphere,** to provide the electricity for a Tesla to make that (relatively constant speed) 100 mile trip. If a small gasoline engine were used instead inside a similarly aerodynamic and light and small vehicle, maybe two gallons of gasoline would have been required to go that 100 miles, which would have released around 36 pounds of carbon dioxide into the atmosphere. Even if a full-sized sports car such as one of my Corvettes made the trip, with their highway 27 mpg, only 3.7 gallons of gasoline would be used, which would send 67 pounds of CO2 into the atmosphere. **The Tesla (indirectly) causes nearly four times as much carbon dioxide to be dumped into the atmosphere than my big-gasoline-engined Corvette would!**

  Therefore, the Tesla, which is being promoted as being TOTALLY green, in reality causes at least four to seven times as much carbon dioxide to be sent into the atmosphere than if it simply had a gasoline engine in it! Otherwise, it seems to be a rather attractive idea! Impressive acceleration and top speed and decent range. Only the immensity of the charging process, and the consequences of that are such terrible necessary requirements. Like discussed above, NO battery-powered vehicle has any of its own energy, and it requires to get all that energy from some different power source, in this case, house electricity. Even if Tesla is right that electric power companies would give tremendous rate reductions for the electricity because it was nearly all used at night, that cannot stop the requirement that the (remote) electric powerplant necessarily has to cause the release of that 240 pounds of carbon dioxide into the atmosphere from the coal burned.

By the way, many of the advantages of the Tesla have to do with its tiny size and very aerodynamic shape. Any car that had a more conventional size and shape would require a far, far bigger motor and far, far more electricity and battery size and capacity. If that car had a similar horsepower gasoline engine in it, the acceleration and top speed would be comparable, and the gas mileage would be impressive. The two main differences would be that the range would be easily 500 miles (with maybe an 8 gallon gas tank) and that the weight of the vehicle would be more engine instead of the same total weight of batteries.

The Tesla information is very vague about its battery system. Obviously, they are protective about their own unique advances. But we have calculated here that to charge at the rate they describe, there must be around 15,000 watts of charging that is done. Their literature mentions that their charger works at 70 amperes. This seems to imply that their batteries must be a series battery pack, because these numbers imply an effective battery voltage of around 200 volts. Such a high voltage (instead of conventional cars 12-volt batteries) makes a lot of sense in permitting far thinner wires to be used inside the car and in the charger and connectors, although even 70

amperes requires fairly stout wiring.

I suspect that you will NEVER see any reference to a Tesla being driven at night (because all those light bulbs use up a LOT of electrical power which is therefore taken away from being available for the electric motor); nor being driven with the (included) air conditioning operating. Automotive air conditioning normally takes around 6 horsepower, so the 23 required horsepower for that 60 mph highway driving would become 29 horsepower. This would both reduce the range by 25% and increase the charging time by 30% (as well as increasing the carbon dioxide given off at that distant electric powerplant by another 30%).

I realize that there are many optimistic people who simply say that the detriment of burning coal (which currently provides around 51% of all the electricity used in the US) could be eliminated by CHOOSING to use nuclear powered powerplant electricity instead. First, you don't have any way of deciding where your electricity is made, but second, few people seem to realize that the US already mined essentially all of its Uranium some years ago, and all of the 39 Uranium mines in the US have been closed and completely shut down for some years as a result. We import virtually all the Uranium used in American powerplants! No one seems to know that! (Only a very small percentage is actually from US sources, and that happens to be from the decommissioning of nuclear weapons, for just a few percent.)

There are certainly other even more optimistic people who simply assume that photovoltaic cells (solar cells or PV) can supply the needed electricity. First, such electricity is only available during the daytime when the sun is shining (and Tesla describes recharging through the night). But people who want to believe that have no clue as to how many PV cells would be needed! We have calculated above that around 18,000 watts of electricity would be needed to do the charging that Tesla describes. In a different energy-related page in this Domain, we present the Physics of PV devices, where around 7 watts per square foot of PV cells is possible during bright sunlight around noon. Even under those perfect conditions (noon, no clouds) around 2600 square feet of PV cells would be required. That web-page presentation describes that it is common that around $150 in total installed cost is involved for each square foot of PV cells. This would mean that around $390,000 worth of solar cell installation would likely be required to provide the amount of electricity the Tesla describes being needed! I suppose that if you can afford a $92,000 electric car, you may also be able to afford $390,000 of solar cells to charge it! But keep in mind that this is for NO CLOUDS and only around noon! Even more solar cells would be required for nearly any real climate!

See the problems? Even though that Tesla can show impressive acceleration and top speed, and decent range, and even though it is such a tiny car that the amount of electricity used is only around three cents per mile (while even at 50 mpg with a small gasoline engine, the gasoline would currently cost around 6 cents per mile), the bottom line regarding why it is even supposed to be desirable is allegedly how GREEN it is. But the reality is that some distant electric powerplant has to pump at least four to seven times as much carbon dioxide into the atmosphere than if the vehicle had simply had a smaller gasoline engine.

The single point for which it is sold is therefore (sadly) totally invalid. It may be fortunate that the only people who will be able to buy a $92,000 car probably have plenty of money

available! However, I suppose that most of them will not even be bothered by the need for maybe an extra thousand dollars of specialized heavy duty wiring being installed in their house to be able to charge the Tesla. And their likely lifestyles are such that they will never even notice if their electric bills happen to get a lot higher because of charging their Tesla.

I see it as a wonderful "novelty" for rich people to play with. For the practical reasons presented in this article, it seems inconceivable that "normal" people will ever benefit from such battery-powered vehicles or even use them (except for golf carts and electric wheelchairs).

It would be nice to be able to say that there was any chance whatever that this technology could advance to actually becoming useful some day. But Tesla even notes that they have already accomplished impressive efficiencies of around 90% and 80% at peak use. What a Tesla has is probably about as good as it will ever be able to get. And if it were not for the horrible requirement that some distant electric powerplant has to release massive amounts of carbon dioxide into the atmosphere to be able to charge the Tesla, it actually could be a useful product. But when a product is SOLD and PROMOTED as being totally green, while the actual reality is entirely opposite, it then turns out to be a really terrible idea!

The truly sad thing is that if millions of people could some day drive vehicles that are electric powered like the Tesla, Global Warming would necessary become far worse as a direct result.

An Entirely Different Approach!

I would be willing to help Detroit or Toyota or someone else to build a far more practical vehicle, which is vaguely similar to some parts of the Tesla!

Long ago, I realized that NO driver ever actually USES the huge horsepower of the over-powered cars that are sold, EXCEPT for a maximum of less than 30 seconds at a time. In all the time I have owned my Corvettes, and an Austin-Healey 3000 and other sports cars, there has NEVER been any time where I had my foot to the floor for more than 15 seconds, and that was during a quarter-mile drag where the vehicle went from zero to around 120 mph in around 13 seconds. So it occurred to me that it really is foolish for people to buy cars that have giant engines that are advertised as 470 horsepower or 505 horsepower!

In an entire year of owning and driving a Corvette, I doubt that there are more than a twenty times when I really use power for more than maybe three seconds at a time. I realized that meant that I actually USED all the power that Corvettes are known for, for maybe ONE MINUTE TOTAL per year!

I had started assembling an experimental vehicle, based on a 1985 Oldsmobile Cutlass Ciera 3.0 liter V6 front-wheel drive car I then had. (It was later vandalized beyond possible repair, so I have not yet again pursued the project with any other car [yet]). The car was mid-sized, capable of holding five or six people, a pretty standard vehicle. Its moderate sized engine permitted tolerable acceleration but never anything really interesting (to a Corvette owner!)

I noticed that the rear wheels (of the front-wheel-drive car) really did not do anything other than support the rear of the car!

I also knew that even a STANDARD car battery can contain around 80 ampere-hours of electric power in it, which, at 12 volts, is about 1 kWh (as discussed above). That meant that the one standard battery could provide about 1.5 horsepower for an hour, but that also meant that it contained enough power to provide 1.5 * 60 or 90 horsepower for one minute, or 180 horsepower for 30 seconds, or 360 horsepower for 15 seconds!

So my experiment was/is to be a car like the generic Cutlass Ciera, with its standard 120 hp (76 kW) engine, but where EACH of the rear wheels was replaced by an electric-motor-driven wheel, (or equivalently, a Tesla-type electric motor) driven directly from its single battery. (Total, two motors, resembling car starter motors, and two standard car batteries in the trunk, a rather minimal added expense beyond the modest cost of the standard Cutlass Ciera!

Maybe it would represent adding $1,000 to the cost of NEARLY ANY front-wheel-drive car. And what would be the result?

If EACH of the rear wheels could provide 360 horsepower for 15 seconds, then that vehicle should have acceleration that would be beyond belief! I intended to put an activating switch under the gas pedal, where when I would floor it, the Ciera engine might be producing its 120 hp (76 kW), PLUS the 360 horsepower from EACH rear wheel, or a total of 840 horsepower (625 kW) (but for only 15 seconds max!)

Under all NORMAL driving, the Ciera would get the excellent gas mileage that its small engine could provide, and that engine could probably be even smaller, a four-cylinder instead. But for those few seconds when acceleration was desired, it could be spectacular!

Note that this vehicle was essentially ALREADY approved by the government safety testing and all the rest, so it would immediately be street-legal. The tire-grip might not permit it, but 0-60 in less than 3 seconds seems reasonable! FAR faster than ANY car on any road today!

And all from only maybe a $1,000 increase in the cost of the vehicle!

The giant vehicle manufacturers all design and build either under-powered tiny vehicles that get great gas mileage or they design and build vehicles with hyper-performing high-horsepower engines that perform great but which have lousy gas mileage. The approach I have described above is better than both, in that it combines the best of both general designs! And at a vehicle price that would not be much above their current under-powered offerings!

I guess that what I have described here is a sort of Hybrid vehicle, since the gasoline engine would drive alternators that would recharge the batteries after a performance show. But it entirely different from what the vehicle manufacturers think is a Hybrid!

However, in my intent of modifying my Ciera, I was aware of two problems that seemed possibly hard to overcome. I knew that standard car starter motors only generate around 10

horsepower, where I wanted much more. The other problem is a result of that, in that a standard car battery is designed to have the energy drain rate of the standard starter.

I considered re-wiring a standard starter to have fewer windings of heavier wires, so that it drew a lot more current, and therefore generated more power. However, with my target of around 240 horsepower, I was not really sure whether my modification of a starter motor would cut it! So I was quite excited when the Tesla came along and it has an electric motor which they rate at 180 horsepower! And equally, their battery-pack is clearly capable of supplying the electricity very rapidly for such horsepower. So the Tesla apparently has the resolutions to BOTH of the issues that had concerned me! And where the Tesla needs to be able to withstand that level of energy flow continuously, all I would need would be a max of about 15 seconds worth. I suspect that would mean that less-expensive batteries might be sufficient and the motor could be designed to have an operating lifetime comparable to car starters, measured in minutes!

In any case, I believe my approach makes a lot more sense than what any of the giant vehicle manufacturers are now selling or designing, primarily since it can allow "nearly stock" vehicles, for both government safety approvals and for vehicle pricing that the public might be able to afford.

This presentation was first placed on the Internet in April 2006.

Automotive-related presentations in this Domain

Automotive Engine **Physics In an Automotive Engine** (Feb 2003)
Automotive Vehicles Physics In Automobiles and Trucks (April 2006)
SUV Rollover Accidents A method to make SUVs the safest vehicles on the road (late 2005)
Hybrid Vehicle An Entirely Different Approach to a Hybrid Vehicle (1992, May 2008)
Are the auto manufacturers allowing unqualified people to buy vehicles? (late 2010)
Police Radar, how Police Radar Works (June 1991)
Hydrogen. Hydrogen as a Fuel for Automobiles and Other Vehicles (August 2003)
SUV Rollover Accidents The Physics and the Math (first presented on the Internet January 2002)
High-Speed Transportation **200 mile per hour TRANS Super-Efficient Transportation System** (invented in 1989)
Automotive Engine Significant Improvement (2001)
Horsepower Gauge An inexpensive and accurate Dynamometer for Vehicles (invented around 1966)
Audible Highway Warnings **Improved Highway Safety - RoadTalker** Ridge Patterns in Highways for Warning Messages (invented in 1995)
High Speed Police Chases A method to eliminate them (invented in 1997)

Vehicle Diagnostic System Based on Vibrations (invented in 1998)
Tire Pressure Monitor Very accurate and inexpensive (invented in 1995)
Lane Speed Information every two miles, for Drivers Real-Time Traffic Conditions (first Internet in 2000)
Daylight Headlights Driving with your Headlights On (Apr 2002)
Oil Change Monitor Automotive (invented in 1998)
Police Radar, how Police Radar Works (June 1991)
Soft-Riding Tires (first presented on the Internet 1998)
Snow Plow Urban Snowplow Truck that Minimizes Snowpiles (invented in 1975)

Energy-Related presentations in this Domain:

Becoming Self-Sufficient A thorough presentation
Global Warming The Physics (June 2004, June 2008)
Climate Change The Physics (June 2004, Feb. 2007)
Alternative Water Heater HeatGreen - A Simple and Non-Fossil-Fueled Water Heater, HG3a (biodecomposition) (March 2007)
Alternative Furnace HeatGreen - A Simple, Non-Fossil-Fueled Home Heating Furnace, HG3a (biodecomposition) (March 2007)
Solar Heating Low tech, low cost approach (April 2007)
Heat and Cool a House **Naturally, without a Furnace or Air Conditioner** (1977, Nov. 2000)
World Energy Supplies **Coal, Oil, Natural Gas, Uranium supplies and consumption** (May 2010 Report)
Asphalt Pavement Environmental Effects of Asphalt Pavements, Roofs, and Parking Lots (August 2007)
Perfect Energy Source From the Earth's Spinning (1990, Nov. 2002)
Source of Energy Using the Moon (1990, Dec. 2009)
Tornadoes The Physics of Tornadoes, including How they Form. A potential energy source (Feb. 2000, May 2009)
Survival Ark, **Sixty-Acre Floating Communities for Survival** For Sealevel Rising (July 2008)
Climate Effects of Electric Power Plants
Global Warming Effects of Carbon Dioxide
Hydrogen. Hydrogen as a Fuel for Automobiles and Other Vehicles (August 2003)
Solar Heated House **NorthWarm Totally 100% Solar Heated House - Version 1** (1979)
Solar Cells **Photovoltaic Cells, PV, Electricity from Sunlight** (Jan 2002)
High-Speed Transportation **200 mile per hour TRANS Super-Efficient Transportation System** (invented in 1989)
Electric Cars Battery-Powered, Hybrid Cars and Hydrogen-Powered Vehicles (April 2006)

Windmills Practical Wind-Generated Electricity (Residential, some Watts) (1975 and April 1998)
Tower Windmills **Practical Large-Scale Wind-Generated Electricity, 1200 KiloWatts (Community, a thousand homes)** (a million construction jobs and 12,000 MegaWatts of electricity Nationally) (June 2007)
Earth Energy Flow Rates due to Precessional Effects (63,000 MegaWatts of Energy) (Sept 2006)
Nuclear Wastes Productive Disposal of Nuclear Power Plant Wastes (1980s, Sept 2005)
Conserving Energy
Storing Energy Various Methods
How Much Solar Energy
How the Sun Works in Creating Light and Heat
Energy Inventions Related to Energy Crises
Generating Electricity From solar, wind or other sources nearly 24 Hours a Day (2001, tested 2003)
Generating Electricity **A Unique Method of Using Solar Energy to Generate Electricity** (late 2010)
Alaska Pipeline Alyeska pipeline Local Climate Effects (August 2005)
Home Air Conditioning **Natural, GREEN and FREE!** (1978, December 2000)
Hybrid Vehicle An Entirely Different Approach to a Hybrid Vehicle (1992, May 2008)
Woodburning Furnace Fireplace, Woodstove - JUCA Super-Fireplaces (designed 1972, manufactured 1973 on, still not matched)
Burning Wood for Heating The Physics of Burning Wood as a Heating Fuel (published 1978)
North Pole Heating Faster than anywhere else
Global Warming Solutions
How Airplanes Fly **Aerodynamic Lift, Bernoulli Effect, Reaction Lift** (April 2003)
Efficient Flight Greatly Reducing Turbulence and Drag for Aircraft and Airfoils, TURCAN (summer 1998)
Construction School My Concept of a GREEN Campus (1990, Dec 2008)
Conservation of Angular Momentum **A Violation of the Conservation of Angular Momentum** (Sept 2006)
Hurricanes **A Credible Approach to Hurricane Reduction** (Feb 2001)
Automotive Engine Significant Improvement (2001)
Global Warming **Why No Leaders Seem to See Urgency in Global Warming**
Source of Energy (Artificial Tides) (1998, 2010)
Source of Energy (Energy Harvesting) (1975, 2010)
Making Electricity **Make All Your Own GREEN Electricity** (2001, 2003, 2010)
Woodstove Energy Production from a Radiant Woodstove (published 1979)
Firewood Ratings **Firewood Info Chart**.

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