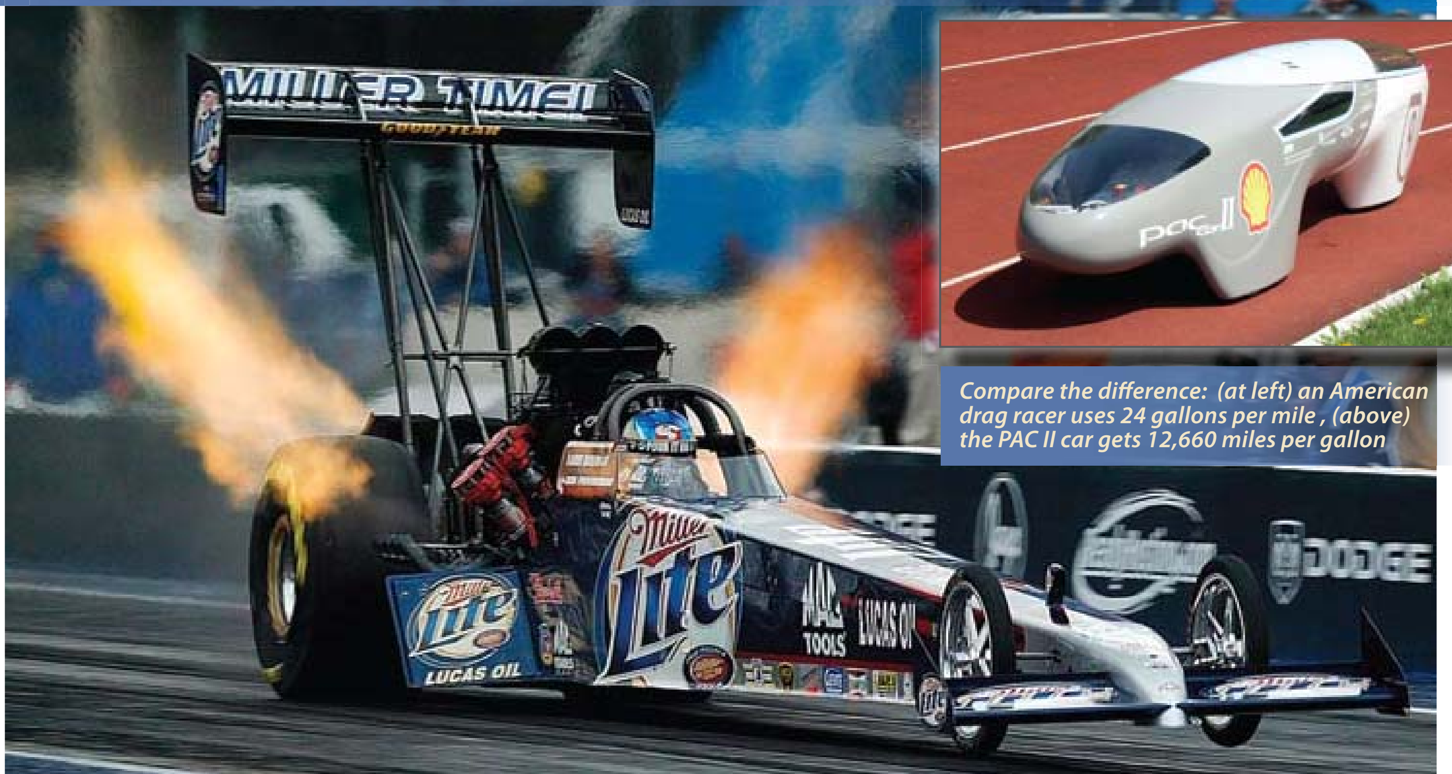
Gasoline: Past, present, and future



Compare the difference: (at left) an American drag racer uses 24 gallons per mile , (above) the PAC II car gets 12,660 miles per gallon

Guest Column: *by Rick Rys*

Part 3 of a 3 part series

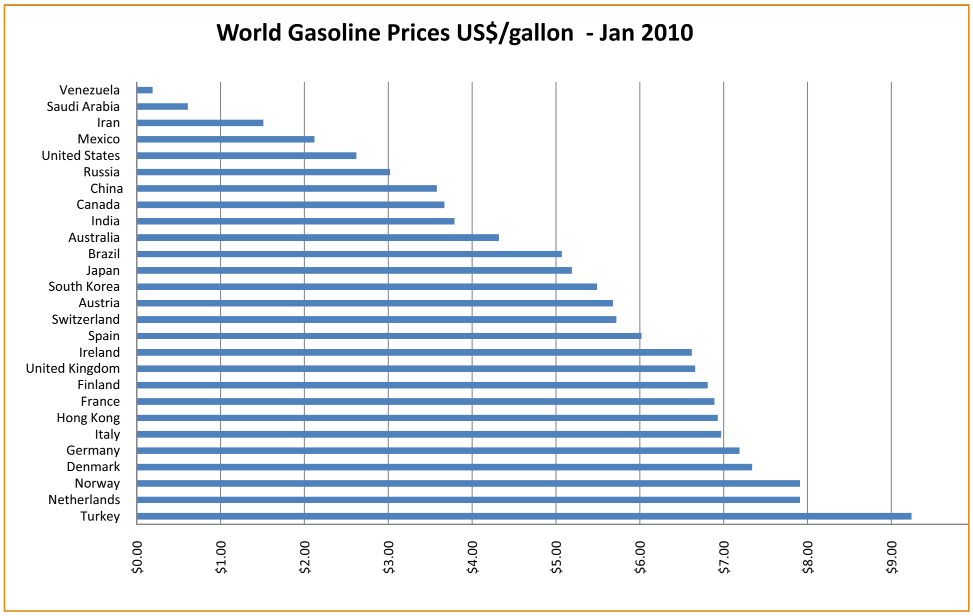
In the first part of this series we have seen how the 1970 Clean Air Act drove EPA and CARB to reformulate gasoline to help clean up air pollution in cities across the US. In the second part of the series we looked at the declining rate of oil discovery and the inevitability of "peak oil and gas." We looked at the difficulties of reducing CO_2 emissions and took a peek at the emerging Biofuels Industry. In this third and last article, we will look at some of the obstacles to achieve high fuel economy, and some of the issues in the competition for the energy sources that will power future vehicles.

There are many who think the car companies could easily make a car that gets 100 mpg. This article will help you understand the challenges to achieving high fuel economy, with a number of different propulsion systems.

New Ideas abound

There has never been a time when so many new concepts, prototypes, and vehicles have competed for the future platform we will use for personal transportation. Some of this is marketing to create an image. However, much of it is real engineering to find the right technical innovations that match what the buying public will find compelling enough to use for personal transportation. The success or failure of new innovations depends not only on the technology, but on timing, and complex business dynamics. Success depends on having the right product ready to meet market demands and the constantly changing local regulations. The relative price and availability of petroleum fuels, biofuels, electricity, and hydrogen will also play a big role.

The choice of car, propulsion system, and how it is driven drastically affects the fuel economy. From a pure physics point of view you could argue that if it is uphill one way you should be able generate power when going downhill the other way only paying for frictional losses. A top fuel dragster can consume 6 U.S. gallons of nitro-methane for a quarter-mile which is about 24 gallons per mile. At the other extreme is the world record PAC-Car II. In the 2005 Shell Eco-Marathon, it used a hydrogen fuel cell engine to achieve an amazing 12,660 miles per gallon (gasoline equivalent). The current Shell Eco-marathon record for a combustion engine entry was set in 2004 by the team from Lycée La Joliverie (France) at 8021 miles per gallon. The Shell Eco-marathon began in 1939 at a Shell research laboratory in the United States as a friendly wager between scientists to see who could get the most miles per gallon from their vehicles. The first bet was won with 49.7 mpg in 1939.



This chart gives a snapshot of gas prices around the world. Source: http://www.hybridsuv.com/news/world-gas-prices

Price is the driver

The path to super efficient cars has many technical obstacles, but the main driving force that has allowed the conventional "otto cycle" internal combustion engine to win our loyalty is the relatively low price of gasoline. Most people understand that fuel prices are likely to increase in the future, but until they actually increase there is little incentive to purchase more efficient vehicles. Taxing fuel is politically very difficult. In Venezuela, where gasoline is the cheapest in the world (currently about $0.19 per gallon), price hikes in 1989 sparked severe social protests. Hundreds of people were killed. In the US, the CAFE fuel standard is the major force at work to increase fuel economy. CAFE or "Corporate Average Fuel Economy" standards originated in 1975 for cars and trucks less than 8,500 lbs. The ongoing debate and frequent rule changes to CAFE over the past 4 year's leaves this effort uncertain. It is not surprising car companies prefer to sell larger cars. When fleet average fuel economy is regulated and fuel prices are low at the pump, conventional large cars will sell out first.

With massive growth in 2009, China has emerged as the largest car producer and consumer in the world. In the first 4 months of 2010, the total sales of automobiles were 6.17 million in China (3.52 million in US), and the total sales were expected to be around 17 million (13.65 million in 2009) for 2010, nearly twice as much as the USA. Russia, Brazil, and India have seen strong growth while the US, Europe, and Japan are stagnant.

Both the cost of gasoline and the cultural preference for performance and or size directly impact the cars that consumers choose. For example, in Japan where gas is expensive the Prius is the #1 selling car, while in the U.S. the Ford F-series Pickup is the #1 seller. In Europe, the VW Golf is #1, and the $10,000 BYD F3 (closely followed by the Buick Excelle) is #1 in China. Interestingly the BYD logo (shown above) looks like it took some design elements from the BMW logo.

Energy wasted

According to the CA Energy Commission about 15 percent of the energy from the gasoline you put in your tank gets used to move your car down the road or run useful accessories, such as air conditioning. The rest of the energy is lost to engine and driveline inefficiencies and idling. Therefore, the potential to improve fuel efficiency with advanced technologies is enormous.

You would think there should be a law against such blatant inefficiency. There is a law – The Second Law of Thermodynamics. The biggest losses occur in the engine, because it is technically hard to convert heat from the fuel to useful work.

European and Asian automakers have begun to bring idle-shutdown systems to ordinary gas cars, but only on a small scale and mostly overseas. BMW, for instance, uses a shutoff system on its four-cylinder European models that gets fuel savings of ~5%; BMW will bring this feature to its U.S. vehicles. Mazda, Ford, Kia, Audi, and Mercedes-Benz are also working on similar systems. The Porsche Panamera and the upcoming 2011 Cayenne have a push-button auto start/stop system that must be manually activated. Of course hybrids do this already.

So how come these are not being adopted in the U.S. when fuel savings are estimated at 5% to 10% in congested traffic? One reason is because the Environmental Protection Agency doesn't factor in much idling time for its fuel economy tests, so there is little benefit to the numbers on the mileage stickers. The diagram at the bottom of this page illustrates energy use and loss.

Performance & Economy

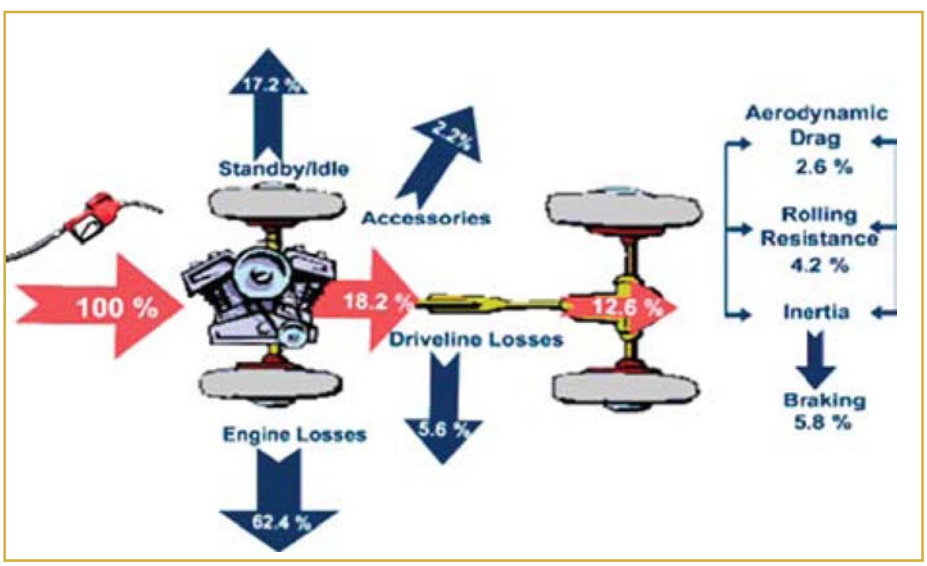
Suppose we want performance and fuel economy. The BMW 335d has some rather impressive specifications with 425ft-lb of torque it is rated for 23 city and 35 mpg highway. Not bad, but…. It seems there is a new market developing that I would call the SUPER-ECO sports market where you get both supercar performance and beat the econo-box fuel economy numbers too. In the past, performance and economy appeared to be mutually exclusive. The dragster and the PAC II car have very little overlap one car for performance and one car for economy.

Enter the Porsche 918 Spyder concept hybrid car. This is a clear example that engineers are hard at work to supply vehicles for this new SUPER-ECO class. The 918 claims 78 mpg, 198 mph top speed, and 0-62mph in 3.2 seconds. Too bad it is just a concept. The TESLA all electric roadster sports car is a car you can buy and it has a 53kW*hr battery and a 244 mile range putting it in the new SUPER-ECO class. There are other ways to make the compromise too. The Loremo is a 28 HP conventional diesel that weights 1200 lb, goes 100 mph and gets 120 mpg. The main technology for the Loremo is the patents on crash protection. With adequate crumple zone and technology from race car cage protection, it is possible to keep safety high. Performance however is weak and you cannot buy this car in the US just yet. The Volkswagen L1 concept car is a 2 passenger, diesel hybrid with a fuel economy of some 170 MPG. If you had gas lines or rationing these low cost cars would quickly catch on. So yes car companies can make cars that get 100mpg.

A few of the hybrid and electric cars that are turning heads include: (from top to bottom, the Porsche 918 Spyder concept hybrid car, the TELSA all eclectric roadster, and the Volkswagen L1 concept car which is a diesel hybrid.

Fuel Options

We could use many different fuel sources to power a vehicle, but it is very convenient if the fuel has a lot of energy so it does not need to be either heavy or bulky. Heavy fuels, fuel tanks, and engines reduce payload. Bulky fuels reduce space for people and cargo. The perfect fuel would be light weight and very small, and the engine that converts fuel energy to push the car would also need to be small and light weight. A light weight nuclear fusion reactor would be perfect. A few grams of hydrogen would provide a range of a million miles so you never need to refill, plenty of extra heat for passengers, defrost, and electrical accessories. Assuming we get good throttle response it would also crush the competition on the race track due to its light weight. Unfortunately, even though it is conceptually possible, it is just a dream (like the dilithium crystals of Star Trek) and we are constrained by both physics and the state of development of many dif-

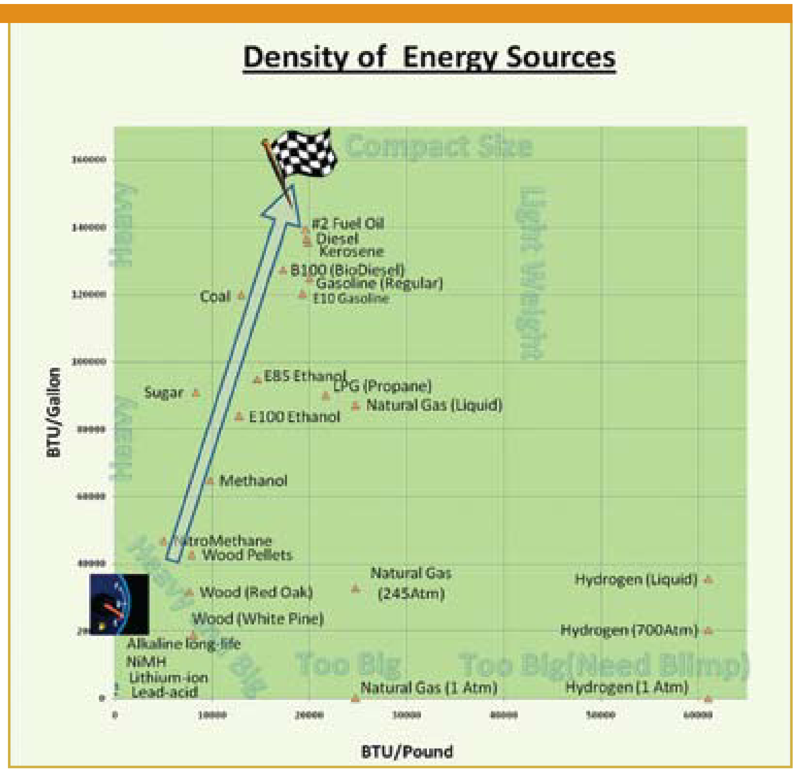


This illustration shows how a typical gas engine uses energy. Source is http://www.consumerenergycenter.org/transportation/consumer_tips/vehicle_energy_losses.html ferent technologies. It's nice to think outside the box but let's look at the near future.

The Energy Density chart shown at right, allows us to see how key properties of major propulsion fuels compare. The chart shows that Gasoline and Diesel fuel have a big advantage over the other competitors. They are low weight and only slightly bulky. There are very few chemical reactions that can make more heat than our current hydrocarbon fuels. One reason is that most of the fuel for your car comes right out of thin air. Oxygen outweighs Hydrocarbons and it has been conveniently placed everywhere we drive. For example:

1 lb of Hydrogen needs 8 lb oxygen, (34.5 lbs air)
1 lb of Methane needs 4 lbs oxygen, (17.24 lbs air)
1 lb of Propane needs 2.8 lbs oxygen, (12.1 lbs air)
1 lb of Gasoline needs 1.8 lbs oxygen, (7.8 lbs air)

You can see that batteries don't present themselves too well on this chart, but as you will see, they are not quite as bad as they look.



Source: Developed by Rick Rys using multiple industry sources to illustrate the differences in energy density.

Nitro-methane (fuel for dragsters) looks to be about the same size and energy content as wood pellets. So why is it so powerful? The weight of a dragster engine far outweighs the 6 gallons of fuel it needs to make a single ¼ mile run so fuel weight is not critical. Nitro-methane contains its own oxygen so less air is needed. Air has the unfortunate impurity of nitrogen which hogs 79% of the space and hardly reacts with anything so it simply goes along for the ride, consuming power to move it, reducing efficiency, and taking up space that could be used to cram more fuel in each piston stroke. Without the nitrogen though, engines run hot and reach higher pressures, which would quickly destroy an engine not built for the stress.

Biofuels seem to be the answer to keep the cars we know and love because they are so close to the fuels we use now. To make Biofuels in the quantities we are currently consuming is an unsolved technical and business problem. The amount of land required, the farming methods, and the manufacturing facilities will be enormous. Our history with corn ethanol indicates that Biofuels on a large scale are bound to have some unpredictable consequences and will be an evolutionary development with missteps likely.

Hydrogen

At first glance Hydrogen seems like a great fuel, it is light weight, and it burns to water with no CO_2 in the exhaust. Except hydrogen made from natural gas produces plenty of CO_2. Making it from water electrolysis has some efficiency issues and the grid today is heavily powered by CO_2 emitting generators. Hydrogen is by far the lightest fuel around; just 1 pound of hydrogen has the energy of 3 pounds of gasoline. Hydrogen's light weight is why it is so convenient for the space shuttle. The big problem with hydrogen is that it is bulky. It is 6 times bulkier that gasoline even if it is compressed to 700 atmospheres (2600psi). Even exotic liquid hydrogen is still 4 times the volume of gasoline for the same energy. Low pressure hydrogen would require towing a blimp to get any appreciable range and blimps don't go through tunnels or underpasses very well and don't fit in normal parking spaces. To partially compensate for hydrogens bulk, a relatively efficient hydrogen fuel cell can be used. Efficiency is in the 36-45% range, much better than a piston engine, but well short of batteries.

It's not clear why BMW bothered with the Hydrogen 7 car, a vehicle with a piston engine that could swap between hydrogen and gasoline. Hydrogen in a piston engine gets the same poor efficiency as gasoline. A 2007 article in Technology Review stated, "In the context of the overall energy economy, a car like the BMW Hydrogen 7 would probably produce far more carbon dioxide emissions than gasoline-powered cars available today." The Hydrogen 7 was a design exercise, and is not to be confused with very quick BMW ActiveHybrid 7 which is basically a mild hybrid with an engine stop feature.

Natural Gas (Methane)

T-Boone Pickens outlined a plan to generate grid power from wind, and shut down most of the Natural Gas fired generating stations to cut our oil imports and divert natural gas for vehicle propulsion. On Feb. 26, 2010 DOE released an update on US Wind potential. This update shows that the contiguous 48 states have the potential to generate up to 37 million gigawatt hours annually. By contrast, total U.S. electricity generation from all sources was roughly 4 million gigawatt hours in 2009. That's about 9 times what we use today and certainly enough to technically displace any fuel from the power industry, and this ignores the off-shore wind potential. In terms of $/BTU, Natural gas has been the cheapest hydrocarbon on the market, and recent advances in extraction have noticeably increased US supply driving prices even lower. Natural gas has a lower CO_2 footprint than gasoline (about 23% less CO_2) and is compatible with existing piston engine technology. Like Oil, Natural gas is a limited resource that will eventually hit peak production. Natural gas can be liquefied and stored easier than Hydrogen, but high pressure cylinders are still required and these add weight. Propane can more easily be stored as a liquid but still requires pressurized tanks. Interestingly, Propane is typically one of the most expensive consumer fuels considering its energy content.

Biofuels

Biofuels are already part of the mix, but neither gasoline engines nor diesels have been specifically designed to run on the emerging Biofuels. The vast majority of the FlexFuel vehicles cannot run E100. They are capable of running E85, but actually nearly all run on E10 as few E85 stations are available. Running on E85 and E100 have a big penalty in fuel economy and fuel should sell for correspondingly less to give the consumer the same value in miles per dollar. Ethanol has an octane of 126 and could in principle be used with a much higher compression ratio to obtain a higher efficiency to partly compensate for its lower energy density. Car companies have little incentive to make "ethanol only" engines without E100 fueling facilities already in place.

Renewable fuels like Ethanol are part of the answer. However, considering the current farming practices for corn-based Ethanol, estimates show that they have only reduced US greenhouse gases by 1/19th of 1% and made us only 1.1% more energy independent.

We will ignore the guy down the street burning used cooking oil as that is not a scalable solution. The latest specification for Biodiesel at this writing is ASTM 6751-09a. Most car companies now limit to B5 or 5% of the blend. This is due partly to the sophisticated fuel injection and exhaust treatment systems on the newer diesel engines. Biofuel dealer Jason Burroughs tried 100% Biodiesel, that supposedly met the ASTM 6751 standard, on his 2009 VW TDI, but at only 1,380 miles, he ran into some CEL trouble – code P247A: EGT Sensor 3 Bank 1: Exhaust Gas Temperature Out of Tolerance. The dealer threatened to void his warranty if he used B100. There was no engine damage here, but it seems clear that car manufacturers are not geared up for pure Biodiesel. The 2008 MA Clean Energy Biofuels Act requires a minimum percentage of Biofuel as a component of all diesel fuel and home heating fuel sold in the Commonwealth, starting at 2 percent in 2010 and ramping up to 5 percent by 2013. Massachusetts is the first state in the nation to require Biofuel in home heating fuel.

Like Gasoline, Diesel is blended with varying specifications based on the climate. There is ample cold weather evidence that B100 bio-fuels do not meet the same Cloud Point, Pour Point, and CFPP specifications that is achieved by typical refinery blending systems which use extensive analytical equipment to certify each shipment to each geographical area.

The *Seattle Times* claimed that BMW was "planning" to bring the 116D to the US market in 2010.

Biofuels versus Electric competition

At a recent Biofuels conference our group had a revealing discussion that compared the overall energy balance for Biofuels with solar electric. Consider 1 acre of farmland in Iowa. At best about 5% of the sunlight that hits a crop will be converted to biomass energy. With only a 50% growing season and spacing between rows, we get maybe 2.5% of that acres solar energy into the Biomass. Typical Biofuels facilities can convert about 50% of the biomass energy to heat of combustion energy in a liquid fuel. We are now down to about 1.25%. Now add the fertilizer, fuel for tractors and the energy to run the Biofuel factory and we are easily down to about .6%. Consider that we will put this fuel into a vehicle with not more than 25% engine efficiency, and we are now down to about 0.15 % efficiency of sunlight hitting that acre to push a vehicle down the road. No wonder it took 300 million years to make fossil fuels.

So now let's compare this to PV electric generation with an electric car. Let's say we have 1 acre of PV electric panels installed in Arizona with a spacing of 50%. With today's technology we can easily get 12% of the sunlight to convert to electric power. We can get that power into the grid at about 90% efficiency. We are now down to 5.4%. Now getting that power out of the grid and into a battery may be about 70% efficient, so we are now down to 3.8%. Transferring the battery energy into work to push a car should be about 90% for a good motor. The overall efficiency is about 3.4%. This is some 23 times more efficient than Biofuels. In other words, it would take about 23 acres of Iowa farmland which competes with food farming to push a vehicle with Biofuels while the same size vehicle could be pushed the same distance with only 1 acre of dry Arizona desert. That does not mean that PV is the winner. The infrastructure for Biofuels is much better developed. The cost of PV panels and transmission lines to connect to the grid are very high and electric vehicles have some issues too.

Electric Vehicles:

> *"Electric power is everywhere present in unlimited quantities and can drive the world's machinery without the need of coal, oil, gas, or any other of the common fuels." – Nikola Tesla*

One of the key factors why we switched from electrics to gasoline in the early 1900's was the driving range. Today's electric cars have a range of about 120 miles at best and running out of power miles from home is an issue as it takes time to charge batteries. Former SAP executive Shai Agassi has an innovative plan to run a whole country (Israel) using only electric cars. He also wants to convert all of Hawaii to electric cars. The idea is you buy the car, but the battery management company owns the battery. Pull into the service station and swap out the battery in 2 minutes and go on your way. You pay for the power and the cost of the battery distribution system. Charge your car at home and you will never need to go to the battery station until the battery wears out. The Nissan Leaf price is $32780 in the US. Add a federal tax credit of $7500 and local credits in CA, GA, or OR, and the price will be even lower. These tax credits shrink after it has sold 200,000 units and is then phased out over a year. *The Times* of London claims the battery pack costs about $9000 and Nissan can make a profit at the $30,000 level. The car has a claimed range of 100 miles.

The Nissan Battery pack

The Nissan has a lithium-ion battery that stores 24 kW*hr of energy. To put that into perspective that is equivalent to the energy in about 0.7 gallons of gasoline. The battery pack is made of air-cooled stacked laminar cells with manganese oxide in the cathode. The battery and control module together weigh 480 pounds which is more than 100 times heavier than 0.7 gallons of gasoline. A good chunk of the vehicles estimated total weight of 2800 lbs. The Nissan Battery (shown above) takes up the space below both the front and the rear seats. Energy density might have been higher but compromises were made for toughness and fast charging performance. That low energy content may seem ridiculous at first, but there are a few advantages that help to level the playing field. First up is the efficiency of converting battery power to work which is about 90% compared to only 15



Top: The Chevy Volt has over 50,000 customers on a waiting list to purchase this efficient little car.
Middle: The E-Tracer is a 1200 lb. 2-passanger enclosed cabin electric motorcycle.
Bottom: Michael Czysz has designed a 100HP motor-cycle with and electric drive system .

to 20% for gasoline. Second up is the gasoline fuel tank and engine which weigh a lot, and the single Nissan electric motor which is relatively light. Third is the cost for fuel. At $.15 per KW*hr (my approximate New England electric rate), it costs $3.60 to charge up the battery. This is estimated to be less than a third the fuel cost compared to a 30mpg gasoline car. Clearly the 100 mile range is an issue, and you may need to plug in at work or your buddies house in order to make it back home. Ed Begley, Jr., an electric car advocate, noted wryly, "The detractors of electric vehicles are right. Given their limited range, they can only meet the needs of 90 percent of the population." In addition, new Nickel-metal hydride and lithium batteries are non-toxic and can be recycled, and "the supposed 'lithium shortage' doesn't exist".

The 149 HP Chevy Volt will cost about $40,000, but it still has over 50,000 people signed up to buy it, although with subsidies consumer prices could be as low as $30,000. It has a 16 kW*hr battery, 2/3 as large as the Nissan, but because only half the battery capacity is normally used, it can travel for only about 40 miles on the battery alone. It will have a 71Hp 1.4L 4 cylinder gasoline generator, so it will be possible to use for long trips. As many car owners have a large number of short trips, this arrangement could be quite desirable.

BMW has the prototype MiniE 100% electric car and has made the ActiveE concept based on the 1 series coupe. These are basically car conversion experiments, but a task force known as Project I (the "I" stands for innovation) is studying the optimum means for individual mobility in the huge cities of the future and has identified the plug-in electric car as a favorite candidate.

Racing & Competition

In this article discussions on Mass transit, car-pooling, better planning, and telecommuting, and many other ways we could conserve are avoided in order to focus on personal transportation.

There is a very interesting competition for highly efficient vehicles going on in the next few months. The Progressive Insurance Automotive X PRIZE is a $10 million competition to inspire a new generation of viable, super-efficient vehicles that people want to buy. The competition has just started in April and will continue through August at the Michigan International Speedway in Brooklyn, MI, where competing vehicles from across the globe will participate in a series of scored performance and efficiency tests. Competition events will be open to the press and the public during special Public and Media Days. The goal of the prize is to:

- Stimulate automotive technology, manufacturing and marketing breakthroughs that:
- Radically reduce oil consumption and harmful emissions, and
- Result in a new generation of super-efficient and desirable mainstream vehicles that people want to buy.

If you want efficient and desirable to own, the E-Tracer (shown above center) is a 1200 lb 2-passenger fully enclosed electric cabin motorcycle. With a 120Hp (or optional 268 Hp) motor it is very fast. Included in that weight is a 20kW*hr, 250lb Li-Ion battery, which is almost as large as the Nissan battery and larger than the Chevy VOLT. With exotic sports car performance, sleek aerodynamics, and a cruising range of 150 miles it combines exhilaration with efficiency and is competing in the Progressive X-prize competition. There are emerging race circuits for electric cars too including the NEDRA for drag racing, and the emerging EVCup. The "Killacycle" electric dragster motorcycle goes from

0-60mph in less than 1.0 second. The TTXGP is a series of zero carbon motorcycle races described as the Grand Prix for clean emission racing. MotoCzysz builds and sells a light weight high performance 100HP electric drive system including ten 1.25kW*hr batteries, motor, and controller.

Michael Czysz has entered the Isle of Man TT Zero Race where he is using that drive system on his new E1pc bike. The Isle of Man Government will award 10,000 UK pounds to anyone who achieves a 100mph lap speed on an electric motorcycle.

Engines and Fuel economy:

Of the Chemical energy released by the fuel in an engine, only a disturbingly small part of that energy pushes our car. About 18-30% of the chemical energy in Gasoline, and about 25-40% for Diesel engines, is converted to work at the crankshaft. Most of the energy in the fuel leaves the engine as wasted heat in the radiator and exhaust. The ideal engine would not have any radiator and would have a cold exhaust, but such an engine is not possible. Why can't we come up with a more efficient engine that would extend fossil fuels and make Biofuels more practical?

Most conventional gasoline engines can be described by the thermodynamic Otto cycle, although few realize that Toyota Prius (and other hybrid vehicles) uses a slightly more efficient variant called the Atkinson Cycle due to an extra linkage on the connecting rod. Diesels have both a more efficient thermodynamic cycle and about 11% more energy in each gallon. The Otto and Diesel cycle engines still dominate new car sales, but there are innovations including the BMW Turbo-Steamer concept car which directly challenges the thermodynamic limitations of the piston engine by using some of the same thermodynamic know-how of combined cycle stationary power generators.

A potential competitor to piston engines is the fuel cell. You may not be aware that a company called BloomEnergy has recently released a fuel cell that runs directly on light hydrocarbons like Methane, Propane, or Ethanol. Other companies like Panasonic also have hydrocarbon fuel cell products on the market and working. Although expensive to make, the fuel cell is essentially a battery with a flowing electrolyte that is only depleted when the fuel runs out. They run very hot, and can have a remarkably high thermal efficiency. The Bloom Box system uses no exotic metals and has a thermal efficiency (from energy content of the fuel to AC electric power including the inverter) of about 51%, which is about triple that of a normal internal combustion gasoline engine. Hybrid designs can work with Biofuels and conventional turbines to achieve efficiencies of over 70% which exceeds even the best stationary power plant efficiency which is about 60%. Hydrocarbon fuel cells don't run on Gasoline or Diesel and have been slated for stationary power generation, but future innovations and cost reductions may give them a role in transportation especially well suited to the Chevy Volt series hybrid design.

Conclusion:

Gasoline and Diesel fuel will gradually contain more Biofuel content and hydrocarbon fuels will be around for the foreseeable future but not in the quantities available today. There are market and environmental forces that will make our traditional hydrocarbon fuels very expensive in a matter of 5-10 years. Corn Ethanol will decline and relatively clean and domestically available Natural Gas will play a big role in the next 20 years. The emerging wind energy business is pushing for a national RES (Renewable Energy Standard) i.e. 25% renewable power by 2025. From the discussions of the basic physics of energy storage and conversion in this article, you can see that replacing hydrocarbons will require ingenuity and it will take all kinds of energy along with improved efficiency to adapt.

Hydrogen for cars may be a dead end if battery technology continues getting better. Battery power has the advantage of an existing power distribution system, while hydrogen filling stations don't yet exist. Electric cars are more expensive to buy and cheaper to operate, but major changes to the way we generate electric power are needed to reduce CO_2 emissions and power our cars. Invention and innovation are happening at unprecedented levels with untold concepts, prototypes and new company formation and failures too. The new SUPER-ECO class of sport cars promises that we can get both sports car performance and great fuel economy.

We cannot drill our way out of peak oil and along with environmental concerns new technologies and conservation are coming. May the best ideas prevail! ♦

Editor's Note: Rick Rys is a BMWCCA and BMWMOA member. He is a registered chemical engineer (MA). He worked for Foxboro Company for 20 years, but has run his own consulting engineering company for the past 13 years. He developed equipment, software, and control systems to manufacture and blend gasoline and diesel fuel at many oil refineries worldwide to meet the EPA and CARB requirements for reformulated gasoline. Rick can be reached at rys@R2Controls.com.