**Ecosceptor, LLC**

**Fuel Economy Technical Report**

1. **Is improved fuel economy possible**

When questioning whether HHO systems and other technologies can improve fuel economy on today’s automobiles, the first logical place to start is “Is it possible?” Statistically we may surmise that it is indeed impossible to do what is not conventionally done on a regular basis. Magicians capitalize on the uniqueness of their “tricks”. Within the scope of increasing the efficiency of the internal combustion engine (ICE), reasonable parameters can only be established when considering *facts*.

* 1. **How efficient are today’s automobile engines**

The modern automobile is rather complex, and involves many conversions that tend to skew simple analysis. To singularly isolate “engine efficiency”, an overall efficiency of the automobile in general must be viewed, then the losses broken down to where a scientist may be able to more accurately determine the inefficiencies attributed to the engine alone. One study (Marc Ross, Physics Dept. U of Michigan) attributes 17% of inefficiencies to be tied to vehicle loads (air drag 5%, tire rolling resistance 5%, brakes 5%, and accessories 2%). Only 3% losses are due to automatic transmissions (manual transmissions have even less), which leaves a total of about 80% of all losses taking place within the engine. This makes the modern engine an optimistic 20% efficient. Only about 11.52% of the total loss is due to internal engine friction. The rest (68.48%) is simply the engine’s inefficiencies in converting chemical energy to kinetic energy at the crankshaft (11.52% + 68.48% = 80%).

* 1. **Has anybody ever done it before**

To claim to be the first to accomplish anything is incredible, and discreditable at the same time. It is easier to make substantial claims if there are predecessors that have achieved results that make your claims seem reasonable. Have there been prior inventors that have eclipsed the commonly accepted limits of vehicle efficiency? Yes there are literally thousands. I could post within this thesis many names and patent numbers (many owned by auto manufacturers and petroleum companies) that show to those practiced in the art, a means whereby dramatically improved fuel economy is achieved. I have compiled a short list for illustration purposes.

* + 1. **Pogue**

In 1936 a Canadian, Charles Nelson Pogue, challenged the way we view internal combustion engines, and the way we view fuel economy. Using his patented “carburetor” (US Pat. No. 2,026,733 issued 1-07-36), he drove a 1935 Ford with a flat head V-8 for many skeptics and achieved over 200 miles to the Imperial gallon each and every time. His accomplishments were documented by some very credible sources. To name a few, D. F. Smith, Ford Motor Co.; T. G. Breen, Breen Motor Co.; and S. Stockholm (independent tester). The average mileage for all tests exceeded 204 miles per Imperial gallon (about 176 miles per US gallon).

As scientific minded individuals, though, we want to know if the device is operable with today’s gasoline and automobiles. That question is not easily answered, as it was deemed inoperable with leaded gasoline that dominated the petroleum market from shortly after Pogue’s debut until the late 1970s. It appears that the tetra-ethyl lead had a detrimental effect on the Pogue device (for more understanding research Thermal Catalytic Cracking; TCC).

* + 1. **Ogle**

On April 30, 1977 a 20-something year old high school drop-out/inventor named Thomas Ogle once again captured the world’s attention with his 1970 Ford Galaxie 500 powered by a 302 V-8 engine. He publically traveled from El Paso Texas to Demming New Mexico and back on about 2 gallons of gas (104 US mpg). This was verified by not only the press, but also supported by Robert Levy, an El Paso Physicist; John Whitacre, professor of mechanical engineering at the University of Texas; and Gerald Hawkins of Texas A & M.

His patent (US Pat. No. 4,177,779, issued 12-11-79) was bought by a retired Navy Admiral named C. F. Ramsey of Longview, Washington. I personally spoke with the technical person hired by Admiral Ramsey to get the Ogle device marketable. He claimed that there were technical issues that made it difficult to make a user friendly product, but they were able to get far in excess of the publically known 100 mpg from a similar automobile.

**iii Others**

The US Patent Office and periodicals are filled with literally thousands of inventors that have claimed mileage gains that have exceeded the 200% threshold (triple the mileage). In the early 1980s an inventor named Ray Covey sold books on how to build a device, claiming a minimum of 200% increase in mileage. About that same time a father and son team were touring the circuit with their Naylor High Mileage Vapor Phase Carburetor that they claimed would achieve a minimum 150% increase in mileage. Shell Oil Co. even promoted a 1959 Opel as getting 376 mpg in 1973. I could literally take up an entire report repeating success stories that show that our automobiles are not anywhere near at the efficiencies they are capable of with petrochemical fuels. Let it suffice to acknowledge that it has successfully been proven over the past century that much better efficiencies are realistic from the internal combustion engine than we even now get.

1. **How did they do it?**

You just have to scratch your head and wonder if they were really good scam artists, or if they figured out what others couldn’t. Although only a couple of the better known inventors were mentioned above, I assure you that through my research over the past 17+ years there are many lesser known inventors that have claimed to have achieved even better results than those listed (though not as well documented). If such a feat were possible, we must wonder to ourselves how they did the seemingly impossible. I offer for your education and enjoyment the basic principles employed by the majority of inventors that have achieved a 100% or better improvement in fuel efficiency.

* 1. **Vaporizing the fuel**

It is an established fact of chemistry that liquid petrochemical fuel does not burn. Only the vapors that are intimately homogenized with the air can burn. The higher percentage of liquids that are injected into the combustion chamber, the longer it takes to completely burn the charge. As the vapors that are present burn, the resultant heat generated helps to vaporize more of the liquids, which then burn, generating more heat, which vaporizes more of the liquids, until all of the liquids have fully vaporized and burned.

Unfortunately a typical engine only has 9 – 12 milliseconds (ms) between the firing of the spark plug and the opening of the exhaust valve that begins bleeding off the pressure in the cylinder (at cruise speeds). The boiling points of the constituents in gasoline range from about 135 to 435 degrees F (at atmospheric pressures). This means that a substantial amount of the fuel will enter the combustion process in liquid form. Furthermore, the burn times range from less than 1 ms to over 33 ms *after* it is vaporized. Therefore the odds are that a portion of the fuel might not even vaporize within the usable window, and much of the fuel will not burn within the usable window, and even more of it will not contribute to power at the wheels.

After the spark plug fires, a small flame kernel is formed. That kernel expands, burning the fuel vapors around it, into a pea, then a nut, and eventually the majority (if not all) of the combustion chamber is engulfed in a raging fire. At the very moment of ignition spark, the combustion chamber is filled with ambient air and what is known as an aerosol of gasoline. The aerosol is a combination of vapor, small liquid droplets, and larger liquid droplets. As the flame spreads, consuming the vapors, it begins to first vaporize, and then burn the droplets.

Obviously, the higher the percentage of gasoline that is vaporized, the more will burn within the 9 – 12 ms before the opening of the exhaust valve. Vaporizing the fuel increases the flame front spread rate and consumption rate, and the release of thermal energy from the stored chemical energy from the fuel. This equates to more of the chemical energy being converted to kinetic energy.

* 1. **Merely heating the fuel**

A large number of patents have been filed for improved fuel economy by fully vaporizing the gasoline before admitting it into the intake air stream. Many inventors have proven that merely adding thermal energy to the fuel increases the percentage of fuel that is able to phase change to a vapor prior to the combustion event. Although all of the fuel may not be in vapor form when the spark plug ignites, more of it is in vapor form, and more of it burns during the normal combustion cycle to produce useful work. For every 25 degrees F. increase in fuel temperature, an additional 10% will vaporize before the combustion event.

* 1. **Chemical additives**

Chemicals are added to the petrochemical element of gasoline to achieve a number of objectives: assist in removing carbon deposits, lower moisture content, aid in quick starts (especially in cold weather), improve or stabilize octane ratings, improve vaporization rate, intensify the oxidation process, and improve the burn speed to name a few. The gasoline producers use additives in the fuels to achieve various goals depending on season, region, legal requirements, and altitude.

The function of an additive is not to replace the fuel elements with a substitute fuel element, but to replace a small fraction of the fuel element with a substance that alters the characteristics of the majority of the fuel. If better cold starts are the target of an additive, then an aromatic hydrocarbon (HC) may be added in minute amounts to supply sufficient vapor to allow the spark plug to initiate a flame front, for example. In commercial use, additives typically constitute 1000 parts per million (ppm) or less of the total fuel. Thousands of different aftermarket chemical fuel additives are registered with the EPA. Marketers’ claims vary, but a high percentage of them list improved fuel economy among their claims.

* 1. **Tuning**

Performance and economy are two perspectives of the same subject. Performance targets efficiencies in filling the cylinder, combustion, conversion to mechanical work, and evacuating the cylinder. Economy targets all of the above minus maximum cylinder filling. I would like to reference well known principles established in the performance arena as more has been written about performance than has been written about fuel economy. Let it suffice to say that if a technique affects performance, it would also have an effect on fuel economy (although methods of implementing the techniques might be different). Therefore performance methods that improve combustion efficiency (and there are many) would also improve fuel economy.

Forty years ago tuning was done on an engine to accomplish more power within a targeted RPM range. If exhaust gasses were monitored, it was merely to determine if more power could be extracted with better tuning. Today, tuning processes look at exhaust gasses because of environmental reasons. The tuner isn’t necessarily noble in this consideration, but obligated by law.

New vehicles leaving dealer’s showrooms have complicated tuning strategies in their computers (ECUs) that have near artificial intelligence, as applicable to operating the vehicle. The ECU doesn’t simply monitor the sensors and make algorithmic decisions as was the case 20 or 30 years ago. The new ECUs are capable of recalibrating themselves to compensate for normal wear within the sensors and the components they monitor, and alter programming to accommodate changes in altitude, barometric pressure, quality of fuel, and many other conditions. The programming is designed to maximize power, fuel economy, and most importantly, vehicle emissions.

Tuning for vehicle emissions, under the current Tier 3 structure (currently defined EPA emissions statutes), usually ends up compromising performance and economy. For example, to combat the formation of NOX emissions, ignition timing and camshaft timing is retarded from what would be optimal for performance and economy. Individuals sell “Performance Modules” on ebay which are nothing more than $0.15 resistors that replace the Intake Air Temperature sensor and tell the ECU that the incoming air is colder than actual. Colder air is less prone to produce NOX emissions, and therefore the ECU advances ignition timing. This “Performance Module” trick usually delivers as the seller claims, improved performance and economy, but increases overall production of NOX emissions. (These devices are not legal, but mentioned to illustrate the benefits in performance and economy that are potentially there.)

If vehicle emissions were not a consideration, modern engines would be capable of far better fuel economy than they deliver. A good example of this would be to compare a US spec vehicle to an Australian or European spec vehicle of the same make, model, and engine. The foreign spec vehicle typically delivers at least 25% better highway mileage than the US version due to differences in emissions laws (and thus tuning requirements).

“Tuners” as they are now called, are skilled performance specialists that can alter factory ECU programming, or install and tune what is known as a “stand-alone” ECU; an aftermarket ECU that replaces the factory unit. One of the methods used by Tuners to improve fuel economy is to lean out the air-to-fuel ratio (AFR) and add a little more ignition timing advance. At cruise and part throttle conditions, good power is delivered but with a substantial improvement in fuel economy. (This is known as “Lean Cruise Mode”.)

* 1. **Engine modifications**

Nobody in the automotive engineering community would argue that the Over-Head Valve (OHV) engine is far more efficient than the Flat Head engine of the early part of the last century. This single design change opened the doors for substantial improvements in performance, economy, and the control of harmful exhaust emissions. The OHV design debuted in 1949 on the Oldsmobile Rocket engine, yet is still the basic design used in today’s engines. The current engineering community has been able to develop sophisticated engine designs that can vary camshaft timing, intake runner length, even the number of cylinders that are consuming fuel and contributing to work on demand. Certain aftermarket engineers have been able to customize the factory offerings for even greater performance and economy.

Many aftermarket companies sell camshafts, exhaust components, air induction systems, pistons, and so forth that improve power in a given RPM range, and improve fuel economy. These modifications improve the density of the incoming air, velocity in the ports, compression ratios, and inevitably, overall engine efficiency.

The author has personally performed upper engine (head and manifold) porting on a 1988 Dodge Shadow which resulted in highway mileage increasing from 29 to 42 mpg. On a 1989 Chrysler LeBaron with more extensive engine modifications, performance went from 156 HP to 430 HP, city mileage went from 23 to 35, and highway mileage went from 27 to 42-45 mpg. Larry Widmer of Endyn (Ft. Worth, TX; TheOldOne.com) has achieved even more spectacular results.

* 1. **Hydrogen (and variations thereof)**

Stable bottled diatomic hydrogen has been added to gasoline engines in various percentages of mass of fuel under a wide range of conditions and for various reasons. The hydrogen itself has been in multiple forms. Most laboratory experiments use bottled H2 gas, as it is safe, containable, easily metered, and commercially available. Very few laboratory condition experiments have been carried out with on-board electrolytic generators. This makes comparing apples to apples rather difficult, but not impossible (more on that later).

Hydrogen improves the efficiency of a typical test engine by an average of 30% by itself. Most of the tests available add varying percentages (and in some cases qualities) of hydrogen and looked at 2 – 10%, and 10 – 90% combustion rate (how long it takes to burn 2% of the charge, 10% of the charge, etc.), NOX and HC emissions, torque, thermal losses to coolant and exhaust, peak pressure at various crank angles, and overall BSFC (Brake Specific Fuel Consumption, which means the amount of work done per amount of fuel consumed; or put another way, efficiency). Interestingly enough, most tests are within a narrow range of hydrogen as a percentage of mass, usually 1% to 2%. Few reports experiment with more than this narrow range, and so far no report (that the author has been able to find) has tested the point of diminishing returns by adding less than 1%.

Nevertheless, the consensus is that hydrogen reduces the thermal losses to the coolant and exhaust (more of it is converted to useful work), the 2 - 10% burn time is significantly reduced (10 – 20 crank angle degrees [CAD]), the 10 - 90% burn time is also significantly reduced (5 – 9 CAD), provides for significantly leaner AFR before lean-out limit (most substantial when Lambda exceeds <0.85), dramatically reduces NOX (by a factor of 5) and HC emissions at lean AFRs, and reduces cycle-to-cycle variations in cylinder pressure (“COVIMEP” in technical reports) by 30%.

* 1. **Thermal Catalytic Cracking (TCC)**

Forms of thermal cracking began emerging as early as 1913 within the petroleum refining industry. At the turn of the 20th century, gasoline constituted about 23% of total crude oil products. Initially, there was no need for gasoline as a consumer product and most of it was dumped back into the hole from whence the crude was extracted. With the advent of the automobile, the demand for gasoline grew. By the late 1930s, the demand for gasoline outgrew the demand for other crude oil products as a percentage, and non-gasoline petroleum products were stacked and stored in an effort to deliver gasoline. A new process called Thermal Catalytic Cracking was implemented that would take HC compounds too heavy to be used as gasoline, super-heat them, add hydrogen, and run the blend across a bentonite clay catalyst. Later, a hydragenation process was developed that could remove hydrogen from lighter elements and combine the resultant ionized elements to increase their density to a state suitable for use as gasoline. By 1950 gasoline constituted about 43% of total refined crude oil products.

An interesting phenomenon occurs when TCC is used. According to Avogadro, a molecule takes up a fixed amount of space in the æther regardless of molecular size. Therefore, a gallon of crude oil, a gallon of diesel fuel, a gallon of gasoline, and a gallon of liquid propane all have approximately the same number of molecules. (Technically, Avogadro’s Law uses the term “moles” of molecules and not gallons.) If a diesel fuel (**C16**H34) molecule was cracked into 2 octane molecules (**C8**H18) with the appropriate amount of hydrogen added, a gallon of diesel fuel would yield 2 gallons of octane. One gallon of diesel fuel could be cracked and reformed into 16 gallons of liquefied natural gas (**C**H4)! In fact, modern refining methods do indeed yield about 44 gallons of just kerosene out of a 42 gallon barrel of crude, in addition to the other products!

It has been established that the Pogue carburetor did more than simply vaporize the fuel. It actually cracked the larger molecules within the fuel into smaller molecules, then either stabilized them by removing hydrogen from the humidity (H2O) in the air, or admitted the fractured molecules into the engine in an ionized state. With the introduction of tetra-ethyl lead to pump gasoline, the lead would coat the walls of the metalic heat exchanger rendering its catalytic properties inert.

Bruce McBurney (HIMACresearch.com) established the benefits of TCC as a means to improve fuel economy with an on-board “cat cracker”. His apparatus was tested by Professor Eugene Cherniak, an analytical chemist at Brock University in St. Catherines, Ontario. The formula for what Bruce was achieving approximates to C8H18 + H2O = CH3OH + CH4 (natural gas). In practical application, McBurney claimed 72 mpg from a full-sized Dodge Maxi-Van with a 360 CID V-8.

Whereas gasoline powered engines are typically 18% efficient, propane powered engines are typically 42% efficient, and natural gas powered engines are considered to be about 60% efficient. In the TCC process, the *volume* of fuel is increased (Avogadro’s Law) and the resultant fuel is more efficiently converted to useful work within the engine. This is how Pogue was able to get such phenomenal results even with an inefficient flat-head V-8 engine.

* 1. **Plasma**

Several inventions have been devised to reformulate fuel to a smaller molecular level through means of firstly converting the petrochemical fuel to a plasma, adding hydrogen or water (in some but not all inventions), then admitting the reformed fuel into the engine. Henkel-Koeh (Pat. No. 3,897,225, 7-29-75) burns a small amount of fuel to generate a plasma field, then injects additional fuel across the plasma field before forcing the plasma fuel across a catalyst. Jonson (Pat. No. 7,194,984) claimed to be able to phase change fuel into a plasma within a low energy plasma induction field mounted in the engine’s exhaust. These and other plasma devices claim to increase engine efficiency by transforming the fuel into a plasma state first, then combusting it either in the plasma state, or in a partially stabilized and ionized state. Mileage claims are typically 200% to 300% increases.

* 1. **Magnets**

All fluids have what is known as “surface tension”. This is observable when one is able to float a steel sewing needle on top of a glass of water. Surface tension is what keeps liquids in their liquid state, as opposed to simply evaporating away. The strength of the surface tension can be overcome thermally. The amount of thermal energy required to overcome the surface tension of a liquid can be quantified as the boiling point of the liquid. If the surface tension can be reduced by a non-thermal means, then the thermal energy requirements to overcome the surface tension (boiling point) is reduced.

Magnets have been shown to reduce surface tension in liquids by reorganizing random charge clusters within the liquid. Molecularly, the liquid remains unchanged; both in molecular arrangement, and electrical and ionic charge. Charge clusters are what make groups of molecules clump together like microscopic solids. Differences in magnetic and electrical biases cause opposite charges to attract, therefore clumping clusters of molecules together. For the liquid to evaporate, it must first overcome the magnetic pull that keeps the molecules together within the liquid state. Magnets reorganize the arrangement of charged clusters, reducing their size, thereby enabling an easier (lower energy input) release from the liquid medium to a vapor state. Typical gains in economy from the use of magnets on fuel lines range from 10% to 12% from improved fuel vaporization.

* 1. **Turbocharging**

A turbocharger is a double scroll compressor that harnesses normally lost exhaust energy and recycles it back into the intake charge by compressing it and forcing it into the engine. As the exhaust gasses are exiting the engine, they are directed across a turbine that is connected by a common shaft to a compressor wheel, which forces air into the engine. Turbocharging is typically not considered a fuel economy improver, because of its tremendous power potential (therefore its intended use). Most turbocharged applications incorporate large turbos that perform well at higher RPM levels to make substantial power gains. For a fuel economy application, smaller turbochargers are used to recycle lost energy at normal driving RPM levels.

Sizing a turbo to produce a relatively small amount of pressure at normal driving levels will tap some of the lost energy in the exhaust to overcome the parasitic losses associated with the intake stroke of the 4-stroke engine. The net reductions in parasitic losses are realized as improved fuel economy. Having converted 2 Dodge 6-cylinder engines for such an application, the mileage gains were from 18 to 23 mpg (roughly a 28% increase in efficiency). Due to cost considerations, turbocharging is not normally used as a fuel economy enhancer within the aftermarket arena (although it is heavily used by OEMs).

* 1. **Water Injection**

Water vapor expands twelve times as much as nitrogen per BTU of heat input. Water vapor found in the combustion chamber (either from the humidity in the intake air charge or as a byproduct of combustion) will absorb the thermal energy released from the fuel as it burns and expand along with the nitrogen. Any nitrogen content that can be displaced by water vapor will show an improvement in performance and economy by a relative (X12) amount. The compromise is that the nitrogen is drawn into the engine with the ambient air, and the ambient air provides the oxygen for combustion. To displace nitrogen with water vapor compromises the available oxygen for combustion, and is therefore limited.

Most performance water injection applications spray a water (usually mixed with methanol) aerosol into the intake air stream (or in extreme cases, directly into the intake ports). In a performance application the benefit of adding water in aerosol form is to reduce peak combustion temperatures, thereby reducing detonation and potential for engine damage. Power adders (turbochargers, superchargers, and nitrous oxide) can be “cranked up” without engine damage, and power levels can be increased.

For fuel economy applications, the liquid droplets found in the aerosol first have to phase change to a vapor inside the combustion chamber. Whereas this is advantageous for the performance application, this vaporization process (latent heat of evaporation) absorbs valuable thermal energy that could otherwise be used to expand the gasses inside the combustion chamber and push down on the piston. Usually the net gain in fuel economy is zero. If water *vapor* is admitted into the intake air charge, there are no thermal losses to the evaporative process and the water vapor simply expands at the higher rate, thus increasing the mechanical conversion from thermal energy to kinetic energy. Claims of 15% to 30% are typical, with 50% increases not unreasonable.

1. **How Combustion Works**

It is often thought that when the spark plug fires there is a massive explosion that “blows” the piston down the bore, much like “Rambo” tossing a grenade into a building and watching the bodies and debris fly. In actuality, it is a much more controlled and less chaotic process. When the spark plug fires, it initially affects the oxygen molecules within the gap between the electrodes. The electrical energy affects one or both of the orbital electron bonds that join the 2 oxygen atoms together forming O2-2 (fractured oxygen molecules) and O-2 anions (free-floating oxygen atoms). This is an endothermic reaction (absorbs energy). The thermal electric energy from the spark (in excess of 2000 degrees F.) also releases hydrogen atoms from the HC molecule. This too is an endothermic reaction. Once the hydrogen atom (H+) is free, it is attracted to the negatively charged oxygen anion and bonds, forming either OH- or HO2-, commonly denoted as the OH radical. This is an extremely exothermic reaction (releases energy), relative to the energy requirements to split the oxygens and hydrocarbons. This exothermic release will usually break the second bond of the oxygen, splitting off an oxygen anion and OH radical (again, endothermic).

The energy released by the formation of OH- and H2O is used to further split more oxygen atoms and release more hydrogen atoms from the hydrocarbon molecules, thus forming more H2O and yielding more release of thermal energy. Each and every time a change occurs to any grouping of atoms, energy is either consumed or released. [Ideally, if we could supply a fuel in monatomic form (no molecules, just atoms), there would be no endothermic events (everything would be exothermic) and the net release of energy would be many times the net energy we are able to retrieve under current chemistry models.] Eventually the supply of hydrogen atoms in the HC molecules begin to deplete. In the absence of abundant hydrogen atoms, the oxygen atoms begin to bond with the carbon atoms forming first CO, then CO2. Approximately 65% of the exothermic energy release comes from the formation of H2O, about 30% from the formation of CO, and the remaining 5% from the stabilization of CO2.

The thermal energy released from the burning of the fuel acts upon the nitrogen and other gasses in the cylinder and expands them. As these gasses expand, they create pressure. It is this pressure that pushes down on the piston. The piston is mechanically coupled to a crankshaft via a connecting rod that converts mechanical pressure to mechanical rotational force.

On either end of this process is the ingestion and expulsion of gasses (intake air/fuel charge and exhaust gasses), relative to the intake action and exhaust action of the engine. Air and fuel are drawn into the engine on the intake stroke. The ingestion action occurs as the piston descends the bore increasing the volume of the chamber (and thus decreases the absolute pressure), then acts upon an open valve to draw in the air/fuel charge under vacuum. It is during this phase that much homogenization occurs between the air and fuel, as well as some vaporization of the fuel. When the piston is in relative distance to bottom dead center (BDC), the intake valve will close, thus sealing the chamber. The piston then sweeps upward, reducing the volume of the chamber, compressing the air and fuel into a tighter space, and making the homogenized mix more volatile. At some calculated distance BTDC (Before Top Dead Center) in crank degrees (dependent on load, RPM, and other engine conditions as determined by the ECU), the spark plug fires, initiating the above-mentioned combustion process.

When the spark plug fires, it creates a small kernel of plasma that begins the net exothermic reaction of burning the fuel. The flame propagation process enlarges the plasma kernel more and more until (ideally) the entire chamber is engulfed in a plasma flame. This plasma flame is responsible for converting the chemical energy in the fuel to thermal energy. Any small liquid fuel droplets caught up in the process will appear to burn from the outside, getting progressively smaller until they cease to exist in the liquid form. The burning process described is the oxidation of the fuel vapors as they vaporize from the liquid droplet.

Shortly before BDC the exhaust valve opens and begins bleeding the pressure from the cylinder off into the exhaust port and manifold. This happens before the piston reaches bottom dead center (BDC) on the power stroke. If the exhaust valve didn’t open until BDC, the piston would be forced to push the gasses out the valve, with a resultant parasitic loss. When the exhaust valve opens, there is still a considerable amount of the charge still burning and expanding (and thus a considerable amount of pressure). This energy is wasted, lost to the exhaust manifold in the form of heat, and catalytic converter in the form of unburned fuel. It does not get converted to mechanical energy at the crankshaft. This illustrates one of the most egregious inefficiencies of the ICE.

1. **Can it be improved?**

To determine if a process can be improved upon, we would first need to define the inherent strengths and weaknesses of the process, and then find a way to overcome the weaknesses and/or enhance the strengths. One of the single greatest weaknesses in the modern internal combustion engine is the limited amount of time that is allotted for complete combustion, and the *harnessing* of that released energy. As already established, the fuel is still burning when the exhaust valve opens. Ultimately, the fuel will be completely burned (at least 95 – 98% effectively) before being discharged to the atmosphere, partly due to the continued burn in the exhaust manifold, and partly due to the catalytic converter.

Considering the basic petrochemical constituents in gasoline have a vapor point ranging from 135 degrees and 435 degrees F, it would naturally be assumed that a high percentage of the fuel will be drawn into the cylinder in a liquid (albeit aerosol) form. Considering the heavier elements in gasoline take about 33 ms to burn, it would naturally be assumed that there would be fuel still burning when the exhaust valve opens, and that the release of thermal energy from the chemical source would not be converted to kinetic energy to do useful work. Considering the heavier elements that take the longest to burn are also the hardest to vaporize, it would naturally be assumed that they might not even fully vaporize and burn at all before the exhaust valve opens, thus contributing to either HC (unburned fuel) or CO (partially burned fuel) exhaust emissions (before the catalytic converter). As the piston descends the bore, the volume in the cylinder (area above the piston) increases thus reducing the potential pressure against the piston. Also, as the piston nears the 90 degree ATDC point, it accelerates and effectively begins to outrun the pressure wave. This means there is only a small window of opportunity to convert the thermal energy to kinetic energy; about 45 crank angle degrees (CAD). At 2000 RPM, 45 CAD takes only 0.0037 seconds (3.7 milliseconds).

Here are a few proven techniques commonly used to improve the combustion process.

* 1. **Improve flame propagation speed**

The flame propagation speed is the rate at which the flame front travels from the spark plug to the outer reaches of the combustion chamber. To better understand this, picture a 1 foot diameter circle drawn on the ground. In this circle, place small chunks of wood and coal. Then spray gasoline around inside the circle. Next drop a lit match into the relative center of the circle. The speed at which the flame gets from the match to the drawn circle would be the flame propagation rate. In this illustration, the gasoline would represent the vaporized fuel, the wood would represent the liquid droplets of the lighter fuel elements, and the coal would represent the heavier liquid fuel elements.

The faster the flame can engulf the combustion chamber, the sooner all of the fuel can begin the process of burning. Higher compression ratios are a mechanical means of speeding up the flame spread by squishing the air and fuel molecules closer together (less distance to travel to fully engulf the combustion chamber). Altering this requires disassembling the engine and replacing pistons or milling the cylinder head. Another way is to improve vaporization of the fuel prior to spark event, as vaporized fuel will carry the flame front at a much faster rate than aerosol droplets. Adding an “accelerant” to the combustion process, such as a form of hydrogen or a fuel additive, will carry the flame front faster than the fuel alone can. Hydrogen (H2) has a flame speed 5.7 times that of gasoline (237 vs 41.5 cm/sec). Therefore hydrogen (or other accelerant) can carry the flame front ahead of the gasoline to engulf the entire cylinder in about 17.5% of the time required by gasoline alone (over 5 times faster). HHO can have a flame speed of over 200,000 cm/sec as has been shown at the University of Idaho (Chris Eckman).

* + 1. **Better vaporize the fuel**

Since liquid fuel doesn’t burn, it is physically impossible for liquid to carry a flame front. It must first be vaporized before it will ignite. By fully vaporizing the fuel, the flame front is able to travel across “charged and ready” fuel vapors to the outer reaches of the combustion chamber. Charles Pogue, Tom Ogle, Ray Covey, and other experimenters expressed an increase in power along with the improved fuel economy. A higher chemical-to-kinetic conversion rate will inevitably *have* to improve both power and economy. Even adding thermal energy to the liquid fuel prior to being sprayed from the high pressure fuel rail to the low pressure intake manifold by the fuel injectors will improve the percentage of fuel vaporized (about a 10% increase in vaporization for every 25 degrees F. of thermal energy). Reducing the surface tension of the fuel with magnets will allow a higher percentage of the fuel to vaporize at existing thermal energy levels (up to 11% according to studies).

* + 1. **Better homogenize the fuel with the air**

Fuel vapors cannot burn without oxygen, nor can pure air (without fuel). In order for the fuel vapors and air to combust, the two need to be properly mixed. Modern engines do a remarkable job of homogenizing the air and fuel through swirl and tumble activities designed into the port and combustion chamber shapes. Older open chamber heads deliver a considerably lower rate of swirl and tumble, thus limiting performance and economy potential. Even with well vaporized fuel, poor cylinder activity (swirl and tumble) does a poor job of propagating the flame front, whereas good cylinder design promotes a rapid flame spread even with aerosol fuels. Swirl port technology also improves the vaporization rate of fuel droplets with a fixed thermal energy input due to increased mechanical turbulence activity (which also promotes vaporization) much like water is rapidly vaporized at very low temperatures at the bottom of a water fall. A well homogenized air/fuel mix will be better conditioned to carry the flame front.

* + 1. **Add a combustion accelerant**

Combustion accelerants can be added either to the fuel or to the incoming air. Common accelerants are naphthalene, hydrogen, ozone, acetone and alcohols to name a few. The objective of an accelerant is to either speed up the burn (both flame spread and consumption rate), make the burn hotter, or both. Accelerants are used typically in trace amounts compared to the fuel. A liquid accelerant added to gasoline at a rate of 1 ounce per 25 gallons would be trace amounts, where the accelerant is not necessarily considered fuel, but a combustion modifier. The same could be said for a vaporous accelerant (“Brown’s Gas”/hydrogen) at a rate of 0.7 liters per minute (lpm) added to a 2 liter engine ingesting 375 lpm of air (0.187% of air mass, cruise condition, 20% throttle angle).

* + 1. **Increase combustibles turbulence velocity**

Of course the easiest to understand method would be to create swirl and tumble characteristics within the combustion chamber that better vaporize and homogenize the fuel, and ultimately carry the flame to the unburned fuel. A lesser known and slightly harder to understand principle is that of dissimilar burn rate fuels. As fuel burns, it generates heat, which expands whatever medium surrounds that thermal source. If an accelerant is used, it will burn much faster than the primary fuel, creating turbulence eddies (pockets of pressure and vacuum) in the wake of the flame front that will better vaporize and homogenize the remaining air and fuel mixture. This speeds up the rate of consumption, yielding better chemical to thermal conversion efficiencies, and thus fuel economy.

* 1. **Improve combustion rate**

Whereas getting the flame to engulf the circle would illustrate flame travel speed, combustion rate would be how quickly the wood and coal chunks burned in the previous circle illustration. Simply getting the flame as far as possible as fast as possible doesn’t necessarily fully combust the fuel within the charge. Any fuel partially combusted or left uncombusted equates to energy that remains (at least in part) in chemical form, yet unable to release the thermal form of energy to be converted to useful work. Even fuel that is partially burned needs time for the thermal energy to interact with the other gasses and expand them to create pressure. The quicker the fire is started, the easier it is to harness the chemical energy.

* + 1. **Better vaporize the fuel**

Better vaporized fuel will not only carry the flame front to the outer areas of the combustion chamber faster, but vaporized fuel will also burn completely in less time than liquid droplets. The higher percentage of fuel that is converted from chemical energy to thermal energy within the usable window, the more it will contribute to pressure within the cylinder, and thus, the more that will be converted to kinetic energy at the wheels. A more thorough combustion of the fuel within the allotted window means more power, better fuel economy, and lower exhaust emissions (HC, CO, and usually NOX).

* + 1. **Better homogenize the fuel with the air**

Using the afore-mentioned techniques to better homogenize the fuel with the air, activity within the cylinder promotes more thorough combustion the same way stirring a burning rolled up newspaper allows the burnable paper that has no access to either oxygen or the flame front to come to the top where it can be consumed in the fire. The constant tumbling and swirling inside a cylinder will uncover unburned fuel and expose it to oxygen, thus allowing more of it to burn within the allotted window.

* + 1. **Add a combustion accelerant**

Adding a combustion accelerant (as previously listed) provides for a more thorough burn due to the intensified exposure of individual HC and O2 molecules to each other within the parameters of a controlled plasma flame. Furthermore, the earlier any fuel molecule can be “lit off”, the sooner it can complete the process of conversion outlined as: HC + O2 -> H2O + CO2 + Heat.

* + 1. **Increase combustibles turbulence velocity**

The more turbulence occurring within the combustion process, the more the flame front is “thrown” toward unburned fuel and oxygen. Also, the more turbulence within the combustion chamber, the more the unburned fuel is “thrown” toward the flame front. Furthermore, the more turbulence within the combustion chamber, the more the liquid fuel droplets are “torn” apart, thus exposing more surface area of the droplets to the oxygen and flame front.

* 1. **Improve thermal-to-pressure/kinetic conversion efficiency**

Burning the fuel is the first conversion done within the engine. The fuel burns and chemical energy is converted to thermal energy. As far as a motive force, thermal energy by itself is useless, performs no work. It must be converted to useful work through yet another conversion; thermal-to-kinetic. This process also has its efficiencies and deficiencies. Efficiency would include the convenience of ingesting abundant ambient air as an expansion medium. The tool used to enable this conversion is called the expansion medium. Air, more specifically the nitrogen in the air, is the majority of the expansion medium in an engine, as it constitutes about 78% of the air ingested by the engine. As the engine burns the fuel, carbon dioxide and water vapor are formed (by a ratio of 8:9, CO2:H2O) and also become part of the expansion medium. Water vapor expands at a rate 12X that of nitrogen per BTU input, and carbon dioxide expands even more. Carbon dioxide typically equates to about 13.5% of exhaust gasses, which means water vapor constitutes about 18.2% of the exhaust in a stock engine. So in a typical combustion event, over 18% of the expansion medium is water vapor. An increase in water vapor content would contribute even more to the ability of an engine to convert the thermal energy to kinetic energy.

* + 1. **Engine design parameters**

If an engine were to be designed exclusively for fuel economy at cruise speeds, smaller ports, longer rod ratios, higher compression ratios, longer stroke to bore ratios, higher degree of swirl in the intake passages, perhaps even catalysts inside the engine would maximize the fuel economy potential. In the United States, power is of paramount importance to the typical car buyer. Therefore auto manufacturers go to great lengths to make engines very powerful, while still catering to EPA, and attempting to preserve fuel economy as much as possible. Many engine design experiments have shown significant increases in fuel economy, and some even power with economy. To take a production engine and “tweak” it for more economy is one thing. For a manufacturer to implement such changes would mean retooling, and possibly more cost prohibitive measures. It would then have to go through the certification process (and expense). Major engine redesign is typically looked at as a last resort from most perspectives.

* + 1. **Expansion medium**

Water vapor expands at 12 times the rate of nitrogen per BTU of heat input. Of course, more water vapor would push harder on the piston than the nitrogen it displaces. Adding water vapor to the intake charge, as outlined in the “Water Injection” section displaces not only nitrogen, but also oxygen. Therefore there is somewhat of a trade-off in oxidation value (amount of oxygen in the combustion charge) in order to enhance the expansion medium value. By adding electrolyzed water, or “Brown’s Gas” to the intake charge, the benefits of hydrogen as an accelerant are realized *AND* the resultant byproduct, water, acts as a much more powerful expansion medium once combusted. The oxygen in Brown’s Gas replaces the oxidizer lost by the displaced ambient air, restoring the engine’s ability to more fully burn the fuel.

Exhaust gas recirculation (EGR) has been used since the early 1970s as a means to control the formation of NOX emissions. It acts inertly (neither contributes as a fuel nor as an oxidizer) in the combustion process, thus reducing the flame speed and peak cylinder temperatures. Ideally (for emissions reasons only), combustion temperatures should never exceed the NOX threshold of 2500 degrees F. to totally eliminate that pollutant. EGR at least helps engineers with that goal. One of the side benefits of EGR is the water and carbon dioxide content derived from previous combustion. EGR engines are able to capitalize on the improved expansion medium to push harder on the piston. Ignition timing requirements must reflect the slower burn rate with EGR, but overall, compromises are met, whereby small net increases in fuel economy can be realized with lower NOX exhaust emissions. With HHO added to an EGR equipped engine, the downside of slower flame front is offset, and the loss of oxidizer is offset, to where the process is able to realize the emissions and fuel economy gains from EGR without the net losses normally associated.

* + 1. **Controlling moment of peak cylinder pressure**

In engineering terms, it is agreed that the optimal time (in CAD) to generate peak cylinder pressure is at 14 – 15 degrees ATDC, which is known as Critical Crank Angle (CCA). From about 14 degrees BTDC to about 14 degrees ATDC the piston just sits there while the crankshaft moves over center. Past CCA the piston begins to move down the cylinder bore. Peak Cylinder Pressure is controlled by adjusting ignition timing, and where possible, camshaft timing. Upon initial observation it might seem like the most advantageous moment for Peak Cylinder Pressure would be at or near 90 degrees ATDC, as this is where conventionally the maximum point of leverage can be gained. After all, do we gain more leverage with a wrench pointing away from our body, or with it perpendicular to our body? In an engine, though, the applicable force is pressure, pressure that potentially diminishes as cylinder volume increases. (If you have a pressure in a syringe, the pressure will push the plunger outwardly, but only to the point where pressure equalizes with the ambient pressures. If this plunger continues outwardly, a vacuum will form. The same can be said about the piston moving down the bore of the cylinder, thus increasing volume.)

To explain how this works in an engine, imagine a professional archer shooting 3 arrows with a 100# rated *arched* bow and 3 arrows with a 100# rated *compound* bow. Remember, both bows are rated at 100# of thrust potential (akin to BTU potential of a fuel). Which bow will shoot the arrows farther? The compound bow? By a large margin?!? But they’re both rated at the exact same “BTU content” 100#! With the same energy rating, both should hypothetically shoot their arrows about the same distance, +/- a reasonable margin of error. Right? Well, no. The arched bow delivers that 100# of force to the arrow over a string travel of approximately 6” to 10”, while the compound bow delivers that same 100# of force over a mere 2” to 4” of string travel. By concentrating that force, it yields a much larger margin of work done.

Aside from difficult to control variables like port shapes and camshaft timing, a way to improve the efficiency of the engine would be to speed up the propagation of the flame front, accelerate the consumption rate of the fuel in the combustion process, delay spark timing (less timing advanced is required with a faster burn), and “sling-shot the piston down the bore”.

* + 1. **Increasing peak pressure at CCA while lowering overall temperature**

Again, things aren’t necessarily as they seem. On one hand it is established that there are 2 conversions going on inside an engine. The first conversion is chemical energy to thermal energy. This conversion is accomplished by burning the fuel. The second conversion is chemical energy to kinetic energy, where the heat generated expands the gasses inside the combustion chamber creating pressure which pushes down on the piston. To accomplish higher peak pressures while simultaneously reducing overall engine and combustion temperatures, it is necessary to define a few things. Overall temperature would be defined as the average combustion temperature over the power cycle of the engine (whereas high and low peaks are averaged out), plus thermal losses to the coolant system, thermal losses to the exhaust system, and thermal losses to the ambient air through the walls of the engine itself.

Since the phenomenon occurring inside the combustion chamber can be likened to an explosion, I’ll use “explosion” terminology to describe how the requirements can be met. In the explosives field of science, there are 2 basic types of fuels used; percussion and incendiary. A percussive bomb will destroy a target without generating much ancillary heat. An incendiary explosion, on the other hand, is good for starting fires as it generates copious amounts of heat. The percussion bomb will knock out a target quickly without much fire, an incendiary bomb doesn’t do much initial damage but generates tremendous amounts of fire damage. The percussion bomb could be likened unto the compound bow and the incendiary bomb can be likened unto the arched bow.

Between the “arched versus compound bow” and “incendiary versus percussion explosion” examples, it should be well illustrated that increasing the rate of flame spread and the rate of fuel combustion are very powerful tools in increasing performance and fuel economy while simultaneously generating far less waste (loss) heat (and NOX).

1. **How does the HHO improve efficiency?**

Having looked at many principles of science, and what has been done in prior art, let’s look at how HHO ties together well understood principles of physics to deliver an average of 20% to 50% increase in mileage, with the occasional 100% + increases.

* 1. **Add hydrogen/oxygen blend to the combustion process**

Since most of the university studies center around bottled hydrogen gas (H2), and we are researching the use of “Brown’s Gas”, and we claim that Brown’s Gas is more dynamic than gasoline or even hydrogen gas, it might be reasonable to define Brown’s Gas. In the electrolysis process, two plates are charged electrically and submersed in an electrolyte solution. In the case of the typical HHO system, potassium hydroxide (KOH) or other caustic is mixed with water to form the electrolyte. The electrolyte allows electricity to pass through the water portion, thereby placing a charge on the individual elements that constitute water; namely the positively charged hydrogen and negatively charged oxygen. Since opposites seek to neutralize each other, the positively charged hydrogen cations are attracted to the negatively charged cathode, and the negatively charged oxygen anions are attracted to the positively charged anode.

Once the hydrogen is liberated from the water molecule, it collects on the cathode. It is magnetically held in place. In doing so, it partially neutralizes the overall charge effect of the plate and weakens the plate’s ability to attract additional hydrogen. As the hydrogen cations (H+) accumulate on the cathode, some of the cations will combine to form stable and neutral diatomic hydrogen gas (H2) and buoyantly float to the top of the water. A similar phenomenon occurs with the negatively charged oxygen at the anode.

Therefore the majority of typical Brown’s Gas is in the form of stable H2 and O2 gasses, by a ratio of 2:1 by volume and 11:89 by mass. In an automotive application, there is another factor that comes into play and that is the vibrations of the vehicle chassis acting on the electrolyzer. The hydrogen cations (H+) and oxygen anions (O-2, oxygen atoms) have tremendous buoyancy. The vibrations within the electrolyzer, combined with the flow of water through the cells will tend to dislodge the gaseous clumps of H+ and O-2. Depending on the vehicle, road conditions, and even ambient temperatures, the percentage of monatomic elements released from the electrolyzer typically equate to upwards of 15% of total volume.

In addition to H2, H+, O2, and O-2 gasses, there is also a small percentage of OH- radicals present in the Brown’s Gas mix. The OH- radical is formed when one hydrogen cation is released from the water molecule and the net negative charge of the remaining OH- is attracted to the anode. Now that we have an approximation of what constitutes Brown’s Gas and how it is different from bottled hydrogen, let’s look at its characteristics.

Firstly, (2) H+ has 6.6 times the energy of H2. Simply from a thermodynamics perspective, there is a much greater return in the combustion process than would be for bottled hydrogen. Considering the splitting of O2 into O2-2 and (2) O-2 is endothermic, the addition of oxygen anions leaves a greater net energy in the combustion process for conversion to kinetic power. Plus the oxygen anions will readily bond with the available hydrogen and carbon in the combustion process, thus speeding up the combustion process. The OH- radical is akin to a partially formed water molecule in the combustion process, and will also act as an accelerant in the burning of the fuel, because it’s ready to accept an additional H+ cation (from the HC molecule) and form a stable H2O molecule (with associated release of thermal energy without the endothermic energy requirements normally associated with the process).

As has been pointed out previously, hydrogen gas burns at 5.7 times the speed of gasoline. It acts as a powerful accelerant in the combusting of the HC fuel. Carrying the flame to the outer reaches of the combustion chamber at a 5.7 times faster rate than gasoline alone, its major contribution to the combustion process has little to do with the Joules of energy it may contain, but more with its ability to make the dominant HC fuel more effective within the allotted window of time.

Also, as has been pointed out, modern engines use EGR as a means to combat NOX emissions. EGR has detrimental side effects that Brown’s Gas overcomes. Whereas EGR will slow the spread of the flame front, Brown’s Gas increases the flame spread to a point that is still faster than the engine with no EGR. Whereas EGR displaces ambient air and therefore the oxidizer oxygen gas, Brown’s Gas contains one or more varieties of oxidizer(s) to more than compensate for the displacement by the EGR.

Whereas water vapor is a much more powerful expansion medium than the nitrogen in the air (by a factor of 12X), Brown’s Gas reverts to water after combustion, and that water is available as an expansion medium.

The typical HHO system powers the cell with “Brute Force”, where battery potential is applied to the anode and cathode at all times. Using this method, the attractive force that holds the radicals tight against the plates virtually eliminates the H+, O-2, and OH- radicals, as only the stable diatomic H2 and O2 molecules can free themselves from the plates and buoyantly float to the top. References too numerous to mention have proven that pulse width modulation (PWM) dramatically increases the percentage of radicals present in the resultant gas. During the off time, the attractive force holding the radically charged gasses against the polarized plates rapidly diminishes, allowing the buoyancy of the charged gasses to release from the plates and float to the top. Furthermore, in addition to an increase in the *quality* of the gas, there is an increase in *quantity* of gas due the increased amount of bubbles able to free themselves from the plates. As these bubbles float away from the plates, liquid water takes their place and becomes available for the electrolytic process. As long as bubbles cover the plates, water cannot be electrolyzed.

Another draw-back of brute force is the reality that the demands of a typical automotive engine change as the throttle is depressed and released. Under load, higher volumes of HHO gas are required than at idle. PWM systems are able to vary the output of the HHO cell to more closely match the needs of the dynamic engine. Changing the dwell on the PWM can alter the output from the HHO cell as conditions and requirements change.

As has been alluded to within this body of work, the HHO cell is a dynamic breathing entity. As bubbles form on the plates, current draw and gas production is reduced. As temperature increases, current draw and production is increased. As the water in the electrolyte is consumed, the residual electrolyte has a higher conductivity, increasing the current draw, thermal output, and gaseous output. A means of tracking the current draw at any given moment has successfully been implemented by certain inventors to account for changes in operating conditions. By tracking current draw, changes can be made to the PWM drivers to maintain a more consistent output at any given demand.

Whereas a simple PWM has shown great value in the creation of quality Brown’s gas, higher frequency tuning has shown potential for even greater gains in both quantity and quality. PWM is a relatively simple electronic circuit that is easily adapted to the HHO cell. The resonant frequencies that have shown exceptional merit have also proven to be quite difficult to tune. The “magic” frequency changes rapidly as the plates are covered with gas bubbles, the bubbles release exposing the plates to water (changing the effective surface area of the plates), the temperature of the cell and electrolyte changes, and other factors. Very few inventors have been able to effectively utilize the potential of high frequency “tickling” of the plates.

Ecosceptor, LLC (Ecosceptor.com) offers a hydrogen fuel cell controller called **The Hhombre** that utilizes all of the principles just listed (including the “tickling” frequency). In addition, it incorporates 2 LED indicators that alert the driver when water is needed in the system. The Amber LED tells the driver it is time to add water. The Red LED alerts the driver that the water level is critically low and that the system has been shut down to prevent damage. When water is added, the system will resume normal operation after the next key cycle.

* 1. **Tuning**

Whereas factory ignition timing settings are typically retarded from optimal to combat NOX emissions, it is proven that the addition of hydrogen reduces NOX emissions by a factor of 5 (NASA, 1974) and therefore optimal ignition timing settings can be targeted for performance and economy without the concern for NOX formation. Furthermore, since hydrogen and especially Brown’s Gas (rich in radicals) speed up the flame spread and rate of combustion, less timing advance is required for optimal performance and economy. Factory ignition timing settings are usually appropriate for a combustion process with trace amounts of Brown’s Gas present (for performance and economy). With higher percentages of Brown’s Gas, timing retard is usually beneficial.

Whereas it has been proven that the addition of trace amounts of hydrogen allows for a much leaner air to fuel ratio (<85% Lambda) without excessive flame out (flame extinguishes without combusting the air/fuel mixture) or cylinder variations, and without the formation of HC or NOX emissions, less fuel has to be added to the intake charge to deliver full power. If anything, removing a percentage of fuel from the intake charge will increase power output due to the new stochiometric requirements of the modified fuel. Test data suggests that with trace amounts of hydrogen present the Lambda can shift from the conventional 14.7:1 AFR to as lean as 17.5:1. Conclusive studies are not available at this time to quantify the requirements of Brown’s Gas, but it is estimated that the trend would continue resulting in even leaner AFR limitations.

Whereas it has been proven that the addition of even trace amounts of hydrogen improves torque; less throttle angle is required to sustain a given power output (highway speeds). Less throttle angle means the engine consumes less *air and fuel* total, thus improving fuel economy.

Since most of the benefits derived from the addition of Brown’s Gas require tuning for maximum benefits, the dominant tuning tool used in the industry has been the Electronic Fuel Injection Enhancer (EFIE). The EFIE has been around for over 20 years. It is now the industry staple because of its long-standing reputation. When it was introduced 2 decades ago, the ECUs were more simplistic. The adaptive strategies accepted the modified sensor signals the EFIE delivered and allowed the hardware (HHO cell and other devices) to deliver the performance and economy gains.

Traditionally, the hardware alone, without any tuning, typically only showed about a 10% to 15% gain in fuel economy due to the programming schedules in the factory ECU. On OBD I vehicles (1995 and older) the EFIE worked miracles. Sadly, the predominant vehicles on the road today are usually 12 years old or newer. As of this writing, that means they are 2000 models or newer. It has been circumstantially shown that the EFIE is rendered ineffective on the newer vehicles due to the adaptive strategies programmed into the ECU.

Ecosceptor, LLC is finalizing design on 2 different ECU controllers that take into account the modern adaptive strategies. Whereas the EFIE is effective on older narrow band oxygen sensors, and moderately effective on newer wide band sensors, Ecosceptor’s controllers are designed to be most effective on narrow band sensors, AFR sensors (Honda & Toyota use these extensively), as well as wide band sensors. Ecosceptor’s **O2ffset** is what the EFIE should to be for the modern automobile. The narrow band version delivers an analog signal (digital EFIEs put out only 2 different voltages) that the ECU accepts. It accounts for decel fuel cut recalibrations. It delivers gains that last.

The AFR version of the O2ffset ties the upstream AFR sensor to the narrow band down-stream sensor to prevent the adaptive strategies from recalibrating around it. The few tuning strategies previously attempted on AFR vehicles do not take into account the recalibration process and are soon rendered useless by the ECU. Only by treating the entire feedback system as a complete system have we been able to extract maximum sustainable gains from AFR equipped vehicles.

The Wide Band EFIE has shown moderate gains, even on newer vehicles. In fact, the WB EFIE has been proven even more effective than any of the traditional NB versions. That was our starting point for designing a Wide Band O2ffset. Researching what everyone else was doing led to disappointing results in our own experiments. We decided to thoroughly research how the wide band oxygen sensor functions, how the ECU interacts with it, and observe the strategies included in the software. This exhaustive R&D led us to a simple approach that far surpassed anything else we’ve been able to find. As with the AFR O2ffset, the Wide Band O2ffset treats the entire feedback system as a whole, thus negating the adaptive strategies and recalibration processes that thwart the efforts of most others.

In addition to controlling the air/fuel ratio, the O2ffset has provisions to alter ignition timing by a small margin; usually sufficient to appreciate substantial gains. The EFIE has no such provisions.

Ecosceptor, LLC’s flagship product carries the company name, **The Ecosceptor**. Whereas the O2ffset alters sensor signals to shift the ECU’s internal tables, the Ecosceptor literally takes control of the fuel injectors to deliver the appropriate air/fuel ratio at all times. It works with sensor signals to keep the adaptives at bay as well. It represents a harmonious package that delivers gains never before possible with previously available tuning products.

It should be noted that electronic controllers designed to alter operating parameters should *never* be used on stock engines. In stock form, the stock tuning schedules are optimal (just ask the judge that may oversee your court case). Tuning controllers are only appropriate on vehicles that have hardware that alters the combustion characteristics of the engine, and then only to restore balance to the new system. We have observed that a stock 2004 Nissan Titan operated at a 14.7:1 AFR post cat. After HHO, orgone, Pulstar Plugs, and a Smart Emissions Reducer (ExtremeEnergySolutions.net) was added, the post cat readings were a richer 14.4:1 AFR. With tuning, the stock 14.7:1 AFR was restored with a resultant gain in fuel economy and performance.

1. **Conclusion**

It should have become obvious that the engines currently sold in the US are not nearly as efficient as possible. In fact if fuel economy numbers are compared for vehicles sold in the US against the same vehicles sold in Europe and Australia, the American versions do not achieve near the economy of the foreign versions. It should be evident that many prior inventions have delivered on dramatically improved fuel economy. It should be evident that there is a long list of products that scientifically have the potential to dramatically improve fuel economy. It should be evident that fuel economy isn’t the only issue at hand, whereas exhaust emissions are also a major consideration. It should be evident that with the consideration of EPA regulations concerning exhaust emissions that factory tuning wastes much fuel to feed the catalytic converter and combat NOX emissions formation. It should be evident that between the provided evidence supporting the potential of various technologies, and the evidence supporting the potential of the tuning, that incredible improvements to both performance and economy are possible. It should have been made evident that even elaborate claims often violate no known laws of physics or chemistry. It should also be evident that Ecosceptor, LLC is in this game to help you win.

Ecosceptor (Ecosceptor.com) is building a business focusing on helping inventors and companies get the most out of their scientifically sound products with our tuning aids. In addition to electronics, Ecosceptor offers training, not only on our products, but will assist you in building your training program to further maximize your product’s potential. We want you to be the hero. We want your product to be the household name. We build relationships and people first and foremost, and successful business as a close second.

A more comprehensive fuel economy guide can be found as *The Ultimate Fuel Economy Book* at www.cafepress.com/fet.

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