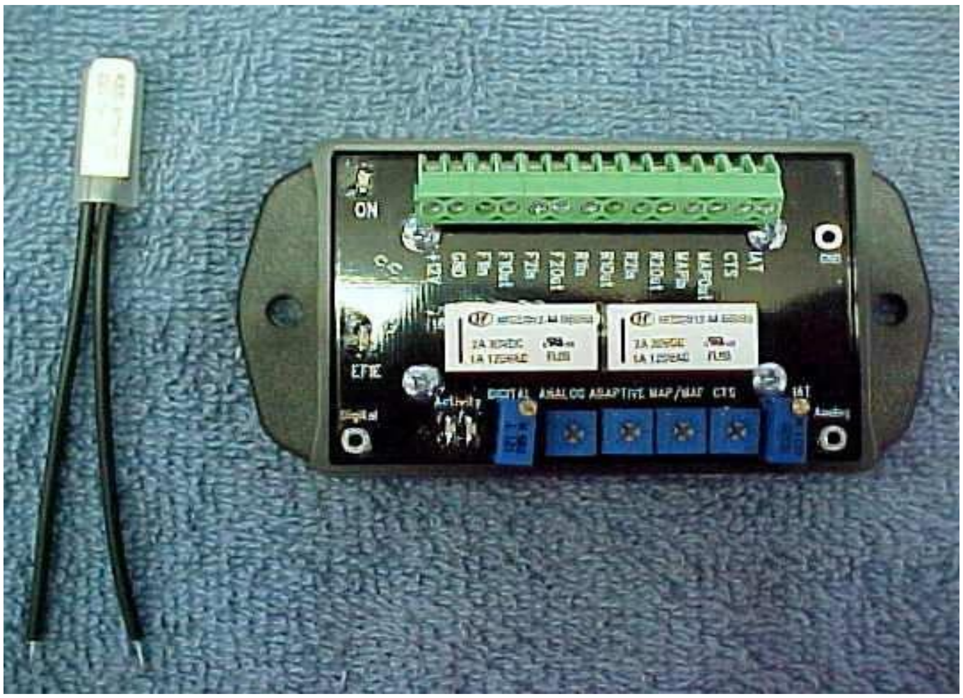
Tuning 101

How To Gain Success From Your HHO System

Part One



There are many people that are installing **HOD** systems **(Hydrogen On Demand)** in their vehicles all over the world, **but not many people that are doing it correctly**. If you have experienced mileage gains with HOD only to lose them over and over no matter what you try this article will help. I have spent the last 8 years experimenting with my own vehicles, and many others, and I have finally achieved the goal of consistent performance and results using HOD along with the proper engine and ECU tuning techniques. I want to help others avoid the frustration of not installing correctly the FIRST time. Most experimenters make the mistake of taking shortcuts. They install a MAP/MAF enhancer, but not an EFIE. They don't optimize ignition timing with the IAT sensor. They never use a scan tool to verify their modifications are working. This guide will teach you the professional way to install and tune an HOD system in a gasoline powered vehicle. For some, the steps outlined in this guide will be too much, and for those people I recommend a True Digital EFIE and a MAF/MAP enhancer. However if you are all thumbs and virtually have no automotive knowledge I recommend a " ECU flash module " such as the Volo FS2. **The Volo WILL NOT COMPETE with the**

results you will get with manual old fashioned tuning, but it will be simple and require less manual intervention. **It will normally at best, only produce gains of 3% to 11%**

BASELINE- This is THE most important step. Establish what your current highway MPG baseline is by doing a point to point 100 mile or greater highway mileage loop test. Purchase and learn how to use a scan tool. At 55-65 MPH cruise, log your Short-term and Long term fuel trim averages, MAP/MAF number, TPS number, ignition timing, and typical IAT and CTS temps. **Repeat the test and the logging at least twice. If you don't know what your baseline is, you won't know if you've accomplished your goals.**

THE ELECTROLYZER-

This is the core of your HOD system. Just like a radio is of little use without a good antenna, an HOD system is of little use with a poor electrolyzer. Try as you might to increase engine efficiency, an inefficient electrolyzer will soak up most of any gains you might achieve by putting out too little LPM of hydroxy for too much current from your battery/alternator.

With most vehicles it's important to stay under 30 amps of current draw to avoid electrical strain on the alternator/battery. At 30 amps you should be seeing at least 3 LPM from your electrolyzer with minimal heat. (under boiling temperature**) In most cases you should NEVER need to exceed 15 amps of total draw for the supplemental effect of hydroxy to work on up to an 8 liter engine..**

Note** **It is never advisable to install a generator that draws more than 15% of your alternators rated amperage output.**

Contrary to popular belief, it's not always best to run the maximum hydroxy you can produce. For 4 cylinder cars usually ¼ to ½ LPM is plenty to get the job done. 6 or 8 cylinders get a little better kick from 1-2 LPM. The people out there on YouTube that are trying to build these "mega-cells" for HOD purposes are totally missing the point. Are you trying to run the car on water or simply enhance combustion? Pick one. Too much HHO and you'll actually force the engine to work harder, fighting the upward motion of the piston, screwing up engine timing, and more. A little water gas goes a long way, but at least ¼ LPM is essential to begin to do anything. Controlling the output of your electrolyzer is a must. This is best accomplished with a CCPWM or a manually operated PWM. The **High Power PWM** is the most advanced control system on the market at this point in time. **The Gen 20 system** has one of the highest efficiency rating of any electrolyzer currently on the market,

Do lots (and I mean lots) of research on electrolyzers. The Gen 20 has the best LPM for the current draw, with the lowest heat. (although many others lie about their specs so

use caution)
Look for lasting build quality and know what's inside anything you purchase. Do not accept anything less than 316L grade stainless steel for electrodes. Even 304 WILL break down over time, so make sure it's 316L or better. Try to find positive postings or results with a specific electrolyzer before you purchase it.

Mount your electrolyzer in a suitable place away from moving parts and away from the engine heat as much as possible. Wire the positive lead through a solenoid (relay) and an ammeter. Negative goes straight to a good vehicle ground. Use a ignition active source to fire the solenoid and a toggle switch to kill that circuit in the event you dont want to use the hydroxy.

THE FUEL LINE HEAT EXCHANGER- This device, when used by itself will not produce fabulous increases in fuel economy, but when included with HOD it makes a very notable improvement, which is why I include it here. It's just a simple assembly of metal pipe fittings with in/out ports. (I have used the water4gas design and it works well) You seat the device to your radiator hose for heat exchange and re-route your fuel to it before the injection manifold. The fuel is then pre-heated for better vaporization when it gets to the injectors. The device is wrapped in aluminum foil and header wrap to act as a thermal blanket and heat the unit/fuel throughly. To install just follow your gas line from the rear of the vehicle to your injection manifold. If you have a fuel pressure release valve on your injector rail use it first to release the gasoline pressure, then cut into the line and re-route using high pressure fuel line hose and brass hose barbs to your heater, then back to the injection manifold. Lastly, wrap the heater in foil and wrap and use ties to lock into place. Use crimp type hose clamps for the connections and be sure to check regularly for leaks to prevent any danger of fire.
THE EFIE DEVICE (for narrowband O2 sensors)- If you were to install the above but do nothing else, chances are for most cars your MPG would either stay the same or get worse. Why? because the hydroxy is creating a different combustion environment inside your engine. It's an environment your car's ECU and sensors are no longer addressing properly, because you have deviated from factory specs. You are now burning your fuel better and reducing hydrocarbon deposits in the exhaust. Your o2 sensors are not seeing anywhere near the normal
amount of hydrocarbons (pollution) in the exhaust and in fact see more clean oxygen. Why is this a problem? Because factory programming tells the ECU that a lean burn condition is taking place when in fact it is not. The ECU can't allow potential damage to the engine, so it will add more fuel to see the level of hydrocarbons and less oxygen it's used to seeing. Any gains created by your HOD system are then swept away by the ECU increasing the fuel consumption.

Add the EFIE. The EFIE (Electronic Fuel Injection Enhancer) effectively tells the ECU through the O2 sensors that the oxygen content of the exhaust is normal, thus restoring the balance and allowing the HOD system to work in a positive direction with fuel economy gains. The EFIE "tells" the ECU everything is ok in the exhaust by adding a slight increase in the O2 sensors' voltage to offset the amount of oxygen your HOD system is adding.

The EFIE can also be used to lean the fuel mixture very slightly by telling the ECU the exhaust is slightly rich in hydrocarbons, but this cannot be done easily without tuning other sensors on the car to coincide. Attempts to do so without tweaking other sensors usually results in a check engine light or trouble code. See the various sensor mods below for more on this.

For most cars pre 2000, usually only the O2 sensors previous to your catalytic convertor (upstream) are the ones that will need to interface to an EFIE device. For cars post 2000 both the "upstream" and the "downstream" sensors will need to be addressed.

All EFIEs are **NOT** created equal. Most EFIEs are the old fashioned design that just adds a voltage to the O2 sensor signal. This works to a point, but on newer cars you can only add very little voltage before you're caught and the ECU triggers a check engine light. DO NOT USE OLDER STYLE EFIES OF THIS DESIGN ON UPSTREAM O2 SENSORS. They will work, then trip codes, work, then trip codes. Why? Because the O2 sensor signal is like a sine wave, or even a binary signal. It must have a low point (0,lean), and a high point (1,rich). When you start adding voltage offset all the time you're making the high point higher and the low point higher as well. Soon the low point is no longer low, (1111111) and therefore not acceptable to the ECU. You can use old fashioned EFIEs to address the less critical downstream sensors if needed, by using them to add a small 350-500mv offset to the downstream signal at all times.

You need an EFIE that sets a higher high point but allows the low points to pass through to the ECU, satisfying it's need to see the full wave, and the full picture of what's happening with the AFR. A good EFIE simply tells the ECU the AFR is rich more often, but not ALL the time like an older EFIE. These good EFIES are sometimes called " true digital" EFIEs because they generate both the "1" and the "0"s the ECU must see to believe it's just the o2 sensor doing it's job. What you are changing with this EFIE is referred to as the oxygen sensor switch point, that is, the point at which an o2 sensor signal is translated to the ECU as a "rich" signal, or a digital 1. This switch point is adjustable, from 500mv all the way down to .050mv. In other words, the lower you set the switch point, the more often you're telling the ECU you're running rich, which will lean things out. Typical switch points for HHO tuning fall between 350-100mv on most cars with most o2 sensors.

Do not go down a whole lot in switchpoint until you address the other sensors on the vehicle, or you will run into check engine lights, rough engine, bucking, stalling, sputtering, pinging etc.

FOR AFR / WIDEBAND O2 SENSORS -For vehicles that dont have narrowband O2 sensors but instead have wideband or AFR style sensors, you'll need to purchase a Wideband EFIE. Some people have reportedly had luck tuning wideband sensors by cutting the harness side of the blue signal wire and inserting series resistance from 11-19 ohms. Wideband O2 sensors are current based devices instead of voltage based. Methods for attacking widebands use a method to control current flow on the blue signal wire.

CTS SENSOR MOD- The goal is to add about 10 degrees to your coolant temperature sensor reading. It's important to note that the actual coolant temperature will remain the same as it normally would be. We are merely fooling the ECU into "seeing" it 10 degress hotter. Why? A seemingly warmer engine promotes less fuel usage and unlocks leaner mixtures for the ECU, which it can now run because the HOD is protecting the engine by keeping it cool, as well as burning smaller amounts of gasoline more efficiently.

Find the CTS sensor and the wiring harness leading to it. With a razor remove a small amount of insulation on both leads of the sensor, then solder a resistor across the leads in parallel to achieve the desired 10 degree offset. I used a 3.9k ohm resistor but you might need as high as a 5k to get it right. Try not to go much above a 10 degree offset or you might run into starting issues because the ECU will think the engine is already warm when cold starting. Better yet, make the resistor mod switchable with a toggle and you can switch it in AFTER the engine is warmed up. This will avoid cold start issues entirely.
How do you know you've raised the temp 10 degrees? The crude way is to look at your temp gauge on the dash. The best way is to use a scan tool such as a scangaugeII to know exactly what the ECU sees.

IAT (Intake Air Temperature) SENSOR MOD- Once again we need to fool the ECU into thinking it's sensors are in agreement about the current conditions. If you have the CTS tweaked but not the IAT the ECU is not likely to comply with leaning out of the fuel trim. You must unlock more tables in the ECU by doing this mod. Sometimes the IAT sensor is incorporated into the MAF sensor as one unit. You'll need to track down the pair of wires that goes to the termistor to modify the stream. This mod also changes the ignition timing curve. THIS IS A MUST TO GET THE BEST MILEAGE YOU CAN FROM USING HHO. Do not skip this step!

The IAT has a big effect on engine ignition timing. When it comes to improving combustion efficiency ignition timing is everything. Raising the temp retards the timing and lowering it advances it. With a hydroxy system we are actually looking to retard the timing because of the flame propagation speed increase within the combustion chamber using the system. It's important to add that the next modification of the MAP or MAF sensor will advance the timing, so you're looking to adjust the IAT temp a little over the mark for timing so that our final MAP/MAF adjustment brings the timing in perfectly. 80-100 degrees above ambient sounds dramatic, but is typically a good starting point. You will need to experiment with resistor values to find the right one for your vehicle. I used a 20k pot with a 500 ohm resistor in series to keep it from shorting out the sensor. This mod is also switched with a toggle after the engine warms up. This mod is sweet in that it allows me to "dial" in the correct value for the IAT, and find the optimal setting for economy. I adjust IAT for max power.
NOTE: A scan tool is a MUST for this mod. You need to know the IAT that the ECU

sees to make the mod.

RE-ADJUST THE EFIE- ok, the CTS and IAT sensors are in agreement for a slightly leaner mixture, so time to adjust the O2 sensors as well with the EFIE. Now that you have effectively "lowered your lean limits" to the ECU, we can drop more switchpoint on the EFIE and get away with it. No check engine light or trouble codes to worry about, just don't get carried away. Go a little bit lower, maybe 50-150mv more then you have previously set.

MAP/MAF SENSOR MOD- The last mod, (probably the most important) is your load sensor mod, aka the MAP or MAF mod. These sensors give the engine an indication of load by measuring the volume of air coming into the intake. Higher pressures mean more gas is needed, lower pressures mean less gas is needed. Simply put these sensors translate the need for x amount of fuel into voltages which are sent to the ECU.

With hydroxy we don't need as much fuel as we did for everything before the system, even under load, so we can safely reduce some of this fuel. Even better, with the CTS, IAT and O2 sensors now in agreement for a leaner mixture, tweaking the MAP/MAF should be a piece of cake. You can either build the LM317T voltage regulated MAP adjuster all over the net or purchase one and install it on the VREF line (NOT the signal wire) of a MAP. (usually 5v)I adjusted my VREF down to about 4.85v. Make it switchable as well so you can toggle between your adjusted MAP voltage and the stock v factory VREF.

For some MAFs it's alot more complicated. If the MAF has a VREF you can attack that, if not you can go for the fluctuating signal voltage and attenuate that with a POT, OR you can put a low resistance resistor (say 1-4 ohms)on the ground wire to generally knock the air values down. Generally speaking, you must find a way to reduce the air volume the ECU sees through either the MAP or the MAF sensor. You can do this electronically or mechanically. **In more recent years I have opted for the voltage attenuation method for MAF/MAP modification. It has proven to be more dependable throughout the load ranges on most vehicles.**

One of the biggest mistakes people make is they use their MAP or MAF enhancer as a fuel leaning device, and believe that no EFIE is needed if they use a MAP/MAF enhancer. This is completely wrong! Yes, it is true that lowering the MAP/MAF readings will reduce the amount of fuel the injectors are sending. However, the fuel you are taking away with the enhancer can easily be detected with the O2 sensors. The O2 sensor readings go lean because there's less hydrocarbons coming out after you take away fuel with the MAP/MAF enhancer. The result is your long and short term fuel trims will actually go positive and ADD more fuel to compensate! This is why many experimenters report losing mileage or going full circle with gains and then losses using only a MAP/MAF enhancer. You MUST address both the load sensors and the oxygen sensors. If both are in agreement about less fuel being needed, you will then see a fuel economy increase. Part two of this guide will teach you more about how to read what the ECU is "thinking" with your scan tool and adjust your mods and enhancers perfectly.

Automotive Terms Glossary.
AFR: Air/Fuel Ratio. Also Air/Fuel Ratio sensor.
AFS: Air/Fuel Ratio Sensor. Also spelled "A/FS".
CEL: Check Engine Light. The engine trouble light, that lights up on your dash when the ECU detects an error condition. See DTC.
COP: Coil On Plug. A type of ignition system that doesn't require spark plug wires, and has a coil mounted directly to each spark plug.
CTS: Coolant Temperature Sensor.
DIS: Distributorless Ignition Systems. Systems that utilize electronics instead of a distributor to calculate spark timing.
DTC: Diagnostic Trouble Code. The code number that the ECU gives you to help diagnose an error condition. For 1996 and newer vehicles, these can be read by standard OBD-II readers. Older vehicles may have a system for initiating a blink code, whereby the error numbers are read by the number of blinks of the Check Engine Light.
ECM: Engine Control Module. Also Electronic Control Module. See ECU.
ECT: Engine Coolant Temperature sensor. Also called CTS (Coolant Temperatrue Sensor).
ECU: Engine Control Unit. The vehicle's computer. Is often called by other names, but ECU seems to be the most common. See ECM, PCM and others.
EFI: Electronic Fuel Injection.
EFIE: Electronic Fuel Injection Enhancer. A device used to modify the signal from an oxygen sensor so that the ECU will lean the fuel mixture.
EOP: Engine Oil Pressure sensor.
HEGO: Heated Exhaust Gas Oxygen sensor. Another name for an oxygen sensor.
IAT: Intake Air Temperature sensor.
MAF: Mass Air Flow sensor. Measures the amount of air flowing into the engine.
MAP: Manifold Absolute Pressure sensor. Measures the pressure inside the intake manifold. The ECU compares this to the barometric pressure sensor (outside air pressure) to determine the difference between the pressure in the manifold and the outside air.
MAT: Manifold Air Temperature.
MIL: Malfunction Indicator Light. Same as CEL (Check Engine Light). See above.
O2S: Oxygen Sensor.
OBD-II: On Board Diagnostic system. Prior to 1996 the systems varied by manufacturer. Jan 1, 1996 marked the beginning of a mandated standard for all new vehicles to conform to. This was ODB-II. Now the same reader can plug into any car and read it's information, including engine sensor readings, trouble codes, etc. For more information see this page.
PCM: Powertrain Control Module. The computer. See ECU.
PCV: Positive Crankcase Ventilation. Also PCV valve. See wiki for more information.
Stoichiometric (Stoy'-kee-o-metric) Ratio - Not an acronym, I know. But it comes up a lot and I don't have another good place for it. This is the theoretical perfect combustion ratio of 1 part fuel to 14.7 parts air.
TPS: Throttle Position Sensor.
VCM: Vehicle Control Module. Yet another name for the ECU. Aren't acronyms fun?
VSS: Vehicle Speed Sensor.
WOT: Wide Open Throttle sensor.

Stay Tuned for Part 2

If you've made it this far and have the above items installed and functional, CONGRATULATIONS! You've made it further than most. Part two of this guide will help you get the most out of the system with proper tuning on the fly, as well as some special tricks I have learned to further increase your success.