Electrolytic Automotive Hydrogen Generation:

It's not just a bad idea, it's against the Law

The idea of using a car's battery or *surplus* current from the engine's alternator to electrolytically produce Hydrogen gas in order to boost gasoline mileage, or even eliminate the need for gasoline all together, is very appealing to many people. However, the laws of physics guarantee any attempt to fully fuel one's car using such techniques will fail.

The first law of thermodynamics states that energy can neither be created nor destroyed, energy can only be converted between forms. In other words, there is no such thing as "free energy"; an increase in energy in one location is always accompanies a decrease in available energy elsewhere.

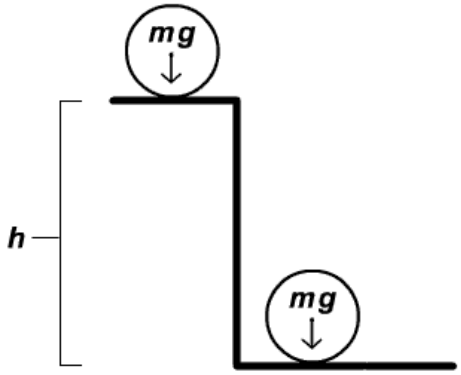
The energy to power an automobile comes from the fuel used, which in turn must come from something else.
The sun originally supplied the chemical potential energy contained in gasoline. Plants (and animals) absorbed energy released during nuclear fusion within the sun in the form of light through photosynthesis. After dying, these plants and animals formed the fossil fuels used today, including crude oil used in the production of gasoline.
Hydrogen gas, like gasoline, contains considerable amounts of chemical potential energy. However, *unlike* gasoline (oil), there are not vast natural reserves of Hydrogen gas present; the Hydrogen must be manufactured before use.
The energy source used in the manufacture of Hydrogen gas is of critical importance in determining the practicality of Hydrogen as a fuel, especially if one intends to produce Hydrogen gas via electrolysis of water.

The amount of chemical potential energy present within Hydrogen gas depends upon how the Hydrogen gas is reacted. The final product(s) of the reaction will determine just how much energy is released. The amount of energy released in the reaction equals the amount of chemical potential energy the reactants lost in the process.

Compare the following example of gravitational potential energy to the chemical potential energy contained within Hydrogen.

A ball resting near the edge of a table possesses some initial amount of gravitational potential energy (PE_g) which is directly proportional to the ball's mass (m), its height (h) above the ground, and the gravitational acceleration (g) the ball experiences.

$$PE_g = m\,g\,h$$

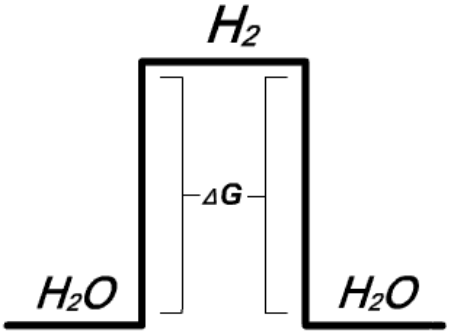


If the ball should fall from the table to the ground, the ball would loose all of its potential energy as it is converted into other forms of energy, including Kinetic Energy and Heat Energy. When all is accounted for in the end, the sum of the energy lost by the ball into other forms comes out to exactly equal its initial Potential Energy value. The Maximum amount of energy which can be extracted from the ball (the maximum amount of *Work* the ball can perform) as it falls is equal to the ball's initial amount of Potential Energy.

If the ball is initially located on the ground ($h = 0$), the ball would possess zero Potential Energy. Thus, in order to lift the ball up to height, h, *Work* needs to be done on the ball. The minimum amount of work which must be performed on the ball is equal to the potential energy the ball will possess at the new height.

Potential energy must always be measured with some type of reference amount to which the object has potential over. In the example using gravitational potential energy, the reference was the ground, defining any object at that height to have zero potential energy. Using the ground as the reference for gravitational potential energy is very convenient but not required. Any arbitrary height could be chosen as the point of zero potential, doing so would effected the specific values of the object's potential energy at those heights but this is immaterial since only the change in potential energy is important, not the absolute value.
In the case of the water producing Hydrogen gas system, a convenient, but arbitrarily chosen, level of "zero" chemical potential energy can be defined as the chemical potential energy contained by water within the system.

Like the ball resting on the ground, Water (H_2O) is in its stable, low energy, state in which no further energy can be extracted in its current form. Hydrogen gas (H_2) is represented by the, *energized*, ball sitting atop the table, possessing a certain amount of chemical potential energy.



In order to produce Hydrogen gas, energy must be expended to do *Work* on the water to increase Hydrogen's chemical potential energy. In this case, instead of lifting a ball against gravity, energy is expended to break the chemical bonds present within the water, causing an increase in what is known as the Gibbs free energy (G). The Gibbs free energy represents the amount of chemical potential energy a system possesses. The minimum amount of energy needed to convert water into Hydrogen gas and Oxygen gas is dictated by the overall change in the Gibbs free energy of the reaction. When Hydrogen gas reacts with Oxygen gas to produce water, the maximum amount of energy which may be obtained from the reaction equals the change in the Gibbs free energy.

The electrochemical process in which an electric current is used to split water molecules into Hydrogen gas and Oxygen gas is known as *electrolysis*. Electrolysis is accompanied by a positive change in the Gibbs free energy, meaning that the process in not spontaneous and energy must be spent in order for the reaction to proceed.

$$2H_2O_{(\ell)} \xrightarrow{electrolysis} 2H_{2\,(g)} + O_{2\,(g)}$$

The reverse process of electrolysis in which Hydrogen gas and Oxygen gas spontaneously react together is accompanied by a negative change in the Gibbs free energy. This reaction produces water as the sole byproduct. After arriving at thermal equilibrium with the surroundings, the maximum amount of energy able to be extracted from the reaction equals the original energy spent producing the Hydrogen gas through electrolysis.

$$2H_{2\,(g)} + O_{2\,(g)} \longrightarrow 2H_2O_{(\ell)}$$

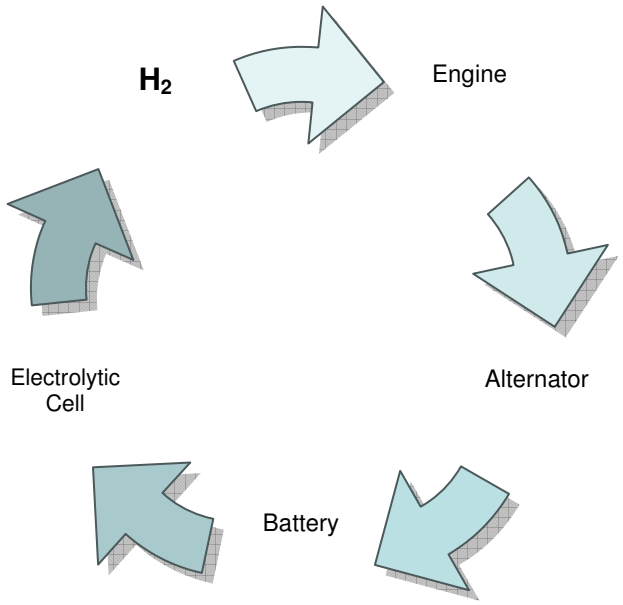
If all energy conversions were perfectly, 100%, efficient, the energy gained by reacting Hydrogen gas to produce water would exactly equal the energy spent to electrolytically produce Hydrogen gas from

water. However, we do not live in such a perfect world where 100% efficiency is possible, there will always be some amount of energy lost to *heat*.
The second law of thermodynamics states that the total entropy (disorder) of a system (the universe) at disequilibrium is always increasing towards a state of maximum disorder. In other words, there are no perfect energy conversions, 100% efficiency is impossible.

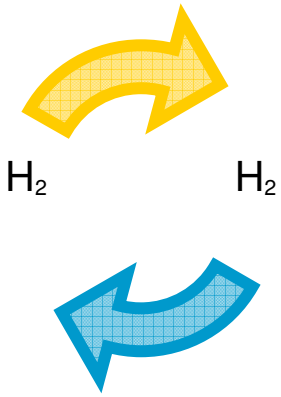
The first law of thermodynamics already forbids efficiencies greater than 100% (outputting more energy than one puts in), and from the second law of thermodynamics, even breaking even in an energy conversion (100% efficient) is prohibited.
Attempting to use the energy gained from the reaction between Hydrogen and Oxygen gas to reform an equal amount of Hydrogen gas from water is thermodynamically impossible, much less attempting to not only reform an equal amount of Hydrogen but also have the reaction perform additional work as well.

Many misguided attempts are made involving the use of the electrical system of a car to power an electrolytic cell and split water into Hydrogen and Oxygen gas to be used as the internal combustion engine's sole fuel.
The car battery or alternator is commonly chosen as the source of electrical energy to supply the Hydrogen producing cell with the means to split water. However, what is often not realized is that the electricity used is not in any way, "free energy", instead, the source of this energy is actually the engine itself and, in turn, the fuel used within the engine. As the fuel burns within the engine, a portion of the energy released is used to spin the alternator of the car, generating electrical energy which is used to recharge the car battery and power many of the electrical systems within the car.

The below diagram depicts the stages in the conversion of energy from the chemical potential energy contained within the fuel (Hydrogen gas in this case), through the engine, alternator, battery, electrolytic cell, and finally back into Hydrogen gas to be reused in the engine.



The above diagram can be simplified further by removing all the unnecessary energy conversions resulting in the below process,



Essentially, the process breaks down to Hydrogen gas being used to generate Hydrogen gas, *in addition to* attempting to extract additional work from the process in order to propel the car.

The first Law of thermodynamics forbids a higher amount of energy being extracted from the Hydrogen than what was originally spent to produce the Hydrogen. So in other words, **at best**, this system could only break even at 100% efficiency, there would be no energy left over to move the car, all one could do is maintain the conversion cycle, nothing more.

The second law of thermodynamics requires that entropy in a closed system always be increasing, which thus forbids circular processes such as the Hydrogen to Hydrogen conversion from lasting. Every time a given amount of Hydrogen is spent and its energy reconverted into Hydrogen, less new Hydrogen is produced than one spent to produce it. Even in the simplified energy loop, eventually, all the energy will be lost to heat and no Hydrogen gas will remain. This is true, even more so, when one considers the numerous conversions which must take place in the non-simplified system, further reducing the overall efficiency and hastening the loss of available energy.

Not only can one not extract any energy to propel the car, one cannot even maintain the process without some additional source of energy. If one wanted to use another, supplemental, energy source (for example, a solar panel) to compensate for the energy loss of the system, by remembering the fact that the greater number of energy conversions used, the lower the overall efficiency, one would actually be better off using solely the supplemental energy source as a means to fuel the car than to complicate the process by adding Hydrogen gas and an electrolytic cell into the loop.

Attempting to fully fuel a car's internal combustion engine using solely Hydrogen gas produced using energy obtained, directly or indirectly, from the combustion of Hydrogen gas creates a closed loop of energy conversions, one which cannot exist for any lengthy period of time and will soon fail. Such an endeavor as this clearly violates the Laws of thermodynamics and cannot succeed.

7-14-2006