An Energy Fundamentals Intro and Summary

By Don Lancaster
and Synergetics

http://www.tinaja.com

True or False? (I)

- Gasoline has less hydrogen in it than liquid hydrogen does.
- Fuel cell cars are "much more efficient" than regular ones.
- Silicon pv panels are a net energy source.
- On-board car electrolysis dramatically improves fuel economy.
- Exergy is not important because you have never heard of it.
- Corn is an excellent ethanol feedstock.
- Grid, wind, pv or alternators are all very good hydrogen electrolysis sources.

True or False? (II)

- Amortization dollars and kilowatt hours of electrical production are unrelated.
- An electrical kilowatt hour will have the same quality and value as a hydrogen one.
- "Brown's Gas" is a revolutionary new technology being suppressed by the oil companies.
- There are no economics of scale to pv solar energy; small and personal is better.
- Since energy cannot be created or destroyed, its quality always remains constant.
- Compact fluorescent lamps are always more efficient than incandescent ones.

True or False? (III)

- The main purpose of pv panels is to go offgrid.
- Alternate energy subsidies have proven to be extremely cost effective.
- "Temperature" measures the quantity of heat stored.
- Energy density by weight is the most important criteria for automotive apps.
- Terrestrial hydrogen is an energy source.

Gotcha!

(ALL of the above statements are outright lies!)

Some People...

...will do ANYTHING to save the environment.

Some People...

...will do ANYTHING to save the environment.

... EXCEPT take a science course!

Work and Energy…

- **WORK happens when a FORCE moves through a DISTANCE.**
- **Work is sometimes measured in FOOT POUNDS.**
- **ENERGY is the ability to do work.**
- **Energy is sometimes measured in BTU's of heat, as Joules (or wattseconds) or as watthours of electricity.**
- **POWER is the TIME RATE of energy use.**
- **Energy measures "how much". Power measures "how fast".**

BTU's and Kilowatt Hours...

- A **BRITISH THERMAL UNIT** or BTU is the energy required to raise the temperature of one pound of water by one degree Fahrenheit.
- Or roughly the energy in one kitchen match.
- A BTU equals 777 foot pounds of work. This is the **MECHANICAL EQUIVALENT OF HEAT**.
- A **KILOWATT HOUR** is 3,600,000 Joules. Or use of a 100 watt light bulb for ten hours. Or an average week's use of a microwave oven. Or running up stairs continuously for five hours.
- Or about TEN CENTS worth of electricity.

Some Temperature Basics...

- **BTU's measure the QUANTITY of heat energy.**
- **Temperature measures heat energy QUALITY.**
- **Efficiency DEMANDS high quality energy.**
- **TEMPERATURE SCALES differ in their values for absolute zero, freezing, and boiling...**

  FAHRENHEIT (-459, 32, 212 degrees)
  RANKIN (0, 491, 691 degrees)
  CELSIUS (-273, 0, 100 degrees)
  KELVIN (0, 273, 373 degrees)

- **RANKIN or KELVIN has to be used for heat engine efficiency calculations.**

An energy delivery system...

- ...usually has three major costs...
  - The cost of the FEEDSTOCK.
  - The cost of the DELIVERY SYSTEM.
  - The cost of the AMORTIZATION.
- Typically, delivery and amortization costs will totally dominate. Often making a "free" energy feedstock source noncompetitive.

Amortization...

- Amortization is the timed payment of earlier financed value. Here is a calculator.
- For instance, $10,000 at 9 percent for 8 years amortizes at $146.50 per month.
- Paying cash in advance makes no difference because of the excluded opportunity costs.
- Having value left when payments are completed is simply accelerated depreciation.
- There are no differences between institutional financing, personal savings, or hobbies.

Easily confused are…

- **ENERGY SOURCES - A substance or process (such as gasoline) that can add fully burdened net new BTU's of energy to the economy.**
- **ENERGY CARRIERS - A substance or process (such as hydrogen) that has to be "filled" with old net energy before it can deliver.**
- **Without exception, ALL energy carriers will consume more old energy than they return.**
- **ENERGY SINKS - A substance or process (such as today's pv or corn ethanol) that uses much more net old energy than it delivers.**

Thermodynamics tells us...

- ...that any economy will be ultimately driven by its net energy inputs.
- Obviously, no energy = no economy.
- DOLLAR - A voucher exchangeable for the the personal use and control of 10 electrical kilowatt hours or 30 gasoline kilowatt hours.
- UTILITY BUYBACK AGREEMENTS - contractually equate currently dimes and kilowatt hours as being interchangeable and fungible.
- You can keep score either way.

Gasoline versus dollars...

- It can be useful to think of "spending dollars" as "spending gasoline".
- A solar panel that amortizes three cents a day but generates only two is a net energy sink.
- Taken in their totality, all pv solar panels to date are a large net energy sink.
- An energy sink that will get worse as new dollars are thrown at emerging technologies.
- Thus, not one net watthour of conventional silicon pv energy has ever been produced.
- Proof of this is that not one power utility is yet using pv for routine peaking.

The Magic Switch...

- There is a two position power switch on most any pv panel to date...
- In position "a", you destroy a lot of gasoline.
- In position "b", you destroy even more.
- All the incoming solar energy does is reduce your loses.
- Taken in their totality, all pv solar panels to date are a large net energy sink.

Two Ways to Measure Energy Density...

- **GRAVIMETRIC energy density asks "How heavy?"**
  - **Gravimetric energy density can be measured in watthours per kilogram.**
- **VOLUMETRIC energy density asks "How big?"**
  - **volumetric energy density can be measured in watthours per liter.**

ENERGY DENSITY COMPARISONS

Gasoline	9000 Wh/l	13,500 Wh/Kg
LNG	7216 Wh/l	12,100 Wh/Kg
Propane	6600 Wh/l	13,900 Wh/Kg
Ethanol	6100 WH/l	7,850 Wh/Kg
Liquid H2	2600 Wh/l	39,000* Wh/Kg
150 Bar H2	405 WH/l	39,000* Wh/Kg
Lithium	250 Wh/l	350 Wh/Kg
Flywheel	210 Wh/l	120 Wh/Kg
Liquid N2	65 Wh/l	55 Wh/Kg
Lead Acid	40 Wh/l	25 Wh/Kg
Compr Air	17 Wh/l	34 Wh/Kg
STP H2	2.7 Wh/l	39,000* Wh/Kg

* = uncontained

Which Density is Important?

- **FOR DEEP SPACE, gravimetric energy density can be crucial because of specific impulse.**
- **For AUTO and terrestrial aps, volumetric energy density overwhelmingly dominates.**
- **Tripling the gravimetric energy density of gasoline saves about 26 pounds of weight. Which might be nice, but is no big deal.**
- **You always have to consider the CONTAINED gravimetric energy density. No means of storing hydrogen is know that is remotely as dense by weight as contained gasoline.**

Why Gasoline?...

- **Gasoline (and diesel) have exceptional energy density combined with low cost and acceptable standards of safety and delivery.**
- **Any alternative solution MUST seek parity somewhere near 9000 watthours per liter.**
- **Like it or not, gasoline is likely to remain the de facto standard of energy density comparison for the foreseeable future.**
- **The best of lithium batteries are 36 TIMES larger than gasoline. Standard lead acid batteries are 200 times larger AND heavier.**

Why not Ethanol?...

- Ethanol is a water-loving polar solvent and thus a very poor choice for a fuel.
- Ethanol from corn is horribly energy inefficient and can easily become a net energy sink.
- A case can be made that corn ethanol is an outrageous 15 billion dollar vote buying scam of zero technical or environmental merit.
- Switchgrass or Bagasse (sugar cane residue) may have potential as ethanol feedstocks.
- Ethanol fires resist many firefighting foams.

Why Not Hydrogen?...

- **Hydrogen is ONLY an energy carrier. You have to fill it with old energy before you can use it.**
- **There is more hydrogen in a gallon of gasoline than there is in a gallon of liquid hydrogen.**
- **The CONTAINED energy density of hydrogen by weight is much LESS than gasoline. Energy density by volume is a 3000:1 ludicrous joke.**
- **No vehicle practical means of increasing hydrogen density is known. Liquid hydrogen raises major efficiency and safety issues.**
- **The explosive range of hydrogen is among the widest known. It is ignitable with extremely low spark energy and burns invisibly.**

Efficiency...

- Efficiency is a measure of how much energy you get back for a net energy input.
- Efficiency can be measured several ways...
  - RAW EFFICIENCY -- strict energy output versus energy input as measured in a lab.
  - FULLY BURDENED -- the efficiency after amortization and direct costs.
  - SOCIETAL -- the efficiency after allowing for all hidden factors.
- "Efficacy" is a more correct term when input and output energy forms are different.

Secrets of Thermodynamics…

- **There ain't no free lunch.**
  - **You cannot win.**
  - **You cannot break even.**
  - **Everything eventually goes to hell in a handbasket.**

Or, more formally...

- Energy normally flows from hot to cold.
- You have to input much more heat energy to a heat engine than you recover as work.
- The best you can possibly do is the CARNOT LIMIT set by the absolute temperature ratio. Specifically: (Th - Tl)/Th. Or (Delta T)/Th.
- Good thermodynamics is REVERSIBLE. Meaning that it works equally well in either direction.
- An ADIABATIC reversible process kicks off or accepts no external heat energy.
- An ISOTHERMAL reversible process takes place at constant temperature.

Beware the Mantra...

- "Energy can neither be created nor destroyed" is a true but woefully misleading statement.
- Because the QUALITY and FOCUS of energy will decline with each and every use. You have a three legged stool consisting of...
  - ENERGY - which is the capability of doing work.
  - ENTROPY - which is a statistical measure of the disorder of the present energy form.
  - EXERGY - which is an economic measure of the quality of the present energy form.

Understanding Exergy…

- **Exergy is a measure of the QUALITY and UTILITY of energy in its present form.**
- **Specifically, exergy measures the recoverable and reversible energy fraction remaining.**
- **To measure exergy, you convert energy to some other form, convert it back, and see how much you have left.**
- **Loss of exergy is destructive and permanent. It can be similar to 1:1 exchanging US Dollars for Mexican Pesos.**

Avoiding value destruction...

- **Electricity is just about the highest exergy stuff there is.**
- **The exergy in gasoline can be around one-third that of electricity. Because it is hard to build a gasoline generator above 33 percent efficiency.**
- **Electrical resistance room heat is an example of terribly wasted exergy. Natural gas or heat pumps are often 3X to 5X less destructive.**
- **Electrolysis from high value electrical sources (grid, wind, pv, or alternator) for hydrogen makes no thermodynamic or economic sense.**

A key point being that…

- **The irreversible destruction of exergy through electrolysis is ludicrous.**

- **There ALWAYS will be more intelligent things to do with the electricity.**

Other Problems with Electrolysis Fantasies...

- A switchmode voltage-to-current controller is demanded for efficiency.
- Stainless steel is unusable for electrodes because of the hydrogen overvoltage of iron. Costly and often renewed platinized platinum is needed.
- It is trivially easy to UNDER MEASURE pulse waveforms. Specialized tests are demanded.
- A large body of pseudoscience "electrocity" ignores Faraday's laws. There is no "water powered car".
- Safety and embrittlement issues are extreme.

Why in-vehicle electrolysis doesn't work...

- **The primary product produced is low grade heat, forming a DYNAMIC BRAKE that stops the vehicle in less than normal coasting distance.**
- **Standard automotive alternator efficiency is very low. Engine load increases faster than increasing alternator output.**
- **Only trivial amounts of power can be routed through a standard fanbelt.**
- **Most product designs are uselessly inefficient. Stainless steel can NOT be used for electrodes. Crucial current switchmode drivers are absent.**
- **Costs overwhelmingly outweigh the benefits.**

An on-board vehicle electrolysis summary...

- **Before the stupid mistakes are made, the numbers do not add up by a country mile.**

- **After the stupid mistakes are made (such as stainless steel, a fanbelt, outrageous costs, but no switchmode driver), the numbers become laughingly absurd.**

What About Fuel Cells?

- A fuel cell is an electrolysizer run backwards.
- Max possible efficiency is one-sixth exothermic.
- Motor, controller, and wiring losses further limit efficiency. As does fuel reformation and being unable to use the fuel's carbon fraction.
- Serious issues remain with membrane lifetimes, total costs and system reliability.
- Fuel cells are unlikely to EVER significantly exceed conventional efficiencies. Meanwhile, the ICE is improving at a much faster rate.

Which subsidy do you prefer?

- The OLD CALIFORNIA model in which virtually all of the paybacks went into boiler shop scams that set pv back by many decades.
- The NEW CALIFORNIA model in which it may take FIFTY THREE YEARS of total pv net new energy production to pay the debt.
- The TORONTO model in which they hand pushed and coasted their nonworking hydrogen bus into a major media event. Where, of course, it was lavishly praised for its silent operation.
- The ARIZONA model in which you were given a free SUV for installation of a one gallon tank.

Or these?

- The **DETROIT** model where their bus demos are trucking hydrogen in from Pittsburgh.
- The **MIDWEST** model where a monumental energy sink was cleverly disguised as a twelve billion dollar vote buying scam.
- The **SOUTH CAROLINA** model where they added a five ton evaporative cooler to get their 3 ton but nonworking solar adsorption cooler to look good.
- The **BRAZIL** model that nearly bankrupted the entire country over monumental ethanol stupidity.

Because…

- It makes zero environmental or economic or thermodynamic sense to pay people to put obsolete and known defective gasoline destroying net energy sinks on wildly inappropriate rooftops.

For More Detail:

- This has summarized of these text tutorials...

  SOME ENERGY FUNDAMENTALS
  MORE ENERGY FUNDAMENTALS

- More on electrolysis can be found at...

  MUSE153.PDF
  TRASHELC.PDF

- Ongoing energy developments are viewed at...

  WHAT'S NEW 08

- Custom consulting is available by way of...

  Our INFOPACK Research Service

This has been...

... a presentation by Don Lancaster and **Synergetics**, 3860 West First Street, Box 809, Thatcher, Arizona, 85552. (928) 428-4073.

mailto:don@tinaja.com

Copyright c 2008 and earlier by Don Lancaster and Synergetics. Linking usually welcome. All media, web, and ALL other rights fully reserved. Mirroring or reposting is expressly forbidden.