I sure find perverse joy when I watch all those Bill Beaty and KeelyNet denizens showing off their utter cluelessness of even the most basic scientific principles. So, I guess it may be a good time to review a few...

**Energy Fundamentals**

Let us briefly look at a few of the topics you will need to understand to intelligently evaluate new alternate energy claims...

energy and power— Uh, for starters, energy is the ability to do work, and power equals the time rate of doing work. So, energy is “how much?” and power is “how fast?”.

One unit of energy is the BTU, or British Thermal Unit. Which equals the amount of energy needed to raise the temp of one pound of water one degree Farenheit. Roughly the energy in one kitchen match.

An alternate unit of energy is the Joule. A Joule equals the heat energy provided by one Ampere of current routed to a one Ohm resistor from a one volt dc source for one second. A Joule also happens to equal .000948 BTU’s. Or 0.73756 foot pounds.

One unit of power is the Watt. Or an energy time rate of one joule per second. A watt also equals one amp of current across one dc volt.

A second power unit would be the horsepower. One horsepower equals 745.7 watts, 745.7 joules per second, or 0.707 BTU’s per second, or 550 foot pounds per second.

Going back to energy units, a watt second of energy equals a Joule. One watt hour is 3600 Joules.

One hundred watt hours of energy are easily visualized as a larger light bulb or running up stairs for an full hour. Or eight minutes of microwave cooking. Or 20,000 hours of pv solar calculator use.

**sources, carriers, sinks**— I’ll define an energy source as any substance or process that is capable of delivering net BTU’s or Joules of useful energy to the on-the-books economy.

Gasoline is an energy source since it takes something like the energy in one quart of old gasoline to produce and deliver a gallon of new gasoline.

An energy carrier is any substance or process that has to be “filled” with old energy before it can be “emptied”. Examples include batteries, terrestrial hydrogen, or flywheels.

The filling and emptying process is always lossy. So, more initial energy input is always needed than you can ever hope to get back.

An energy carrier can not ever in any manner be called “nonpolluting”, since it assumes the characteristics of the original net energy sources. And then wastes a fraction of them.

An energy sink is any substance or process which consumes significantly more old energy than it is capable of delivering new. Corn ethanol under American Farm economy conditions is an energy sink because it takes the energy in three gallons of gasoline to produce one new gallon of ethanol. Ethanol today is neither renewable or sustainable.

Photovoltaic Solar is still an energy sink because not one net watt hour of pv solar energy has ever gotten generated. While the latest of panels sometimes are able to return more than their energy used to build them, they cannot yet amortize most fully burdened total solar systems.

**energy density**— If energy delivery is to get evaluated or compared, you will need a measurement scheme.

Two obvious questions to ask are “how much does it weigh?” and “How much room does it take up?” Answers to either of these can be a measure of energy density.

A gravimetric energy density unit that makes for the easiest comparison would seem to be in Watt hours per kilogram or Wh/Kg.

A volumetric energy density unit is Watt hours per liter or Wh/l.

Figure one shows us approximate energy densities for a few popular energy sources, carriers, and sinks.

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### Some Energy Density Comparisons

<table>
<thead>
<tr>
<th>Source</th>
<th>Gravimetric (Wh/Kg)</th>
<th>Volumetric (Wh/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>13,500</td>
<td>9000</td>
</tr>
<tr>
<td>LNG</td>
<td>12,100</td>
<td>7216</td>
</tr>
<tr>
<td>Propane</td>
<td>13,900</td>
<td>6600</td>
</tr>
<tr>
<td>Ethanol</td>
<td>7,850</td>
<td>6100</td>
</tr>
<tr>
<td>Liquid H2</td>
<td>39,000</td>
<td>2600</td>
</tr>
<tr>
<td>Lithium</td>
<td>350</td>
<td>250</td>
</tr>
<tr>
<td>Flywheel</td>
<td>120</td>
<td>210</td>
</tr>
<tr>
<td>Liquid N2</td>
<td>55</td>
<td>65</td>
</tr>
<tr>
<td>Lead Acid</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td>Compr Air</td>
<td>34</td>
<td>17</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>39,000</td>
<td>2.7</td>
</tr>
</tbody>
</table>

---

Fig. 1 – SOME ENERGY DENSITY comparisons.
Gasoline is a useful standard for comparison at 9000 Wh/l and 13,000 Wh/Kg. The best of today’s batteries are only beginning to approach five percent of these values. While STP hydrogen ironically is both the “best” at 39,000 Wh/kg and the “worst” at an utterly pitiful 2.7 Wh/l.

Watt hours per liter do tend to be a lot more significant for earthbound apps, while Watt hours per kilogram become crucial for deep space.

See our Hydrogen library page.

thermodynamics—It is very easy to convert other energy forms into heat. But only a fraction of heat energy is normally convertible back into other forms of energy. The study of this raw deal is called thermodynamics.

Nearly every physical or biological system ends up thermodynamically limited in one way or another.

The three main thermo “laws” are (1) You can’t win. (2) You can’t break even, and (3) You can’t even get out of the game. No exceptions to these have ever been found.

Two key thermodynamic concepts are Carnot’s Law and reversibility.

Carnot’s Law places an inherent efficiency limit to conversion of heat to any other energy type. You always have to waste a lot of heat if you try to convert a little.

The highest possible efficiency you can have would be in a Carnot Cycle that gets limited by your temperature difference between input and output.

For instance, an auto engine will be about 35% efficient, while the best of utility power plants are approaching a 60% efficiency. Most low temp heat recovery schemes appear doomed to failure because of their unavoidably low efficiency limits.

A reversible process is one that produces zero low grade waste heat. Regardless of the direction in which it is run. Examples include adiabatic ones which neither add nor remove heat, or isothermal ones that occur at constant temperature.

Reversible processes are essential for energy efficiency. The bladeless Tesla Turbine is one example of a system that demands irreversibility to work at all. And is thus inherently inefficient.

All of those Peltier thermoelectric modules are also irreversible due to their ludicrous inefficiency.

More on thermodynamics can be found in HACK64.PDF.

engineering economics—There are many costs associated with an energy delivery system. The feedstock price is obviously a factor. But, more often than not, your true delivery costs are dominated by your delivery system price and its infrastructure, the time value of the money used to finance the delivery system, and all the labor you will need to service and maintain the delivery system.

Plus external costs such as health or environmental issues. Or future demcomp expenses. Further confused by any taxes or subsidies.

In the final analysis, it is only the totally burdened system level costs that really should matter.
We looked at this way on back in HACK86.PDF.

It is sometimes convenient to view "dollars" as being so many "gallons of gasoline". You do personally vote for this definition every time you make a withdrawal from the ATM pump at your nearby Texaco bank.

Those fully burdened costs of any energy system could get looked at as the diversion (or "waste") of gallons of gasoline from other uses.

Thus, today oil is at least six times more "free" than solar pv energy is. Especially when you include costs of storage batteries, fancy wiring, and synchronous inverters.

entropy and exergy—Entropy is a crucial thermodynamic property that tells us that, when left to their own devices, systems tend to go to hell in a handbasket. Or more precisely, will often increase their amount of chaos or disorder. Because of entropy, it is exceedingly unlikely that your pool balls will rerack or the dishes will end up washing themselves.

Not all kilowatt hours are equally useful. Exergy is one measure of the value of recoverable energy in any given form. Thus, electricity may be worth ten cents a kilowatt hour and gasoline only three. The reason being that it is easier and more efficient to convert electricity to other forms.

While conservation of energy tells us that energy can not normally get created or destroyed, the twin exergy and entropy factors guarantee that all energy degrades in time. Usually into irrecoverable low grade heat.

We recently looked into exergy in MUSE151.PDF.

energy efficiency—The efficiency of any system is the ratio of how much you get back compared to how much you put in. For all closed systems, the efficiency will always end up being less than 1.0 or 100 percent.

But it is real easy to make big time mistakes when measuring efficiency. For instance, there could be multiple energy inputs. Such as electricity and heat in any heat pump. Or hydrogen electrolysis that can be exothermic, endothermic, or thermoneutral.

Efficiency measurements may also conveniently forget that much of the life cycle costs are in the labor and equipment amortization.

Efficiency measurements must not ignore exergy. Hydrogen electrolysis manages to convert ten cent kilowatt hours into kilowatt hours worth only a fraction of a cent.

Electrolysis energy from on-grid electricity makes zero economic or thermodynamic sense.

It is often enormously difficult to measure power in a nonlinear system with strange waveforms. Especially if any mechanical or low delta-T heat energy is involved.

Virtually all typical low budget power measurements are flat out wrong! The usual problems are not appreciating the difference between average and rms measurements. Or not understanding crest factors. Or realizing how nasty low delta-T heat
% VISUAL BASIC .ASP MULTI-SLOT BANNER ROTATOR
% ==============================================================
% Copyright c 2001 by Don Lancaster & Synergetics, Box 809, Thatcher, AZ, 85552
% (928) 428-4073 Email: don@tinaja.com Website: http://www.tinaja.com
% Consulting services available per http://www.tinaja.com/info01.html
% All commercial rights and all electronic media rights fully reserved.
% Linking welcome. Reposting expressly forbidden. Version 1.6
% These Visual Basic code fragments show you how to have multiple banners appear
% in several slots on a web page, autotamalating without any repeats. Each end
% user sees a new banner grouping every time they reload or refresh. One easily
% changed master data base handles dozens or hundreds of individual web pages.
% You can Click Here for a demo. Use your refresh repeated.
% First, create a data base file of banner advertiser info having array strings for url,
% text, and image. Such as This Example Typical entries might be...
% 
% blink(3) = "http://www.thirdadvt.com"
% bimg(3) = "thirdadvt.gif"
% balt(3) = "Third Advertiser Text Blurb."
% This textfile gets stored at a reachable place on the ISP's site. Next, create a
% typical .HTML page renamed as a .ASP file, using default Visual Basic. Near the
% beginning of the body, add...
% 
% <%k = (Instr(pattern, "a"))%>
% x = a(j) a(j) = a(i) a(i) = x Next
% pattern = a(0) & a(1) & a(2) & a(3) & a(4) & a(5) & a(6) & a(7) & a(8)  %>
% This code defines eight letters in an array. It then loads the banner data. It
% then creates an eight character string having the eight letters randomly shuffled.
% Later on your page, you create a banner image location in the usual way, most
% often as a table entry that includes this code...
% 
% for i = 1 to 8
%   img src="http://www.tinaja.com/banners/"alt='<%=balt(kk)%>'
% endfor
% This says to find the numeric position of letter "a" in the string. The image url for
% blink(position) is combined with the src and alt text for the desired url.
% You repeat the process with <%=kk = (Instr(pattern, "b"))%> for the second banner
% slot, continuing as needed to complete the page.
% More examples in BOUNCY.PDF. Some ASP Booksare found here.
% For InfoPack consulting: don@tinaja.com

Fig. 4 – VISUAL BASIC .ASP CODE for a custom banner rotator.

Measurements can get. Only recently have low cost chips gotten developed for accurate power measurement.

Some of the perils and pitfalls that are involved are in MUSE112.PDF, in MUSE113.PDF, MUSE125.PDF, or others in our Tech Musings library.

Home Power is a useful but overly optimistic resource for energy info. Also see our It's a Gas library page or our custom InfoPack services.

N-Connectedness

Sometimes one math concept can end up with many uses. One example might be called the N-connectedness problem. Which asks us: "How many different paths are possible between n different objects?

Figure two gives an example where we see the 66 possible paths between 12 objects. Play with several values of n for a while, and you’ll see that the generalized formula is \((n^2 + n)/2\). Or \((n)(n+1)/2\). The connections start off slow, but end up building nearly at the square of n.

String art anyone?

One use would be in peer-to-peer networks. But n-connectedness also explains why adding surprisingly few people to a group may dramatically change the dynamics and create lots of new problems.

It might be interesting to build a real time n-connectedness map of a website where the thickness of your connections revealed the popularity of each page access and the color the from-to direction. Revealing all of your site strengths and weaknesses. We may save this for later.

Those Microchip Technology folks have developed a unique elegantly simple use for n-connectedness. One that involves...

Interfacing LED Displays

How many light bulbs does it take to change a microcomputer port? If you are building something using a moving massage ad display, or just want to use lots of LED’s, this can get to be a very real question.

A typical micro port line has three states: A high impedance for inputs, a logic low output, or a logic high output. A LED will only light when a current limited voltage of just over two volts is applied.

Note that two or more series LED’s will not light if they are in parallel with a single lit LED. Because their combined thresholds are too high. Note also that a LED will withstand five volts of reverse voltage. Thus, a LED will not light when it is reverse biased or if its voltage is too low.

Figure three shows us a unique n-connectedness setup that lets you control an amazing 56 LED’s from a single 8-bit port. Any particular LED is lit when one terminal is set to logic zero and the other to logic one. All other port lines are made inputs.

Yes, there’s all sorts of sneak paths of two or more lamps. But, as we’ve just seen, they can not light because of the combined thresholds or the reversed polarities.

To light several LED’s at once, you have your software scan the needed outputs at a rapid rate. The bulbs will get dimmer as their duty cycle drops. External tri-state drivers can be added for more brightness. Note that only one LED can be lit at a time, or sneak paths will result.

Also note that you get two LED’s per path, one for each direction.

Certain LED’s will actually be more efficient at higher current levels. Four times the current for one fourth the voltage is applied.

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Shuffling without replacement says that once you’ve used a number, it gets removed from your pool of future available numbers. Such as one card dealt from a deck.

It turns out there is a subtle flaw in the “obvious” shuffling algorithm of “exchange each card at random with itself or any other”.

Consider three cards. There could only be six shuffling outcomes (ABC, ACB, BAC, BCA, CBA), but there are twenty-seven possible results of any of three cards swapped with itself or the two others.

It is not possible to arrange 27 whole objects into 6 equal sized piles. Which says that some of your outcomes will be more likely than the others. This bias does become quite small as \( n \) increases, but it still is an obvious no-no for a true shuffle.

Instead, use this algorithm...

**To shuffle \( n \) items, replace all items with themselves or any other item lower in the deck, chosen at random.**

By swapping only equal or lower cards, you eliminate the favoritism and end up giving equal odds to all outcomes.

The details vary with your choice of language and device. Basically you start a countdown loop that picks a random number equal or less than your current card.

Since few languages include a swap command, you copy the swapper to a temp location, move the swappee to your original swapper location, and finally move temp into swappee.

A Visual Basic example is shown as part of upcoming figure four.

**Banner Ad Rotation**

How can you make unique images show up in different places on a web page? Such that each and every user views a different display every time they return or refresh?

The trick is to go to .ASP or Active Server Pages that might let your ISP dynamically generate new pages “on the fly” when and as needed.

I have recently covered some .ASP tricks in **BOUNCY.PDF** and have got a handy list of .ASP titles on our [Apple Assembly Cookbook](http://www.microp.com)

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An .ASP file usually includes both HTML code and scripts. When called, __synergics__ says that once you’ve used a number, it gets removed from your pool of future available numbers. Such as one card dealt from a deck.

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Tech Musings

the .ASP file dynamically generates a final delivered web page by following the script commands.

I wanted some features that were different than a stock banner rotator could deliver. I wanted to have eight slots per page which would fill with different ad banners. With no repeats and fresh delivery each time. And with one data file that automatically updated hundreds of site pages. Figure four shows some details. You can view a demo on our Guru’s Lair home page just by hitting your refresh button several times.

Basically (literally since I used VB), you set up an abcdedfgh string. You then randomly shuffle this string to build a new string with all the letters rearranged. Such as hbfecgdag. We then find out what position ad “a” is supposed to be in, and then put it there. The process repeats for ads “b” thru “h” autorotating all of the ads into appropriate slots.

Note that .ASP pages have to be tested “live”, because only your ISP normally has the code to use them to generate the desired output. The file delivered to your end user is not the original .ASP file! A simple “View Source” won’t hack it.

More on banner possibilities are in BANNYEAR.PDF and adv01.asp.

Thermodynamics Books

I have gathered some of the better thermodynamics titles together for you as this month’s book reference. These also can be picked up on our Book Access page. A reminder that you can support the Guru's Lair at no cost to yourself by buying all of your books through this link.

My favorite popular thermo book remains Sandforth’s Heat Engines. See if you can’t find it as the ancient Doubleday Science Series paperback.

New Tech Lit

From ISD, a nice CD ROM on their line of speech recording chips. Free snap dome switch samples are offered by Snaptron, while micro cut quality woods are sold by the folks at Midwest Products.

A few assorted web links: Access to Ulrichts Periodicals Dictionary is now at last online. Superb coverage of older Tektronix oscilloscopes is clickable at the Tektronix Resource Site. One of the site webmasters is Stan Griffiths, who is the author of Oscilloscopes: Restoring a Classic.

Some Heathkit schematics are up at Circuit Archive, and a linked list of major newspapers is at Inkpot. This Free Energy Fraud forum traffic seems light. And is mostly the same old same old from the usual suspects. A key problem with manic pursuit of anything is that you may become what you attack. Finally, the NREL has posted a rather well done Hydrogen Energy Economics paper.

Trade journals for this month include Steve Hansen’s labor-of-love Bell Jar on homebrew high vacuum. Plus e-drive on electric vehicles, and binding finishing & distribution and Print-on-Demand business.

A reminder that many outstanding Surplus Bargains can be found here, and are offered on eBay as well.

For all the fundamentals of active filter circuits, do be sure to check out my Active Filter Cookbook. Find it at www.tinaja.com/amlink01.asp.

And a final reminder about our cash-and-carry InfoPack consulting at www.tinaja.com/info01.asp.

Let’s hear from you. There are lots of new possibilities here.

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