SZÉKELY ENGINEERING
EXPLANATIONS & EXAMPLES

Of Geothermal Energy - Part II

Is it only me, or do any of you remember reading or being told that the earth's crust is so thin compared to its overall size that it's like the skin of an orange? Well, actually, with the crust averaging (to be generous) 11 miles thick, comparing it to the nearly 8,000 mile diameter of the earth is more like comparing an eggshell's 0.3 millimeter thickness to an egg's 60 millimeter or so major axis, with the eggshell proportionally about twice as thick as the earth's crust.

If you take the time to read the Wikipedia article attached to the first hyperlink in this piece, you'll find that temperature can increase as much as a degree Fahrenheit for every 66 feet of depth or so, reaching a peak of between 390 and 750 degrees Fahrenheit at the point where the crust interfaces with the plastic mantle below. Note that I said "can increase", not "will increase". The 11 mile thick average spoken of above is based upon the weighted average between sea and land crust thickness mentioned in the Wikipedia article, and with the crust thickness on land being between 20 and 30 miles thick, heating because of close contact with the mantle is not the norm on land.

It's why springs are usually cold rather than hot, and is why geothermal energy is (so far) cost-effective only in certain areas like Iceland, Northern Italy, California, and the like, where the volcanoes which trace the outline of the ring of fire are within spitting distance of tectonic plate boundaries. Having said all that, if temperature did in fact increase uniformly with depth without regard to where one was drilling in an attempt to recover geothermal energy, just how deep would one have to go to recover useful heat?

Well, let's see . . .

With average underground temperature below the frost line being in the neighborhood of 50°F, and heating system hot water having to be 140°F for a radiant floor or 190°F for baseboard fintube, you'd have to go down about 1 to 1.9 miles respectively to get to the necessary temperature. This is well beyond the capabilities of commercial water well drilling equipment, and, in the case of the latter, even exceeds the average depth of commercial oil and gas wells.

And the point to all of this has been ???

As implied, but not explicitly stated, in the last issue, making heat with electricity via a heat pump is not cost effective except in areas where the cost of electricity is about a third of the cost of the fossil fuel (oil or gas) which would yield the same amount of heat.

That is, the coefficient of performance of a heat pump in winter in NYC is down around 3 or so, which means that it costs about the same (about a dollar per 50,000 BTU per hour) for a furnace or boiler at $2.80 a gallon for fuel-oil as it does for a heat pump using electricity at 20¢ a kilowatt-hour. With the reality that electricity here in town has been more like 30¢ per kilowatt hour of late, a heat pump has to have a wintertime coefficient of performance closer to 4 or 5 than to 3 for it to be competitive with an oil-fired heating plant.

As of this writing, in this neck of the woods, natural gas is even less expensive (and cleaner) than oil. Propane is about as clean as natural gas and has a higher energy content, but costs more.

To get back to where we started from, the appeal of real geothermal energy is that no fuel is burned, not even that used to make the electricity consumed by a heat pump.

The one thing to keep in mind, however, vis-à-vis both true geothermal energy and heat pumps, is that both require pumps to move water through loops buried in the earth, or to and from aquifers in the case of open circuit Geo Exchange systems. In the case of a conventional air-cooled heat pump or air conditioner, the fan which moves air over the condenser coil requires less horsepower than would the pump which moves water over a liquid cooled condenser coil, owing to the differences in density and viscosity between liquids and gases.

Life, Energy, and Civilization.

The late Isaac Asimov, the science-fiction writer who started life as a PhD Biochemist and may be better known by the general public for his screenplay for the film *Fantastic Voyage*, also wrote a plethora of hard science books for the layman, among which is *Life and Energy*, an explication of the extraction of chemical energy by biological processes such as digestion and photosynthesis.

Understanding any complex entity or system requires understanding the fundamentals from which the complexity is constructed, and this leads me to the reason for the reference to Dr. Asimov's book.

We live in a world so far removed from that of only a century or two ago that we use locutions like "energy conservation" without really having internalized what energy is and where it comes from.

You may recall from your days in high school that there are different forms of energy, of which, chemical energy is the form which is locked into every fuel source other than nuclear. You may also recall something called the Law of Conservation of Energy, more properly the Law of Conservation of Matter-Energy, which is that matter and energy can neither be created nor destroyed by ordinary [non-nuclear] means.

What all this means is than when you burn wood, fuel-oil, gasoline, kerosene, ethanol, or anything else, the heat applied when you lit the fuel started an exothermic chemical reaction, one which releases more heat energy than is necessary to keep the reaction going. *Endo*thermic chemical reactions on the other hand, such as occur in the cooking of food, require that heat energy be continuously applied to keep the reaction going. It's what allows steaks to be cooked from rare to well-done.

That is, burning of fuel is a "chain reaction" much like a nuclear reaction. The difference is that the masses of the combustion products of the former, because of the Law of Conservation Matter-Energy, add up exactly to the mass of the fuel that was burned along with that of the oxygen in the air which combined with it in the process of burning. In the case of a nuclear reaction, some of the mass seems to disappear.

So what's up with all this???

When chemical elements are combined into compounds there is energy locked into the chemical bond holding the compounds together. This energy is released when the bonds are broken and, in exothermic chemical reactions, additional energy is released when elements form new bonds with other elements in the process of burning.

Nuclear energy is a whole other thing. To put it into the simplistic terms in vogue early in the last century (3 subatomic particles rather than the current posited 24), there is a ton of binding energy in the nucleus of an atom keeping all the positive charges within glued together and that energy is released when the nucleus is split via a nuclear fission reaction. Nuclear fusion, which is what goes on in stars, is what gets those positive charges to stick together in the first place.

The masses of the component particles in a fission reaction, as well as the product particle in a fusion reaction, don't quite add up to those of their source particles, and it's why the law is referred to as the Law of Conservation of Matter-Energy. Einstein showed us the two (matter and energy) are different manifestations of the same thing.

So where does all this energy come from?

Locally, it's from the sun, but generally it's from all the stars in the universe, and when the last one goes out, it's over.

There is such a ridiculously large amount of energy liberated in nuclear reactions that this isn't likely to happen in any time frame we can wrap our brains around, but it will happen. Having said that, if you could convert all the matter in an airline ticket to energy, it'd be enough for the airplane to stay in the air continuously (as in 24/7) for 148 days. Current technology only converts a fraction of a percent of nuclear fuel to energy, but even at that nuclear plants need to refuel only every few years – and then there are the French and breeder reactors.

The point of all of this is that so long as the sun shines we *can't* run out of energy, and on a geological time scale, even petroleum is a renewable resource.

Civilization started with fire and agriculture. We should try to avoid going backwards.