

Let's Talk About a Realistic Energy Policy

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by Karl Denninger

This is a particularly insightful article on the use of LFTR technology. Karl restates what many of us have known for years. In my view, we need to do away with the dual/parallel technologies of nuclear weapons vs. nuclear power plants and start using nuclear energy that is clean, safe and available in abundance. - DeltaDude wsrl.org

Ok, if you've listened to Pickens and the Ratigan show, you know that they seem to think that we can fix things with natural gas and perhaps with some renewables.

That will never work. Nor will drilling here - we can replace some of our demand, but not all of it. Further, the amount of oil we have is finite.

Indeed, all of the various energy resources are finite. Even The Sun is finite. It will eventually run out of fuel and "die." It just won't happen for a very, very long time.

We have about ten years of natural gas supplies in proven reserves at *present* rates of consumption. But "growth" is a nasty thing; it's a compound function, and I discuss this often - compound functions cause trouble, and usually quickly.

Pickens wants to move trucks (at minimum) to natural gas. Nice sentiment. But he's talking his book and pushing something that, if we double our consumption - and if we replaced gasoline and diesel we would - the "solution" would only last five years, make him filthy rich, and still leave us screwed.

There has to be a better way. We need a solution that will last at least fifty years.

What if I told you that there is one?

It's coal.

But not how you think of coal.

We think of coal as going into a power plant that makes electricity. But that's wasteful, believe it or not.

Here's the math on gasoline, diesel and coal.

1 lb of gasoline contains about 2.2×10^7 Joules of energy.

1 lb of coal contains about 1.6×10^7 Joules of energy.

These are reasonably-comparable; another way to look at this is that you need about 137% of coal (in pounds) as you do in gasoline for the same energy content.

We currently consume [378 million gallons of gasoline](#) a day. At 6lbs/gallon (approximately) this is 2,268 million pounds. Reduced to short tons (2,000 lbs) this is 1.134 million short tons of gasoline/day, or 414 million short tons a year. Converted to coal, this is 579 short tons.

[The most-current value I can find for distillate \(diesel fuel\) is 3.794 million barrels a day.](#) At 42 gallons to the barrel, this is 159 million gallons of diesel fuel. Diesel contains about 20% more BTUs per gallon than gasoline, but is about 17% heavier at 7lbs/gallon, so if we convert simply based on weight we get close. So we have 1,113 million pounds of diesel daily; reduced to short tons that's 0.557 million short tons of diesel daily, or 203 million short tons a year. Converted to coal, this is 284 million short tons.

Add these two and we get 863 million short tons a year of coal equivalent.

Why is this important?

[Because according to the EIA](#), again, we consume about 1,073 million short tons of coal a year, virtually all of it being burned to produce electrical power.

How much coal do we have? [According to the EIA](#) the total reserve base - the reasonable commercially recoverable coal, is about 489 billion short tons. That's roughly **four hundred years** worth of supply at

current rates of use. If we assume our population will grow at about 1% a year and per-capita energy use remains roughly constant, we should have enough coal to last at least 200 years.

Now stay with me a minute.

Remember, we consume less than that amount in coal-equivalent between both gasoline and diesel.

Consider this: There is 13 times as much energy in coal in the form of Thorium as there is available by burning the coal, and right now we literally throw it away in the ash pile!

What is *Thorium*? It's a *fertile* material. That means that when struck by a neutron in a reactor it *transmutes* via a nuclear process to an element that is capable of *fission*. Note that Thorium itself is not fissionable - that is, it will not (directly) split and release energy. Instead it captures thermal neutrons and turns into Uranium-233. U-233 is *fissile*.

There is a type of nuclear reactor that utilizes this fuel cycle. Instead of the traditional nuclear reactor which uses water as a *moderator* and coolant (either a boiling or pressurized water reactor) these reactors use a liquid salt. In the vernacular they're called "LFTR"s, pronounced "Lifter."

You've probably never heard of them. But they're not pie in the sky dreams. *Our nation ran one for nearly four years* in the 1960s at the Oak Ridge National Laboratory. It was scrapped in favor of the traditional uranium fuel cycle we use today *because the fuel it produces is very difficult to exploit for nuclear weapons, and it breeds fuel at a slow rate*. The natural process of the nuclear reactions in the core of such a unit produces a byproduct that is a very strong gamma emitter that is difficult to separate from the other reaction products. For this reason - and because we wanted both nuclear power and nuclear weapons - we built the infrastructure for uranium and plutonium rather than thorium.

Thorium-based reactors have several significant advantages and a few disadvantages. We have much less experience with LFTRs than traditional nuclear power, simply because we stopped working with them for political and war-fighting reasons. They use a fluoride salt which is quite reactive when in contact with water, but the reactivity is a bonus in all other respects, because it tends to encapsulate the reaction products (the nasty fission products that you don't want in the environment) through that same chemical process. It runs at a much higher temperature (typically 650C) than a traditional reactor and unlike a traditional reactor the fuel and the working fluid is the same - there are no fuel rods that can melt and release their nasty fission product elements, as the fuel is dispersed in the coolant.

Finally, the unit is intrinsically safe. It does not require high pressure; the working fluid and coolant is a liquid at ordinary atmospheric pressure. This gets rid of the need for high-pressure pumps, pipes and similar materials. Without the moderator the reactivity is insufficient to sustain a chain reaction, and the moderator is in the reactor vessel itself through which the fuel/coolant is pumped, so criticality is impossible outside of the reactor vessel and inside the vessel the fuel and coolant are the same, and a liquid. The working fluid is contained in the reactor loop by an actively-cooled plug. If power is lost cooling ceases and the plug melts; the working fluid then drains into tanks by gravity under the reactor and cools into a solid, as it cannot maintain criticality outside of the reactor itself (there's no moderator in the tank or the plumbing.) As the fuel is in the fluid, there is no core to melt as occurred in Japan and being dispersed over a much larger area the working fluid naturally cools from liquid to solid without forced pumping and cooling. *This safety feature was regularly tested in the unit at Oak Ridge - they literally turned off the power on the weekends and simply went home!*

There are some downsides. The working fluid requires special metals made out of Hastelloy. But these are no longer particularly-special materials, being used in other chemical plants where highly-corrosive material is commonly handled. They are expensive, but then again so are traditional reactor pressure vessels which require high-pressure integrity and thus special welding and inspection techniques.

Why did I just spend all this time talking about LFTRs?

Let's remember two facts from up above:

- There is 13 times as much energy in coal in the form of Thorium as there is available by burning the coal.

and

- We use 863 million short tons a year of coal equivalent in gasoline and diesel fuel which is less than the amount of coal we burn now.

One final piece of information: The Germans figured out how to turn coal into synfuel - gasoline and diesel - before WWII. This process, called *Fischer-Tropsch*, requires energy to drive it and is currently in commercial use in some places that have a lot of coal but little or no oil, such as South Africa. Malaysia also has an operating plant. Typical operating temperatures for this process are in the neighborhood of ~350C.

This light bulb should be coming on about now. *We can replace our gasoline and diesel consumption, plus replace the coal-fired plant electrical generation, and have lots of energy left over - all while completely eliminating the requirement for foreign petroleum from anyone!*

Now let's put the pieces together.

We'll start with the same amount of coal we burn today.

We have the fuel energy in the coal, and we have 13x that much energy which we are going to extract from it in the form of the thorium naturally contained in the coal.

Let us assume we consume twice the fuel content of the coal extracting the thorium. We have 11x the original energy left (once in combustion of the coal, and 10x in thorium energy content.)

We will then use the *Fischer-Tropsch* process to turn the coal into synfuel - gasoline and diesel. We will be rather piggish about efficiency (that is, presume we're not efficient at all) and assume we put in twice as much energy as the coal contains in fuel content converting it. Since the process heat from the reactor is of higher quality (higher temperature) than the Fischer-Tropsch reaction requires by a good margin, we can do so directly without first converting to electricity (which would introduce more losses.)

We now have all of our gasoline and diesel fuel, and we also have 8x the original BTU content of the coal left in thorium energy content.

We will then use the remainder to generate electricity.

So what we do we have out of this?

A nuclear and physical technology that:

- **Replaces all of our gasoline and diesel fuel requirements.** This ends our foreign oil imports. It also allows us to remove all foreign military activity related to securing that foreign oil. It is essentially a lock that we can drop \$200 billion a year off our military budget this way, and it's not unreasonable to expect that we might be able to cut the DOD in half. Over 20 years this is at least \$4 trillion in budget savings, and might be as much as double that. Those funds should do nicely to build the plants involved.
- **Continues to use liquid hydrocarbons for light and moderate transport needs.** Sorry folks, there's nothing better. I wish there was too. There isn't. Some day there might be, but that day is not today. The problems with the alternatives are all found in thermodynamics as a consequence of energy density and those are laws, not suggestions. The energy and money required to produce a plug-in vehicle or hybrid is, for most users, *greater* than the incremental cost of the fuel over the entire lifetime of the car. Hybrid and all-electric vehicles make no sense unless you have no rational way to produce the liquid hydrocarbons. We do have the ability using the above.
- **Reduces our carbon emissions by the amount of the former oil imports that were burned.** We still burn the gasoline and diesel, but that's in the form of the converted coal. Since we're only using half the hydrocarbons we used before between coal and oil, our CO2 emissions go down by the amount of the formerly-burned petroleum. I'm not an adherent of the global warming religion but if

you are you have to love this plan for that reason alone.

- **Provides us dramatically more electrical power than we have now, and more-efficiently on a thermal-cycle basis.** Conventional nuclear power uses Rankine-cycle turbines. This is one reason why they need access to large amounts of water. Due to the higher temperature of operation these reactors can run combined-cycle generating turbines, which makes practical siting them in places where they are air-cooled yet they can still achieve reasonable thermal efficiency.
- **Is sustainable for two full centuries, even assuming our historical 1% population growth rate and no decrease in per-capita energy use.** Within 200 years we should be able to get fusion figured out. 200 years is a long time for technology to advance. This much is absolutely certain: *There is no other option that is reasonably feasible with today's technology and which has an exhaustion horizon of more than 100 years available at the present time, allowing for our historical population growth and no dramatic reductions in per-capita energy consumption.*
- **Is not subject to the same constraints and risks that exist for today's reactors, even though this has nuclear power at its core.** The accident in Japan, for example, cannot occur with these units because they do not require active cooling after being shut down to remain safe. The working fluid also tends to bind any reaction products, which inhibits the spread of any material if there is a pipe break or other release into the environment.
- **Produces much less high-level nuclear waste than conventional reactors.** Most waste is burned up in the reactor via continual reprocessing on-site. The final waste product produced is a tiny fraction in volume of that from conventional plants. It is not zero to be sure, but these units present a much-smaller waste profile than do traditional uranium/plutonium cycle nuclear plants.

The biggest disadvantage is that we've only built one of these reactors, at Oak Ridge, and then we stopped because a decision was made to pursue "conventional" plants due to their dual-use capability. But the challenges presented by LFTR technology are known, and the ability to build and operate such a plant is not "pie in the sky"; we've performed all of the necessary technical parts of assembling this alternative individually and ran one of these reactors for four years.

Are their engineering challenges in this path? Yes. Is it "free energy"? No.

Can this be made to work given what we know now, at a reasonably-competitive price? YES.

If you're going to propose something else then show me the math. If you can't, then get on board, because this is the bus that will work.

Incidentally, China and India appear to have figured this out as well; I'm not the only one with a brain.

We had better lead on this or we're going to get trampled.