Farm Grown Fuel

I have driven a lot of different kinds of tractors in my time. We had an old butane tractor growing up. The fuel lines on that one were leaky. Often as not, they would catch fire. The fires weren't big, but the tractor had a large pressurized tank that sat right over the engine. I always wondered if that thing might go off like an atom bomb some day.

The main workhorse on our farm was a Ford diesel. They taught me how to drive it when I was too young to reach the clutch or shift gears properly. My father would put the tractor in gear standing on the running board. He would put me in the seat, let up on the clutch, and then jump off. I would drive the tractor around in circles for hours in the hay field without changing gears or stopping. Then I would shut it down and climb off.

They taught me how to cultivate later on. That involves driving carefully through the crops with a cultivator behind the tractor that tills up the soil right close to the standing rows of seedlings. If you get it right, you can wipe out the weeds, and push a little shuffle of dirt right up next to the seedlings and cover the weeds there. Ideally, you can wipe out the weeds and leave nothing but rows of crops standing. It all rarely works like that.

I have a vested interest in good cultivation. As a youth, my peers were out watching movies and going about and socializing while I was working in the fields. The better the cultivation job, the less work there was to do. Even with a lot of very nasty herbicide, it seems our farm was often weedy. There we many, many days when the space above my knee and the tops of my feet got sunburned from sitting on a tractor all day long. To this day, I dream of cultivators cutting down those weeds and leaving pristine rows of crops behind.

It took me many years to realize that my father was not a good farmer, even though our family had been farming in that area for more than two and a half centuries. He was too distracted it seems. In my adult life I have tried to improve upon those old lessons. LEF is an organic farm, which means we use no herbicides, which means doing a good job of cultivating is much more important. We are niche farmers growing seeds in many, many small patches. The rear cultivation rigs I grew up with are drastically inferior to "under belly" cultivators that run right under the tractor. Now we have swapped down to an under belly one row system, and it's a dream come true for an organic small farmer. Even in wicked rainy years, even though we have many, many types of crops to contend with, the one row under belly allows for very precise weed control. There is something particularly satisfying about fulfilling childhood dreams.

The experiment at LEF is not necessarily to innovate new methods of farming or new energy systems. We are happy to use the tools others have created, if possible. Our role, so we have thought, is to see how the pieces might fit together in a post-industrial society. Can we produce enough energy on the farm to (mostly) grow our own food, plus export enough salable products to support ourselves? On a residential level, our energy systems have worked far beyond our expectations. Daylight drive electric motors cover all of out needs for stationary mechanical power. Growing fuel to feed mobile farm machinery has been more challenging.

I first heard about running an engine on woodchips when I was a teenager. I was fascinated by the idea. I tried hard to research it, but I couldn't find much. That was before the rise of the internet. Going over the list of technologies we would need to run Living Energy Farm (LEF), woodgas was on the list. As an adult, far more information is available.

The first gasifier I built was the infamous "FEMA Gasifier." I say infamous because it's nearly impossible to get clean gas out of a FEMA Gasifier (Federal Emergency Management Agency). That gasifier was intended to be an emergency design that farmers or other people could build in the event that the energy supply was disrupted. I managed to make some smoky gas that would almost run a small engine. The results were not impressive.

When we started LEF, we had (and still have) an old, reliable Ford tractor named Eyore. It was born before I was, and has never been rebuilt. But it starts and runs quite reliably. We got a gasifier kit, and payed way too much for it. It was a complex kit, but in retrospect, had some serious design flaws. (It came from GEK in Berkeley, which is a moot point now anyway because all they are making are very expensive systems.) It took quite a while to put it together. We had a skilled technical intern on the farm at that point, and he was helping out. We built a solid steel frame and mounted the gasifier on the front of the tractor. I had spoken carefully with the supplier. They had assured me the gasifier would handle the 35 horsepower engine on the tractor.

It was a momentous day when we finally fired up the gasifier, and tried to run the tractor with it. We warmed up the engine on the tractor, starting on gasoline. We fired up the gasifier using a blower that draws air through it to get the fire inside up to temperature. And then we turned off the gasoline. In a moment the tractor engine started to sputter. I adjusted the air valves controlling the flow of air and woodgas going into the engine. And then the sputtering stopped. The engine just purred right along, running on nothing but woodchips! What a day that was. To imagine something as a teenager, and then realize the goal decades later is a fine feeling.

I got on the tractor and tried to drive it around. It took a few minutes to get used to adjusting the valves, but then it worked fine. I drove all over the farm, and showed everybody I could find. We went through that routine a few times over the next few weeks. Then came time for the big test. An engine idling or driving about at low speed is not using nearly as much fuel as an engine pulling a load. I put the bush hog (mower) behind the tractor, fired up the woodgas, and took it out to the field. Driving to the field was fine, but once I engaged the bush hog and pulled the throttle open, the engine would run for a bit, then cut out. Clearly it was starving for fuel. I went through that cycle again, and it was clear the gasifier was getting quite hot. After 15 minutes or so, the gasifier was smoking hot, the tractor was not running well on woodgas at all. I switched it back to gasoline, and drove back to the shed.

After it all cooled down, we opened it up, and the damage was extensive. The inner core of the gasifier was melted. A wood gasifier has to be sized to match the engine that is going to run from it. The assertion that the gasifier would handle our 35 horsepower tractor was wrong. The gasifier also had stainless steel sheet at the hottest part of the gasifier. Stainless is great for being corrosion resistant, but it is generally not the best for running at high heat or dissipating heat. That was a sad, sad feeling looking down into the gasifier and seeing lumps of melted and mangled metal.

We rebuilt the gasifier, and made another sturdy steel rack to mount it on a smaller tractor named Lucy. That took some time. Lucy had an 18 horsepower engine, so in theory she was better suited to the gasifier. Eyore is old and very worn, but also a trusted and reliable partner in farm work. Lucy was a bit younger, also very worn, and not so reliable. Lucy didn't like woodgas much. She would run it, but complain the whole time. For some reason, I never could get the air flow to balance out and stabilize through any filter, and running with no filter is just not a good idea.

In spite of my teenage fascination with woodgas, I had to admit this wasn't being easy. And to make woodgas, you have to cut down trees. The biggest historical use of woodgas was in WWII, particularly in Europe. But there was also rapid deforestation, particularly in France, during the war. We have looked at other options.

Why not use draft animals? They eat grass, and reproduce themselves, right? We have experimented with that on a small scale at LEF. We had a couple of oxen on the farm for a while. But we could not take the time to train them properly. And some cattle are better at going through fencing than others. We finally had to concede that we did not have the time to manage them properly. Draft animals are a fundamentally decentralized technology. Draft animals can have a relation with humans that is not highly abusive, though that is certainly variable. The big problem with draft animals is that they eat every day. Small tractors sit for many months at a time, eating nothing, though they certainly require more big-world infrastructure to make parts and what not. The bottom line is that there is no

way we can feed all the world's populations with draft animal agriculture. Some of the world's poorest farmers still use oxen. Perhaps they have their role in other places, but not on our farm.

Biodiesel and ethanol have gotten a lot of attention, and government support. But these fuels put rich people's machines in direct competition with poor people's stomachs. Using food as fuel is just a bad idea from a social justice perspective. A more fundamental issue is that of the grade of energy. Starch to make ethanol and vegetable oil are both high-grade energy sources. It is always better to use lower grade energy sources when possible. Speaking as a largely self-sufficient farmer, producing bulk starch and vegetable oil on a scale to fuel engines would not be easy on a sustainable basis, if it is even possible. Industrial biodiesel and ethanol are bulk commodities produced in a centralized industrial manner. A post industrial world powered on biodiesel and ethanol would favor political centralization and abuse.

A few years before we started LEF, I was talking to a friend of mine. He is an old-school machinist of the highest caliber, the same one who introduced us to nickel iron batteries. My description of him when I talk to friends is that he knows more about old machines than God. I am not sure if that's literally true, never having discussed the issue directly with the latter party, but my machinist friend he has been a huge help to me and LEF. I asked him one day to tell me how many different ways he could imagine to run a small tractor. I had no idea what I had just stepped into. There was steam this, distillate that, "tractor fuel" which was neither gas nor diesel. The conversation went on far longer than I anticipated. One intriguing option was pine sap.

On the farm on which I was raised, all the old southern longleaf pines had "cat faces" on them, big wide scrape marks left over from sap collecting. They scrape the bark off the tree from an area maybe a foot wide and 5 feet tall. They put a pan at the bottom and collect the sap that runs down. It's a practice dating back many centuries. The old term "naval stores" refers to the products made from tree sap that were critical to keeping the old wooden ships sealed and seaworthy. One of those products is turpentine. You heat up the sap and condense the vapor, and that is turpentine. Turns out turpentine burns in a very similar fashion to kerosene. A lot of engines made before WWII were made to run on kerosene and "distillate" fuel, and they should work fine on turpentine, so said my machinist friend.

The stately old pines I played under for my entire youth seemed to keep growing and thriving in spite of the "cat face" scrapes. Since that time, I have researched the matter enough to know that some form of pine, and indeed other resinous trees, grow in every ecosystem on the Earth outside of the most severe deserts or arctic regions.

The whole question of what constitutes a sustainable level of mechanization is a complex one. Answering that question at the societal level is completely undermined by the fact that the U.S. is a society of mechanically ill-informed people. That is a big part of the reason that so many of our "environmental" projects are getting misdirected. People just don't know how our current systems work, much less how much more efficient systems might work. We are left at the mercy of corporate profit.

The industrial agricultural system is in trouble in a lot of ways. What replaces that system is a complex question. Certainly, growing food is a revolutionary act, particularly at this point in our history. The simplistic answer is that the closer our methods are to older, more "natural" methods, then the better. Growing food at the level at which one can handle the process with simple hand tools is noble, but some more technology is going to have to be involved.

The simplest answer is not always the best. I have some friends who live without electricity at all. I applaud their providing a counterpoint to modern technological foolishness. They use candles. Many poor people in the world use kerosene for lighting, but that is smoky, a fire hazard, and a petroleum product. The simple answer for people living at low population densities is not the best answer for millions and billions of people. Small number of people can hunt wild game, use products straight from the forest, and use bees wax candles. When I look at large numbers of people wanting and needing lighting for long periods of time, I think the lowest environmental footprint is achieved with

small nickel iron battery sets dedicated specifically to lighting and electronics, as we have discussed here.

What's truly sustainable as regards global food production? Certainly, there are as many localized answers as there are farmers. That said, it's cleat that the massive, industrial food systems we have now are not sustainable, or ethical. Draft animals might be useful in some times and places. But we need something beyond that as well. Of course, the overwhelming problem at the moment is that very few people are convinced of the need to simplify our lifestyles at all, much less to the degree that is almost certainly required. It's truly a tragedy on a monumental scale. If we downscaled thoughtfully, in living and farming, we could improve the quality of our lives in the process. Sadly, it seems all but inevitable that we are going to hit the wall hard and then try to figure it out.

The term that comes to mind as regards supporting large numbers of people is "intermediate industrialism." For farming, we need small-scale machinery that can support us more effectively and efficiently than either massive diesel machines, hand methods, or draft animals. On a larger scale, that would look like well-insulated buildings, many more people involved in food production, people living near where they need to work so they do not drive, durable tools like nickel iron batteries for lighting, and small farm machinery.

I really love the small farming setup we have at LEF. It's efficient, and downright fun -- well, sometimes anyway. Just like with housing, by far the most important part is making sure the systems are well designed rather than just trying to throw "renewable" energy at traditional, energy consumptive systems.

To reduce fuel consumption and simplify our equipment at LEF, we have downsized our machinery. We are getting rid of rotary mowers and replacing them with sickle bar mowers that are more efficient. No-till could use a lot less fuel, if we can achieve an effective way to manage those methods. Not all farming can be no-till though. And at the end of the day, we still need some fuel.

Most everyone has heard of Honda motorcycles. Honda is a Japanese name, the name of a man in Japan after WWII who wanted to build motorcycles. He didn't have enough gasoline, so the first generation of Honda motorcycles was supplemented with turpentine fuel.

We fired up our first turpentine tractor recently. It was dramatically easier than woodgas. We filmed the first run. I started the engine on our little underbelly tractor, and warmed it up running gasoline. Then I turned off the gas valve and turned on the turpentine. After a couple of minutes, we could smell the piney smell, and the engine just purred along as pretty as you please. It cut out once when I tried to drive it. But then when it was fully warmed up, I took it out to the field moved some dirt around. The performance was flawless. Very nice. The limitation was that this was store-bought turpentine. It's quite expensive, and of no environmental benefit coming from industrial sources. We are going to be tapping some pine trees, and see how the whole scaling issue works out. If we are careful to reduce our fuel needs, how much turpentine will we need, and how hard will it be to produce? Is this a technology that could be uses in many places around the world? At this point, we are looking for answers.

Another approach we are going to try is simply heating the pine resin right on the tractor using the exhaust heat from the tractor to gasify it. We have not tried that yet, so there's not need to speculate too much right now.

Any farm-grown fuel is likely to have lower octane, and a slower burn time. That cannot be changed. Older engines turn slower than modern ones. Slower engine speed is better suited to the slower burn time of low-octane fuels. Older engines can also tolerate much more variability of fuel mix, though perhaps with some sacrifice in efficiency. Older engines also have lower compression. That is useful as turpentine may have a tendency to pre-ignite in higher compression engines.

One of the limitations of any farm-grown fuel is startup. Gasoline vaporizes very easily, even at cold (or at least very cool) temperatures. That makes it easy to use gasoline to start an engine. Turpentine, woodgas, or gasified tree resin will only run on an engine that is pre-heated. We are already

producing biogas. The big lesson so far in producing biogas is that the digester must be kept warm in winter. We are creating a larger, better insulated biogas digester. Our plan has been to use biogas as a start-up fuel for woodgas, turpentine, or gasified resin.

In recent months, our ability to produce biogas has improved considerably. Recognizing the importance of keeping the digester very warm and feeding it regularly, we are optimistic our new, larger digester will produce quite a bit more gas. Using biogas as a starter fuel for a turpentine tractor means creating the infrastructure to produce both biogas and turpentine. During the summer when we need fuel for the farm is also our best season for producing biogas. The temperatures are warmer and we have a lot more plant material from our seed crops.

Our current plan is to try to use the biogas as a tractor fuel, and possibly forgo the turpentine. We would have to filter the biogas to deal with the hydrogen sulfide that's in biogas. The sulfide is corrosive. We could use a DC compressor to pressurize gas into propane tanks. We would likely have a largish pressurized storage tank, and then use the propane bottles designed for propane forklifts on a small tractor. Natural gas carburetors are easy to come by, and cheap. A lot of people, and industries, run stationary engines from piped natural gas. (There are also some city buses and other large vehicles running on "CNG," compressed natural gas. That equipment is higher pressure and more expensive than our equipment will be.)

The prospect of having one piece of infrastructure – a biogas digester – that serves to create both cooking fuel and tractor fuel seems quite appealing. Biogas would also have the advantage of working fine in modern, high-compression engines. (Turpentine needs older, lower compression engines.) The big problem will be seeing if we can handle the corrosive elements in the biogas, and compress it enough using simple equipment to be a reasonable fuel for small tractors. If we can manage our farm in such a way as to minimize fuel needs, the whole prospect of farm grown fuel becomes a much more manageable proposition.

Turpentine, gasified tree resin, and biogas are speculative engine fuels for us at this point. If we can find a farm-grown fuel source that works well, it would be a decentralized, community accessible energy source. Collecting tree resin is a fundamentally de-centralized process, and so is small scale biogas. We will have to see how these fuels work mechanically, how they scale, and how much work it is to put all the pieces together.

I know a lot of people might say that we should plan to use fossil fuel, but less of it. There is a monstrous problem hidden in our energy system that few people consider. The first successful commercial oil well Pennsylvania in the mid 1800s was 70 feet deep. Though oil prices are very low right now, that does not change the fact that all the oil that is left is very deep. The decline curve of oil production will come, and it will be slow at first. But at some point, we may loose the technical capacity to reach oil many thousands of feet deep, on land or under the ocean. There will with certainty be a precipitous drop in oil production, though pollution and climate change may make their presence known in a more dramatic way before that time comes. My point is not to predict the future, but rather to point out that having easily accessible fuel sources that truly are environmentally benign, if we can find such a thing, is highly desirable, even if those sources are quite modest. A little goes a long way on farm. We cannot count on the coming changes happening slowly.

I have no illusion about producing biofuels on a scale to support people commuting to work in private cars. That will end by the will of the laws of physics. But supporting modestly scaled machinery on a self-sufficient farm seems a more attainable goal.

With any machine, lubrication is a problem. We have been pleased to realize (yet another pearl of wisdom from my machinist friend) that castor oil works as engine oil. Thus a post-industrial economy could grow its own lubricants. We have not done that at LEF, but castor oil remains a product grown on a large scale in other countries. It has been moved to the other side of the world because the castor beans are quite toxic. Castor oil is widely used as a lubricant.

We could imagine some idealized vision of "re-wilding" and living more simply like our ancestors. That would only work if billions of people die. Even from the perspective of valuing wild nature, a human die-off is nothing to wish for. Apart from the unimaginable horror such a set of events would represent, it would almost certainly mean the destruction of most of what is left of the wild lands and animals still living on Earth. We desperately need to scale down gracefully. The intelligent use of machines is an absolutely critical part of that soft landing. Re-wilding, candles and gardens are romantic, and that they should be. Industrial "renewable" energy is doing more harm than good, mostly because it is allowing us to ignore the addictive and destructive nature of modern consumerism. The intermediate road of using appropriately scaled tools to support a transition to a sustainable world is the wise path. One day, one community will make DC motors. Another will grow castor oil. Another will make solar hot water panels. They will all grow food. It's a better life than the one we have now.

The older generation -- my generation -- will never embrace that vision. I argue with them, but I know it is futile. They speak in panicked tones about climate change, but they are not going to give up their industrial energy systems, "renewable" or otherwise, no matter how massive or obvious a pile of information accumulates to show the error of their ways. Conservatives are not the only ones who deny science. Many people will speak in panicked terms about climate change and extinction while they continue to bolster their privilege, and when you march in the street, they will put themselves at the front of the parade and declare their solidarity. Their goal is to draw you into their ideology that supports aggregated energy systems, centralized production, and the value of the current housing stock. Yes, the planet is being sacrificed to support the resale value of current housing. You do not need to dwell on feeling indignant about that. We need a better answer.

We have to build the future. If you want to engage in direct political activism, then that's a good thing, not a bad thing, always. The shape of our future will be determined by the shape of our economy and its relation to the Earth in the years to come. You are empowered to build a better world yourself.