Cooking With Renewable Energy

Food is essential for life, but storing and preparing food comes at a price. American kitchens use more energy than American farms, and American refrigerators use more energy than the tractors on American farms. In thinking about starting an energy self-sufficient community, I created a mental list of technologies that I felt like I understood, at least to a minimal degree. At the time (long before we discovered daylight drive and nickel iron batteries), I thought of conventional off-grid electricity as being very limited. I figured we would use candles for light in the dark of winter if we had to, and carry water if need be. None of that came to pass. Woodgas for the tractors? Maybe. For cooking? Solar and biogas. Simple solar cookers work well, but only in good sunny weather. And you have to go outdoors to the cooker to tend your food, which complicates cooking. I had a basic understanding of biogas, so I thought we would use that. (Biogas is the same thing as methane is the same thing as natural gas.)

We built some simple solar cookers from the beginning. We have a small parabolic cooker that we still use. It looks like a small satellite dish covered in tin foil. It sunny weather, it's faster than a solar oven. We built a big solar oven didn't work well. We have a commercially manufactured one now that works well, but only in good weather.

A rocket stove is a small cookstove that uses small wood, burned at high temperature so that it burns clean and hot. We built a few rocket stoves. Some worked better than others. We finally purchased a commercially made rocket stove, and golly it worked better than the homemade ones! Imagine that. To this day, we still use the rocket stoves some. But they are too smoky to use inside, so some years ago, we purchased a used cookstove. It was an indoor cookstove, like the old-fashioned ones that lots and lots of people used to use, and some still do. They look like an ordinary stove, with a cooktop, an oven, and in many cases and built-in water heater. The one we found was old, but in decent shape. It cost us hundreds of dollars of our hard-earned farming money.

Our goal is to run our farm with farm-grown fuel, using the simplest, most durable technologies available. That said, traditional farms are built over generations, and we were working with rough land. We had a tractor with a front loader at that time. The cook stove was a heavy piece of metal. I chained it up to the front loader, lifted it, and moved the tractor forward, crawling slow as an ant, toward where it needed to go. I was being as careful as I possibly could. In retrospect, I should have had someone spotting me, someone walking ahead and directing. There was a bucket, a plain plastic bucket, sitting on the ground in front of me, and I didn't see it. As I crawled along, ever so slowly, ever so super-carefully, the bucket got pinned under the cook stove as I moved forward. And then with no explanation at all, the cookstove kind of wobbled, turned itself loose from the chains, and came down with a heartbreaking crash. I sat there on the tractor, rather stunned. I went to look at it, and saw the bucket. I looked at the intricate cast iron cooktop, cracked in more places than I could count. The stove itself was warped and buckled. Bad day.

We scraped up all the pieces. They hung around for months while tried to figure out how to put it all back together. I finally had to concede that it would be a tremendous amount of work, and the final result would be leaky and flimsy. We bit the bullet and got another used one. This time, I had more people helping, and we put it in place. We still use it some. It is our indoor cooking source in bad weather when we have no sun and not enough biogas. It is inefficient and polluting, but we hope to be finished with it soon. If our DC Microgrid has exceeded our expectations, good renewable cooking technologies have been far more challenging.

Our first biogas digester was made of a few plastic, 55 gallon drums. We set it up. It worked, but we only got enough gas to cook one meal every 10 days or so. The gas would not burn through a regular gas stove. It had too much carbon dioxide and other gases in it presumably. I made a burner that worked well enough.

Seeing the low output of the biogas digester, and noticing the fantastic performance of both our solar hot water and electric systems, we decided to try to build a high-temperature solar storage system.

That has been done on an industrial scale many times. There are various ways it's done. The more elaborate systems use computer controlled mirrors focusing light onto a central point. Simpler systems use rows and rows of parabolic troughs to focus heat onto collector tubes. Mineral oil has been used to transfer the heat from the collector tubes to central storage tanks. The problem with mineral oil is that it can burn, and has. One large project went up in a huge ball of flame in California a few decades ago. When I first started working on the project, there were a couple of "heat transfer fluids" on the market, some of them simply modified mineral oil, some of them more esoteric chemicals. All of the various "heat transfer fluids" are on the market are expensive. The number of such fluids grew rapidly in a few years.

We spent about 7 years and an unfortunate amount of money (in our modest economy) trying to build a community scale high temperature solar collection and storage system. We used mineral oil as a heat transfer fluid. We tried parabolic troughs and a parabolic dish. I imagine with a better engineering budget, or some engineering budget, something better than our meager results would be possible. It just didn't work well at all for us. The nail in the coffin came a couple years ago. It's probably because of climate change, but in the last 10 years the concept of "normal weather" has all but ceased to exist. As farmers, the weather has a big impact on our lives. We went through 8 months with only a few days of actual, full sun. People need to eat several times a day. You can't wait for months for lunch! Mechanically, it is challenging to concentrate sunshine to create very high temperatures and move that heated material to a storage tank. It takes more sophisticated equipment than we have.

A year ago, we decided to return to biogas. We got a kit, and set it up. It's about 6 times as large as the drums we used in the early days. We put a solar heating coil under it, and insulated it well. It has been making good gas, but not enough for our whole community for full time use. We have learned some important lessons.

If you live in an area where it gets cold in winter, keeping a community-scale biogas system warm enough is challenging in winter. That's been our biggest lesson. Another big lesson is that biogas is like having a flock of animals to take care of. You cannot ignore animals, and you cannot ignore your "archaea," that's the living organisms in the digester that make gas. Or to say that differently, you can ignore them for a while, and they will kind of go dormant. You can restart your digester after it has not been fed for a while, but you have to restart slowly, feeding at a moderate rate, or else you will get lots of carbon dioxide instead of biogas. Another interesting thing to know is that are different kinds of archaea, and some of them can tolerate quite high temperatures. I put a solar heating coil under ours. At that time, I was worried I could overheat it, so I put the coil under the digester where the heat transfer would be gradual. That is not optimal.

We are now building our third generation biogas digester. The solar heating coil is going to be inside the tank where the heat transfer will be much, much more efficient. The trick is you can run it quite hot (over 150 F!), but temperature changes should occur very slowly. In our case, we are putting in a much larger (2000 gallon) plastic tank, and wrapping two layers of straw bales around it, and then putting the solar heating coil in there. (Plastic tanks are pretty cheap.) In our new system, the size of the heating panel is very small related to the tank, so the temperature should be warm, but it should not change quickly because of the thermal mass. That's the plan anyway.

The biggest surprise in our quest to cook using renewable energy has been daylight drive solar electric cooking. We mentioned that previously, so we need not explain it again here. It works great. We are hoping that the combination of an improved biogas digester and solar daylight drive will work together to get us off of firewood finally. We are still using our second biogas digester while we build the third. In summer, with daylight drive electric cooking and more biogas (because of warmer temperatures), we can go days at a time without needing any firewood. Figuring out a good cooking system has been quite a quest.

The biogas system once again demonstrates the divine marriage of renewable energy and community-scale systems. Trying to run a biogas digester on a single family basis would not work. The

time it takes to manage a flow of inputs to keep the digester fed, as well as managing effluent output, would overwhelm a single homesteader who has many other chores to attend to. A community scale system is ideal. Biogas can also be done on an industrial scale. There are many industrial biogas facilities in the U.S. There are a couple of problems with industrial biogas. First, it takes us back to that disconnection between energy use and production as we have now with fossil fuel, thus encouraging poor design and waste. Second, centralized waste production is a bad idea. The effluent coming off of a biogas digest is great fertilizer, but it really should be near where it is going to be used on an agricultural basis. The economics of transporting waste over long distances just doesn't work out. The wastewater treatment systems used by urban areas in the U.S. right now consume truly massive amounts of energy. They also use massive amounts of chlorine. That is not something we can continue to do in the long term. Biogas systems integrated into agricultural economies makes a lot more sense.

Resources:
The best book for giving you an overall sense of how community scale biogas works is *The Chinese Biogas Manual.* It is available for download from numerous sites on the web, including https://www.tngun.com/wp-content/uploads/A-Chinese-Biogas-Manual.pdf
Another excellent document is *Biogas Plants* by Ludwig Sasse, available here https://www.build-a-biogas-plant.com/PDF/BiogasPlants_Sasse.pdf
The most accessible pre-manufactured unit is from https://www.homebiogas.com/
The unit is simply two sturdy plastic bags, ones for the digester, one for gas storage. The kit has no insulation whatsoever, and is thus made for very warm climates. The design is good, except the input for human wastes is poorly placed, being right next to the effluent pipe. The accessories are great. The biogas burner is excellent, and the low-flush toilet is also very good. Overall, using a large plastic tank and the accessories from Home Biogas is what we would recommend.