Biomass Gasification:

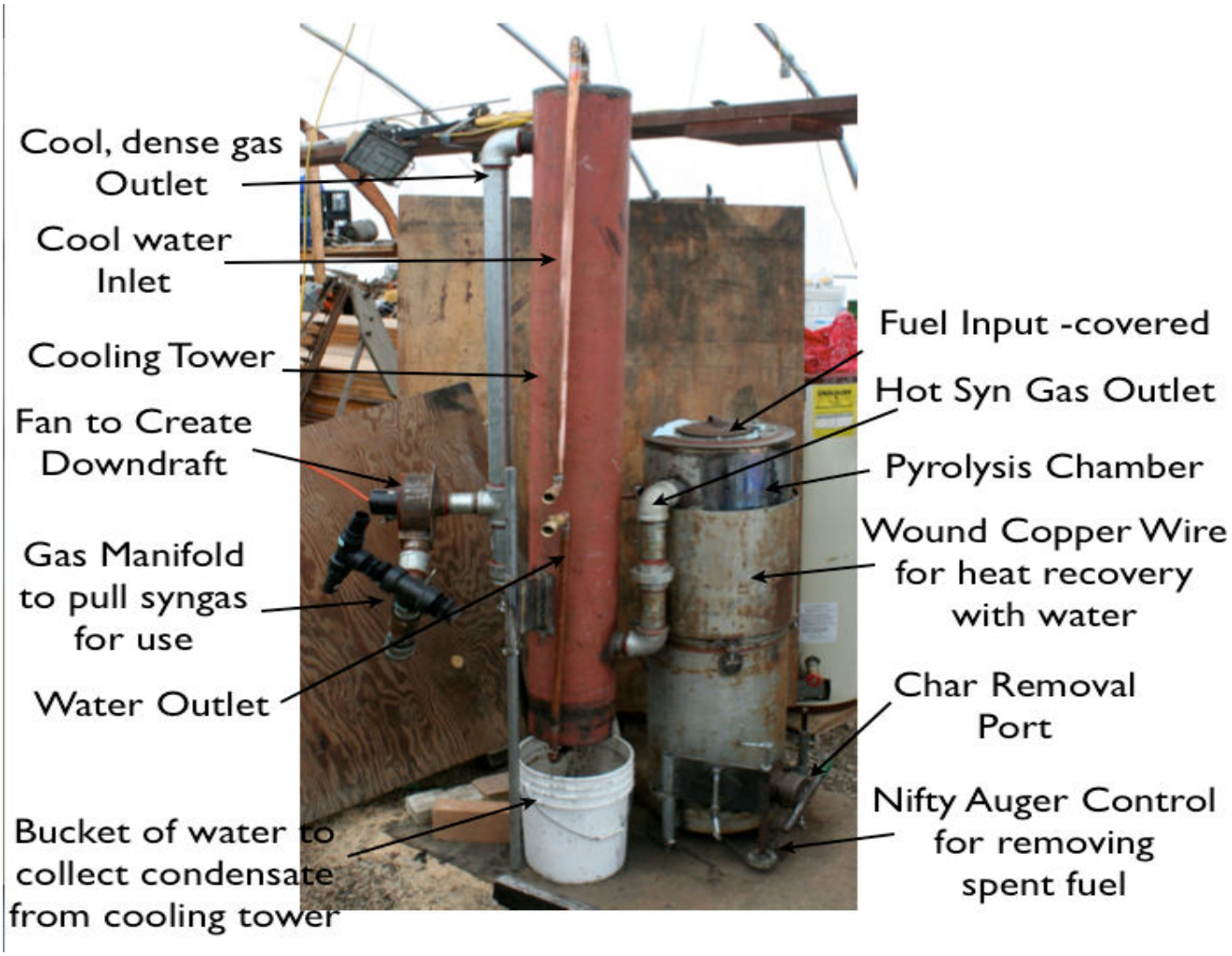
...you can heat and **power** your home... with ***WOOD.***

By Robert Frost

A year or so ago I learned about the technique of biomass gasification while talking over a beer or two with some sustainable farming friends and other contrarians. From that day on, I can honestly say that the way that I view sustainable living in semi rural areas has never been the same. I'll let you all in on one of the best-kept secrets of the century - all the talk about "Green Biofuels" is missing a key player. Its not just about corn vs. cellulosic ethanol - you can run internal combustion engines with wood just as easily!

The technology is amazingly simple –over a million engines ran on this simple technology in Europe during WWII after the blockade cut off oil supplies to Germany. It involves taking the waste gases inherent in the combustion of wood or biomass, and further processing them to allow the powering of all manner of heat engines - by harnessing hydrogen and other combustible gases from a process know as 'gasification'.

This article will not get into the "How-To's" of gasification or too deeply into the physics of it (check the resources at the end for further study). Furthermore, I am not a scientist or engineer, I'm just a concerned guy living in Suburbia who happens to know a lot of cool people that like to weld. What this article WILL get into is why I am convinced that gasification is a paradigm shifting technology that allows us to begin to envision not only a carbon neutral future, but also one that is powered by carbon *negative* technologies.



We should start with a high level description of how wood chips & pellets can power an Internal Combustion Engine (ICE). When organic carbon burns (the wood chips in this case) hot and clean in a gasifier, you create water vapor and carbon dioxide, (don't try this with treated lumber!) -and you also get a bunch of heat. Gasification takes these three byproducts (heat, water vapor & CO2) of combustion and uses them to fuel a second reaction by concentrating the heat onto a bed of charcoal. These coals reach 1600+ degrees in the gasifier, which is hot enough to break the water vapor (H2O) into hydrogen, and the CO2 into carbon monoxide (CO) in a reaction permitted by the consuming heat created in the combustion process. Both of these gases, H and CO (syn-gas) are combustible, which is great because if they weren't this whole process would be a flop. A cooling tower then cools the syn-gas (a cooler gas being more dense) to less than 100 degrees, and also filters out any ash, water vapor or tar. The resulting syn-gas is 20% Hydrogen, 20% Carbon Monoxide, and roughly 60% Nitrogen which is merely a background gas. When under 100 degrees or so, this mixture is roughly 118 Octane and will run an I.C.E. with a modified carburetor that will deliver a roughly 1:1 air/fuel mix. Check the Gen Gas site and our Videos describe the process in much more detail.

The model in our videos is sized to run a 30hp engine, which should be enough to power a 15kw generator on about 10 to 20 pounds of pellets per hour (will vary by engine and wood pellet type). By collecting the waste heat from the internal combustion engine, the gasifier itself, and the cooling tower you also have a significant source of usable heat for any number of purposes from home heating to aquaculture.

So, with the intro done, I'd like to simply explain more about why I think gasifiers rock:

Accessible Biomass gasification, in its current state, is open source and grassroots. Most of the people cobbling together gasifiers are normal Joe's and Jane's: backyard tinkerers. We and hundreds of others have put thousands of dollars and hundreds of hours into our units - and we will email you all the info you care to read. Using the FEMA plans (located in the Resource Page of my blog) normal people, using normal tools like welders and saber saws and normal items like steel drums and pipe, can make a fully functioning wood chip gasifier just like we did in a few days of work. No CAD designs, no high tech fibers imported from China, just good old grime-under-the-nails tinkering. The plans are free, the parts are usually salvaged, and the skills are not hard to come by. What I find exciting about it is that you and I can make our *own* energy at home for little money. Plus, if you build it yourself, you can fix it yourself should it break. And, since you built it, sourcing parts is no problem. The alternative is that manufacturing small home gasification units from salvaged parts can become a nice little cottage business for the entrepreneurial tinkerer to provide clean, low cost renewable energy to their communities.

Heat and Power Gasification makes both electricity and heat in one unit, simultaneously. I guess to be entirely honest, the gasifer makes heat and syn-gas, and our Co-Gen system uses the syn-gas to power a gas generator. Most energy systems today do one or the other. You can heat your home very well with a wood burner or masonry stove, but you still need to power the lights and computers with something else. PV and Wind produce electricity and are getting slicker by the year, but do not provide heat. Both are still very expensive and difficult to build at home. More importantly, neither is a very workable option in Wisconsin where our winters are cloudy and cold and our wind resources are spotty. Also, making hot water from a PV unit is insanely expensive, and while dumping excess wind energy into a hot water tank has been done, it is not nearly as efficient as using the waste heat from the gasification process to heat a home. Since heat will always be available whenever we are using the unit, it means we can design heating with waste heat into the home energy system as a main component, not just something to use as an extra should we have a surplus of wind. Another way to think of it is that if we need heat we get electricity as a by-product (damn!) or if we need electricity we have extra heat on hand. I like that a lot. Finally, the emissions from burning the syn-gas in an ICE, results in a reversion of the H and CO back to water vapor and CO2, both very clean combustion gasses.

The next two features are my favorites though.

Fuel. While we have yet to run the math on how many tons of wood a gasifier will need to power a home for a year (which will depend greatly on size and efficiency of the home of course), it looks to be a favorable equation. A lot of the concern about heating with biomass is that there simply isn't enough wood to do it. That is especially true with cordwood burners that need slow growing hardwoods to reach their claimed efficiencies. But the gasifier runs well on many biomass sources, including chipped softwoods. This opens up a lot of fuel source possibilities since you do not need a large trunk diameter.

In Europe, where biomass energy is more common, many countries practice Short Rotation Coppice (SRC) management of their productive forests to maximize their yields. Most managed woodlands in the upper mid-west are pine for its pulp--taking 20-30 years to reach harvest size. But in a SRC system, fast growing deciduous softwoods are grown rather than coniferous trees allowing harvest to take place in as little as 3 years with some hybrid willows and poplar. This allows a significant increase in tonnage/year -as high as 20,000 lbs. annually on an acre of willow. Many types of softwood like Maple, Box Elder, Poplar, Aspen, etc will re-grow from their stumps after their trunks are harvested. This means that the root structure is in place after harvest and no replanting is needed. Because the full root system is there, the re-growth is very vigorous, as anyone trying to cut down a Box Elder knows! This means that once your acreage needs are known it is possible to set up a rotational stand of trees where one section is cut every year--you cut the first section, then move to the second the next year while the first re-sprouts. If you designed your plot right, by the time you get to the end of your plot, the first row has re-grown to a sufficient thickness that you can start over--now *that* is sustainable forestry! Entire industries could be rebuilt on sustainably grown wood chips as a fuel source rather than corn, or on a smaller scale, willow could be incorporated into the windbreaks of a CSA farm to allow the production of energy in addition to food.

Bio-Char. The main "waste" product from gasification is charcoal. For every pound of chips you put in, you get about .5 pounds of charcoal out the bottom. Importantly, this charcoal, has a plethora of uses: it can filter water, it can be used as a secondary fuel source (it cooks veggie brats nicely!), or it can be used to create *Terra Preta* or Bio-Char.

Terra Preta is so amazing I can only begin to explain it here. *Terra Preta* enables soils to lock its fertility in for *millennia* as the charcoal prevents leaching. Carbon molecules are hugely attractive to most water-soluble nutrients. This means that dissolved nutrients in the soil, which are normally washed away in a strong rain can be "locked" up in the Bio Char. These nutrients hang out on the carbon molecules until a plant's feeder root or a merry little symbiotic fungus ambles over and breaks a bit free using some mild acids.

The plant then uses that nutrient to grow, and eventually dies or sheds its leaves, returning the nutrients to the soil via the decomposers. This is not new, except instead of that unused nutrient washing away and breaking the cycle, it becomes reattached to the carbon to begin the cycle again. This is HUGELY exciting for us sustainable farmers! This step in the process closes the energy cycle -replacing the removed wood with Bio Char ensures the sustainable fertility of the soil for future generations.

Also, since the carbon in the wood was captured from the atmosphere by green plants, and since the gasifier consumes less that 50% of the carbon in the wood, (the greater percentage remaining sequestered as charcoal), the process is truly carbon negative. Charcoal is very stable in living soils -*Terra Preta* discovered in the Amazon is over a thousand years old! This means that if we return the charcoal (Bio Char) to the soil, ***50% of the carbon input into a gasification system is sequestered for centuries*** ... And we begin to heal the atmosphere with every KW of energy we produce with these systems!

Possibilities Now you can hopefully feel some of the boundless excitement I do when I think of the possibilities of making electricity and heat sustainably with a rather simple machine that one can make locally from salvaged parts. So lets talk about those possibilities and applications. In 2008 we created a working gasifier based on plans from FEMA. We took that simple design and were able to power a small generator and make electricity. But we had no good way to capture waste heat and the syn-gas was a bit dirtier than we would have liked which fouled the engine. So we took our learnings from 2008 and designed a dedicated gasifier that is intended to recapture significant amounts of waste heat while producing high quality (clean and dense) syn-gas. Our current gasifier + Co-gen system is destined for the home of one of the designers where it will provide all the heat in his radiant floor heat system and electrify his small home while producing extra electricity in a grid tie system.

In the very near future we intend to build another unit intended to be the heart of a greenhouse/workshop. In this iteration, the gasifier will provide the power and heat for the production of biodiesel using a modified Appleseed Processor while boilers will also be set up to heat a 2000 gallon aquaculture system where we will raise fish in a system modeled after Will Allen's tilapia (or lake perch) tanks. The tanks are filtered by watercress and other bio-filtering plant beds (tomatoes, hyacinth, duckweed. Ethanol and methane production would also couple well with a gasifier's heat and electricity outputs. We estimate about $2000 in material to reproduce the Gen 2 unit, though our use of salvaged items cut that at least in half. At this cost, which is similar to that of a new furnace, the technology is attainable to a very large portion of America and makes it feasible for a truly vast array of applications.

So there you have it: Biomass gasifiers provide a do-it-yourself Co-Gen heat and energy system that allows the use of renewable, sustainably grown forestry products, while creating Bio Char in a carbon negative process that will allow you to farm sustainably for generations. This technology is not the science fiction of hydrogen, nor bears the fiscal expense associated with currently available sources of renewable heat and energy production. Gasification is here, now, and possible within the economic means of many Americans.

The challenges that we currently face are powerful and diverse. To overcome these challenges, we need to implement as many options as possible if we are to leave the future in the state I envision for our children. We can do this. Be the Change!

Interested in learning more? Check out the following resources for more information:

Videos of our Gasifier Project (our own video list - mostly our Gen 1 (FEMA) unit)

Gen Gas (info and where we got our plans)

Wood Gas (technical site with lots of info including stove plans)

Gasifier Plans and Resources (a collection of resources helpful to gasifier builders)