Make Charcoal. Don't burn it.

A Demonstration of Carbon Negative Energy

Distributed carbon negative energy sources will be important for Climate Security.

The goal of this experiment is to show how CO2, naturally removed from the atmosphere by photosynthesis to build biomass, can be harvested as a stable form of carbon by the pyrolysis of the biomass. Pyrolysis of biomass will also yield combustible gases for carbon negative energy. The resulting charcoal (biochar) can be put to a

myriad of useful applications, such as: animal feed, filtration, soil amendment etc.

The grass tablet biochar (pyrolytic carbon) shown above was made in an iCan TLUD with a variable speed blower. This charcoal was air quenched and is thus bone dry. When wet, it is very soft and can be formed to fit a variety of shapes. I have found, for example, that grass tablet biochar saturated with cold water is effective at reducing the pain of burns.

The following pages illustrate some of the ways the above biochar was made. Note: Grass biochar will be ashy as grass has considerably more ash content that wood.

Grass tablets broken into short sections prior to being loaded into the fuel chamber of the iCan reactor.

These tablets were made from field grass about 3 years ago in Shelburne, VT. Note that the longest fibers are about the length of the diameter of the tablet. Shorter is better.

These tablets are about 4 cm in diameter.

They were produced by a BHS Energy Slugger

http://bhsenergy.com/slugger.html

The primary air holes in the bottom of the reactor can. These holes were made with a 5/32s drill bit.

Note: The number and size of holes can be varied. For Natural Draft (ND) TLUDS, I often use a smaller hole size. Holes of this size will make for a very hot and fast process when used with dry wood pellets in a ND TLUD.

The three brackets used as feet are useful for ND applications. They are not required when a fan is used.

This is a view of the top of the reactor can. It shows the use of three two inch washers as deflectors. I prefer this design to ones that use a concentrator ring as it appears to develop more turbulence in the gases. Note the three vertical arms that help hold the draft can in place. The draft can will sit on top of the brackets used as anchors for the deflector washers.

Ignition of the grass tablets in the iCan has started. The draft can is in place, the secondary air gap is clearly shown. The unit is sitting on a grate just above a variable speed blower taken from a Pellergy pellet gun for residential furnaces.

I load the reactor to the top of the top indent on the side of the can. I shake the tablets to settle them to reduce air channels that will promote combustion of the grass. However, the tablets expand when heated and can easily block all primary air flow. This will end pyrolysis and produce clouds of smoke. A sufficiently strong blower/fan can overcome this problem and maintain the pyrolysis. Once the pyrolysis is fully established, the fan speed can be reduced or even turned off for periods.

Note the draft can in the photograph is 4.5 inches tall. In an earlier life it held 4 lbs of tuna fish.

A second view of the system just after ignition and before the outer shell has been added.

The draft can is a 4 lbs tuna fish can, The reactor can is a 3 lbs Costco coffee can. The Costco coffee cans have remarkably better steel than most other cans.

1. Gap is about 2 cm. This is only a first order approximation. Other sizes should be tested.

2. Fuel load was approximately 1 kg of grass tablets.

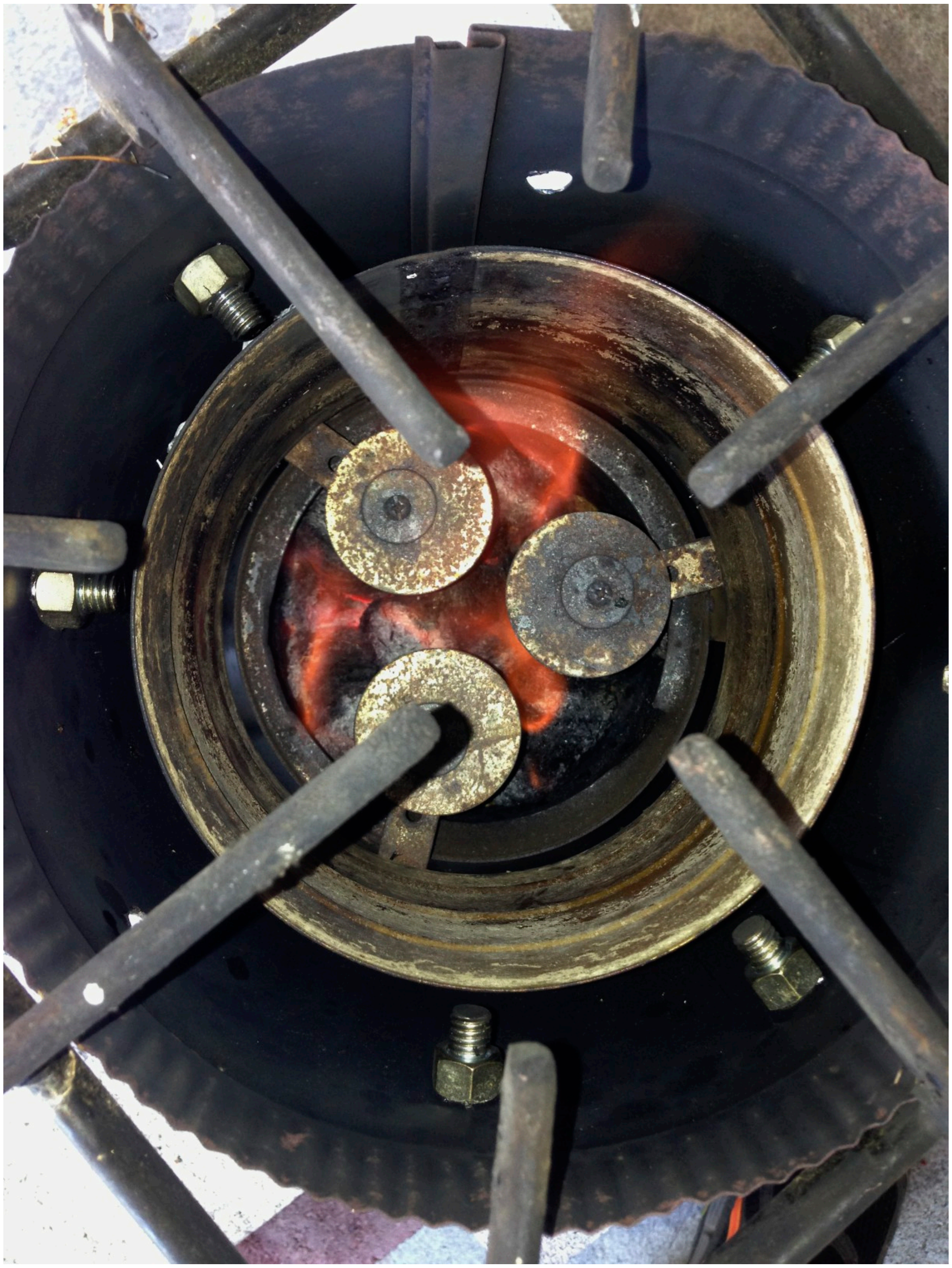
3. Charcoal yield is in the range of 17% - 19%

A view into the unit shortly after lighting the gelled alcohol starter. Some of the pink starter can be seen on the grass tablets.

Grass tablets soaked in rubbing alcohol could be used as starters as well. Of course paraffin soaked cardboard would also work etc. There are many ways to skin the ignition cat.

The system is now fully assembled with the outer shell of a section of 8” stove pipe and the grate to support pots and pans.

The outer shell collects air from the blower, pre-heats the air as it rises past the pyrolysis zone, and then guides it up to the secondary air slot. It also protects the secondary air slot from wind gusts. As a result, the unit works even in windy conditions.



A view down thru the grate into the burning gases. The temperature of the gases below the deflectors can be above 700 degrees C. The gases at the grate can be 300 - 400 degrees C. The temperature is some what dependent on blower speed. Too much air flow can cool things off. At the end of the run, I turn the blower off so as to not blow out the last of the burning gases.

Make charcoal, don't burn it.

a practical way to use the heat from burning pyrolysis gases

It is easy to make charcoal as you cook. I have not bought charcoal in years.

If an 8" hole is cut in the bottom of a Weber, this configuration can be used.

A 9" hole would allow the use of a stove pipe outer shell as shown above.

This shows a Weber charcoal starter, with the inner basket removed, used as the outer shell. In this configuration, a reactor can loaded with wood pellets could be used as a ND iCan with no fan required. It might also be useful to use a second coffee can for the draft can as this will extend deeper into the Weber kettle. This will reduce the cooling of the hot gases by extraneous outside air.

A fan or blower can be placed below the reactor can. If need be, the Weber can be raised up on bricks.

A view down through the hole in the bottom of the Weber kettle into an empty iCan system. In this case the draft can is the 4 lbs tuna fish can.

If you use wood pellets as your fuel, you will be cooking over burning wood gases for some delicate real wood flavoring. At the end, you will have some very nice charcoal for use in your gardens. If applied to flower beds in year one, there are clear “benefits” to be seen in year two - even in what passes for pretty good soil in Vermont.

Slow Cooking the Carbon Negative way

When the iCan is loaded with 1,400 grams of wood pellets, the run time in ND mode is about 85 minutes, or about 80 minutes of cooking time allowing for 5 minutes of start up.

The kettle, with the lid on, reaches temperatures in excess of 425 degrees F directly over the flames. This will vary some but within a reasonable range on the order of 25 degrees, except at the start and very end. The sections of the kettle cooking with indirect heat will reach temperatures in a range from bout 300 F to 375F. So both direct and indirect cooking is possible. The very clean exhaust exiting the kettle will reach 400F and a bit more at the exit point.

These temperatures allowed me to cook slices of zucchini using both direct and indirect heat. The direct heat is good for branding with grill marks and adding a nice golden glow to the zucchini slices.

Hot dogs were beautifully done at about 5 minutes per side using direct heat.

Half pound cheese and bacon pub burgers, pre formed at Marty's, typical grill fare, were fabulous. Nicely brown with dark grill marks yet, a perfect juicy medium in the center -- cooked all the way through. They were rated as better than the burgers at a high end foodie restaurant in Hardwick, VT.

The store made sausages and the steak will be fabulous. They will be grilled to perfection, and, because of the slow cooking over lower temperatures, as in a Big Green Egg, they will be moist and tender - not dried out. Unlike cooking with the Big Green Egg, a smoker, the food does not have a heavy smokey flavor. Rather it has a lovely and delicate true "wood" fire flavor.

"Slow" cooking times range from 10 minutes to about 20, give or take, depending on the nature of what is being cooked and the method of cooking.

If you want to take your grilling results to the next level, I recommend you try slow cooking the carbon negative way. The proof is in the eating.

At the end, when the iCan self extinguishes, the charcoal harvest will be on the order of 19% of the weight of the feedstock you loaded into the fuel chamber of the iCan. Mix it with compost, and, after a few weeks, add it to your gardens. Your soil will benefit greatly.

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Please consider all of the above merely as suggestions and departure points for further experimentation and, I am sure, improvements.

I look forward to seeing what others can do with these ideas.

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FAQs

1. The temperature sensor used is a hand held Omega unit, Model HH11A.

2. The audience for this draft is stovers interested in making grass biochar, cooks who are interested slow cooking the carbon negative way, and STEM educators.

3. Do you have any special relationship with the makers of the BHS Energy company?

I know the BHS folks but have no special relationship. I am not aware of current pricing for the Slugger. But the slugs are not free. I'd contact BHS for more economic data on slugging costs.

4. You used smaller holes for ND. Any theory there?

I use smaller holes for ND iCans because I generally use wood pellets for ND and they require a lot less primary air.

5. Can you give a reason for preferring washers over a concentrator ring?

The washers appear to give much better turbulence in the burning air/fuel mix. ESP. combined with a slot for secondary air. Worth trying. The general rule of thumbs it the more turbulence, the cleaner the combustion and the more complete [efficient]. The TDI diesel is an example of this. The visuals of the combustion process are interesting. Also the noise of the burning gases is quite loud - even "explosive".

6. The secondary air gap seems enormously large. How much have you tried varying this gap.

In this project, the gap shown is about 2 cm. I usually use a some what smaller gap, esp. with ND iCans. But, with the relatively larger primary air holes in this reactor, so much gas is produced when using my standard wood pellets that I wanted lots of secondary air. The gap is easily adjusted by raising or lowering the three brackets the draft can sits on. On only rare occasions, as in too much forced primary air, will flames exit out the secondary air gap. Other wise, the air flowing in tends to shape the flames and keep them away from the edges. This helps to keep the metal cool.

7. A big surprise was hearing of tablet expansion and air blockage. A holey briquette might solve that. Any estimate of the % change?

No estimate. Only that the darn things expand enough to choke out the pyrolysis and make a mess if you are not careful. If no fan/blower, then you have to use very few tablets in the reactor and lots of draft.

8. Any data possible on this fan or alternatives to this specific blower?

Sofasco Blowers. DC Blower, 24V. DB15458 Series. They're about $65 each.

http://www.sofasco.com/products/dc_blower/db15458.html

I have a three watt fan. I have not yet used it. I have free access to the beautiful variable speed blower used in this project. The power range is great and very useful. The 3 watt fan is intended to work with small batteries or a small PV setup.

9. It looks like it might be a little difficult to get briquettes into the reaction chamber because of the washers.

They are easily fed in by hand with little difficulty. Of course wood pellets are even easier to add. Or it is easy to unmount one of the washers, load the reactor, and then remount the washer.

10. What weight is the fuel load was used in this project?

About 1 kilogram of grass tablets was used. The charcoal yield was approximately 17% of the weight of the fuel load. Your mileage will vary as you change the various parameters in the system.

If wood pellets are loaded to the same height, about 1.4 kilograms of fuel can be placed in the reactor. That is, given approximately the same volume for fuel, it is possible to work with about 40% more fuel that has about 5% more BTUs per pound. The wood pellet form factor allows for much better packing of the fuel and provides a greater level of energy density in the reactor.

11. Does the flame "stick" anywhere? Everywhere on any circumference?

The flame is VERY dynamic with high turbulence and makes a good deal of noise. If anything, esp. with grass tablets, the gas production is not always even across the pyrolysis front and gas may only come up from a section of the fuel bed. In the end, tho, all of the grass is pyrolized.

12. How long for a typical run?

Running hot, the kilogram of grass tablets will provide useful heat for about 45 minutes. Your mileage will vary considerably as you vary the fan/blower speed etc. Please remember that this set up is only a first order approximation. I am sure it can be improved upon.

13. Any estimate on amount of gel, and how much applied each time? GACC testing has a limit (5%??). Any way to avoid a gel?

I do not use much gel. Many other starters, such as paraffin soaked cardboard ala Paul O., alcohol soaked grass tablets, etc. Gel is NOT required. I use it because it is fast and easy.

14. Are you recommending always using the added stove pipe? Takes a few seconds to add?

I always use an outer shell. It protects the secondary air gap from wind gusts, allows the secondary air to be pre-heated, protects the inner cans from being knocked over, etc. It adds an element of safety, which is very important. I use several devices as shells: a section of 8" stove pipe or a Weber charcoal starter. Or the unit could be put in an insulated housing with a door for easy access for swapping units in and out for run times as long as desired. Importantly, the outer shell makes the system just about impervious to stormy conditions.

15. The 300 C value sounds too low for good cooking. Might this be excess air? If so, why only late in a run?

The temperatures produced in simple TLUDs are non linear and vary quite a bit over time, esp. as the pyrolysis zone gets closer to the primary air source. It is possible that, in this particular model, there is too much secondary air that is cooling the hot gases. But you need enough secondary air to avoid soot which will cover the food not in a pot or pan in an unpleasant way.

I do a lot of cooking in my Big Green Egg at 300 degrees F. Slow cooking. Keeps the foods moist and avoids charred outsides with under cooked insides.

16. How do you extract the charcoal from the reactor at the end of the run?

I carefully and gently shake it out onto an large concave aluminum ash pan from an old Weber to get a visual on the results. But any pot with a large aperture will do. Then I pour the charcoal into another coffee can and cover the top with a steel disk to keep the air out. This quenches the hot charcoal relatively quickly and keeps it dry.

17: If the iCan is fueled with wood pellets and used in the ND mode, are you recommending two coffee cans here only - or just an option? When one or the other?

Option. Use a taller stack if you want the gases injected deeper into the Weber kettle. You may also need a taller draft can, stack, in the ND mode. With a fan or blower you really do not need a draft can at all, except to form the secondary air slot - or use one of Paul O's disks with 80 holes.

18. I don't know the Weber charcoal starter, but is "inner basket" important?

The inner basket in the Weber charcoal starter holds the charcoal. I remove it to get a straight pipe with no obstructions.