

Pyro ☉ Grilling

Cooking Over Real Wood Gas Flames



Five benefits of Pyro ☉ Grilling

1. Tastes better: cooking over real wood gas flames;
2. Clean burning: No smoke, no soot on food, little soot on pots or pans.
3. Less expensive than store bought charcoal;
4. Great for your garden: when mixed with compost, charcoal makes a great soil amendment - numerous other applications;
5. Good for the environment: ~ 35% - 40% of carbon in the wood pellet fuel is diverted from the atmosphere to valuable uses on land.

Pyro ☉ Grilling introduces the concept of pyrolysis and demonstrates a practical application of pyrolysis. It is a simple and enjoyable way to integrate a passion for cooking with a delight in gardening as well as concerns for the environment. The results, as you will see, are greater than the sum of the parts. The proof is, as they say, in the eating. And the gardening.

The conventional approach to grilling is to burn charcoal or propane to create the heat for cooking. Pyro ☉ Grilling takes the opposite approach and makes charcoal while grilling.

Pyro ☉ Grilling is powered by an iCan Top Lit, Up Draft [TLUD] gasifier made from two coffee cans. Heat, in the range of 500 - 600 degrees C, generated by the [pyrolysis](#) of biomass in the oxygen starved reactor can, turns wood pellets into charcoal and wood gas. The wood gas is flared off as it is created. Pyro ☉ Grilling captures the heat of the burning gas in the kettle of a Weber grill. It is the heat of this burning wood gas that cooks the food and boils the water. It is the burning wood gas that imparts a remarkable flavor to the food cooked over it. You simply can not get this wonderful flavor cooking over propane or charcoal.

The simple fact is that carbon is too valuable not to use, as the Amerindians knew 1000s of years ago when they made Terra Preta, which remains exceptionally productive today. Biomass is, in general, about 50% carbon taken from the atmosphere by photosynthesis. With our simple and low cost iCan TLUD, we can 'harvest' about 40% of that carbon. As a result, only about 60% of the carbon in the feedstock returns to the atmosphere during the pyrolysis process. Nearly 40% of the carbon that was in the biomass will be diverted to applications such as soil amendments, nutrient management, animal feed supplements, and various filtering applications - such as removing zinc from highway storm water runoffs. It turns out that pyrolytic carbon is very resistant to oxidation and will thus pay dividends in agricultural applications for 100s of years. This is in stark contrast to industrial fertilizers made from oil and gas that only work for 1 year.

The proven value of carbon, in turn, suggests that the carbon in the atmosphere can be thought of as a vast, under utilized, carbon resource and asset. Two examples: Cool Planet is turning such carbon, captured by photosynthesis, into gasoline. Joule, <http://www.jouleunlimited.com/>, is using microbes to work with CO₂. Our Pyro ☉ Grilling is perhaps a third, if very small scale, example of adding value to carbon formerly in the atmosphere.

A Little History of Pyrolysis

"[Manufactured Gas](#)" of yesteryear, dating back to about 1800, was made by the pyrolysis of coal. This yielded gas for lighting buildings and streets as well as "coke"

which was used to make steel. Manufactured gas was key to the industrial revolution for over 100 years.

An example of a current use of charcoal is Tennessee sipping whisky. The whiskey makers stack up a bunch of wood, turn it into charcoal, and then use the charcoal to filter their product. They use a rather crude form of pyrolysis to decompose the wood into charcoal and combustible gases, mostly hydrogen, CO and methane. The whisky makers simply flare off this gas as it is created. The folks who make wood charcoal for your grill do pretty much the same thing. They simply throw away the wood gas and all of the energy it represents.

Making a Simple TLUD from two Coffee Cans

We make our charcoal using a simple pyrolytic device with no moving parts called a iCan Top Lit Up Draft gasifier [TLUD]. We make our iCan TLUDs from two Costco coffee cans. We can also make small iCan TLUDs from soup cans or bigger ones from 5 or 50 gallon drums. Tin cans are used to create lowest cost, open source, teaching tools

The iCan TLUD used in this example of Pyro ☉ Grilling uses one can as the reactor can. The second can is used simply to create draft. The draft can is made by removing the bottom of one of the cans to create a “straight pipe” with no top or bottom. A piece of stove pipe could also be used, but it will cost more and have to be cut to size.

On the next pages there are photos of the the top and bottom of the iCan reactor can. It is easy to make, but does require some measurements, drilling of holes, and the assembly of a few simple parts bought at a hardware store.

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

A TLUD requires a limited supply of primary air to sustain pyrolysis. The primary air supply also is a key determinant of the speed at which the TLUD converts the feedstock to charcoal and gas. It is important to tune the primary air supply for the desired results with any given feedstock, form factor, and moisture content.

Note: The number and size of holes can be varied. For Natural Draft (ND) iCan TLUDS, I often use a smaller hole size. Holes of this size, 5/32s, will make for a very hot and fast process when used with dry wood pellets in a ND iCan TLUD.

The three brackets used as feet, as seen above, can be useful for ND applications. They are not required when the reactor can is supported above the ground, as it is when used with a Weber grill or a fan.



This is a view of the top of the iCan 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 increases the turbulence and the residence time of the gases in the combustion zone. 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. This creates the critical gap for the secondary air required for the combustion of the wood gases released by the pyrolysis of the feedstock. Note: Consider installing the deflectors in the bottom of the draft can. It will be easier to load/unload the reactor can.



The two can system can is in place, the approximately 2 CM secondary air gap is clearly shown. The top draft can projects slightly into the Weber kettle through an 8 inch hole that was cut in the bottom of the kettle. The aperture in the bottom of the kettle is as large as possible without removing the sockets for the three legs.

The iCan reactor is loaded to level of the top indent on the side of the reactor can. This will provide over 60 minutes of cooking time. After the wood pellets have been loaded into the reactor can, shake them to level and settle them to reduce air channels that would enable combustion in the feedstock. This would contaminate the wood gases with CO₂.



The outer shell, shown here, acts to protect the cans from accidental tipping as well as to prevent wind gusts from blowing out the gas fire. The outer shell shown here is made from a Weber charcoal starter with its inner basket removed. It could also be made from a section of stove pipe cut to size.



A view down through the aperture in the bottom of the Weber kettle into an empty iCan system. The reactor can and the draft can are sitting inside the outer shell.

In operation, the Weber charcoal starter unit, minus its internal basket, will be placed as shown above. Next the loaded reactor can, prepped with starter, will be inserted into it thru the aperture in the kettle. Lastly, the chimney can will be placed atop the reactor can. It will sit on the three brackets that anchor the three deflector washers.

When everything is in place and centered, the starter is lit with a match or a torch, the grill is placed on its supports in the kettle, and then the kettle top is installed.

The cooking temperatures at the grill surface inside the closed Weber kettle will be 300 - 425 degrees F. The higher temperature will be directly over the burning gases and is

easily hot enough to boil water. On the side, the indirect heat will sustain simmering water very nicely. Thus there are effectively to cooking zones.

1. It is easier to boil water when the “pot” is heated on all surfaces. Even the water surface of an open pot will be exposed to temperatures well about 212 degrees F.
2. A properly tune TLUD will not deposit soot on the food or pots used inside the kettle.

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 about 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 you 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, typical grill fare, are 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.

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, the method of cooking, and the desired results.

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.

FAQs

- 1. The temperature sensor used in testing is a hand held Omega unit, Model HH11A.*
- 2. The audience for this document is stovers, STEM educators, cooks, and gardeners who are interested slow cooking the carbon negative way.*
- 3. 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.

- 4. 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".

- 5. 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 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 sit 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.

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

About 1.4 kilograms of wood pellet fuel can be placed in the reactor. The wood pellet form factor allows for much better packing of the fuel and provides a greater level of energy density in the reactor than working with many other types of biomass.

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

The flame is VERY dynamic with high turbulence and often makes a good deal of noise.

8. How long for a typical run?

This depends on the weight of the biomass feedstock in the reactor. A reactor can fully loaded with wood pellets can provide heat for about 80 minutes. Reduce the amount of fuel to reduce the run time.

9. 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 gelled alcohol as a starter. Many other starters, such as paraffin soaked cardboard, alcohol soaked pellets, etc. can be used. Gel is NOT required. I use it because it is fast and easy.

10. 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.

11. The 300 F value sounds too low for good cooking.

I used to 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.

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.

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

I carefully and gently shake it out into a metal bowl or pot to get a visual on the results. Any pot with a large aperture will do. Once inspected, I pour cold water very carefully onto the very hot charcoal. This requires care to avoid live steam burns. Optionally, 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.

13: 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 a burner disk with 80 holes or so holes. See the work of Paul Olivier for more on this option.

14. 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.

15. Where can I learn more?

The link below points to the Biochar Activity Kit. This was pulled together by Doris Hamill of NASA, Langley. The kit, which consists of a variety of slide decks as well as some illustrated "how to" materials, was designed to be used in grades 9 - 12. It needs polishing by real curriculum development professionals.

<http://www.greaterdemocracy.org/archives/1316>

16. This is an Open Source Project for Educational & Non-commercial use only.

Note: Charcoal made in TLUDs is often called "[biochar](#)".