# A Professional Guide to Making Biochar

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This is guide on how to make biochar professionally. While biochar can be generated without technology such as using piled wood and combustion with a top-down burn strategy, this guide will cover how to expertly utilize a kiln or specialty constructed apparatus to accomplish combustion of volatiles to increase the proficiency of said burn for a higher percentage conversion into Biochar.

*Photo 1 : burning Maple inside a Ring of Fire Kiln*

The basic premise of generating biochar revolves around a process termed Pyrolysis. Pyrolysis is defined as “the thermal decomposition of materials at elevated temperatures, often in an inert atmosphere. It involves a change of chemical composition. The word is coined from the Greek-derived elements pyro "fire", "heat", "fever" and lysis "separating”

***The kiln pictured above can enhance pyrolysis through its simplistic design.***

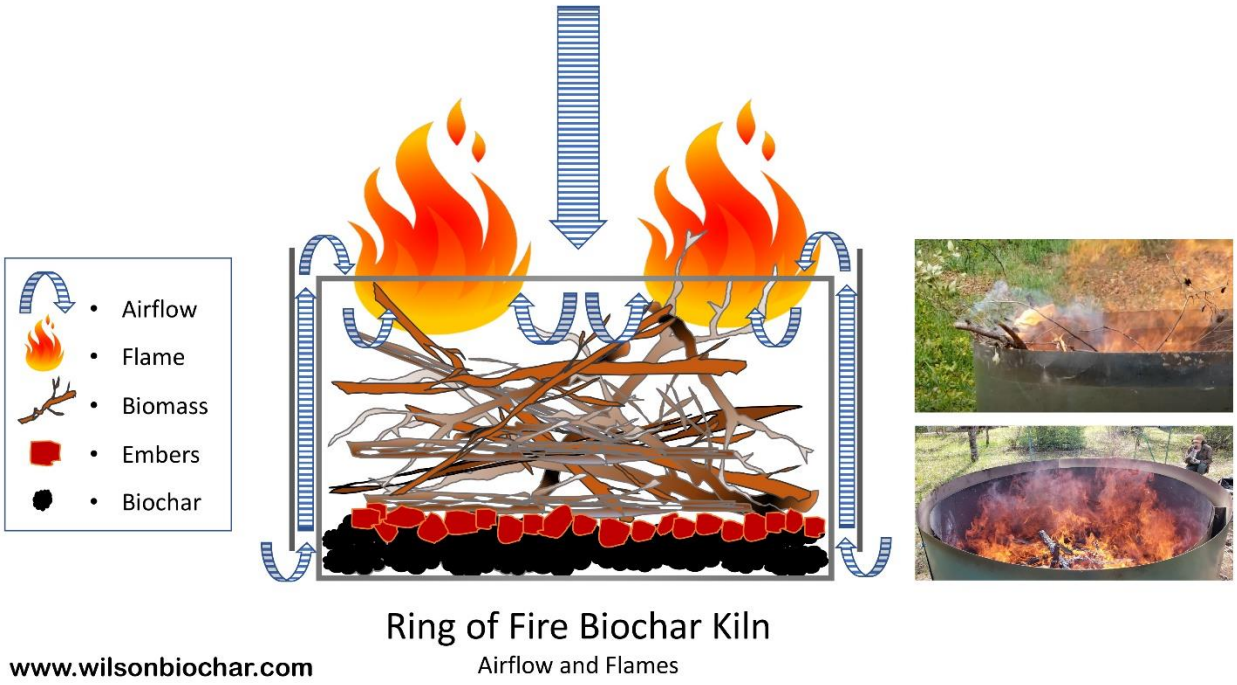


*Figure 1 Dynamics of a Ring of Fire biochar Kiln*

By restricting air flow, we can enact forces to assist our goal of converting low value timber slash into a value resource that can assist ecology in a multifaceted way. This is our goal when using these kilns.

## Key and Optional Equipment:

**MAKE SURE IT'S A BURN DAY AND YOU ARE AUTHROIZED TO LIGHT THIS KILN**
**A PERMIT MAY BE REQUIRED DEPENDING ON YOUR LOCATION AND TIME OF YEAR**
**(fuel reduction permit and NOTIFY THE LOCAL CAL- FIRE STATION)**
**Inside fire season - Broad Cast Burn- includes fuel reduction (permit)**
**County Permit – LOCAL PERMITING MAKE SURE YOU ARE IN COMPLINCE**
Shovel
Pitchfork (*Optional*)
Moisture Meter *(optional)*
500 Gallon Water Tender *(optional if pressurized plumbing is not present)*
Fire hose and/or multiple water hoses with firemen style nozzles at various locations near the kiln.
Kelpie Wilsons Ring of Fire with fastening hardware or custom kiln
Garden Rake
Long sleeve shirt
Work Gloves
Eye protection
McLeod Tool (Optional)

Baseball Cap
Lighter
Propane torch (Optional, good for rain-soaked wood)
Breathing mask (For the quench)

## Step 1: Site location planning

*A site with no canopy is a preferred area to generate biochar*

When one decides to generate biochar utilizing a kiln, they should immediately scout the area for a safe area to do so. Environmental restrictions MUST BE respected, and the size of flame they wish to produce. These Kilns once in full operation; depending on fuel stock, volume of biomass and moisture content, can generate massive flame balls and a flame cap that can be as 10-20 or even 30 feet high. This kilns flames can be carried by the wind or eject flaming materials from time to time

*When feed stocks are nearby with many kiln operators, a flame this size can occur*

*Wind causing flame cap to shoot sideways*

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## Step 2 : Preparation of Materials

When committing to operating a Kiln, it is best practice to first amass woody debris to or near the kiln. This ensures an efficient operation and feeding flow to maximize the flame cap.

Materials should be cut at 6-7foot lengths and be no larger than 6 inches in diameter, **UNLESS** they are very dry, hollow, or infested with termites.

*Photo 2 Extremely dry and termite chewed wood larger than 8 inches in diameter will burn quick in a kiln*

## Step 3: Setting Up the Kiln

Once a location has been determined the kiln can then be set up. Refer to the kiln's instruction manual for proper kiln assembly.

If using the ring of fire kiln, it is important once assembled to shovel dirt around all panel ground openings with a ring of dirt, to stop any atmosphere from being able to enter the kiln. This creates the an environment to generate pyrolysis and ensure proper kiln operating mechanics. If this important step is skipped**, you will lower your conversion yield**

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*Dirt Shoveled against the bottom gaps of the kiln touching the ground*

## Step 4 : Loading the Kiln

Proper care must be taken when loading the ring of fire Kiln. The best feed stock to utilize initially are small sticks and branches which are very dry and uniform girth. The best wood is dry wood with a moisture content of 20% or lower. Dry wood burns very quick depending on its diameter size


Begin loading the kiln with small sticks, branches, and kindling to make a bird's nest type stick pile, completely saturating all space with biomass. It's best to compress the wood pile as tightly as possible within the kiln so when we go to light the kiln, a uniform coal bed will be generated of which we will continue to batch feed till it's full of biochar. The initial filling will set the tone for the rest of the burn and is a critical step to a successful operation.



Repeat filling and compressing until full. If rain is in the forecast and not burning the day of filling, it is best practice to tarp your kiln so we can commit to a burn regardless of the weather.

## Step 5 : Lighting the Kiln

*Sticks outside the kiln body will fall and emit smoke, make sure to always give care when operating a kiln*

The initial lighting can be one of the most dangerous events of the burn. This Depends on the initial volume loaded, so before we commit to lighting all environmental factors MUST BE CONSIDERED. First we must clear the work area of all debris 5 feet before ignition. This can be accomplished using a rake. Once the area is clean of debris, we must then wet a radius around the kiln. A recommended radius is of 10-foot around the diameter of the apparatus. This ensures the operator if an ember does go flying out, ample time will be there to deal with it.


It is best to start the kiln in the center, near the top of the pile for ignition, as pictured above. The flame will grow quickly and may release some smoke at the beginning.  Whitin a minute or less the flame will grow exponentially, and most volatiles will be combusted.

If the wood is very wet, using a propane torch to ignite the biomass is another option. More moisture in the wood will extend burn times to 5 or even 7 hours, depending on the volume, skill of operator and diameter of the wood being burnt. Extremely wet wood over 20% moisture should be avoided. If in case you do choose wet wood, do it periodically, at high temperatures with a large and sustained flame cap.

## Step 6: Operating the Kilns when lit

*Kiln operator keeping an eye on the kiln. Even when they are fetching wood, they follow safe and productive protocol.*

During the operation of the kiln, it is important to understand how the design works. The Goal is to keep the flame cap alive and strong during the burn to consume volatiles that are released from the wood. Keep in mind that wood may eject during the loading process. One must keep an avid eye on the work area. Be prepared to quench any such events and never take your workspace for guaranteed. No matter how safe you may feel, always take precaution and rake around the apparatus periodically. It is important to spray water around the area of the kiln. This aids in our ability as an extra blanket of protection, for various times throughout the burn.

Kiln operating at peak performance releasing fire balls and no smoke, this is what good operation looks like.

It is important to comprehend and ensure the atmosphere entering from the top of the kiln to combust the wood we choose to batch feed. If we feed the kiln to fast, we can stunt our pyrolysis and cause excess smoke and volatiles failing to be combusted.

Adding to much wood to fast and or wet, will result in a massive smoke plum; try to avoid this at all costs.

Wet wood is a big factor when burning. It is best to use the driest materials in the beginning and finish off with wetter materials towards the end. If burning larger logs, it's best to add smaller sized materials and larger sticks first, then proceed adding in the large 5-8 inch items so they rest above the flame cap line.

*Stacking larger logs on top of brush to suspend in the flame cap.*

This guarantees the larger items will cook off with proper air flow to combust volatiles, this will cause the mass to enter the lower part of the pyrolysis chamber at the perfect time to fully become biochar.

*Stacking larger pieces of wood above the kiln line is a perfect way to quickly generate volume inside the kiln, be aware of the flame cap when committing to this method, as it will get very large and very hot*

If you are using split wood inside the kiln, it is best to add it around the inside of the circle standing vertically. Keep feeding in a ring around the kiln until you have filled 1 layer worth all the way to the center. Let the flames catch up to the first layer and then proceed with another layer. If you add it all at

once, you will choke out the flames underneath and cause a smoky scene.

*Split wood takes a lot of time to burn, as this the most condensed part of the wood. Burning this way can take 6-8 hours depending on moisture content and the amount to burn. We recommend to only burn 6-inch rounds and feed stock with lower diameters as primary feed to achieve maximum reduction, which is 20% or less*

Keep filling the kiln when you need too. When the wood falls below the kiln line is a good time to add the feedstock. Depending on what you may be burning, it may sometimes be necessary to pull up larger logs buried in the char bed back to the surface, to continue the pyrolysis action of that piece. A shovel or a pitchfork is very handy for this purpose. A good kiln operator should know the limits of what can be burned, and when to add large pieces. It is best to add lower diameter feed first, placing large diameters on top; inside the flame cap, or to burn all large diameters together. Another good tip is to stab the char bed to check for these half-baked logs, to get them back up to the surface before adding another batch. In many of our operations who achieved expert operator status, minimal equipment is needed. A shovel, water supply and rake are all may it take, to yield 3 yards of fully pyrolyzed carbonaceous material.

*The last batch of an almost full kiln*

When we add our last batch its important to let the kiln cook for a bit. This will guarantee most of the wood we added will be biochar when we are done. A good way to tell is when you see white around the wood but not quite ash, and smoldering with small blue flames.

*(Left), Some larger chunks on the top not burned emiting yellow flame, (Right)blue flame  means it's cooked into biochar*

If you are still observing many yellow flames shooting out of the kiln it is not ready yet. It must look like the above photos or else you will end up with half-baked char. Once it looks like this we are ready to begin the quench process. If you reach the end of a burn and there are still yellow flames, it is ok to quench as it's not worth losing the rest of the ready carbon into ash. **Quench if this may be the case.**

*A Complete Burn ready for a quench*

## *Step 7 : Quenching & Deconstruct Kiln*

*Quenching our Coals as large pieces that did not fully quench are  sitting on the top of the kiln*

When all we are left with is coals and no more biomass is ready to burn or we have filled the kiln, it's time to **quench**.

Quenching the coals inside the kiln before dismantling the kiln body is one of the best ways to stay safe.

Cooling the char bed before touching the kiln will do help us in three ways.

1. Reduces heat so we can approach the kiln and take it apart
2. Reduces the risk of airborne dust when we go to shovel and spread it for the quench.
3. Reduces the risk of a potential fire hazard if a gust of wind were to send embers flying off the pile.

Another good tip is to make sure to rake the area before opening the kiln body. This helps whoever may want to use the char next and keeps unburnt materials out of the biochar bed for the quench. Once the coals on the surface are fully drenched, we next spray the angle irons needed to undo the kiln body. Refer to your kiln operating user manual on how to deconstruct and construct your kiln if you are

unsure.  When removing a panel on the RING OF FIRE, its best to push the body into the bed and then pull away.

*Push the Kiln body into the coals to free it*

*Pull away from the kiln body to remove it*

Continue to spray the coal beds as you shovel out some of the biochar. It works best to work slowly and to use the a wide spray setting on your hose nozzle. Therefore, we recommend the firemen style hose nozzles as they offer an impressive width to quench the char with a good amount of pressure.

*Spraying from a distance keeps the operator safe*

*Moving the char while spraying works well to quicken the quench*

Keep spraying and moving the biochar away from its original footprint. Shovels and rakes work very well for this task. A lot of steam will be emitted and very fine specs of carbon. **This carbon is very dangerous** and is highly recommended to either wear a protective mask or stand upwind away from the steam. Where the steam is going is where the fine particulates of carbon will go. When shuffling around the char pile is when this carbon dust mostly becomes airborne. TAKE PRECAUTION

*Fully quenched pile that is steaming, steam can also be a sign of a hot spot and should be investigated.*

Spreading the biochar around at about an inch depth is the best way to insure all the coals received water to stop the combustion process. If there are any large logs left inside the pile it is best to remove and set them aside on the kiln body frames. Apply a liberal amount of water to these chucks as they can

reignite if proper care is not taken with them and become a hazard.

## Further Safety Tips and recap.

**Biomass Materials:**

1600 maximum pounds of woody derbies with moisture content below 20%
No logs larger than 5-7 inch diameter unless extremely dry with cracks and holes
Lengths of larger branches should be no more than 8 feet long.

**Key Persons:**

1-2 Operators, the more the easier (public events are good as there are many eyes to see if a problematic situation does occur)

**Safety and Contingency**

Each operator should be trained to observe embers if they may be emitted from the kiln, and to wear protective clothing when operating the kiln. They will instantly address any problematic situation and handle them as they occur. We spray, and extinguish periodically the area around the kiln, while monitoring ejecting or falling combusting materials on the sides, such as sticks not fully placed in the burn radius, or leafy loose material. Adding leafy dried materials such as bay leaves, are high potential for ejecting of hot embers. We make sure to add these materials with sticks and other heaver materials to assist via downward pressure by weight, to cause efficient combustion of these materials, turning them into ash or carbon but not embers, by trapping them in the stick matrix. Certain larger logs placed into the kiln that have not undergone pyrolysis, will require separation from the char bed and excessive quenching. This will ensure safety once we depart the location. On windy days it is a requirement to extinguish the kiln before we take the panel off, as to not expose embers to a gust and cause an unfortunate event. *This will be explained in the next section*. We only use the kiln where we have an ample supply of water, and or need a water tender. If something does go critically wrong, we will contact the local fire department immediately. Each member is required to have the number on hand **before ignition. FOR PUBLUC EVENTS NOTIFY YOUR LOCAL CAL FIRE STATION**

**Safe Operation Procedures:**

**On Low wind days:**

Assemble Kiln
Shovel a ring of dirt around bottom of the kiln to ensure little to no atmosphere attempts to enter.
Fill kiln to the top with very dry materials.

Place kindling in the center.
Ignite the kiln at the center from the top.
Wait for first batch of material to burn into a coal with minimal flames and intense heat.
Add second batch to the top of the kiln.
After a few batches go through this cycle you can begin to add higher moisture content wood.
After Kiln fills to the brim let sit until turning a whitish color with a bit of ash content on the surface.
Spray water on the areas near the angle iron and washer assembly points to cool down bolts that need to be removed.
Begin to remove panels
Extinguish each ember area that now being exposing by removal of kiln panels.
Continue to deconstruct the kiln, while spraying panels to be cooled and lay flat on the ground 20 feet from original operating area.
Continue to Extinguish char bed removing any large pieces that have not undergone full pyrolysis.
Extinguish till no more steam is visible
Extinguish large logs so no more steam is being emitted
Stay at location 30-60 minutes to observe char bed and guarantee full extinguishing of all embers.

**On High Wind Days**

Assemble Kiln
Shovel a ring of dirt around bottom of the kiln to ensure little to no atmosphere attempts to enter.
Fill kiln ½ it's volume with very dry materials.
Place kindling in the center.
Ignite the kiln at the center from the top
Wait for first batch of material to burn into a coal with minimal flames and intense heat.
Add second batch to ½ volume of the kiln.
After a few batches go through this cycle
After Kiln fills to the ½ volume of char let sit until turning completely white with some ash content on the surface.
Extinguish Kiln partiality before deconstructing the kiln
Extinguish areas where kiln is assembled with water to cool down bolts that need to be removed.
Begin to remove panels
Continue to deconstruct the kiln, while extinguishing areas for panels, also spray kiln panels to be cooled and lay flat on the ground 20 feet from original operating area.
Continue to Extinguish char bed removing any large pieces that have not undergone full pyrolysis.
Extinguish till no more steam is visible
Extinguish large logs so no more steam is being emitted
Stay at location 30-60 minutes to observe char bed and guarantee full extinguishing of all embers.

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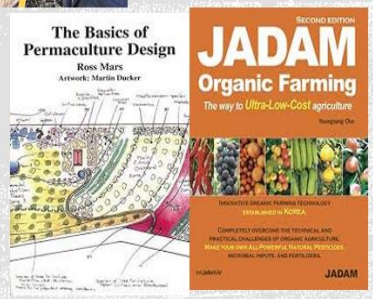


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WE BELIVE THAT EVERYONE DESERVES QULAITY FOOD AT AN AFFORDABLE PRICE!