Greensmithing:
Measuring my Carbon Footprint

As a lifelong environmentalist, as well as a lifelong blacksmith, I have tended to keep myself from thinking very much about the environmental impact of my work. (I think the the two defining characteristics of the human species are opposable thumbs, and an infinite capacity for denial.) So probably many of you have done the same thing.

This magazine and ABANA are dedicated to the growth and improvement of our craft, not just right now, but into the future. To do that, we need to make sure we help maintain a livable planet for future smiths to work on!

This article is an attempt to study the carbon footprint of my blacksmith shop. Don't worry, I'm not going to preach at you. I'm just going to tell you what I've learned. Maybe it will help some of you lower your carbon emmissions, and maybe save a few bucks too.

How this project started: My dear wife Elizabeth and I were sitting around a campfire one night not too long ago, drinking wine and talking. And she admitted to a sense of despair about the future. She didn't think we humans are capable of changing our ways enough to stop the spiraling climate disaster. I, on the other hand, actually feel an increasing optimism that it is possible. We already have identified the problem, and we already have the most of the tools and knowledge we need to change. We just need the will to do them. So it seems to me we're two-thirds of the way there! Elizabeth did not find this argument convincing.

So I said, well maybe it's not possible to save ourselves, or maybe it is. How might we prove or disprove that this is possible? (After 37 years, she doesn't even groan or roll her eyes anymore.) It seems to me if an individual living in modern society (more or less) can't avoid emitting tons of the carbon dioxide that is rapidly warming the planet, then certainly a whole society of individuals can't do it.

So an obvious test would be: Can I actually live in a way that doesn't add to the amount of carbon dioxide in the earth's atmosphere. That is, in the current parlance, can I live with a net zero carbon footprint? How can I really measure this, rather than just relying on the statistic that the average American produces 16 tons of carbon dioxide (CO_2) per year?

As I pondered and researched this issue over the next month or so, I realized that it's very difficult and slippery to really know the carbon footprint of our inividual lives. I personally can't actually measure the carbon footprint of my bag of groceries, or my last Amazon order.

But my blacksmith shop is actually a place that is self-contained enough to actually measure my carbon footprint with reasonable accuracy, by myself. My energy inputs are obvious and measurable. A bucket of coal is an easy thing to weigh, so is a chunk of steel.

So I set up a notebook as a carbon ledger, to record all my carbon consumption, as well as offsets to that consumption. (I'll explain those later). My goals were: 1) to measure the actual carbon/energy inputs of a one man professional blacksmith shop, and 2) to see if through thrift, efficiency and carbon offsets, I might be able to run my shop in a carbon neutral, or even carbon negative way. I'm not talking here about buying "carbon offsets" somewhere, I'm talking about offsetting carbon right in my shop.

Now before I describe how I set up my carbon ledger, and what I learned by doing it, I want to repeat that I'm not saying this is what you should do, I'm just describing what I did. I know full well that my business and situation is not typical. Not everyone can make their own iron and charcoal. And many people feel the need to make more money than I do . But still I hope the solid information I've gathered can help you think about your own shop a little differently.

And I'll tell you here, in case I lose you in the data weeds ahead--- the carbon footprint of your shop might not be quite as bad as you expect, and where most of that carbon is really coming from might not be quite what you expect either.

How I set up my carbon ledger: Since most of my work uses solid fuel, it made sense to measure carbon itself, rather than CO_2. I can just weigh my coal and charcoal directly and record that weight. For other fuels and materials, I could pretty easily find figures for CO_2 emissions required to produce those, and then convert that CO_2 figure to solid carbon weight. CO_2 is 27% carbon by weight, so that's a simple conversion to make.

The CO_2 emissions for burning the hydrocarbon fuels are nice solid numbers that are easily available. Determining the carbon footprints of other inputs, like electricity or steel was more difficult, because the estimates vary widely according to how they are produced. In those cases, I looked at all the figures I could easily find, read how they were determined, and used my own judgment to pick a number somewhere between the high and low figures.

So for the positive side of my carbon ledger, these are the things I recorded as **carbon positive**:

Coal	just recorded by the pound (as each 13 lb bucket gets emptied)
Electricity used	at 0.5 lb Carbon per kWh
Propane	at 3.5 lbs Carbon per gallon
Steel (purchased)	at .3 lbs Carbon per lb
Gasoline	at 5.5 lbs Carbon per gallon
Acetylene	at 10 lbs Carbon per medium tank

(Note: I had a hard time finding a good number on the acetylene. Regardless, it's such a minimal part of my usage it wasn't really worth recording. As to the gasoline, I recorded all of what I put in my ancient Toyota truck even though a part of those miles weren't truly for business purposes. Also, all the gas for the chainsaws was included, regardless of whether the wood was for making charcoal or heating my home.)

There were also some **carbon neutral** entries in my ledger: the **charcoal** that I used for forging

fuel, and for smelting bloom iron.

Before going much further, we need to talk a bit about the amazing substance we call charcoal, the fuel that we used for all metallurgy for thousands of years, basically until about 200 years ago.

Charcoal is, of course, wood or other plant matter that has had all the volatile substances cooked out of it, which leaves a very pure carbon fuel that burns at a much higher temperature than the wood it was made from. The wood the charcoal was made from was CO_2 in the atmosphere just a few years ago, and would largely return to the atmosphere as CO_2 again in a few years, after that wood decomposes. Therefore, using the wood as fuel is **not** changing the balance of CO_2 in the atmosphere, and is replacing the use of coal, oil or gas which **would** alter the CO_2 balance.

I have done a fair amount of forging in charcoal only, and it is a wonderful fuel. But it is also an expensive fuel, whether you are buying or making it. So usually, rather than forging in straight charcoal, I use it in conjunction with mineral coal. I could just mix it with the coal, but I usually use it by feeding charcoal into the center of the fire, which lets me push the coked coal to the center less often.

But there is a further and greater climate impact of using charcoal, beyond just avoiding the fossil fuel use. Charcoal is a very stable form of carbon, that can last 10,000 to 20,000 years before it breaks down into CO_2 again. If we return charcoal to the soil instead of burning it, we are locking away carbon from the atmosphere into the earth for many, many, centuries. If we had not converted it to charcoal, the wood would have quickly decomposed to return that carbon to the atmosphere. So by converting the wood to charcoal, we have effectively removed carbon dioxide from the atmosphere.

Charcoal also has tremendous benefits for soil fertility and plant growth. When charcoal is returned to the soil like this, it is commonly referred to as “biochar”, if you'd like to learn more about this from Mr. Google.

So when I use **charcoal** as a **fuel**, I consider it as **carbon neutra**l, as it is basically coming from the current carbon cycle. And when I return **charcoal** to the **soil**, I consider that **carbon negative.**

Other inputs that I considered carbon neutral were bloom iron and scrap iron. Because I have smelted the iron from it's ore using only charcoal as fuel, it's carbon neutral for the same reasons stated above. If I used scrap iron, which is iron I did not create the demand for, but rescued from field or dumpster, I also called that neutral. I did not record bloom iron or scrap iron in the ledger, but I did record my use of charcoal, as I wanted to see what portion of my total fuel use it amounted to.

Now for the negative side of my carbon ledger, these are the things I recorded as **carbon negative offsets:**

Biochar: just recorded by the pound
Electricity produced: solar production to the grid at 0.5 lb Carbon per kWh
Ash and clinker: that is, the unburnt portion of the coal and charcoal recorded above
Recycled iron: at .4 lbs Carbon per lb of Fe
Recycled copper: at 1.5 lbs Carbon per lb of Cu
Recycled aluminum: at 1.7 lbs Carbon per lb of Al

OK, a couple of brief notes on these things.

About electricity: several years ago I had a grid-tied solar system installed at my shop. The size of the system was based on my previous year's electrical usage, which averaged 11kWh per day. But after I had the system installed, I converted my ancient fluorescent fixtures to LED's. I now consistently produce more electricity than I consume. You might not realize until you hover over your electrical panel for awhile, that your power hammers and welders and such represent a tiny fraction of your electrical usage. They draw a lot of power while they're working, but they don't draw as consistently as your lights.

About metals recycling: When I began smelting my own iron many years ago, I immediately and viscerally realized what vast resources go into getting metals from their ores. Seeing metal go into a dumpster, which where I live, goes to a landfill without any recovery, just plain hurts me! So dumpster diving for scrap metal has become a bit of a hobby for me. The figures above are how much energy recycling those metals saves over smelting them from ore.

The Results: I kept this ledger as a running total, so I could see how I was doing, but here I'll just present the totals from August 12, 2021 to April 29, 2022, a period of 7 ½ months (250 days). This was a period when I was just home working, with no traveling, so gives a good basic picture of the carbon footprint of the shop.

Carbon Positive:

Coal: by weight	975 lbs Carbon
Electricity used: 850 kWh at .5 lbs Carbon per kWh=	425 lbs Carbon
Propane: 10 gallons at 3.5 lbs Carbon per gallon =	35 lbs Carbon
Steel (purchased): 43 lbs at .3 lbs Carbon per lb =	13 lbs Carbon
Gasoline: 200.2 gallons at 5.5 lbs Carbon per gallon =	1,101 lbs Carbon
Acetylene: < 1 tank, so not recorded	---
Total Carbon Emitted:	**2549 lbs Carbon (9440 lbs CO_2)**

Carbon Neutral:

Forging Charcoal: 268 lbs
Smelting Charcoal: 569 lbs
Bloom Iron and Scrap iron: not recorded, but estimated at 300 lbs

Carbon Negative Offsets:

Biochar: by weight	-337 lbs Carbon
Electricity produced: 1451 kWh at .5 lb Carbon per kWh =	-725.5 lbs Carbon
Ash and clinker: by weight	-345.5 lbs Carbon
Recycled iron: 2780 lbs at .4 lbs Carbon per lb Fe =	-1,112 lbs Carbon
Recycled copper: 73.6 lbs at 1.5 lbs Carbon per lb Cu =	-110.4 lbs Carbon
Recycled aluminum: 102 lbs at 1.7 lbs Carbon per lb Al =	-173.4 lbs Carbon
Total Carbon Negative Offsets:	**-2804 lbs Carbon (10,385 lbs CO_2)**

Carbon Footprint of Germinal Ironworks 8/12/21 to 4/29/22:

Carbon consumed/emitted: 2,549 lbs Carbon
Carbon stored/saved: -2,804 lbs Carbon
Carbon Footprint: -255 lbs Carbon (-944 lbs CO_2)

Thoughts and conclusions: So I set out to see if I could run a carbon neutral blacksmith shop, and I found that I could. ... at least according to the assumptions I made. But even if you think my approach to offsets are flawed, we can learn a few things simply from having actually measured and recorded these things.

If you want to lower the carbon footprint of your shop, don't look to your forge first. .. look out at what's parked in your driveway, and then look up at your lights!

Gasoline was the largest contributor to my carbon footprint, and I don't even drive very much! My shop is at my home, I probably only leave the homestead 2 or 3 times a week, and I drive a little old truck. So if you want to do better, drive less, and slow down! Walk, bike, and get an EV when you get the opportunity.

Electricity: The year before I installed my solar system, my shop averaged 11 kWh per day. For the 250 days of this study, that would have amounted to 2750 kWh, which would have represented 1375 lbs of carbon in the atmosphere! That would have been even higher than my gasoline footprint. But by converting to LED's, and really only turning them on when my natural light is inadequate, that carbon load was reduced to 425 lbs. All by just spending a couple hundred bucks on bulbs and a few afternoons rewiring my fixtures. So if you want to do better, fix those lights. Turn off lights you aren't using. Better yet, go solar.

Forging fuels: I found this data rather surprising. My coal and forging charcoal together amounted to 1,243 lbs. That's only 5 lbs a day! (including weekends and wood cutting days). I guess those days that you aren't actually forging much really sneak past your consciousness. Though most of my work during this period was fairly small in scale, it also included vast amounts of forge-welding. I also suspect that I am much more efficient with my fire management than most people... but that's a subject for another day.

Also, I knew my coal was rather poorly washed, but to find that more than 25% of that fuel wasn't actually fuel at all but just ash was a shocker. Note: probably 1/3 of this ash wasn't even from below the tuyere, but fly ash from the floor of my side draft chimney.

Anyway, you can see that maybe your forging doesn't have quite as awful a carbon footprint as you might have thought.

Well, I hope some of you got a little helpful information out of my bout of extreme nerdiness, and maybe help you save a little carbon, and a few bucks, too.

Lastly, I think I'll add a little dedication to this article: To Mr. Wally Yater.