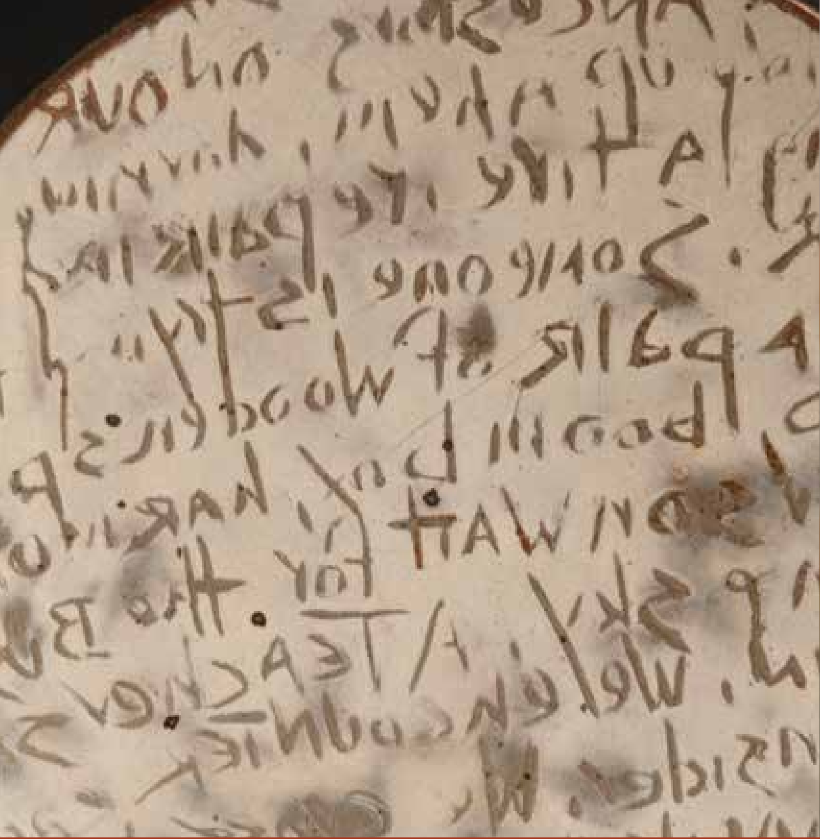


Aesthetics and Environment, KILNS AND CARBON

by Denise Joyal

One spring night in March, as I watched my husband get a head start on the summer by smoking pork ribs over wood coals, I contemplated the new studio and kiln I plan to build. I have fired a number of different types of kilns over the years and tend to favor the atmospheric effects of propane. However, I am also a recycler and a composter, and my house will be powered by solar energy in the near future. Would I be throwing my environmental concerns under the bus in order to achieve the aesthetic I desire? Am I alone in putting aesthetics first? Building a kiln is no small affair. I needed to be secure in my decision, so I started asking questions of various environmentally conscious potters.

Later that spring, I visited John Thies in Thurmont, Maryland, while he was firing his manabigama wood kiln. As he stoked the kiln, we discussed wood-fired pottery and its environmental impact. He told me about one of his teachers, who lived and worked in Colorado in the mid 1970's. The potter used crank-case oil to fire five kilns as he watched the jets from a nearby Air Force base fly overhead. Some local environmentally conscious citizens challenged his firing methods, despite the potter's estimate that ten years' of firing produced the same amount of pollution as one flight of one jet flying over his house. Thies posited that perhaps people's reactions to (or perceptions of) the sometimes billowing smoke—compared to the "clean," cloud-like appearance of contrails in the sky—speak to how we approach environmentalism.

However, if this were the only factor, it would also suggest a tendency to favor the cleaner "looking" propane flame compared to the wood firing Thies prefers. In the environmental debate of today, what we see is less important than what we can calculate. Well-heeled environmentalists and even casual recyclers know a smoke cloud when they see it: but like the potter in Colorado who was, perhaps, ahead of his time, they also recognize a carbon footprint when they can't. One of the primary standards used to measure impacts on air quality and greenhouse gas emissions, "the carbon footprint" is the amount of carbon released from the beginning to the end of any product, process, or event. This includes the mining, processing, transporting, delivery to the user, and the consumption of the fuel.

"Nothing really makes perfect sense in being more environmentally conscious in pottery. You can't stop firing if you want to make wares." John muses as he dons his gloves and stokes his kiln again. While he doesn't discount the importance of environmental consciousness, his decision to fire with wood has more to do with the results he gets from his firings. The finish it creates, he says, is "the natural birth of the wood."

Warren Frederick and Catherine White have an anagama and a gas kiln at their studio in Virginia. I called to ask them both questions about fuel costs and consumption. We talked about carbon dioxide and the "carbon footprint" as the big sticking point in environmentalism these days. We also discussed aesthetics. They both agreed the reason they fire wares in an anagama kiln is because they love the surface. As artists, their aesthetic decisions were their primary concern.

Denise Joyal's stoneware bowl, 7 in. (18 cm) in height, fired in Del Martin's kiln to cone 10 reduction. CO_2 footprint: 1.45 lb.

Del Martin's large bowl, 16 in. (41 cm) in diameter, propane fired. CO_2 footprint: 13.28 lb.

John Britt's teabowl, 4 in. (10 cm) in height, stoneware, fired with wood and vegetable oil in the Penland Noborigama. CO_2 footprint: 0.63 lb.

A CARBON COMPARISON ACROSS

POTTER	TYPICAL ELECTRIC FIRER	PETE PINNELL	DEL MARTIN	CATHERINE WHITE WARREN FREDERICK
Kiln	top-loading barrel	Geil DB-12	fiber-lined car kiln	propane kiln
Fuel	electricity	natural gas	propane	propane
Cubic Feet	7	12	50	36
Fuel Consumed	87 KwH	24 Therms (.29 gallons)	50 gallons	50 gallons
If Wood, What Type				
Firing Cone	10	10	10	9
Firing Length	12 hr firing	12 hr firing	12 hr firing	12 hr firing
Total CO_2 Output	116.6 lb	289.44 lb	640.5 lb	640.5 lb
CO_2 per Cubic Foot	**16.66 lb**	**24.12 lb**	**12.81 lb**	**17.8 lb**
Assuming Wood is 75% Neutral	**N/A**	**N/A**	**N/A**	**N/A**
Fuel Cost	$.0827/KwH	$1.25/therm ($105/gallon)	$1.60/gallon	$3.60/gallon
Cost to Fire Entire Kiln	$7	$30	$80	$129.60
Cost per Cubic Foot	$1.03	$2.50	$1.60	$3.60

John Britt, author of *The Complete Guide to High-Fire Glazes: Glazing & Firing at Cone 10*, is a potter who puts significant weight behind environmental concerns. In an article titled "Firing with Vegetable Oil," Britt challenges potters to be more environmentally aware and to consider their fuel choices. He cites Sam Clarkson's transformation of the Penland two-chamber noborigama kiln to a wood- and used-vegetable-oil-fired kiln from what was a wood- and diesel-fuel kiln. Britt noted that "Clarkson wanted to minimize both the cost and the detrimental effects of burning hydrocarbons while pursuing his passion for high-fired pottery." Britt also told me he felt any environmental argument that wood was 100% carbon neutral was "too pie-in-the-sky" and that I should look into that as well.

Perhaps less clay-focused sources would help answer my dilemma. A recent National Geographic article touting the virtues of wood as an energy source stated, "Wood is 100% carbon neutral if the trees are replaced, because burned or decomposing, wood still releases the same amount of carbon it consumed during its lifetime back into the atmosphere." However, John Gulland, co-founder of www.woodheat.org believes that wood is 75% carbon neutral. Gulland notes that only some of the CO_2 from decomposition actually enters the atmosphere. "On a scale of carbon neutrality, (burning wood) is better than burning a fossil fuel, but it's not the same as wind or solar." For the purposes of this article, we need to assume that some amount of the wood used in a firing may not be completely burnt, in which case the carbon footprint may be slightly reduced, at least in the near term. Mark W. Anderson, professor of ecology at he University of Maine, suggests that "these biofuels (wood) contain 'biogenic' carbon. Under international greenhouse gas accounting methods developed by the Intergovernmental Panel on Climate Change (IPCC), biogenic carbon is part of the natural carbon balance and it will not add to atmospheric concentrations of carbon dioxide." That said, you should still count these carbon emissions if you want to be honest with

A FULL COMPLEMENT OF KILNS

ALISON SEVERANCE	JOHN BRITT	JOHN THIES	KIRKE MARTIN	KRISTIN MULLER
catenary arch cross draft	2 chamber norborigama	3 chamber norborigama	anagama	anagama w/ noborigama chamber
wood	wood & vegetable oil	wood	wood	wood
45	60	300	220 (estimate)	220 (estimate)
1.75 cords	0.2 cords 25 gal. used veg oil	1.5 cords	3 cords	10.5 cords
Hardwood	Poplar	Oak	Hardwood mostly oak	80% pine 20% oak, maple, ash
11	10	12	12 front, 9-10 back	11-12 front, 9-10 back
12 (plus 6 hr pre-heat)	18–24 hrs	16-18 hours	3.5 days	8.5 days average
	1300 wood 156.75 bio-fuel			
11375 lb	1456.75 lb	9750 lb	19500 lb	68250 lb
252.7 lb	**24.28 lb**	**32.5 lb**	**88.63 lb**	**310.23 lb**
63.19 lb	**8.03 lb**	**8.125 lb**	**22.16 lb**	**77.76 lb**
$30/bundle from sawmill	free lumber scraps free oil	$75/cord split	$52/cord for unsplit logs $15/cord for end cuts	free
$90	$0	$112.50	$120	$0
	$0	$0.38	$0.54	$0

yourself about your impact on the environment. The simple fact is that once carbon dioxide goes into the atmosphere, its effects on climate systems are the same wherever it comes from, fossil fuels or biomass. By logic employed by the Department of Energy here, you could consider fossil fuels to be "biogenic" and part of the natural carbon cycle, you just need to assume a much longer time scale for what you call "natural." The real question is not where your carbon emissions come from in terms of fuel, rather it is one of how large your emissions footprint is from all sources.

Anderson recently published *Reducing Your Footprint: A Handbook for Reducing Household Carbon Dioxide Emissions*. His data includes the average per pound of CO_2 output generated fuel type includes propane, wood, natural gas, and electricity (averaged from all production sources including the CO_2 from production and delivery of each fuel). Note: Your carbon output for electricity will vary from this average depending on the specific way in which it was produced. Informed by these numbers, I was able to draw some specific conclusions regarding the CO_2 output of a variety of kiln types.

In general, I knew that the larger a kiln is, the more efficient it is (primarily because of residual heat and the amount of thermal mass), so I searched for a way to compare them. I felt the most logical criteria for comparing kilns of different sizes and types was to determine the pounds of CO_2 output per cubic foot of stacking space. This would put every kiln on equal footing. I factored in fuel types, the amount of fuel used on average and then divided by the cubic feet of each kiln. I also calculated the cost per cubic foot to fire these kilns, a reasonable factor to consider when deciding what kiln to build. I used both the 100% and 75% carbon neutral assumptions for wood. At the same time, it is important to note that, while wood is individually renewable in this way, on average wood-firing introduces more carbon per cubic foot into the atmosphere than an electric kiln.

The most surprising result however is, using 75% carbon neutrality as an assumption, the noborigama kilns have half

Warren Frederick's *Dot Plate*, 11½ in. (29 cm) square, propane fired. CO_2 footprint: 1.36 lb.

John Thies' porcelain bottle, 9 in. (23 cm) in height, fired to cone 12 in a manabigama. CO_2 footprint: 9.03 lb.

Allison Severance's teabowl 4½ in. (11 cm) in height, fired to cone 12 and salted in a wood-fired cross-draft kiln. CO_2 footprint: 8.06 lb. *Photo: John Keith.*

the carbon foot print per cubic foot of stacking space as a standard 7-cubic-foot electric kiln. Certainly this favors the norborigama in terms of both environmental friendliness and aesthetics if wood-fired surfaces are the desired effect, especially if the wood used to fire is replaced by planting new trees. The primary factor here is fuel and kiln style. Single-chambered wood kilns introduce nearly 2 to 3 times the CO_2 output per cubic foot than the electric kiln I compared, while multiple chambered wood kilns introduced between 0.5 and 2 times the CO_2 as the electric kiln.

Natural gas and propane kilns offer alternative environments to both wood and electricity. White and Frederick fire their propane kiln to cone 9 on average 8–10 times per year with a nearly identical CO_2 output per cubic foot as a standard 7-cubic-foot electric kiln. The data used for this article assumes complete combustion of fuel, so if reduction is a desired effect, the additional environmental impact will be based on the degree to which oxygen for the combustion of fuel is limited in favor of a reduced environment in the kiln.

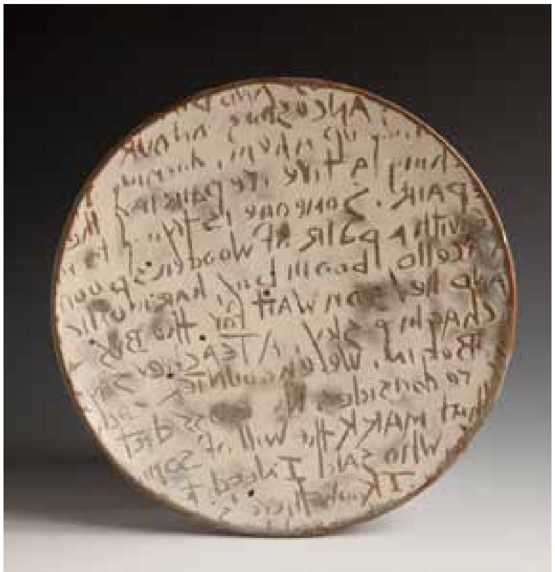
My friend and mentor, Del Martin, has been a successful production potter for over 35 years. In his Sharpsburg, Maryland, studio, he fires a 50-cubic-foot propane kiln to cone 10 once a month. When asked if he felt propane was environmentally sensitive, Martin suggested that nothing truly is. "If a potter really wanted to be 100% environmentally friendly, he would sit in an empty room and meditate on making pots rather than actually making them. They would turn out exactly as he imagined they would."

However Duchampian a notion this may be, Martin did conclude that "most potters actually do want to make pottery," so choosing a fuel based on availability, cost, and aesthetics is a more reasonable solution. Just because there is obvious smoke or flame doesn't mean your fuel is worse for the environment. It just may be that you're using a fuel that is closer to the carbon source.

Based on my findings, it appears that multi-chamber kilns are more efficient than single chamber kilns because they take better advantage of residual heat, and they require the fuel to travel a more circuitous route to the flue, resulting in more complete combustion. Propane kilns can be more efficient than the average electric kiln, but this depends on proper management of the atmosphere in the kiln. Single chamber wood kilns tend to be less efficient than propane, electric or multi-chambered wood kilns.

Knowing this, I feel strongly that I can justify using propane. I enjoy the process, I love the results, and even if I want moderate reduction, I can still be at least as environmentally friendly as I would be using my electric kiln. Now that I no longer harbor guilt in the face of my aesthetic, I need to order some bricks.

the author *Denise Joyal lives in Smithsburg, Maryland, where she owns and operates Kiln Joy Ceramics.*



Catherine White's *Inauguration Text Plate*, 11 in. (28 cm) in diameter, propane fired. CO_2 footprint: 1.25 lb.

CALCULATING YOUR CARBON USAGE

1. The first thing you need to know is what kind of fuel you are using (easy) and how much CO_2 per unit it produces upon combustion:

Fuel/Units	Pounds of CO_2 Per Unit*
Electricity/kwh	1.3
Gasoline/gal	19.6
#2 Oil/gal	22.4
Propane/gal	12.8
Wood/cord	6500.0
Kerosene/gal	21.5
Natural Gas/gal	12.1

*based on the national US average for each fuel type

2. The next thing you need to know is how much fuel you use in a firing:

- Electric kiln manufacturers can tell you how to calculate your electricity (kwh) usage based on how long your kiln is fired on a given setting (usually a calculation based on the number of hours on low, medium, and high).
- For gas or liquid fuel, you will either need a gauge on your kiln's fuel supply or you will need to calculate the difference between your fuel usage on the day(s) when you fire and your "normal" usage (total firing day usage - normal day usage = single firing usage). You may need to perform this calculation several times and take an average in order to be confident in the result.
- One cord of wood is the amount of wood that, when tightly stacked, will fill a space that is 4 × 4 × 8 feet (128 cubic feet).

From here, it's a simple matter of multiplying the units of fuel used by the CO_2 per unit to arrive at your CO_2 output per firing.

3. Okay, so what if you want to know the CO_2 output for a single piece fired in your kiln? You will need to know how many cubic feet of space your kiln contains, and how many cubic feet of space a given piece occupies. You can then use these figures to calculate the CO_2 usage per cubic foot in your kiln and apply that to each piece.

- Cubic feet of kiln = length × width × height measured in feet.
- Cubic feet of ware = (length × width × height measured in inches) × 0.000578704. [1 cubic inch = 0.000578703704 cubic feet.] For round pieces, you should calculate the cube or box it fits into, rather than the exact space it occupies, since the empty space around the pieces is "fired" right along with your ware.
- CO_2 per cubic foot = fuel used per firing / cubic feet of kiln
- CO_2 per piece = CO_2 per cubic foot × cubic feet of piece.