Fire Science: Burning Wood

"A well-made fire is alive. There is a world of difference between a fire which is a pile of burning logs, and a fire which is made by someone who really understands fire. He places each log exactly to make the air between the logs just right. He doesn't stir the logs with a poker, but while they are burning, grasps each one, and places it again, perhaps only an inch from where it was before. The logs are so exactly placed that they form channels for the draft. Waves of liquid yellow flame run up the logs when the draft blows. The fire, watched, burns so intensely and so steadily, that when it dies, finally, it burns to nothing; when the last glow dies, there is nothing but a little dust left in the fireplace."

- Christopher Alexander, *The Timeless Way of Building*

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Does playing with fire define human beings?
We have been playing with fire for millions of years. Ironically, in this age of jet fuel and combustion engines, many people seem less familiar with fire than ever. This information is intended to help bring back that sense of familiarity, as a stepping stone to building a practical post-petroleum future.

***Other critters* stay well clear of fire. We tend to stick out red-handed when the planet gets in a fire-type mess.**

(Other critters don't tend to read web pages, either, so I assume you're a people-type critter. You probably know something about fire? Byt maybe not as much as people(s) who play with embers before computers.)

Some things most people know about fire:

1) It's hot.

Rocket Stoves

Masonry: Rock Puzzles

Water Science

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2) It burns (causes pain and transformation).

3) We can put it out (with water, dirt, baking soda, or a fire extinguisher, for example).

The "fire triangle" is fuel, air, and heat. Take one away, and no more fire.

4) Enough is enough. If it gets too big/hot, I can't blow it out anymore....
(That's right... we just aren't cool enough.)

5) Flames go up. Hot air rises (through convection).

6) Firelight gives a nice glow. (Both heat and light are forms of radiation - the cosy, life-giving kind.)

7) Fire makes soot, smoke, and 'bad' gases. *(Smoke and carbon monoxide are unburned fuel; complete combustion also makes water (steam) and carbon dioxide).*

8) Wet wood doesn't burn well*.

Some things not everybody knows about fire:

1) Some fuels burn better than others.
Wood fuels chart
Heavy wood doesn't necessarily meant better fuel - if it's heavy with green sap or rainwater. Wet wood burns very poorly - half the heat (or more) can be diverted into drying the wood in order to burn it.

If you ask"Is the camp firewood dry?" and they answer, "Sure - it hasn't rained for at least a week," your fire is doomed to poor fodder. Ditto if you see mushrooms growing on the logs. Firewood on the damp ground, uncovered, or mellowing under tarp with no air movement, is not fuel - it is mushroom habitat.

2) Hot chimneys draw up. (When people put an uninsulated chimney out the north side of a house, instead of running it up inside the home or insulating it, it tends to draft downward instead.)

A pipe, tube, chimney, or hollow log can function as a "hot stack." The tube gives the gases a

place to go without interruptions from cold air coming in sideways. The hotter the tube gets, the faster the gas inside it rise, drawing more air across the fire and channeling exhaust gases up and away. A tube or chimney acts like a "smoke vacuum," and can very quickly turn a

smouldering campfire into a rushing tower of flame.

3) Radiant heat bounces off walls.

Poorly designed fireplaces often completely fail to take advantage of this, or worse, people block the heat entirely with walls of glass.

You can direct the heat from fire with a fireback. Put a wall behind it, and some of the heat bounces back across toward you. Put it in a box (like a big square fireplace) and the heat stays near the center and goes straight up. Great for cooking, not for heating the room. You can fan out the walls and bounce heat out toward you, great for warming yourself.

If you want more light and less heat, you can arrange a log in front to bounce the fire's heat back toward the chimney.

Dome ovens focus heat inward. A ring of wildfire can light a distant tree like a magnifying lens.

4) Smoke is unburned fuel.

Smoke is occasionally used as a preservative or artful effect, but mostly it's a toxic nuisance.

By burning fuel completely, so there's no smoke,
a) you need a lot less fuel to get the job done, and
b) you don't get so much turpentine, methanol, soot, carbon monoxide, vinegar, tars, and all those other nasty things that make people cough and rub their eyes when they get a face-full of smoke.

When fire burns completely, it turns carbohydrate fuels *(like wood/grass/paper)* and hydrocarbon fuels *(like oil/wax/fats)* into... carbon dioxide, and water. *It's just a lot of carbon and hydrogen, getting completely oxidized.*

(Side rant: Yes, carbon dioxide is building up in our atmosphere. It's a product of all our combustion technologies -- smelting ores to make metals, burning gas and coal for fuel, refining limestone into lime and cement, and powering our houses and computers with the electricity produced in far-off, coal-burning plants made from cement and metal. Wood heat uses "current" carbon dioxide, assuming more wood is grown to replace the chopped fuel. Fossil fuels release 'ancient' carbon, that has not been part of the atmosphere since the time of the dinosaurs. So while a clean-burning fire produces a little carbon dioxide, a 'clean' electric heater in reality produces far more. Either is an improvement on lots of nasty smoke.

If it helps put things in perspective, methane is an even worse greenhouse gas. So stop eating beans. And dairy, and beef - cows fart too. Water is the most effective greenhouse gas of all. Yet we need it to survive.

Maybe these substances aren't "bad" as such, maybe they're even potentially "good" elements in some ways, but it's dangerous to alter the amounts in a balanced system. Burning massive amounts of fossil fuels over a short period (a few

hundred years) releases trapped carbon, destabilizing the climate. As an individual, you can't put it back the way it was. But if you can provide for your needs from your own 'waste' wood, without depleting your woodlot, you know that your plants are pulling that carbon back out of the air as fast as you put it in. You can even return the mineral ashes to the same forest, along with some rich compost-type waste, to speed things up. It's not "waste" that's the problem, it's wasted waste.)

5) Fire flows. Air is a fluid, so are smoke and water. And it's the gases released from hot wood that burn, just like the fumes from brandy or gasoline - the wood itself only chars.

You can use the same tools to channel hot air that you use to hold and move water. Just have to turn them upside down. And upside-down bucket is an oven or hot-air balloon. An upside-down pipe is still a pipe, or a duct. An upside-down drain is a chimney. And an upside-down siphon is.... well, it's something that most people haven't really thought about using on a fire. We call it a "j-tube," or an "l-tube," or a "thermosiphon," and use it to make fire burn sideways. Ancients used them to make long, hot furnaces for heating palaces, firing ceramics, and processing ores.

6) Remember convection, conduction, radiation?

Convection is hot air rising and wind blowing. Sunlight on your face is **radiation**. **Conduction** is why having a cuddle or hot shower is a lot warmer than watching one.

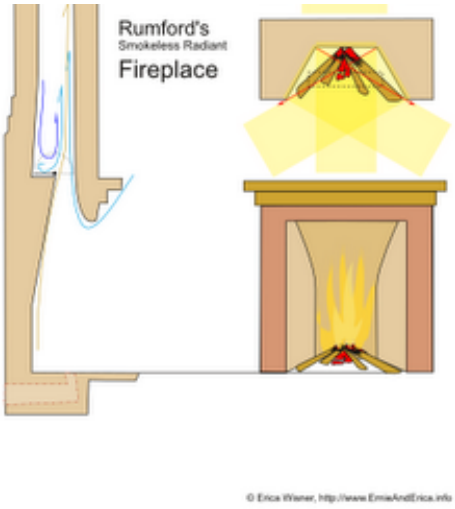
The chimney facilitates convection: it convects heat straight out of your house. We can use reflective masonry to bounce some of the radiation back at us (hence the dish-like diagonal walls of elegant Rumford fireplaces). But like cats, many of us like to sit on a warm surface as well. As long as your body is between the fireplace glow and the cold chair, your seat will only get as warm as your shadow.
Conduction is the process of transferring heat by touch -- and it's by far the most direct way to transfer heat. It's like radiation with zero distance -- heat transfer is limited only by the materials themselves. But we rarely use it for comfortable heat-- stoves are too hot, hearths too sooty, water-bottles and hot showers are too leaky and wet to use while reading a good book. Microvavable heat-packs are about the extent of it.

Hearths: a Home for Fire

If we use everything we know about fire, we can get it to do amazing things, just by how we arrange its 'house'.

The basic hearth is just a non-burnable place to make fire, like flat stone, sand-pit, or bare dirt. But by adding walls, chimneys, or other features, we can create a home that encourages the aspects of fire that are most useful or delightful for our own purposes.

- A Rumford fireplace *(diagram left)* uses a narrow throat to keep the chimney from dropping cold air into the house when the fire is out (cool air flows down just as warm air flows



up, with less desirable results in winter. The curved back helps scoop the smoke up the chimney when the fire is going, and slanted masonry sides reflect and re-radiate the heat back into the room.

A jug stove *(photo, right)* does almost the opposite - it uses dry earth to insulate and focus the heat directly beneath a chimney, which allows an African traveler to heat tea in a barren land with plenty of dry earth but little fuel.

-A "pocket rocket" concentrates the flames at the bottom of a can, where they can warm our toes and convection carries the heat all the way up to the rest of us. It's a good emergency heater for cold hoboes, or a mountain man's hunting cabin. *(pictured, left)*

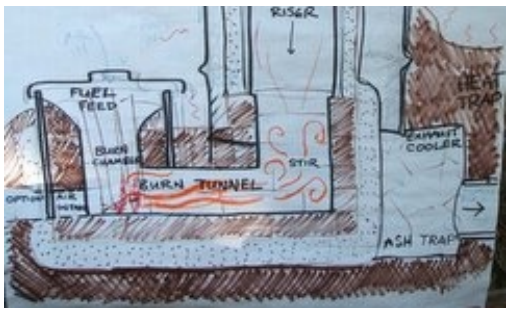
- A masonry stove sends the exhaust from a single, batch-burned fire through a bunch of baffles on its way out, so it heats a massive masonry chimney and creates safe, warm heat for hours. Some larger examples such as the Russian stoves can combine cooking hearths, ovens, and even platform beds: a warm, raised surface owners can actually sleep on in the extreme cold of northern European winters. Others, such as German and Swedish tile stoves, offer a smaller but still efficient decorative heater for a central room.

-A rocket masonry stove combines these, plus extra features:

- a vertical (gravity-fed) feed tube, optional lid
- Multiple 90-degree turns, and masonry surfaces creating just the right amount of turbulence to get your smoke and air to mix, heat, and burn completely. (like an incinerator)

- A short, insulated, and therefore very hot

-A short, insulated, and therefore very hot chimney, creating powerful draw and a very hot spot at the top where the last gases re-burn in a torus of baffled energy.



- A barrel which radiates heat quickly like a woodstove, while directing exhaust gases downward to a horizontal heat-exchange mass.
- A horizontal system of heat-exchange pipes to capture the rest of the heat from our exhausted smoke, convenient for built-in seating or bed designs,
- and conventional vertical (or unconventional horizontal) exhaust outlets to release the combustion gases outside the building.

Of course, in trapping all the heat in metal and masonry, we've invented a fireplace that lets off almost no light at all. On a dark night, the reflected flickering might be just enough serve as a night-light for a small child .. if they found underground flames reassuring.

But no system is perfect.

Light, and other needs like summer cooking or portable heaters, call for other solutions: less mass, different designs, and wise use of nature's gifts (our two feet, candles, and daily sunlight, among them). This Rocket Stove is an example of specialized but resourceful design to create efficient, clean, and comfortable heat with minimally-processed materials.

Other great examples are designed for quick heat, quick cooking, long baking, or other common needs.

Stay tuned for updates on the Rocket Mass Heater permitting process:
http://www.ErnieAndErica.info/rocketmassheaterpermitting

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