Biomass cookstoves and heaters

With the biochar crew at Living Web Farms

What is an (improved) biomass cookstove?

- Personal or family sized cooking appliance
- Metal or masonry construction. Locally sourced materials most appropriate
- Air supply is controlled
- Exhaust is usually vented to the outside
- Improved efficiency and safety over open fire methods
    - Through higher efficiency (more smoke is burned), less indoor pollutants
- Usually simple in design
- Biomass is the fuel
- Widely used in underdeveloped countries where biomass is primary fuel source

What is biomass?

- Definition: The total mass of organisms in a given area or volume
- Practically speaking: Biomass is plant matter that is not food. Sometimes the conversation includes landfill waste, sewage and animal wastes
- In this context: Biomass is the fuel. (***Feedstock***) Specifically,
    - Downed wood from storms, invasive species (1-4" dia.)
    - Sticks, orchard trimmings. (Up to 1" or so)
    - Wood chips. (Screened)
    - Sawdust. (Dry)
    - Dried animal dung

Why biomass?

LOCAL

- Low tech - accessible to everyone
- Nearly ubiquitous access to *some kind of feedstock*
- Reduced dependence on grid, fossil fuels
- Free…. sometimes
- Heat outside of the kitchen
- Make biochar

GLOBAL

- One third/one half of world's population cooking on fires every day. 4 million killed every year from cookstove smoke. (WHO 2012 data)
- *Innovation has potential to make huge difference*

Example: Traditional cooking vs. TLUD

Economy: Much less fuel, longer burn. More upfront processing
Improved Health: Very clean burn.
Women's Empowerment: Very little management necessary.
Biochar: Yes. Improved soils and alt source of income

“Wood doesn’t burn”

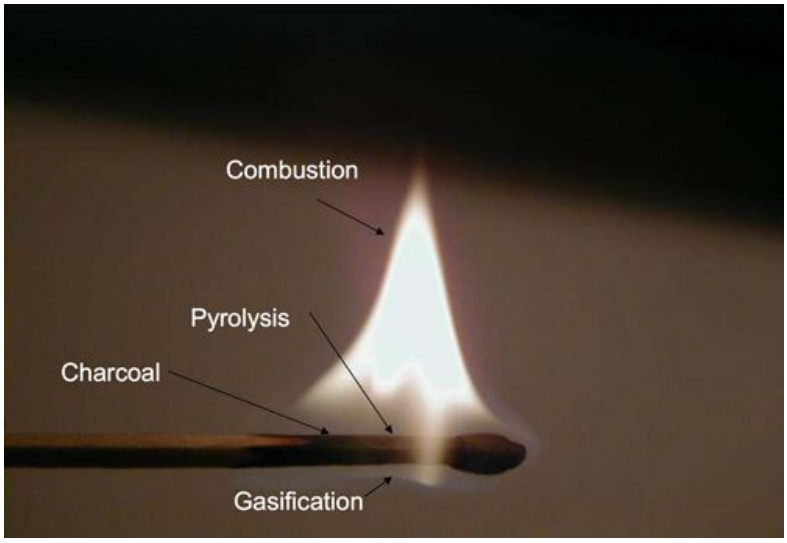
When sufficient heat is applied to wood: (tinder)

- Water boils out. Released as water vapor.
- Volatiles are driven out, burned in the presence of oxygen and heat.
    - In the form of visible smoke. - Actually tiny tar like droplets

Fire ‘takes off’ and:

- Process becomes ***exothermic***
    - Puts out it’s own heat, or, your fire is lit. No more need for tinders.
- Volatiles are further driven out as gasses and burned in the presence of oxygen
- Higher heat environment allows for more difficult volatiles to burn
- Simple gasses are created as tar ‘cracks’
- Simple gasses are burned and fire burns clean and hot (in the presence of oxygen)
- Carbon is leftover, and only then will begin to combust slowly. (Grill is ready!)

The Pyrolysis front: lack of oxygen at the core of the fire prevents char from combusting



- Some stoves are designed to cut this process short, leaving charred wood, we call biochar, leftover.
- High temperatures required
- Control of airflow required

Design Considerations:

- Combustion zone
    - Air/Smoke/Flame mixing zone
    - Clean burn involves maintaining high temperature at combustion zone
- Combustion air inlet
    - Means of controlling or limiting incoming air
    - Preheat air for easier clean combustion

- Stove top
    - Hot gas exits, interacts with bottom of cooking pot
    - Ideal riser height for max combustion without wasting heat
    - Maximize surface area of pot to hot gas for max heat capture

External considerations:

Availability of feedstocks

Variability of feedstocks

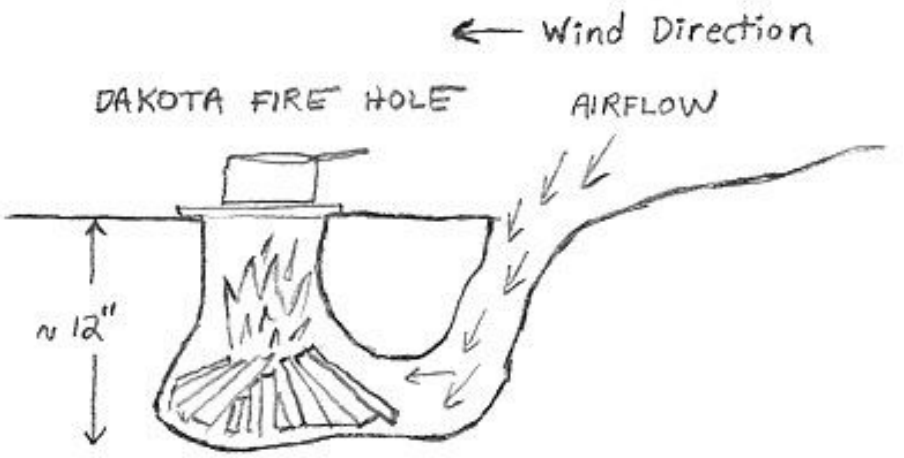
- Heat value - Btu/lb
    - Moisture has a huge effect on heat value, ability to burn clean
    - How do you dry your feedstock
        - 1 lb wood @ 10% - 7.2K
        - 1 lb wood @ 40% - 5.3K
    - Esti. 50K btu/cu.ft. - dry oak chips
- Particle size and shape
    - Effort required to achieve proper sizing
    - Fuel density in chamber
    - Air flow through fuel chamber

Operator influence

- Personal standards
- Community standards
- Availability of feedstock resources
- Available of human resources

Three Designs

- All share similar features that are found in the **Dakota fire pit**
- Top lit fire in pit with tunnel for combustion air.



Rocket stove

- Combustion air moves across horizontal tube, feeds under grate supported fire
    - Preheated combustion air
- Utilizes tall insulated chimney for more complete combustion
    - Flame stays hot until particulates are burned
- Very quick lighting
- Regulate by adding fuel. Tightly packed fuel in combustion zone limits air flow
- Scalable
    - Portable cookstoves
    - Rocket mass heaters
        - Similar to portable stoves - uses insulated chimney riser for complete combustion. Then clear, hot flue gasses are piped through channels in masonry before exiting through flue.

Sawdust stove

- Utilizes dry sawdust. Waste material in huge quantities from local mill and furniture shops
- Works for any small particle clumping biomass: rice hulls, planer shavings, reconstituted newspaper
- Two barrel system
    - Primary air feeds in below for combustion
    - Preheated secondary air enters at secondary combustion zone at top.
- Vented to the outside.
- Experimenters welcome

TLUD

- Pyrolyzing inner chamber of chunky biomass is started by lighting on the TOP
    - Accelerant helps!
- *Generation of wood gas is separated from the combustion zone*
- Combustion zone near stove top, above ‘pyrolysis front’
- Air is pulled up through the chamber. Both primary and secondary are preheated
- Preheated secondary air helps keep temperature up in combustion zone (clean burn)
- Process finished when flame snuffs out. Extinguish charcoal with water. If left alone, char will smolder into ash.
- Highly efficient use of fuel

Resources:

Online resource for understanding improved cook stoves
http://www.appropedia.org/Improved_solid_biofuel_stoves

All about wood combustion
http://mha-net.org/docs/v8n2/docs/WDBASICS.pdf

About smoke and managing a clean fire
http://www.woodheat.org/wood-smoke.html

A boy scout leader's guide to teaching scouts about fire. Actually pretty helpful
http://www.orionn49.com/science_of_fire.htm

7 different ways to build a rocket stove
http://sustainablog.org/2011/09/how-to-build-a-rocket-stove/

TLUD plans
http://www.bioenergylists.org/files/Construction%20Plans%202009-03-11.pdf

More on the TLUD
http://www.newdawnengineering.com/website/library/Papers+Articles/TLUD%20Handbook,%20Paul%20Anderson,%20v.2010.pdf

Soda Can Stove (liquid fuel - included here for fun)
http://www.thesodacanstove.com/alcohol-stove/how-to-build.html

Backyard Biochar with LWF biochar veteran Abraham Cluxton
https://youtu.be/8SgI6bcKNcE?list=PLCeA6DzL9P4vhMbHjDUmL2hlEPMssyL1i

WNC Resident Chris Farmer explaining biochar and TLUD operation
https://www.youtube.com/watch?v=DY8rIWtaLd8