Micro-Gasification: What it is and why it works

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Preface

Every successful cookstove project must address the four essential components: fuels for the heat, combustion to obtain the heat, applications of the heat, and human factors such as costs, cooking preferences/traditions, and user-friendliness. Failure in any of these four will lead to failure in the project. With regard to applications (such as single-pot direct heat or plancha griddle tops or baking), these are mainly issues of stove structure with a focus on the transfer of heat to the pot, and the applications are defined locally and solved locally. The human factors are much more personal and cultural, have less to do with the actual physical stove, but often require the greatest efforts and investments of time and money. Many cookstove projects are outstanding in the components of applications and human factors.

In contrast, the issues of fuels and combustion are often simplified to be "making sticks of wood burn," especially in the most simple stoves. But when additional fuel types are considered, and when issues of complete combustion and emissions are considered, fuels and combustion become more technical, scientific, and challenging. Clearly, the success of the Rocket stoves is linked to its superior combustion of stick-wood, which in turn justifies the truly significant efforts for applications and the human factors. In the case of gasification, there are yet to be any main success stories that include applications and human factors. But concerning fuels and combustion for cookstoves, this article will show that "micro-gasification is a technology that works."

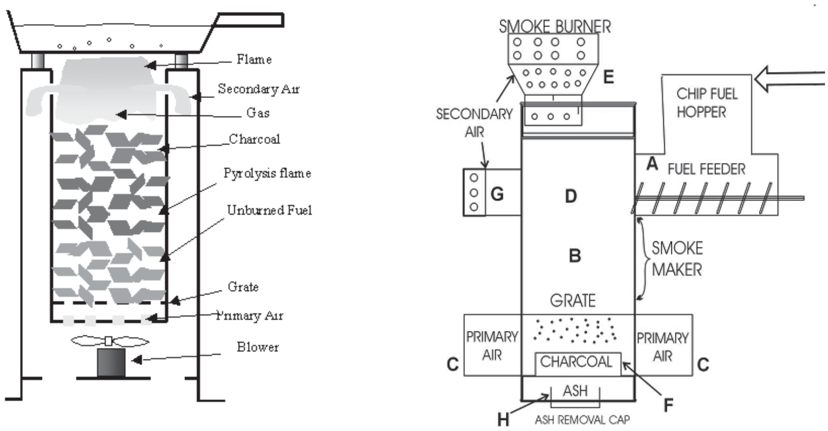


Figure 1 Diagrams of a forced-air TLUD, left, and an AVUD micro-gasifier, right. (*diagram: Tom Reed, left, and Chip Energy, right.*)

Introduction to micro-gasification

When burning any biomass, various gases and vapors called "smoke" must be driven from the solid fuel and then the smoke is burned. For over a hundred years scientists and engineers have known that combustion of biomass is cleaner when the air is well mixed with only combustible gases, instead of having the combustion occur in zones where solid fuel is still present. The creation of combustible gases that are separate from the combustion of those gases is a clearly distinguishing characteristic of a true "gasifier." Practical gasification in small devices (i.e., micro-gasification) was not achieved until 1985 when Dr. Thomas B. Reed conceptualized and accomplished what is now called "Top-Lit UpDraft" (TLUD) gasification with batches of biomass fuel. In 2004 Dr. Paul S. Anderson created a variation of traditional updraft micro-gasification with continuous-operation, being called AVUD for "Another Variation UpDraft" to distinguish it from conventional updraft gasifiers. To achieve these advances, Drs. Reed and Anderson mainly do practical experimentation based on combustion theory and principles*.

Both TLUD and AVUD micro-gasifiers can be constructed in several different ways. Figure 1 shows one diagram for each type. The distinguishing characteristic of these and any other true gasifiers is that the creation of the gases ("smoke") is separate from where the gases are combusted. Of crucial importance in these (and in any stoves) are the flows of primary and secondary air. In the gasifiers, the flows are separate. In most regular stoves, they are mixed. There are cases where the air flows are partially mixed together in the quasi-gasifiers (semi-gasifiers or partial gasifiers) that include several designs in China, the Vesto stove, and the air-jet fan-stoves of Philips and typical pellet stoves. Control of air flow leads to clean combustion, and control also helps prevent too much air entering and diluting the heat.

Micro-gasification in cookstoves

The TLUD gasifier stoves fall into two main categories based on having forced air or natural draft. Two with forced air are pictured in Figure 2. TLUD gasifiers operate with batches of fuel that are pyrolyzed, so they must be emptied and refilled. Therefore, a second fuel canister permits sequentially continual cooking.

The natural draft TLUD gasifiers utilize the principles of Anderson's

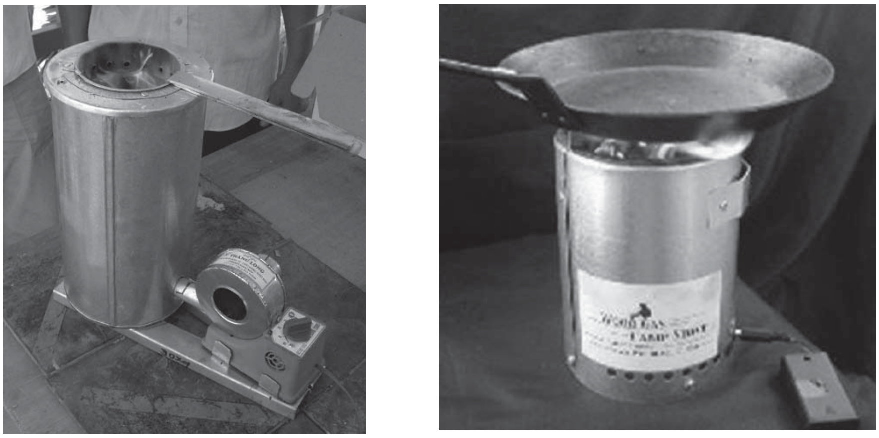


Figure 2   Reed's Woodgas Campstove (left) for sale on the Internet (US$55) and Anderson's Juntos B+ TLUD gasifier (with removable fuel canister) hand-made in Cambodia with GERES (estimated cost under US$20). For cooking, the pot can be placed on top of the unit or (better) be positioned on a simple pot support structure of any size so that the gasifier can be moved for refilling without disturbing the pot. (*photos: Tom Reed, left, Paul Anderson, right*)

"Champion" stove that won the "Kirk Smith Cat Pee Award" for clean combustion at ETHOS Stove Camp 2005. A 15 inch (38 cm) riser or "pre-pot internal chimney" is needed to achieve the natural draft, but additional chimney height is needed at elevations above 3000 feet (1000 meters). This design is maintained in Andreatta's TLUD testing unit, seen in Figure 3.

The AVUD micro-gasifiers are larger than the TLUDs and operate continually as a gasifier with feeding of additional fuel in from the side (Figure 4 and Figure 1). Both natural draft and forced-air versions are possible.

Results and experiences

The leading international advocate of TLUD and AVUD gasifiers (Dr. Anderson) has worked directly with tinsmiths in Mozambique, Brazil, India, Bolivia, and Cambodia to create locally-available TLUD cookstoves. Each experience was different, resulted in additional enhancements, and taught valuable lessons, including patience. Interest by users was always evident, but resources and determination to continue the projects have been limited. Only the December 2006 effort in Cambodia currently has an active agenda, and that Juntos B+ TLUD utilizes the advantages of forced-air from a US$2 blower from Vietnam (Figure 2 right). The original Juntos B has been fully described since 2004 in the Anderson and Reed (2004) presentation, and would be a good place for serious individuals to get a start on making a TLUD cookstove. Anyone interested in any of the TLUD or AVUD micro-gasifiers is encouraged to contact Dr. Anderson via e-mail. He is also posting information about these gasifiers at the Chip Energy website: www.chipenergy.com, but it is extremely difficult to cover the human factors of usage of a new stove technology without hands-on personal contacts.

Fuels

TLUD and AVUD micro-gasifiers excel in the variety of fuels that they can use. The fuel requirements are dry biomass that is the size of chips or small chunks through which the upward primary air can pass, but not blow freely in channels. Pellets and chunky briquettes are excellent, as are cherry pits and many other reasonable-sized seeds. Woody stems, twigs, stalks, and chipped and shredded wood are favorite fuels. TLUDS with forced-air can very successfully burn loose rice husks, but the duration of combustion is rather short (about 8 minutes for a 10 inch (25 cm) tall fuel canister). Stove developers and users who have a "large-wood-mentality" often express resistance about the efforts needed to make large wood into chip wood but actually collection of small wood (twigs and branches) should be encouraged, along with use of agro-wastes that are more easily cut apart or compacted together into appropriate sizes.

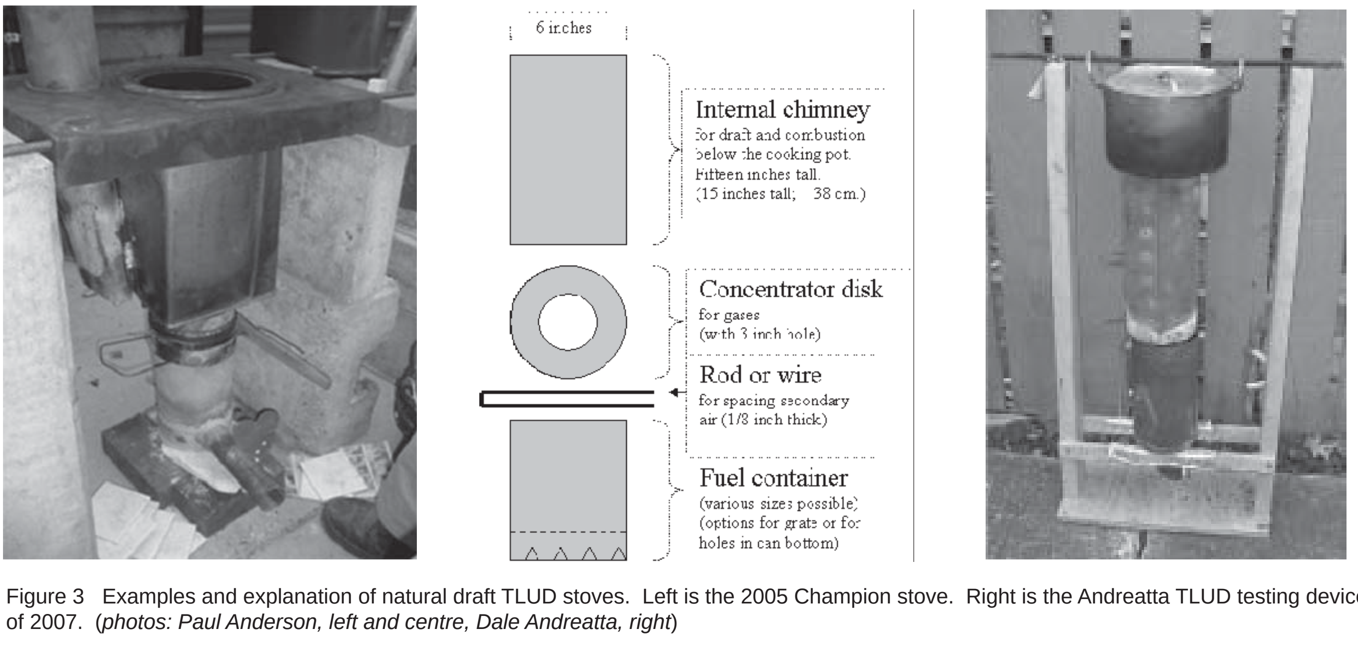


Figure 3   Examples and explanation of natural draft TLUD stoves. Left is the 2005 Champion stove. Right is the Andreatta TLUD testing device of 2007. (*photos: Paul Anderson, left and centre, Dale Andreatta, right*)

Conclusion

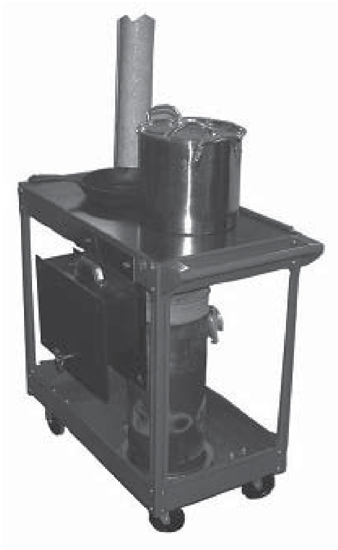
Micro-gasification TLUDs and AVUDs are exceptional in terms of fuel varieties and combustion that is very clean and can be quite easily controlled. With regard to heat applications, individual micro-gasifiers have been made for a wide variety of stove bodies, including plancha tops and single-pots both with and without chimneys. Units have been made in Mozambique, Brazil, Bolivia, India, Cambodia and the USA to show appropriate uses and sustainable costs, but there are not any projects with significant numbers of installed gasifier cookstoves. Although there are not many projects with micro gasification at the moment, the evidence above shows that "micro-gasification is a technology that works."

*The authors acknowledge the valuable assistance of Mr. Agua Das and also note the efforts with TLUD-related gasifiers by Dr. Mukunda of India, by Professor Belonio in the Philippines, by Dr. Dale Andreatta in the USA, and by GERES in Cambodia.

References

Anderson, Paul S. and Thomas B. Reed (2004). "Biomass Gasification: Clean Residential Stoves, Commercial Power Generation, and Global Impacts" Presented to the LAMNET Project International Workshop on "Bioenergy for a Sustainable Development," 8-10 Nov 2004, Viña del Mar, Chile. On the Internet at: http://bioenergylists.org/stovesdoc/Anderson/GasifierLAMNET.pdf

Andreatta, Dale (2007). "A Report on Some Experiments with the Top-Lit Up Draft (TLUD) Stove." Presented at the ETHOS 2007 Conference, Kirkland, Washington, January 27, 2007. On the Internet at: http://bioenergylists.org/stovesdoc/Andreatta/TLUD_Report.pdf



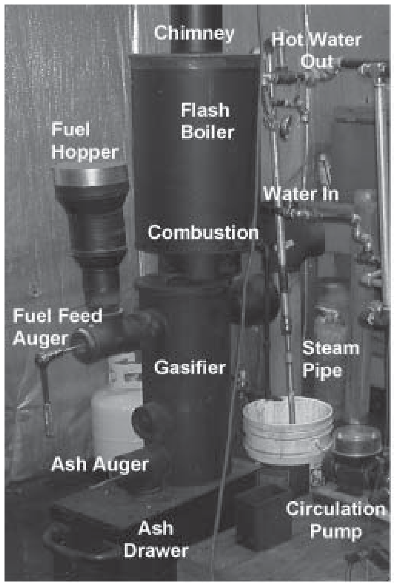


Figure 4 The AVUD gasifier is the lower vertical cylinder with its openings for fuel entry, ash removal, and air flows. Left is the open-cart version of the Chip Energy Biomass Grill (US$150) with the combustor in the tray under the plancha griddle top, plus the chimney. The cart is essentially "stove structure" that could be adobe blocks or stainless steel walls. Right is the Chip Energy Furnace for process heat (200,000 BTU = 211 megaJoules = 50,400 kcal) with combustion at the center of the picture and a flash boiler application in the upper cylinder. Other applications of process heat are easily adapted. (*photos: Chip Energy*)

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Profile of the authors

Paul S. Anderson has extensive international experience from his universityteaching career (Geography) and he has worked on micro-gasification since 2001 when he met Dr. Reed. since 2001 when he met Dr. Reed. He heads the international and improved cookstove (ICS) activities of Chip Energy with hands-on assistance to NGOs interested in the advantages of micro-gasifiers. For information on his ongoing work, see http://www.chipenergy.com/3rdworld.htm.

Thomas B. Reed is one of America's most respected experts on all forms of gasification and other biomass energy issues. He held positions at MIT, Colorado School of Mines, and NREL (National Renewable Energy Laboratory). His activities continue at the Biomass Energy Foundation (BEF) (www.biomassenergyfoundation.org).

Paul W. Wever manufactures heavy steel attachments for constructino equipment (see www.pwce.com), includeing cutting/moving large biomass. Since 2006 he and Dr. Anderson have created Chip Energy's designs and commerical products for biomass micro-gasification at scales for residences and cottage/small industry.

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