Proposal for an Urban Biomass Cookstove Project

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I. Proposal: "Air-controlled" biomass cookstoves should be seriously examined as viable replacements for charcoal cookstoves in urban and peri-urban communities in developing societies.

II. Situation, Problem and Opportunity: Throughout the urban areas of developing societies, charcoal cookstoves have an important role in residential cooking (including other small-scale cooking in restaurants and institutions). The acceptable energy sources for urban cooking are charcoal, LPG, kerosene, alcohol, and electricity. (Solar cooking is omitted because of housing densities and shadows.) All of them require significant "conversion" from their natural sources, and are deemed to be sufficiently clean energy, meaning a "lack of bothersome smoke" or very low emissions of particulate matter (PM). Charcoal competes well against those other high-order heat sources because it is easily and relatively inexpensively made from wood and other dry biomass by unskilled labor. But charcoal has two major drawbacks: A) very high levels of carbon monoxide (CO) emission; and B) the destruction of local vegetation from which the charcoal is made. Therefore, it is important to examine viable alternatives such as modern cookstoves that efficiently combust raw dry biomass such as wood which yields CO and PM emissions ("smoke") even lower than those of charcoal stoves. If these new stoves are successful, task-appropriate, and sustainable for urban cooking, they will also significantly reduce the problems of deforestation and greenhouse gases while providing urban residents with economical and convenient fuel alternatives.

III. Candidate Cookstove Technologies: As of March 2009, the stoves that use dry biomass fuels (mainly wood) without producing problematic levels of CO and PM emissions are all "air controlled" (in contrast to the "fuel controlled" methods of standard combustion). There are at least two major categories of air-controlled cookstoves. One includes the "TLUD" (pronounced "tee-lud"), an acronym for Top-Lit UpDraft pyrolytic gasifiers, with models that use natural draft (ND) or forced air (FA) with simple fans. The other category includes the "Fan-Jet" devices that utilize distinctive turbulent air flows from more powerful air streams. These technologies refer to the core heat-making-devices which are independent of any specific stove structure (the pot-holding body). Almost all of the candidate technologies can be adapted to serve the many varied, culturally-specific stove structures that suit local cooking styles, including those with more than one pot, plancha-griddle tops, high or low positions, and contruction materials of metal or mud or ceramic.

TLUD category: (TLUD emissions data may be viewd online at: www.bioenergylists.org/andersontludcopm and on a poster presented to the PCIA 2009 Forum, now reformatted as Figure 1 on the next page.)

Natural draft = TLUD-ND: Wendelbo's Peko Pe; and Anderson's Champion (both are 2008 models), and the Chip Energy Biomass Grill.

Forced air = TLUD-FA: Reed's Woodgas Campstove; BP's Oorja (or Urja); Belonio's Rice-Husk (several models); and Anderson's Juntos C (which is the Champion stove adapted for use with a fan).

Fan-Jet category (tentative name): (No directly comparable emissions data are yet available.)

Philips' stove (unnamed), Mulcahy's WorldStove (or his LuciaStove); and Dresdelle's Dell-Point model.

This document does not focus on the differences between these ten units, but on their similarity of having exceptionally clean emissions. All ten should be considered for possible use in urban settings (provided their suppliers make them available). We should expect that different units would be preferred in diverse societies, with factors including affluence, food preferences, and access to different dry biomass fuels.

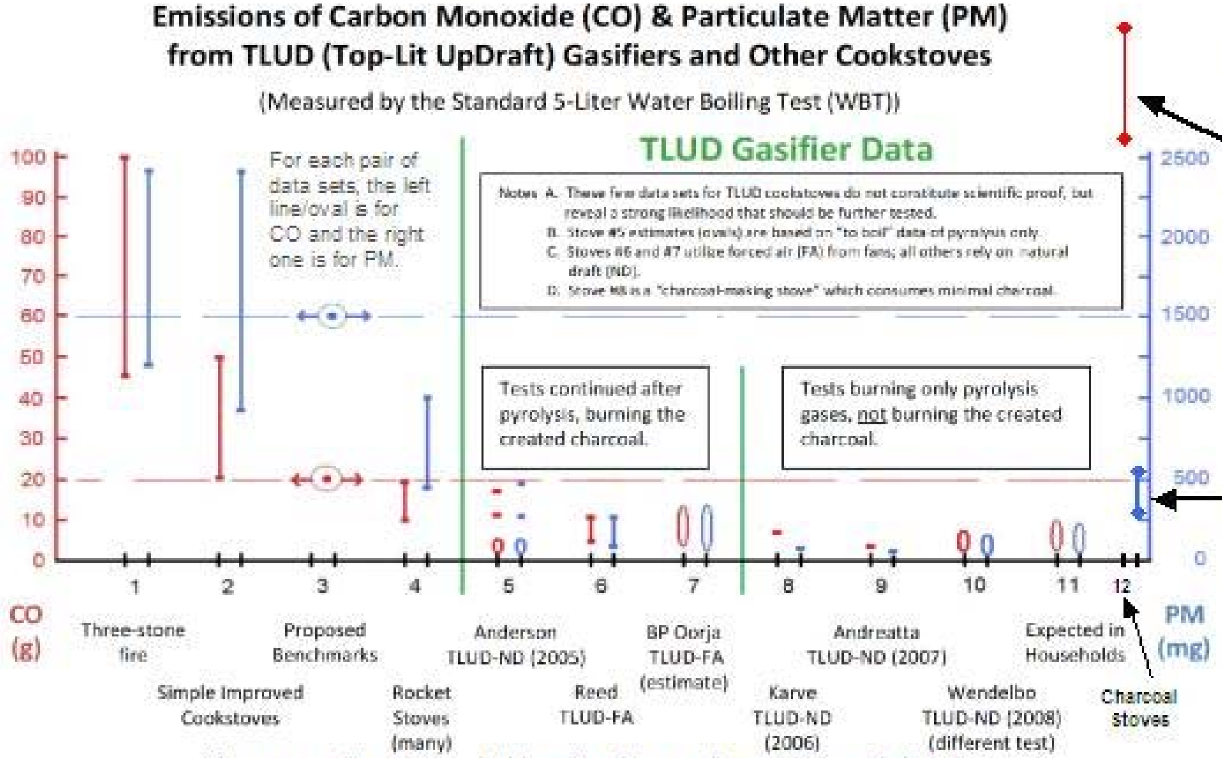
Figure 1: Comparison of CO and PM Emissions from Charcoal Cookstoves with Emissions from Wood-burning Cookstoves

Interpretation of CO and PM Emissions Data from TLUD Gasifier Cookstoves

Source: Reformatted from a Biomass Energy Foundation (BEF) poster presented at the PCIA Forum in Uganda, 23 – 28 March 2009.

Emissions of Carbon Monoxide (CO) & Particulate Matter (PM) from TLUD (Top-Lit UpDraft) Gasifiers and Other Cookstoves

(Measured by the Standard 5-Liter Water Boiling Test (WBT))



Charcoal stoves emit 110-135 g of CO (more than any of the wood-burning stoves) and emit 250 - 590 mg of PM (more than any of the TLUD gasifier stoves).

A 6-page paper with explanations is at: http://www.bioenergylists.org/andersontudcopm

Prepared by: Anderson, Wendelbo, Reed, and Belonio (2008) for the "Beyond Firewood" Conference. (Revised for ETHOS 2009)

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Results: CO and PM emissions from TLUD gasifier cookstoves are between one-fifth (20%) and one-fiftieth (2%) of those from most other solid-fuel cookstoves.

Recommendation: TLUDs should be considered to replace charcoal-burning stoves in urban areas.

IV. Project Notes:

1. **The remainder of this document** has numerous comments and facts to support the need and logic of having a project. Interested parties should carefully read the entire document before drawing conclusions.

2. **Willing partners** are needed in this project. The types of partners include:

a. **Stove Suppliers** (irrespective of end purchase prices). Most of the originators of these air-controlled cookstoves know each other (or know of each others' stoves). At least five of the ten have expressed serious interest in the project, but not all have yet been formally contacted. Individually, all are essentially competitors who need to be welcomed equally in any project. The common goal is to replace charcoal stoves (and save the forests, *etc.*), so the potential market is enormous, literally millions of cookstoves. So the motivation to the suppliers is sufficient if the devices can be made ready for the target populations.

b. **Urban community organizations** (associated NGOs or agencies) ALREADY ACTIVE with stove projects in urban and peri-urban places in developing societies, or at least in the surrounding countryside. They must already have credibility in the target community. They are the outreach arms, the contacts with the people.

c. **Independent researchers** or organizations **that already understand the stove issues** to guide the project and produce credible reports without self-interests. Considering the intricate web of stove funding and projects, there are no unaffiliated candidates, so a "steering committee" of appropriate individuals might be needed for this essential task.

d. **Fuel supply specialists** who can ensure proper supply lines of appropriate fuels (generally, air-controlled stoves use chip-sized fuels). This task also involves appropriate interaction with forestry officials and charcoal makers and transportation providers. The fuel quantities are very low at the beginning, but preparations must be made for expected future demand.

e. **Funding sources** can include the above partners who contribute mainly "in kind" materials and/or services as part of their operations and appropriately self-focused activities. But at least one major external funding source or project sponsor is needed. A coalition of sources would be ideal in anticipation of eventual outreach to urban areas around the globe. An estimated budget is suggested for each of the seven steps of the project, stated below.

V. Steps of the Project:

Step 1. Assessment of interest in the project by potential participants in each of the five types of partners named above. Who is looking to join the association and actively participate? We must have a commited group of serious members to initiate further plans and actions. An early version of the "steering committee" should be organized with a budget to proceed to at least Step 3. To be completed within 2 months (by the end of May 2009).
Estimated cost: No costs other than individual time and self-assessed expenses.

Step 2. The stove manufacturers and suppliers need to learn about each other's stoves and eventually meet, possibly seeing each other's stoves firsthand. The objective is to introduce them to each other and to initiate a discussion to see if, when, where, how, *etc* they might advance "air-controlled cookstoves" with clean-combustion throughout the world. Assuming all share the desire to solve the major problems (emissions, deforestation, *etc*.) associated with cookstoves, can they overcome their competitive barriers? Participants must determine early-on how open and free they can be with each other about their technologies **in relation to the developing world's problems with charcoal cookstoves.** TLUD stoves are a fully open technology without protections. Several other suppliers already have patents granted or pending. They need to determine guidelines for their cooperation relatively soon. Paul Anderson has volunteered to be a coordinator or facilitator among the stove suppliers, if that is agreeable to the others.

This second step can begin even before Step 1 is accomplished. If not sooner, it could be completed by mid-August 2009 if participants meet at Stove Camp 2009 (3 – 7 August 2009, at Aprovecho in Oregon, USA) or at the IBI Regional Meeting (9 – 12 August 2009, in Boulder, Colorado, USA). Step 2 is not an exercise to compare and evaluate the different types of stoves. Rather, it is an effort to review them objectively to understand the strengths of each one. Together the suppliers can examine "application" issues, including the stove structure(s) into which the combustion technologies are implemented. And there are shared concerns about the types of available fuels (present and future). Scientific evaluations until Step 3.

Estimated cost: Stove suppliers cover their own costs with the exception of possible external assistance arranged by the steering committee (if deemed necessary). Participants who are not suppliers also cover their own expenses if they wish to join efforts with these early contacts. Donors are asked for US$20,000 to establish a contingency account primarily to assure communications and information transfers equally for all potential suppliers.

Step 3. Laboratory-style evaluation of the participating technologies, conducted under the guidance of the steering committee. There are several ways to do this, each with different funding amounts. Two stove units should provided by each source of stoves. Testing requires perhaps two months. This effort could overlap with Step 2 and have reasonable results by the end of August 2009. Much depends on the range and depth of analytics seen as necessary in this stage/

Estimated cost: $80,000 (just a guess) from the donors, with stove sources also contributing. We are targeting stove-independent testing standards to understand the varied stoves more uniformly. Benchmarks with similar fuels, similar stove structures, etc. are desired.

Step 4. Fact-finding tests in one community. Requires 3 – 5 stoves from each supplier. The stoves are loaned for finite testing periods in households. The users receive free fuel, including several different types. Many aspects of the usage are noted and measured. The host urban community organization(s) have a crucial role and incur the expenses. This should lead to detailed plans for the next steps. This step may require 3 months, possibly completed by December 2009.

Estimated cost: $200,000 (another guess).

Step 5. Expansion to maybe 20 units of each type of stove (those that have been successful thus far) for a pilot study to be closely monitored in one or more communities. At least six months of trials in households are necessary.

Estimated cost: $800,000 (still guessing)

Step 6. A major test project with 100 to 300 units of each type, for use in at least four countries and involving a wide range of households.

Estimated cost: $2,000,000 to include substantial efforts with fuel suppliers and supplies, readjustment of charcoal industry workers, possible reforestations, stove-related health education, and appropriate reporting of all results.

Step 7. Move to full commercialization of test-proven, viable stove products and fuels. Continued financial support could be directed to special-need locations based on periodic assessments and requests. Governments that currently have subsidies for LPG, kerosene, *etc*. could consider policy changes to accomplish long-term energy and health goals and provide needed funding for their citizens.

Steps 1 – 6 have a total budget of US$2,100,000 plus "in kind" contributions (for discussion purposes)

VI. Some realities of charcoal.

Everything presented in this section is open for discussion and adjustment.

1. Experienced Stovers (including Richard Stanley and Otto Formo) have reported that standard, traditional charcoal stoves use about 2 kg of charcoal fuel per family per day. By weight, the energy in dry wood (~16 MJ/kg or 15 KBTU/kg or 3.5 Kcal/kg or 4.4 KW-hour) is about 60% of the energy in wood charcoal (~28 MJ/kg). That is, charcoal has about 1.6 times the energy of wood by weight. Therefore, if the efficiencies of combustion and heat transfer are about the same for a charcoal stove and a biomass stove, the daily fuel use of 2 kg of charcoal yields the same thermal energy as 3.2 kg of dry wood. We can call this a "Day's Cooking Fuel" or DCF. By this measure, the family would have 14 KW-hour of energy for a day of cooking, whether they use it for 7 hours of 2 KW simmering or nearly 3 hours of 5 KW high-temperature heat.

2. There is frequent mention that a standard, traditional 3-stove fire uses about 7-8 kg of wood per day. The improved cookstoves might cut that down to 2 or 3 kg of wood. But when accounting for cultural variations in cooking and less-than-optimum moisture in wood, a conservative measure of 3.2 kg of wood will fuel a family's cooking for a day. Certainly 3.2 kg of dry biomass fuel can provide a day's worth of cooking in a TLUD cookstove, conservatively matching a DCF of charcoal (2 kg).

3. The energy in wood is about 70% in the volatiles and 30% in the charcoal, but the weight is only 20% of the original wood weight. Assuming a 20% yield by weight, that represents 10 kg of wood per day needed to produce charcoal for a DCF (2 kg). This means that approximately three days of cooking could be done on the amount of wood used to do only one day's cooking with charcoal.

4. The proposed "Urban Biomass Cookstove Project" is based upon having at least one wood-burning biomass residential cookstove design that could burn 3.2 kg of wood efficiently and sufficiently cleanly for URBAN use. Clean burning is defined here to be as clean, or cleaner, than the emissions of charcoal cookstoves currently in use by millions in urban areas. For discussion, let us assume that such a biomass stove COULD be available eventually at widely-affordable prices. In short, residents could burn wood in urban areas instead of charcoal.

5. Some implications of charcoal replacement by wood:

A. Wood harvesting would be reduced by a factor of three, that is, only one-third of the current-use and future-trend wood supply would be needed. Forests might then have a chance to survive or become reestablished.

B. Noting that wood harvesters for charcoal makers would cut only 33% as much wood, two-thirds would lose their jobs. A portion of this job loss could be transformed to job creation if there is "pre-processing" of the wood into sizes appropriate for end-user stoves, but perhaps at half of the harvesters would lose their employment in the industry. Although there is open potential for job creation relative to reforestation or growing fuel crops, those jobs relate to separate projects that historically have not received much financial support.

C. At the char pits, virtually all of the makers of charcoal for cooking would lose their jobs.

D. The number of tons of fuel transported into urban areas increase by an additional 60 percent, but the density of the wood is at least double the density of charcoal, meaning a minor reduction in the volume to transport. If the truckloads were limited by weight, the same number of truckloads would be needed. But if limited by volume, each truckload could have perhaps 50% more weight, reducing the truck transport by 33%, with a corresponding reduction in transportation-related employment.

E. The above A – D implications could reduce fuel costs for the cookstove users, and increase carbon credits relative to the two-thirds (66%) of preserved forest.

6. Charcoal stoves emit 110 to 135 g of carbon monoxide (CO) during a standard 5-liter water boiling test (WBT). That volume is higher than virtually all of the tested wood-burning stoves, as shown in the summary graph of emissions in a document online at www.bioenergylists.org/andersontludcopm and on page 2 of this document. In other words, current charcoal stove usage in urban areas disregards the perils of high CO emissions. Charcoal stoves are terrible for CO emissions, and can be literally deadly in enclosed rooms.

7. Charcoal stoves are used in urban areas because of their low emissions of particulate matter (PM), also called "smoke." They emit 250 to 590 mg of PM in the WBTs (data from Aprovecho Research Center). That is lower than any of the "fuel-controlled cookstoves" (stoves regulated by the placement of wood into the burn area).

8. However, “air-controlled cookstoves” can produce even less PM than charcoal stoves, and can do so consistently. Low PM “air-controlled cookstoves” include the Top-Lit UpDraft (TLUD) pyrolytic gasifiers with either fan-forced air or natural draft. Other candidates are the Philips cookstove, the WorldStove, the Dell-Point burners, the Chip Energy Biomass Grill, and possibly others. All of these units are either some form of gasifier or utilize special forced-air capabilities. And at least a few of them can be manufactured at reasonable prices.

VII. Conclusion

Only now in 2009 are we finally realizing that solid dry biomass fuels can be burned so cleanly in small, residential-sized cookstoves that they can compete in the urban markets for domestic energy. The fuels are primarily wood, agro-waste-briquettes, rice husks, and even tablets of dung. Such fuels typically require some simple processing, such as cutting, compression, and/or drying. But they do not require any chemical transformation. All other fuels acceptable for urban residential cooking require more complex processing, even “refinement,” to be suitable fuels. LPG and kerosene are refined fossil fuels. Alcohol requires distillation. Electricity requires generators. And charcoal requires pyrolysis in kilns that are notoriously wasteful of 70% of the biomass energy.

This discussion has outlined critical factors which support modern “air-controlled” biomass cookstoves replacing charcoal cookstoves in urban areas. The discussion foreshadows the possibility of replacing some of the other (non-charcoal-burning) stoves and, perhaps, spreading to some rural areas. The obstacles include fuel supply, cultural inertia, adjustment of employment patterns, localized public policies, and necessary funds to accomplish beneficial change. But the lack of appropriate cookstove technology is no longer an obstacle, (which is to be proven in the first three steps of the proposed activities). The Partnership for Clean Indoor Air (PCIA) and its individual members are invited to consider this “Urban Biomass Cookstove Project” as an environment-critical proposal whose time has come for action.