The Future of Micro-gasifier Stoves:

Meeting the Goals of the Global Alliance for Clean Cookstoves

Keynote Presentation to the

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Outline

- GACC goals and Micro-gasifier contributions
- Background of Micro-gasification
- Current realities
  - Emissions, efficiencies, acceptance
- Issues of convenience, fuels and costs.
- Expectations within reason.

Energy Issues

- **Important for life:**
  - **Water, food, health, security, and energy.**
- **Sustainable, appropriate renewable energy solutions are in-hand.**
- **But they need implementation.**
- **Our specific interests here are cookstoves and related energy issues.**

Four Essential Components in Any Successful Stove Project

- **Fuels:** Stored and available energy.
- **Combustion Devices:** Release of energy.
- **Applications:** Uses of energy (stovetops)
- **Human Factors:** Cooking preferences, sizes, social perceptions, costs, availability, marketing, etc. **Culture and Acceptance**

GACC Goal

- GACC goal of 100 million stoves by 2020. or **“90 million stoves in the next 9 years.”**
- Proposing **equal thirds** of total = 30 million:
  - **Stick-wood stoves** (standard combustion of solid biomass) (leadership by Rocket stoves)
  - **Micro-gasifier stoves** (combustion of gases created by gasifiers) (mainly TLUD gasifiers)
  - **All other technologies** for making heat (solar, biogas, electricity, LPG, alcohol, charcoal, etc)

A Comparison of Stoves

- **Major classes of fuels – featuring biomass**
- **Efficiencies of biomass stoves**
- **Emissions of CO and PM**
- **Variety of acceptable fuels**

Major Classes of Fuels:

(In General) From Cleanest to Least Clean, From Most Expensive to Least Costly

- **Nuclear, solar, hydro-electric**
- **Gases and liquids from fossil fuels**
- **Gases from biomass**
- **Charcoal**
- **Stick-wood burning**
  - **Rocket stoves**
  - **Simple improved stoves**
  - **3-stone fires**

- ***Not based on combustion***
- ***Carbon positive & non-renewable***
- ***Biogas & Woodgas***
- ***Wasteful production***
- ***Traditional combustion with great variability***

Major Classes of Fuels:

- **Nuclear, solar, hydro-, electric**
- **Gases and liquids from fossil fuels**

- ***Not based on combustion***
- ***Carbon positive & non-renewable***

Those above can be too expensive and/or non-renewable.

- **Gases from biomass**

- ***Biogas & Woodgas***

Those below can have high emissions and low efficiency.

- **Charcoal**
- **Stick-wood burning**
  - **Rocket stoves, simple ICS, and 3-stone fires**

- ***Wasteful production***
- ***Traditional combustion with great variability***

Background of Gasifier Stoves

- **1985 - Reed & 1990s –Wendelbo 5000**
- **By 2005 – Prototypes and “toys for boys”**
- **2005-2009 BP Ourja Stove (w/ fan) 400,000**
- **Present: a few projects, but not yet 1 million TLUD cookstoves.**

Micro-Gasification Stoves

- **Gas-burning stoves**
- **That make their own gases**
- **From low-value biomass fuels.**
- **And at low-cost for the stove and the fuel!!**

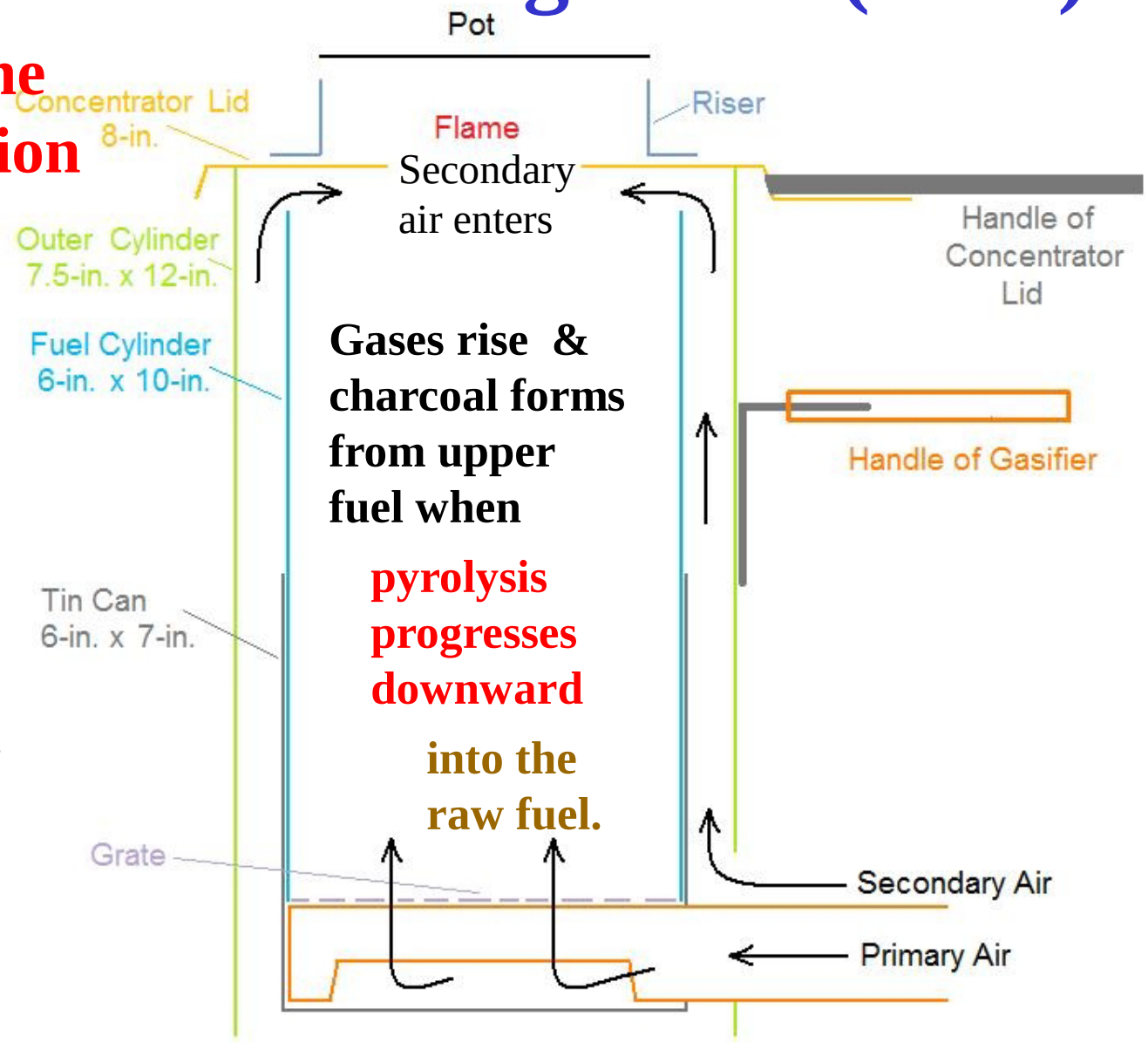
“Champion” TLUD-ND gasifier (2008)

Combustion zone & heat application

* * * * *

“Reactor” or gas generation device or pyrolysis unit, including fuel chamber inside.

ND = Natural Draft
















Variations of TLUD gasifier cookstoves.

[Top row is with fans.]

TLUD Stove Structures:

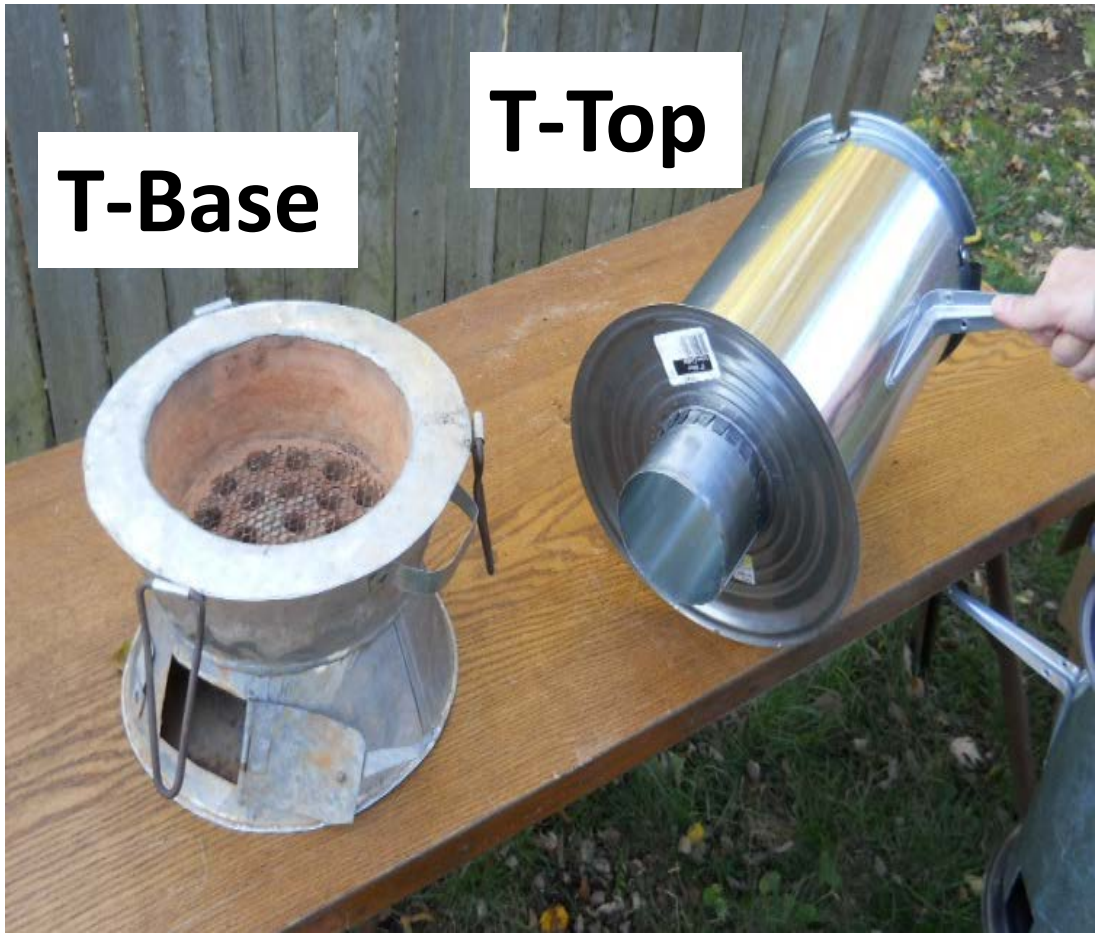
Where do you put the pot?

All options are possible.

TChar Variations of TLUDs

- **Originated in late June 2011.**
- **Many refinements in recent months.**
- **New variations in recent weeks.**
- **Daily innovations.**
- **This is truly the cutting edge of micro-gasifier cookstoves!!!**

TChar for Cooking



Lift off the pyrolyzer T-Top and the hot charcoal falls down into the container for COOKING.

TChar for making Biochar

Have a simple, closed box, bucket, pot, barrel, or hole-in-the-ground as the T-Base to receive the char, and then cover with a good lid.

Much larger T-Top, greater safety, and cleaner operations.

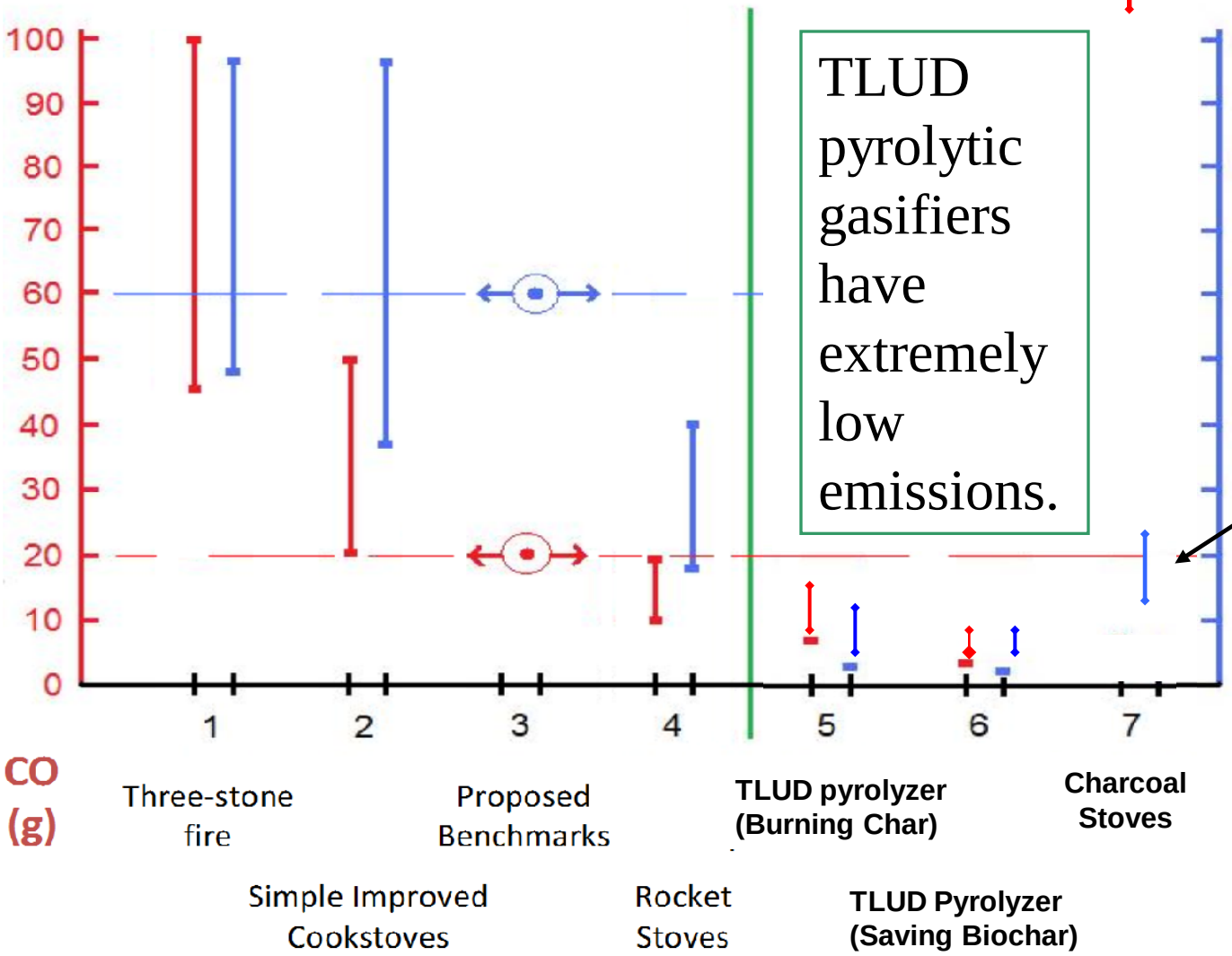
Lift off the pyrolyzer T-Top and the hot charcoal falls down into the container for CAPTURE.

Current Status Check:

Emissions

CO & PM Emissions From Cook Stoves

(Measured by the Standard 5-liter Water Boiling Test.)



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 the tested TLUD gasifier stoves).

Emissions of TLUD Stoves

- **Micro-gasifier stoves have the lowest emissions of any solid-fuel cookstoves.**
- **This issue is clearly resolved. See the data.**
- **Further testing is for refinements and is also verification of what is already known in quantitative terms.**
- **?? Are the emissions at levels acceptable for solving health problems of Indoor Air Pollution (IAP) ?? Only when physicians know for sure.**

Discussion About Emissions

. **Results will even get better. And if bad emissions are reported, a specific stove and stover are the cause, not the micro-gasification technology.**

However,

- **Low emissions do not really drive the stove efforts.** Highly important only to select specialists and enthusiastic/believers.
- **About the same importance as the ability to make biochar**, and the biochar enthusiasts are divided between soil issues and atmospheric/climate issues.
- **Important, YES. But are not true driving forces.**

Efficiencies of Biomass Stoves

- **Thermal transfer efficiency**
  - **20% to 40% is good.**
  - **Much depends on the stove structure, not on the combustion technology.**
- **Combustion efficiency**
  - **High for most stoves. 95% and above**
  - **But even 1% released as emissions can ruin health and the environment.**

Efficiencies are NOT focal issues.

The Real Focal Issues Are:

- **Convenience for users**
- **Fuels (types, supply, costs)**
- **Stove costs (production & retail)**
- **Acceptance (Inertia/Marketing)**

Convenience of TLUDs

- **Minimal fire tending (almost unattended).**
- **Batch system favors some applications or uses of heat, such as water boiling.**
- **Different sizes for different tasks.**
- **Portable versions are an easy option.**
- **Cleanliness (less soot on pots).**
- **Fast ignition to high heat.**
- **Considerable turn-down abilities.**
- **TChar puts charcoal into charcoal stoves.**

The Fuel Challenge

- Fuels FUELS **FUELS**
- **All other cookstove technologies use processed fuels (or at least semi-prepared fuels).**
- **Appropriate dry biomass fuels need to be available to the stove users.**

Abundant Renewable Dry Biomass

(but people only use a highly selective small fraction for energy)

Wood is the main biomass fuel. Collecting stick-wood can lead to deforestation. If wood is plentiful, wood chips are an excellent fuel for the gasifier stoves we will discuss.

Tree-wastes sawdust (pellets), trimmings, twigs, seedpods, leaves, coconut shells/husks/fronds, etc.,

Agro-wastes stems, hulls, husks, roots, cobs, by-products, dung, etc., some into biomass briquettes,

Urban wastes discarded combustibles including paper/cardboard, some D&C, and dried sewage,

Environmental excesses bamboo, dried aquatic invaders, reeds from wetlands, etc.

Thoughts on Fuels

- **“Water, water everywhere, and not a drop to drink….”**
- **“Biomass, biomass everywhere, and none of it is dry.**

  Biomass, biomass everywhere, and how the stovers cry.”
- **Create fuel supply chains for sized and dry biomass fuels. = Jobs !!!**

Future of TLUD Fuels

- **Supply and demand need to be balanced.**
- **Users will expect appropriately sized, dry biomass fuels to be conveniently available.**
- **Fuel supply chains with planting, harvesting, processing, distribution, and sales are BIG BUSINESS.**
- **Gasifier fuel supply means jobs, jobs, jobs.**
- **More money will be made in fuel supply than in stove production. (Chip Energy)**

Costs of TLUD Stoves

- **Champion TLUD in India costs $37.**
  - **Stainless steel; includes tripod pot-stand.**
- **Mwoto TLUD in Uganda costs US$20.**
  - **Tinsmith labor**
- **Tchar TLUD in Kenya costs US$22.**
  - **Includes a charcoal-stove base. Without advantages of quantity purchase of metal .**

Product Life of TLUD Stoves

- **Different metals for different components.**
  - **Thin-wall stainless in fuel cylinder.**
- **Expect most parts to last more than 2 years, and expendable parts are easily replaced.**
- **Appropriate decentralized mass production into almost every country.**
- **Flat-pack for savings on distribution.**

Carbon credit for cookstoves:

Perhaps
US$10 to $20 value
per TLUD stove
per year.

Sufficient to finance nationwide dissemination!

Expectations

- **Small fans for better air control.**
- **Possible TEG for electrical support.**
- **Specialty models for specific fuels and conditions, such as rice husk TLUDs.**

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- **Small fans for better air control.**
- **Possible TEG for electrical support.**
- **Specialty models for specific fuels and conditions, such as rice husk TLUDs.**

These are ALREADY DONE!!!!

But will be done better and widely spread by 2020.

Acceptance

- **Small studies show acceptance!!!**
  - **Malawi (ask Christa Roth);**
  - **Uganda (ask Karsten Becktel);**
  - **Central America (ask Art Donnelly and Paul Anderson);**
  - **Indonesia (ask Nurhuda).**
- **Larger studies are needed!!!**

And Yet to Come:

- **Applications for larger systems.**
  - **Presentation tomorrow.**
- **Reaching to the Developed World.**
  - **When the affluent societies face the issues of fossil fuels, current difficulties for renewable dry biomass fuels and stoves will disappear.**
- **Culturally flexible designs.**

“I estimate that only 20% of what can be known about TLUD technology is currently known.”

Dr TLUD

January 2012

Predictions

- **Ten dollar TLUDs that will last a year.**
- **The rise of “tincanium” when the stove industry embraces the manufacturing potential of modern metal can production.**
- **T-Fuels (fuels for TLUDs) widely and inexpensively available.**
- **The demise of traditional charcoal stoves.**
- **Multiple TLUD stoves in households.**
- **Special purpose TLUDs.**

End of Presentation.

But this file contains more slides about TLUD stoves and related issues.

Portals to TLUD information:

Paul S. Anderson, PhD "Dr TLUD"

www.drtlud.com

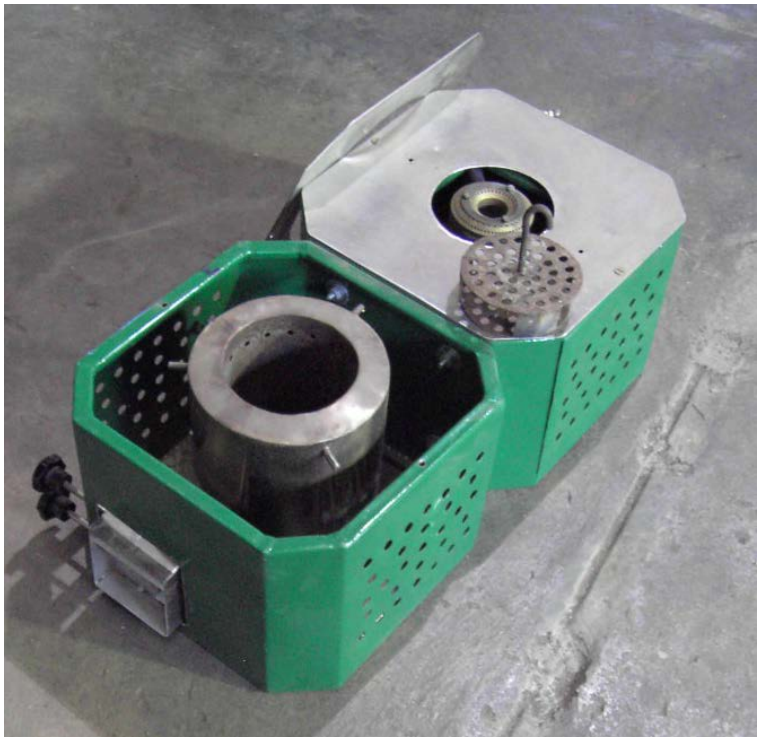
Biomass Energy Foundation (BEF)

www.biomassenergyfndn.org

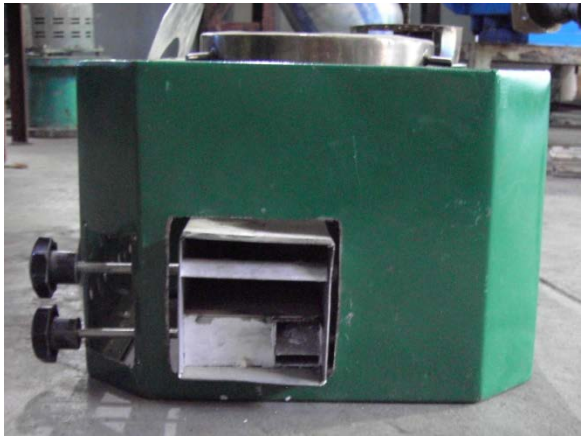
Chip Energy Inc.

www.chipenergy.com

BP TLUD by IISc-Bangalore



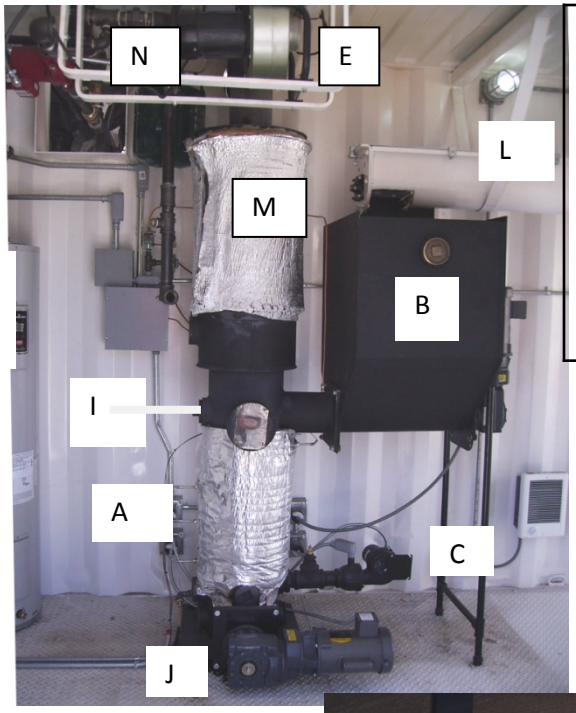
- Mentioned at PCIA-III in Bangalore, but very little information is released.
- 400,000 units installed in India by 2008.
- Uses BP-made pellet fuel.
- Control of fan-forced air.
- Subsidized price of US$17.



CHAB =
Combined Heat and Biochar

TLUD cookstoves and much more!!

Chip Energy Biomass Furnace and “Dragon”



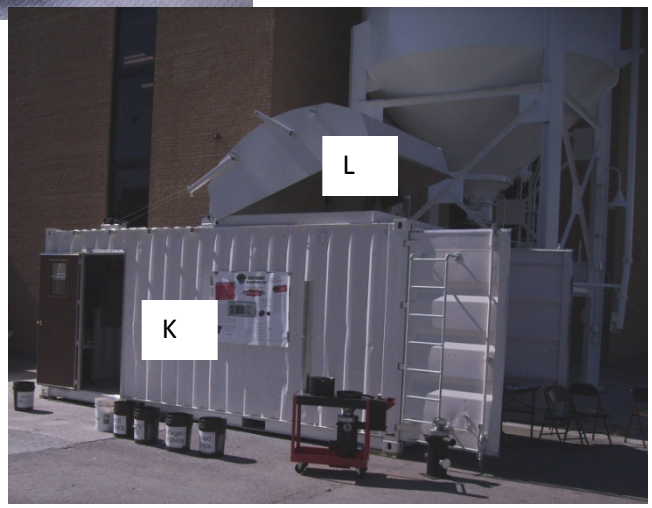
F

G

A. Gasifier 200K BTU (60 kWthermal)
B. Basic Fuel Hopper w/ Air Lock
C. Primary Air Blower
D. Secondary Air Blower
E. Draft Inducer Blower
F. Electronic System Controller
G. Controller Screen
H. Thermal Probes & Sensors
I. Auger for Fuel Entry
J. Auger for Biochar Removal

For the Biomass Furnace Only:K

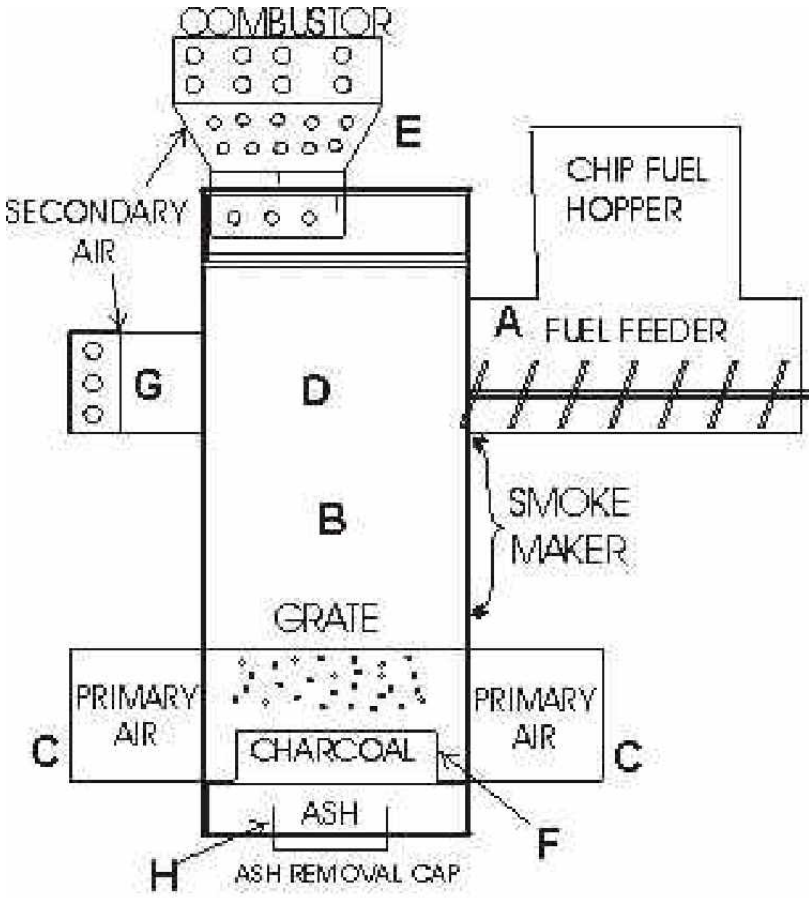
K. 20-ft. Shipping Container
L. Large main fuel hopper, with Auger
M. Flash Boiler 200K BTU
N. Hydronic Pump and Pipes
O. Advanced Electronic System Controller and Screen



AVUD Gasifier by Chip Energy

- UpDraft
- Continuous feed
- 180 K Btu/hr (50 KW thermal)
- 500 lbs/24 hr fuel yields 100 lbs biochar

Flash boiler



Chip Energy Biomass Furnace

(in 20 ft container)

www.chipenergy.com

Goodfield, Illinois

Medium, as in 55 gal. drums

- **Low overhead, simple technology – TLUD pyrolyzers**
- Individuals
  - John Rogers www.spacecoastprogressivealliance.org/joomla/the-environment/1147-bamboo-john-makes-biochar-for-small-farms
  - Doug Brethower (MO) www.freedombiomass.com
- Organizations
  - BEF CHAB Camps www.biomassenergyfndn.org
  - UB International (Ovens) www.biochar-international.org/regional/ubi
  - Re:Char (assisting ACON in Kenya with Nat.Geog.) www.re-char.com
  - SeaChar (National Geographic sponsored project in Costa Rica)
- Others www.biochar.bioenergylists.org/company
- TChar Barrel-size of the TChar cookstoves (next)

Small, as in Cookstoves

- TLUD stoves make charcoal, and there are many projects, but not much is used as biochar.
- NG projects in Kenya and Costa Rica (w/ Dr TLUD)
- The struggle against traditional charcoal stoves
  - To reduce or stop forest destruction, e.g. Haiti.
  - Alternative stove called TChar (TEE-char) makes possible **charcoal cooking with TLUD char in ONE stove** that has a TLUD T-Top and a charcoal T-Base.
  - Alteration for making biochar!!! Good potential where people do not cook with charcoal. ➔ ➔ ➔

Photos of Champion Gasifiers Made and Used in India - 2009

A humanitarian project near Chennai, India, sponsored by the Sunset Rotary Club of Bloomington-Normal (Illinois, USA).

Anderson's "Champion" TLUD made by Servals Automation

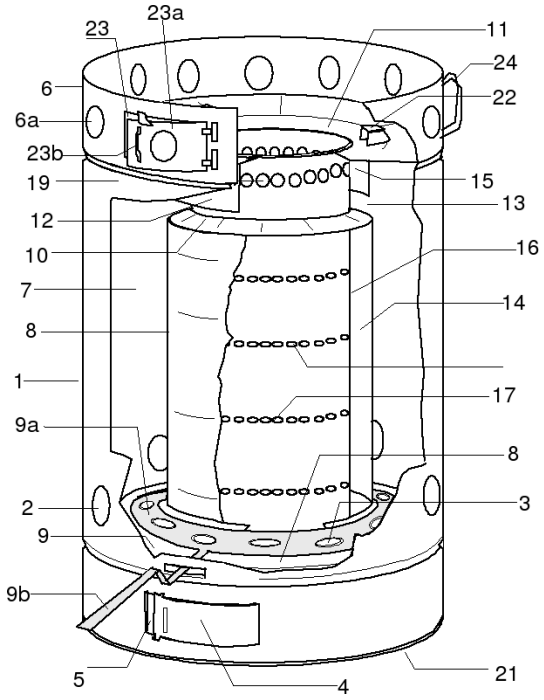
Prices depend on the stove configuration, including gasifier and stove structure for heat application.

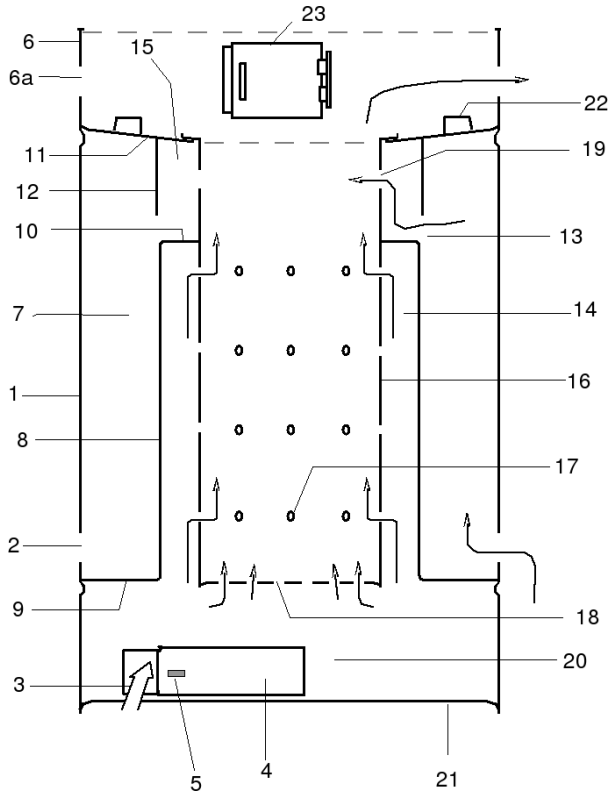
Full set in stainless steel with 2 reactors costs US$32 in Chennai..

Finalized design and production started in Chennai in January 2009. Test sites are needed.

Nurhuda's TLUD in Indonesia

2500 units of model UB-02 have been produced and sold at $10.





Reed's Woodgas Campstove

- Now produced in three sizes in India with 100% stainless steel construction.
- Price: US$55.
- Several thousand have been sold.

Belonio's Rice Hull TLUD – 2008

Stainless steel; now being produced in Vietnam.

Models of Rice Husk Gas Stoves

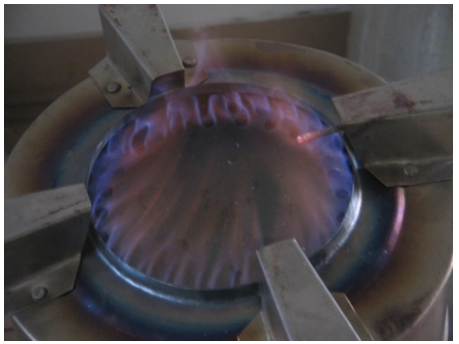
With Drum-Type Burner

With Plate-Type Burner

With Open-Type Burner

The MJ Rice Husk Gas Stove

- The MJ Rice Husk Gas Stove is an improved version of the Rice Husk Gas Stove developed in the Philippines in 2005 by Belonio.
- Gaseous fuel with luminous ***bluish pink*** color flame is produced by burning rice husk with limited amount of air.
- A small computer fan supplies the air into the bed of burning rice husk.



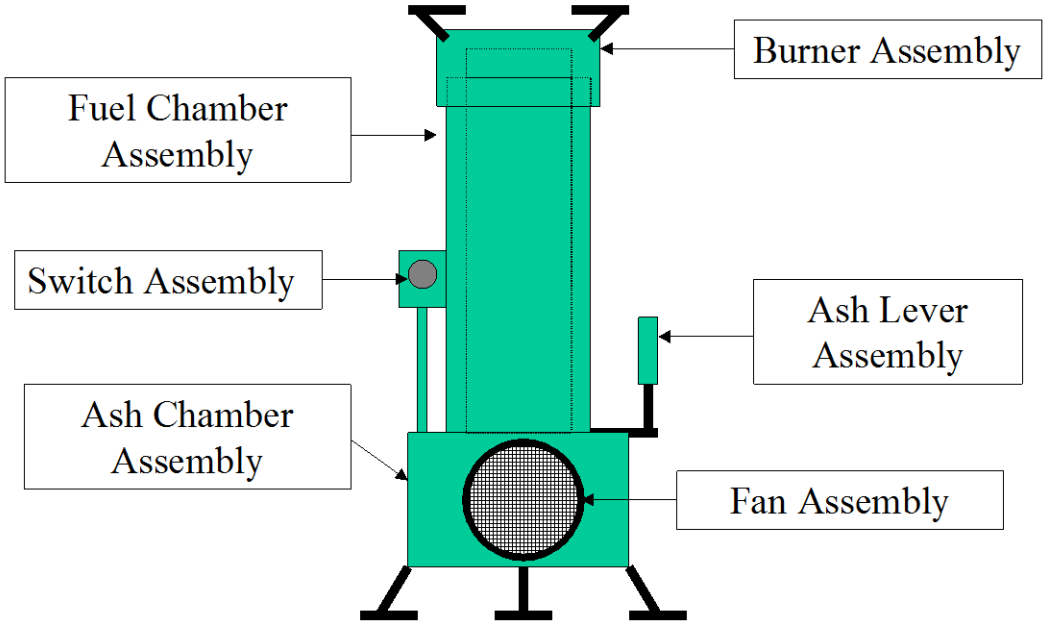
Water Heaters with TLUD Gasifiers – India 2004

Stove Tops for Sunken Pots

Belonio's Rice Husk TLUD gasifier [with forced air]

- Achieved the first consistently successful TLUD combustion of a fine-particle biomass waste, specifically rice husks.

Belonio's Rice Husk TLUD gasifier [with forced air]:



Schematic Drawing of Rice Husk Gas Stove

Belonio's Rice Husk TLUD Gasifier [with forced air]

- The first TLUD gasifier yielding a consistent light-blue flame and low emissions. Suspected to be because of the characteristics of rice husks.

Belonio's Rice Husk T-LUD Gasifier [with forced air]

- Successfully demonstrated remote (delayed) combustion of gases from a TLUD gasifier (all others use close-coupled combustion).

Belonio's Rice Husk T-LUD Gasifier [with forced air]:

- Began limited production in the Philippines, with a cost of US$200 per unit, now less than $40.

Alexis Belonio and some of his stoves.

<US$10

With more features
$20 to $50.