

FabStove (TLUD) Wood Heaters

Seven-minute SLAM Presentation to the
5th Wood Heater Design Challenge, Sept 29, 2022

Paul Anderson is internationally known as “Dr TLUD”
because of his “pyroneer” TLUD work since 2001.

David Lello in South Africa is the initiator, designer, and
fabricator of FabStoves with their TLUD capabilities.

This presentation slide set is already available at <https://woodgas.com/resources> so that you
can get all the details that I must skip over in this fast 7-minute presentation.



Innovation in Combustion



Top-Lit UpDraft TLUD ("tee-lud") micro-gasification creates a pyrolytic front that migrates downward, sustained by a controlled upward flow of primary air. Pyrolysis creates charcoal and woodgas.

The created woodgas burns extremely cleanly with secondary air that enters separately above. The emissions are similar to those of LPG, NG, and Biogas. **This gas-burning stove makes its own gases from solid fuel.** This is TLUD pyrolytic gasification.

Full gasification would also char-gasify the created charcoal and leave ash or clinker.

Regular wood heating that does not separate the primary and secondary combustion cannot attain the same cleanliness.



Consistent Performance

2022-07-07 FabStove Test



Batch operation with no user actions.

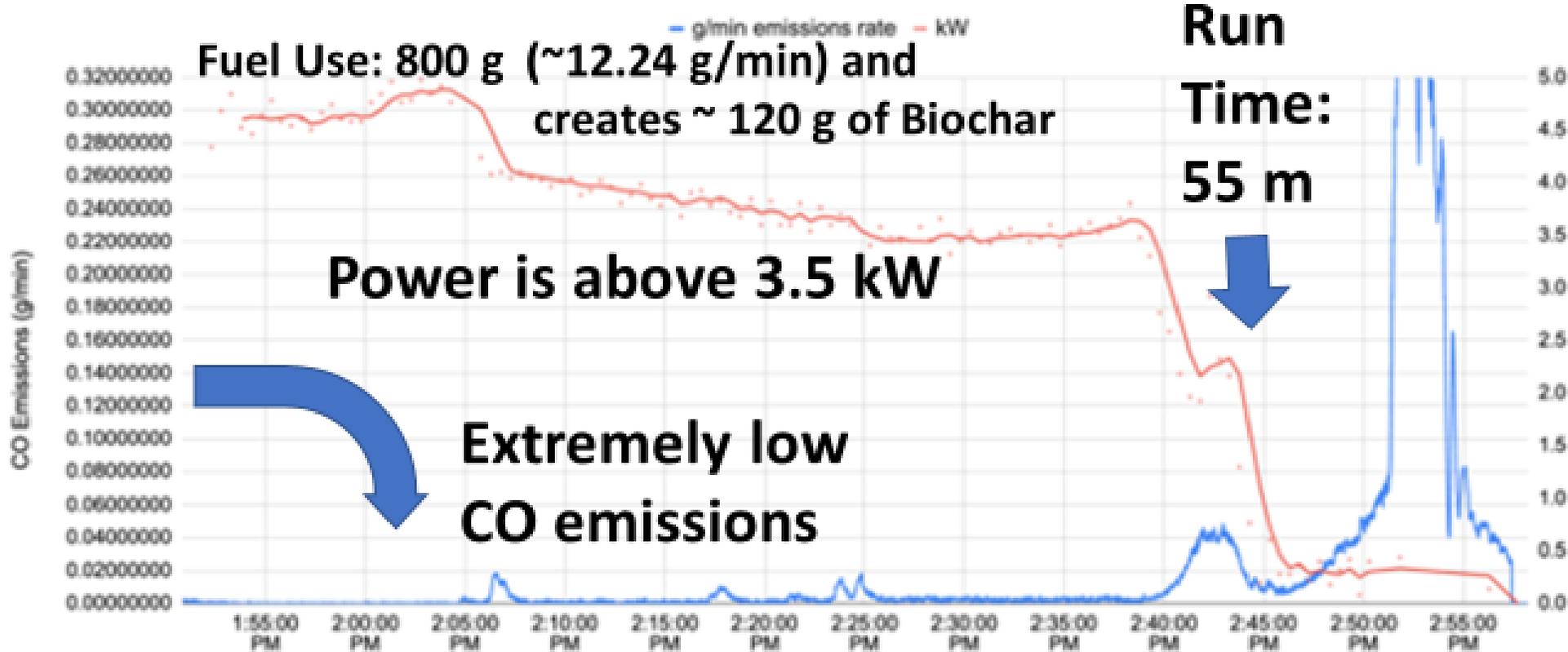
2022-07-07 Fabstove Test

Run Length: 55m

Fuel Use: 800g (~12.24 g/min)

kWh output: 3.43kWh

avg kW output: 3.74kW



Duration: ~1 hour. Up to ~2 hours with larger unit and slower fan.

PM_{2.5} readings are similarly very low.

This is the time when the yellow-redish fire changes to light blue and the pyrolysis has finished. Remove and extinguish the gasifier.



Do not burn the charcoal. It has \$ value.

Every batch has the same result.

Recognized Consistent Performance

The United Nations' energy agency ESMAP classifies TLUD as the **ONLY "Modern Advanced Clean Cooking Solution"** that uses a solid fuel.

The other equated clean fuels-with-stoves are Biogas, Alcohol, LPG/NG, Electricity and Solar.

Source: <https://woodgas.energy/wp-content/uploads/2020/12/Stove-Classification-2017-04-10.pdf>

Super clean combustion is mastered.

The next steps are:

to have an optimal TLUD design and to include a heat exchanger

Classification of Stove Technologies and Fuels (v. 1.0 – 2017)										
Div	Not-Clean Cooking Solutions (ICS)				Modern Advanced Clean Cooking Solutions (MACCS)					
Fuel	Solid Biomass as Solid Fuel: Wood, dung, agro-refuse, charcoal, (Coal is localized and fossil solid fuel.)				Solid Biomass as Initial Fuel for Creation of Gases & Liquid Fuels			Non-Biomass Fuels		
Cooking technologies	Base-line: Three-stone fire	"Improved Cooking Solutions" (ICS)			★ Advanced Clean Cooking Solutions (ACCS)			Fossil-Fuel Stoves Processed petroleum to become gases.	Electric Stoves Electricity remotely generated. Much from fossil fuels.	Solar Stoves Dependent on sunlight.
		Legacy & Basic ICS Stoves	Intermediate ICS Stoves	Charcoal ICS stove	★ Combustible gases and liquids for cooking are created ("refined" or "derived") from initial biomass that undergoes an intermediate process.					
what is combusted?	Biomass as Solid Fuel	Biomass as Solid Fuel	Biomass as Solid Fuel	Charcoal has only 30% of energy of wood.	★ Woodgas from Biomass: Gas-burning with gases from solid dry biomass; makes char.	Biogas from Biomass: Gas-burning with gases from solid wet biomass.	Liquids from Biomass Ethanol, Methanol from biomass.	LPG, NG (nat. gas), DME, (Exclude kerosene) (Coal is solid and seldom clean-burning.)	Electricity Derived from renewable hydroelectric, solar, & (min) biomass. Also from fossil fuels (oil, gas, coal) and nuclear.	No combustion present in solar cook-stove.
Key Features and Stove Types	Three rocks to support a pot; Open fires and sheltered fires. Many supplemental stoves.	ICS Clay, mud, brick, and simple metal to contain fire Artisan produced.	ICS Rocket-style stoves w/ high fuel efficiency and moderately clean burning.	ICS Charcoal stoves cause deforestation and high CO emissions.	Pyrolysis in fan-assisted or natural draft TLUD gasifiers produce gases & "C negative" charcoal with re-sale value. TChar stoves can replace charcoal ones.	Anaerobic digestion of biomass decaying in containers yields combustible gases. Always local production; biogas is never transported.	Industrial distillation of biomass yields liquid alcohol to burn in appropriate stoves. Many as supplementary.	Processed fossil fuels, with high fuel and combustion efficiencies; LPG in metal cylinders or NG via pipelines. Subsidized. "C positive".	No combustion present in the stove; dependent on grid power; batteries are not sufficient. Electric or induction heating elements in a stove structure.	Reflective "dish" or solar-collector box, with need to orient toward the sun. Solar box ovens.

Adapted and expanded from *The State of the Global Clean and Improved Cooking Sector*, ESMAP 2015, Tech Rpt 007/15, Figure 1.1 (p. 13).

Innovation in Design

The FabStove has three major components not found in other TLUD stoves



FabStove

Model 1.5

Available in USA.

Models are being designed for

Three basic thermal sizes:

10, 20, 30 k BTU

[3, 6, 9 kW/h]

The **Stove frame** supports different uses, whether for cooking or **room heating** or other tasks and can make everything look very attractive.

The **Gasifier / fuel canister** is easily **Removeable** for **continual operations** with another canister; **safe containment** of the hot charcoal until extinguished.

The **Forced Air Base** (red) makes this stove truly **FABulous**. **The fan is not in the gasifier.**

Modular, easy maintenance, stainless steel where needed, long lasting, industrial production, low cost. Appropriate, aspirational, and affordable for millions of families in Africa.

With appeal for American camping, patio cooking, and emergency preparedness.

Innovation in Wood Heating

First time TLUD w/
heat exchangers

Many options for different clients and suppliers.

Shell and tube

Straight, spiral, "S-folded", multi-tube, and mini-tube



Hydronic

Flash boilers
Water heaters
(small systems)

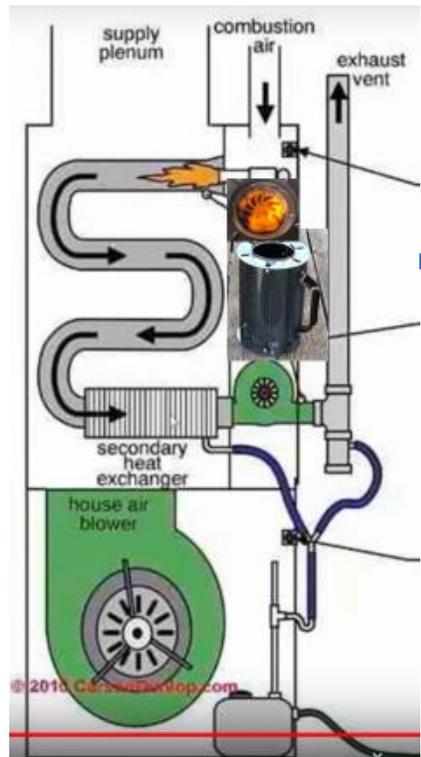
Masonry or high mass



Custom built into benches, floors, walls or iron box.

Condensing

Requires super clean emissions for >90% efficiency



Innovation in User Friendliness

With a little experience, FabHeater operations are very easy.

Pre-use (Set up once)	Initiate (One minute)	Enjoy (50 to 120 min.)	Terminate (Two minutes)	Repeat (Optional)	Post-use (as needed)
Installed and ready	Load and ignite	Duration of up to 2 hours depends on unit size and fan speed.	End of heating session		Disposition of biochar
Pellets in a bin. Starter and ignitor on hand. Extinguisher box is empty. Have holding container for extinguished biochar.	<ol style="list-style-type: none">1. Use a scoop to fill pellets into gasifier / fuel canister(s).2. Add some starter. (~5 grams – ~2 tablespoons)3. Turn on Air Base low speed and any heat exchanger fan.4. Ignite with match / lighter.5. Insert onto air base. Observe stable fire.	Change to high fan speed if desired.	<ol style="list-style-type: none">1. Receive signal (beep or light) that the batch is ending.2. Verify no yellow flames.3. Remove canister. Glove is not required but be careful to not touch the top. Turn off the fan on the air base.4. Place canister with hot charcoal into extinguisher box and close the door.	Repeat "Initiate" with a second (cold) canister.	The extinguished biochar is dumped into an appropriate holding container.
				 <p>Extinguisher box can be pretty or (shown) a cardboard box with aluminum foil lining.</p>	Biochar can be used in gardens, sold or given away.
<p>There is no ash removal and no soot accumulation in the chimney.</p>					

Expected Performance – What to test?

We will bring **3 power sizes** of TLUD FabStoves for cleanest emissions testing.

We will attach at least **3 types of heat exchangers**. Shell & tube; High-mass iron; Condensing

We will have 2 days at BNL to **select the best combination** for full testing.

A. We expect the **30k BTU power with condensing HE to have >90% efficiency**.

But is it the best for American markets, and at what price?

B. We expect the **10k BTU size with Shell & Tube** heat capture will be the **most economical, popular** for emergency preparedness, and of interest to FEMA.

But will it have sufficiently high thermal efficiency?

C. We expect the **20k BTU integrated** (not combined) **FabHeater** to be of special interest for price, **features (including illumination)**, and attractiveness.

But is the American market ready for such a product at this time?

All of these TLUD wood heaters help fight climate change.

Expected Performance - Biochar

TLUD and other true pyrolytic gasifiers create **woodgas that is ~70% of the energy of the wood**, leaving **~30% of the energy in the form of charcoal**, called biochar if it is to be sequestered.

"Thermal" efficiency is measured based on the 70% released heat.

"Fuel" efficiency measurement denies the value of the biochar.

The **value of the biochar is far greater** than the value of ~30% of biomass thermal energy, **because:**

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The **value of the biochar is far greater** than the value of ~30% of biomass thermal energy, **because:**

"Biochar fixes carbon." (K.W.)

Biochar fixes (makes stable) biomass carbon for multi-century sequestration.

Biochar fixes (helps correct) the problem of **excessive CO₂** in the air.

Pyrolytic devices (incl. TLUDs) provide the only **CARBON NEGATIVE** heating of any type. **We can fight climate change with TLUD technology.**

Physical biochar has additional benefits for soils and plants and has **commercial value.** *****Improve your garden.*****

****Carbon credits earn \$ benefits****

Expected Performance & Commercial Potential

Additional features being developed:

TLUD cooking (with hood, off-grid & non-fossil) →

Attractive appearance(s)

Visible-flame illumination →

Sensors & controllers with **IoT**

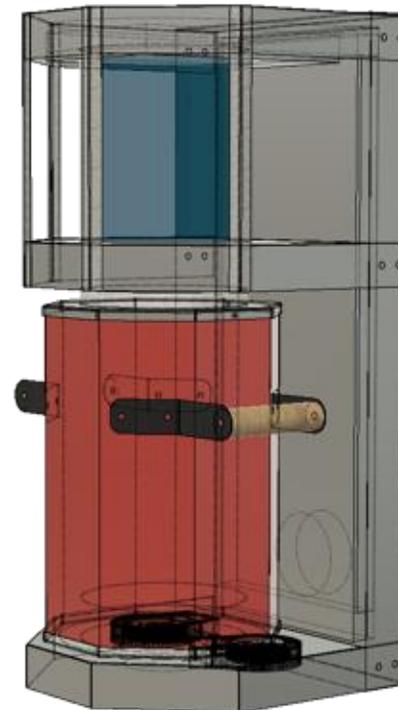
TEG electrical power for:

LED electric light, battery charging, radio, fan, etc.

Integration with solar-home systems

Accessories for user friendliness

Expect further creativity !



Conceptual design of integrated model



**Carbon
NEGATIVE
heating!!**

Commercial Potential

The near future is to have ZERO fossil fuel for simple heating.

End US residential heating emissions that exceed 500 million t CO₂e/yr. (~10% of total USA emission.)

Better done sooner rather than later. Even better if carbon negative.

To be **carbon negative** (that is, to removed carbon) will be a **major advantage or a necessity.**

All aspects of the wood heat industry need to help solve our climate crisis.

Six Markets for Pyrolytic Heat

Large units of 30 to 50k BTU:

1. **Northern states:** Cold climates need larger units. (We can do something extra!). Seeking partners.

Small units of 10 – 20 k BTU:

2. **Tiny houses, mobile homes,** single-rooms.
3. **Southern states:** supplemental heat.
4. **Emergency preparedness:** for FEMA and families. In Feb 2021 frozen pipes burst in over 500,000 Texas homes with average damage of \$27,000 ! Preventable with FabStove heat.
5. **Custom units** per customer preferences, *e.g.*, on a mobile cart or high mass or totally out of sight.
6. **Others:** First Nations, military, international, etc.

Many existing businesses can join with our efforts.

Our Team and Your Future

Co-Leaders: Paul Anderson and David Lello have brought the TLUD woodgas technology to the **Fabstoves intended for millions of families in Africa.** Funding / partners are sought.

Future Associates: **For FabHeater** product lines in America, **we seek American expertise and partners** for:

heat exchangers – All, but especially condensing types

manufacturing -- Existing capacity for volume production

marketing -- Distribution and point-of-sale networks

finance – Funding to facilitate all of the above and more

users – **You!! America needs carbon negative heating ASAP.**

Contact: Paul Anderson, PhD psanders@ilstu.edu

Websites: www.woodgas.com & www.fabstove.com