CHAB Chat – Residential

Subtitle:

The Possible Role of Combined Heat And Biochar (CHAB) in Your Future.

An "Open Air" Discussion Focused on
Combined Heat and Biochar (CHAB) for Households

Overview by Paul S. Anderson, PhD (aka "Dr TLUD")

Email: psanders@ilstu.edu

First discussion on 2 June 2023

Anderson has worked on small pyrolytic devices and processes since 2001.

Documents referenced here are at website: https://woodgas.com/resources

Today we have
an introduction to over 20 topics in 5 categories
Each topic could justify hours of presentations and/or establish professional careers

From these topics we will decide which are to be discussed first and when.

Those marked in Green will have further introductions today.

- Basics
- Uses
- Technologies
- Financial issues
- Examples / Case Studies

Introduction to over 20 topics: Basics

- **Some definitions of terms and concepts**
- **Our objectives**
  - Now (2023) — Current State of the Art
  - Future (2050) — Net Zero new emissions by 2050 – Life as it could become
  - At household scale — But also interested in larger efforts?
- Who's objectives, and how are they different?
  - Impoverished people? — Daily living and survival?
  - Middle-class? — Save the planet, have fun, learn?
  - Affluent? — How to make more money?

Introduction to over 20 topics: Uses

- Uses of physical biochar:
  - Into soils;
  - Into construction materials; Other.
- Uses of woodgas:
  - Captured (condensed) as valued chemicals
  - **Combusted for thermal energy or for clean disposal of biomass.**
- **Uses of thermal energy (What energy sources are carbon negative?)**
  - **Cooking;**
  - **Hot water;**
  - **Space heating;**
  - **Electricity (TEG);**
  - **Drying;**
  - Light

Introduction to over 20 topics: Technology

- Biomass types and supplies
  - Wood (sourced from timber)
  - Agricultural residues
  - **Processed biomass fuels (pellets)**
- Specific Technologies for biochar production and use
  - Retort
  - **TLUD (Top Lit UpDraft)**
  - **AVUD (Anderson Version UpDraft)**
  - **Flame cap**
  - Flame curtain ("air burners")
  - Heated screw / auger
  - Industrial burners

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) Legacy & Basic ICS Stoves	Inter-mediate ICS Stoves	Char-coal ICS stove	★ Advanced Clean Cooking Solutions (ACCS) Combustible gases and liquids for cooking are created ("refined" or "derived") from initial biomass that undergoes an intermediate process.			Fossil-Fuel Stoves Processed petroleum to become gases.	Electric Stoves Electricity remotely generated. Much from fossil fuels.	Solar Stoves Depen-dent on sunlight.
what is Combusted?	Bio-mass as Solid Fuel	Bio-mass as Solid Fuel	Bio-mass as Solid Fuel	Char-coal 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 com-bustion present in solar cook-stove.
Key Features and Stove Types	Three rocks to support a pot; Open fires and shel-tered fires. Many supple-mental stoves.	ICS Clay, mud, brick, and simple metal to contain fire Artisan produced.	ICS Rocket-style stoves w/ high fuel efficien-cy and moder-ately clean burning.	ICS Char-coal stoves cause defor-esta-tion and high CO emis-sions.	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 supplemen-tary.	Processed fossil fuels, with high fuel and combustion efficiencies; LPG in metal cylinders or NG via pipelines. Subsidized. "C positive".	No combus-tion 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).

Introduction to over 20 topics: Financial

- **Costs**
- **Income**
- **Carbon markets** for
  - ER Emission Reduction
  - CDR Carbon Dioxide Removal (BCR = Biochar Carbon Removal)

- **MRV** (Measurement, Reporting, and Verification) and Certification
- **What MRV is available for biochar at residential scales?**

Introduction to over 20 topics: Case Studies

- Deganga Case Study 2016 (and update for 100,000 TLUD stoves)
- Fabstoves, available in North America and coming elsewhere
- Alliance for Green Heat and BNL Wood Heater SLAM 2022

Note: This ends the overview of over 20 topics. The following slides are about the indicated (in green) topics selected for additional comments.

Clarification of some terms and concepts

- "Biochar" is the catch-word. Actually, **we are discussing pyrolysis.**
- Pyrolysis creates **biochar and woodgas** from dry biomass.
  - Pyrolysis is physical-chemical transformation by heat with no or low oxygen.
  - Biochar is much like charcoal but is destined to not be burned.
  - Woodgas is the off-gases of vapors, tars, non-condensables, etc.
    - **Woodgas is "Biogas",** except that that word is already taken by anaerobic gas products.
    - **Woodgas (or "pyrogas") is "dirty"** and if allowed to cool it would appear as smoke, soot and tar.
    - **Woodgas is not "syngas"** or "producer gas" for engines. (from cleaner full gasification processes.)
- When combusted, woodgas releases about 70% of the biomass energy.
  - This is energy that "literally grows on trees." & Woodgas can have chemical value.
- Biochar generally contains about 30% of the energy of the biomass.
- **The value of biochar can far exceed its value as energy.**

Three Technologies for biochar production

- TLUD (Top Lit UpDraft)
- AVUD
- Flame cap (RoCC, Kon Tiki, Ring of Fire, cones, pyramids, trenches)

combined with

Uses of thermal energy

- Pyrolytic energy is the ONLY carbon negative energy!!
  - Cooking: TLUD micro-gasifier stoves; Anila (inconsequential);
  - Hot water:
  - Space heating: AVUD
  - Electricity (TEG):
  - Drying:
  - Light from flames: Not major.

gives us a matrix/table

(next slide)

Table of Key Variables and Case Studies and Examples.

Technologies & Uses	TLUD	AVUD	Flame Cap
Cooking	Deganga Case Study 2016 with update for 100,000 TLUD stoves) Fabstove – N. Am. and World		(A small RoCC kiln could provide heat for institutional cooking and hot water.)
Hot Water	William (Bill) Knauss	EPA SBIR project by Chip Energy	
Space Heating	William (Bill) Knauss **Green Heat Poster**	**Green Heat Poster** **Wood Heat SLAM (See Slide deck)**	(Cost of the heating system is much more than the kilns.)
Electricity	PowerPellet stove with TEG – Kenya		
Drying	**Poster & SLAM slides are at: https://woodgas.com/resources in the section on Heating and Cooling.**		

Poster for Wood Heater R&D Workshop 2022-01-11&12

Two Types of Carbon Negative Heating and Cooking Can Earn CO_2 Removal Credits

Category: Advanced hydronic heater design concepts, and more.

TLUD ("tee-lud")

Top-Lit UpDraft (TLUD) technology powers the **world's only carbon negative clean-burning advanced cookstoves.** TLUD is batch-operated.

Designed for developing societies that still cook on solid biomass or coal and need very low costs.

Could become essential (by 2050) when developed societies cannot use fossil fuels and electricity is likely reserved for higher purposes.

Two basic types: Natural Draft (ND) and Forced Air (FA; fan assisted). Both produce good biochar.

The TLUD-FA Fabstove is available in North America from www.blueskybiochar.com . See video at that website.

The Fabstove uses biomass pellets for Tier 4 performance. See documents at https://woodgas.com/resources

Participation sought for R&D for vented space-heating versions or funding overseas projects

Presenter - Inventor:

Paul S. Anderson, PhD
(a.k.a. "Dr TLUD")

Also invented Rotatable Covered Cavity (RoCC) kilns (patent pending) for larger volumes of biomass. Biosketch is on page 50 of his Dec 2020 white paper *"Climate Intervention with Biochar"* at https://woodgas.com/resources

Email: psanders@ilstu.edu Phone & text: 309-531-4434 in Illinois.

Introduction:

After 4 years of R&D, in 2005 Dr. Paul Anderson developed **two ways to control pyrolytic gasification in very small chambers.** Both types are **carbon negative because they create biochar** while making woodgas for clean burning. Called TLUD and AVUD, they are described in *"Micro-Gasification: What it is and why it works."* (2007) at https://woodgas.com/resources

Vision and Why:

The world climate crisis requires by 2050 that no heating be done with fossil fuels. The biomass-heater business sector must grow to serve hundreds of millions of homes and buildings worldwide.

Using pyrolytic gasification, we can remove many Gt of CO_2 for sequestration as biochar with additional benefits and value. Fortunately, AVUD pyrolytic technology is already proven to work at appropriate sizes.

Growth opportunities will include product refinement R&D, industrial capabilities for production, installation by service sector, biomass fuel supply chains (pellets+), and societal commitment to do what is needed.

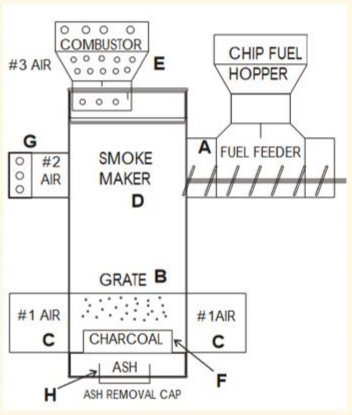
With carbon financing, these heaters should be especially attractive. The **financial benefits of carbon negative heating** can be enabled with data capture and verification using CERCS CharTrac (https://cercs.io).

My white paper "*Climate Intervention with Biochar*" discusses the many components. The "WHY" is because our future depends on prompt actions that we can do now.

AVUD ("a-vud")

Anderson Version UpDraft (AVUD) gasification is functional in small units suitable for **both home and larger heating applications.**

History: 2005 – Discovery / Invention; 2006 - 07 – Concept proven with product development by Chip Energy, LLC, with several sizes including a Chip Energy biomass grill; 2007 – Publication; 2008 – 10 -- With an **EPA SBIR grant** Chip Energy created its Biomass Furnace w/ 200 K BTU/hr (58 kW) continuous heat capacity.



The **US EPA SBIR program** for three years (2005-07) requested proposals for "outdoor wood-fired hydronic heaters (OWHH)" as alternatives to smoky outdoor wood boilers. We were the only applicant ever to be accepted. We constructed a fully automated unit called the "Chip Energy Biomass Furnace." Although successful, we were not selected for Phase II funding. Four units were constructed.

Technology: In 2010 Chip Energy introduced a new type (AVUD) of micro-gasification Biomass Furnace that allows industries, schools and municipalities a solution to stop using fossil fuels to heat their buildings. The Biomass Furnace is a virtually smokeless, high efficiency computer-controlled automated continuous replacement of outdoor boilers. It can use diverse biomass fuels, but pellets are preferred. No patent (yet). We offer much proprietary knowledge.

Difficulties, limitations and inactivity: AVUD technology works fine, but the units were too powerful and too expensive (~$12K) for residential needs, and not sufficiently developed for larger buildings. Both Anderson and Chip Energy moved on to other projects and the wood heat industry was focused on cordwood fuel and residential scale. Today we face climate change, possible CDR funding and new priorities.

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.

FabStove Wood Heater: "FabHeater"

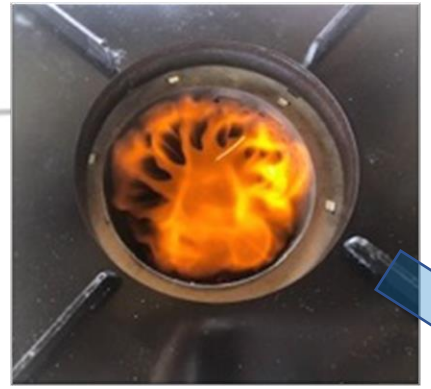
"The future of Wood(gas) Heating"

Innovation

TLUD ("tee-lud") micro-gasification creates woodgas and biochar.

Woodgas burns cleanly with secondary air

Pellet fuel

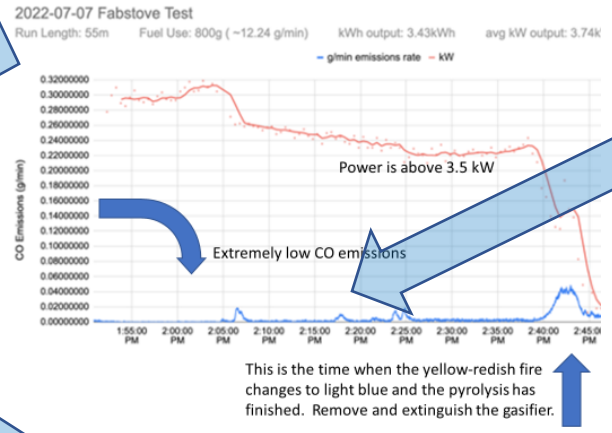


"Biochar fixes Carbon"

Carbon Negative to fight climate change.

Biochar has value for carbon credits and for soils and crops.

Consistent Performance



Heat goes into Heat Exchanger of any type:

- Shell & tube
- Masonry
- Hydronic
- **Condensing**

Expected Performance

> 90% efficiency of the released heat

Super clean emissions

Commercial Potential

Affordable

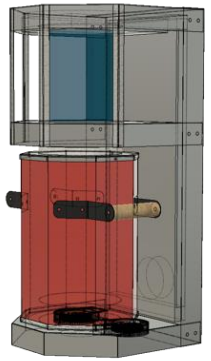
Economical

Appropriate sizes

Future features:

- Cooking
- Visible light
- TEG elect. power

Emergency preparedness



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Electricity	PowerPellet stove with TEG – Kenya		
Drying			

Knauss TLUD heating & cooking devices

- Selected images from the Knauss 5-minute video at: https://youtu.be/u0eJ6LRcKhI

A project in northern Mexico mainly uses abundant no-value pecan shells for heating homes with these TLUD heaters.

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Drying	**Numerous documents are at: https://woodgas.com/resources**		

TEG makes electricity while cooking with pellet fuel in Kenya

- Add some water to the Powerspot generator.
- Start your pellet burner.
- Begin to cook and generate your electricity to charge as fast as an AC plug!

Electricity while cooking! Ecological, cleaner and much cheaper than coal!

PowerPellet

PowerPellet is the combination of our thermoelectric technology and the use of pellets as fuel.

Attaching our TEG to a pellet burner specially designed by PowerSpot to worktogether, a constant electric current of 8W is generated while cooking!

It charges smartphones, tablets, power banks, rechargeable batteries, and lights up to 20 LED bulbs. It can also charge two phones simultaneously, or charge and light at the same time.

Financial

- **Costs** **On the low side because of small sizes and less complications.**
  < $10K; < $1000; < $100; Do-It-Yourself; Earn money as business.
- **Income** **Value of the energy, the physical biochar, and the carbon impact.**
- **Carbon markets** for
  - ER Emission Reduction ---- Replace fossil fuels for simple heating
    - Estimate at least 2 ER credits/yr per stove @ $8 each yields ~$16 from $50 TLUD stove per HH.
  - CDR Carbon Dioxide Removal ---- Truly Carbon Negative with BCR Biochar Carbon Removal
    - Estimate one CDR credit/yr per stove @ $100 to $150 each yields more than the cost of the stove.
    - There is a lack of risk capital in partbecause of uncertainty of carbon markets with new technologies.
- **MRV** (Measurement, Reporting, and Verification) and Certification
  - **What MRV is available for biochar at residential scales?** **CERCS CharTrac**

CERCS™ CharTrac: MRV and more

CERCS
cercs.io

Progressive Web Application for Charcoal/Biochar-Producing Cookstove and Kiln Operations

- Designed for mobile devices (smartphones, tablets, laptop computers)
- Enables secure (encrypted), real-time (timestamped) data collection in locations where Internet/Mobile Data connectivity is limited, restricted, or unavailable
- Utilizes smartphone/tablet sensors and technologies (GPS, Touchscreen, Camera/Scanner, Bluetooth, etc.)

immudb

immudb

STARS 8.2K

OPEN SOURCE IMMUTABLE DATABASE

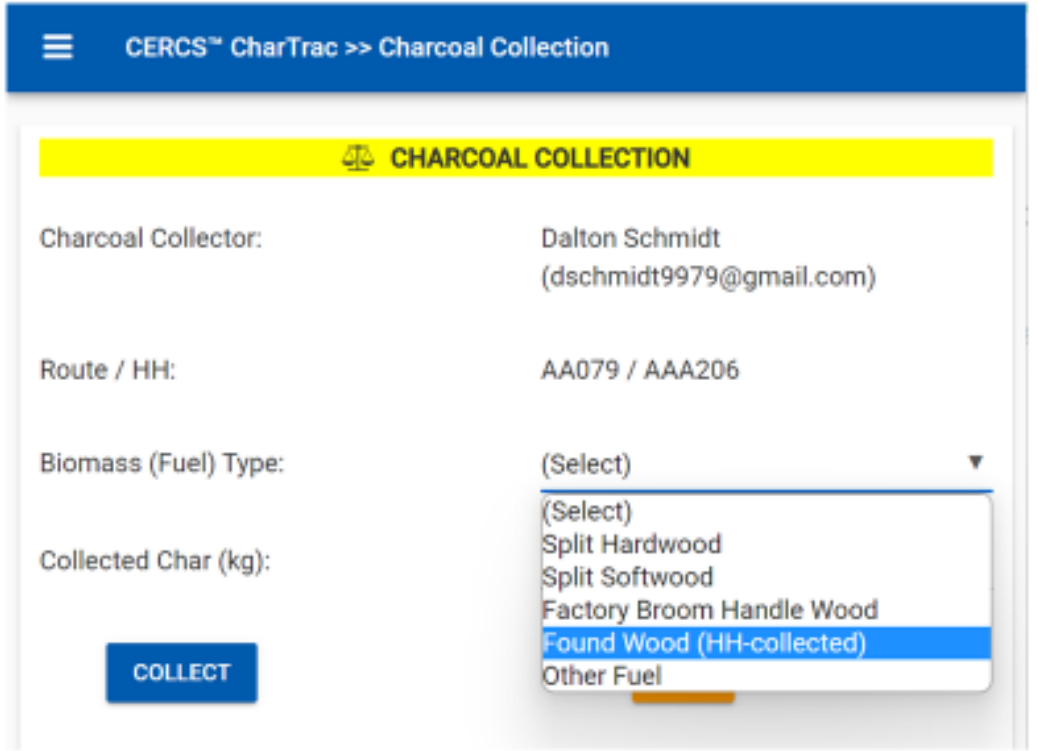
- High performance and easy to integrate
- Supports both Key/Value & SQL
- Cryptographical client-verification, tamper-resistant, and auditable
- Versioned and temporal queries subject to cryptographic verification

immudb was chosen the fastest growing Open Source Project by Ross Index

Algorand

jupyterlab TNG

IPFS



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.

Note: The "resource" documents were not presented today in detail.

Most of these materials are available at https://woodgas.com/resources

- Contact:
- Paul S. Anderson, PhD
- Email: psanders@ilstu.edu
- Mobile and WhatsApp: +1 309 531 4434 (USA central time zone)

Our objectives

- **Our objectives**
  - Now (2023) Current State of the Art
  - Future (2050) Net Zero new emissions by 2050
  - At household scale But also interested in larger efforts?
- Who's objectives, and how are they different?
  - Impoverished people?
  - Middle-class?
  - Affluent?
- **Do we have further meetings and discussions?**
- **What do we want to discuss?**
- **What are our objectives? (Raised hand voting.)**

Open for discussion.