Transition to TLUD Stoves for CO_2 Removal (CDR)

with Biochar and Climate Benefits

A recorded presentation to the ETHOS Conference 2023 **[27 – 29 January 2023** ***www.ethoscon.com*** **]**

Conference Theme: "*Don't just talk about the great things you're doing – share insights so that others can do great things.*"

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

psanders@ilstu.edu

Woodgas International

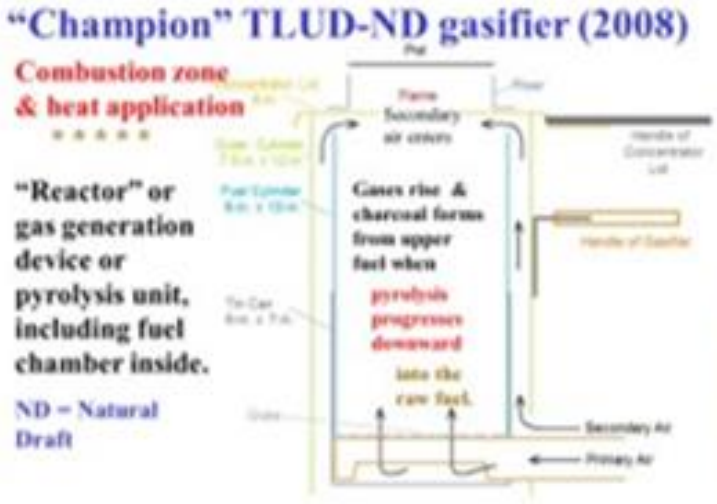
www.woodgas.com

Background slide

For those who have not seen TLUD stove technology before. ND and FA designs are ready for implementation in projects that will reach 1500 HH.

Technology: Biochar-producing TLUD Cookstoves with Natural Draft or Forced Air

Proven products and methods with 100,000 Champion ND-TLUD stoves in the West Bengal area (but not with CDRS).



Cost per stove ~US$40 to $60 when in projects. In-country production or assembly possible. Fuel efficiency justifies the price.

Indian woman cooking food on a Champion TLUD-ND pyrolyzer cookstove.

The most advanced and exceptionally clean burning TLUD-FA stoves are the FabStove and Mimi Moto models. They have small fans for forced air and use modern, economical pellet fuel industrially processed from abundant low-value biomass.

We face a Climate Crisis

We will feel the impact of climate disaster.

- **1. New GHG emissions each year exceed 40 gigatonnes.**
  - **Emission reduction (ER) requires changing lifestyles**,
  - **ER relates to what you eat and wear and do.**
    Your carbon footprint is up close and personal.

We will feel the impact of ER.

- 2. More than **1000 Gt of excessive CO2e in the atmosphere and oceans.**
  - Carbon dioxide removal (CDR) occurs by **impersonal actions of capturing molecules of CO2 from the air and storing them** for multiple centuries.

CDR does not change our lifestyle except for paying to have CDR occur faster.

CDR is much "nicer" and more "life-style friendly" than ER.
CDR via biochar is typically 10X or greater than the value of ER.
CDR via biochar is easier to document (MRV) than is ER.

Biochar is one of the Seven CDR technologies

- **Nature-based CDR** (CO_2 found in living or once-living organisms. Notably of short duration.)

  1) PG Plant growth (not just AF/RF Trees) (using solar-powered photosynthesis to make many types of biomass (carbohydrates) that tend to have short-term duration of weeks to less than 100 years.)

  2) SOM Soil organic matter (living and dying organisms including plant roots, bacteria and fungi that can hold and increase organic carbon in soils. Often associated with regenerative agriculture and "living soil".)

- **"Hybrid" or other CDR** (nature-based physiochemical extraction and/or long-term carbon storage without photosynthesis.)

  3) BC Biochar (using pyrolytic processes for thermochemical transformation of previously produced biomass into long-stable elemental carbon. Can be nearly 50% of plant-growth carbon.)

  4) EW Enhanced weathering (using human-facilitated crushed rocks to have greater surface area for ambient chemical reactions capturing carbon into quite stable inorganic compounds on land or in water / oceans.)

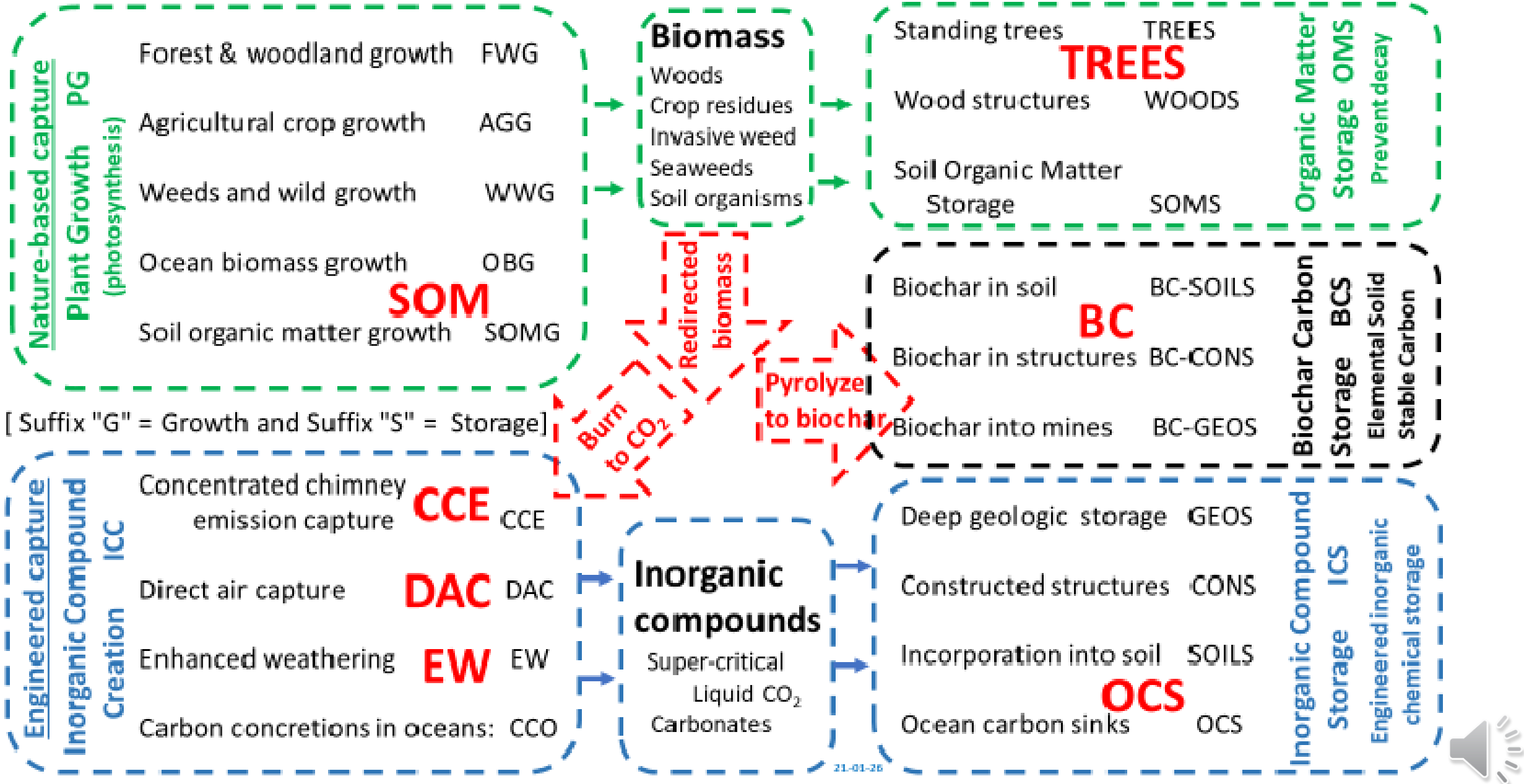
  5) OCS Carbon concretions in oceans (living animals or chemical treatments take carbon from ocean waters to create solids (coral reefs and precipitates) with long-term sequestration.)

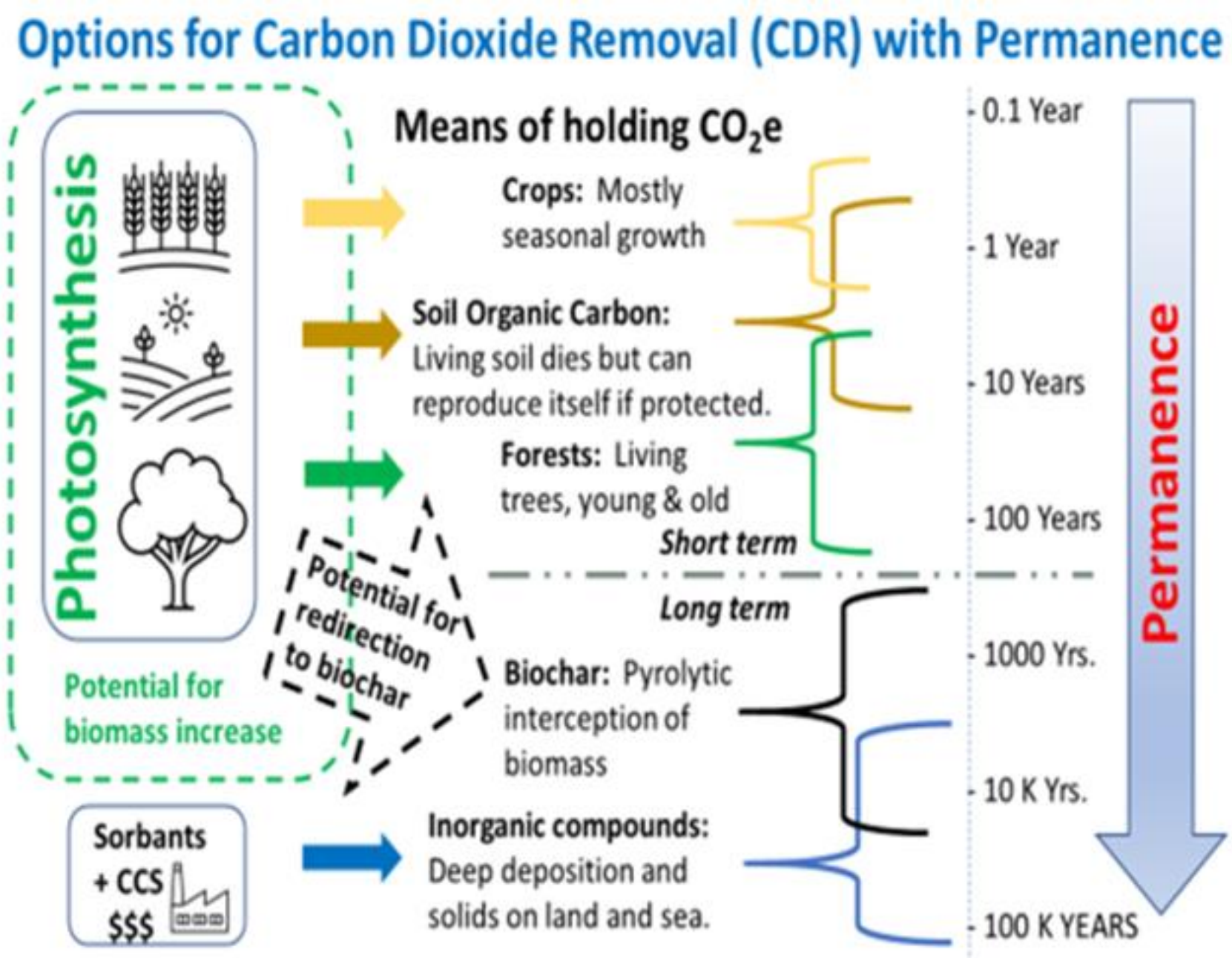
- **Engineered CDR** (human-fabricated devices and methods for physiochemical extraction and collection of CO_2 gas.)

  6) CCE (or BECCS) Collection of concentrated chimney emissions of CO_2 from biomass combustion (using constructed devices for CO_2 collection and long-term geologic storage.)

  7) DAC Direct air capture (using constructed devices for CO_2 collection from ambient air and then long-term geologic storage.)

Options for Carbon Dioxide Capture and Storage (= Removal = CDR = GGR)





Photosynthetic plant growth (PG) does the CO_2 removal, and pyrolytic production of biochar (BC) accomplishes the long-term stability to be true CO_2 removal and storage (CDR).

PG + BC = CDR

I work on "Climate Intervention with Biochar"

- My writings:
  - **A 52-page white paper** "Climate Intervention with Biochar." (Dec. 2020) that includes the possible impacts of TLUD stoves in Section XII (pp. 21-27).
  - **A 50+page sequel called "Roadmap** for Climate Intervention with Biochar." (Feb 2023)

- The ETHOS audience is stovers. So **I will focus on stoves** while pointing out the global importance of biochar for CO2 removal.

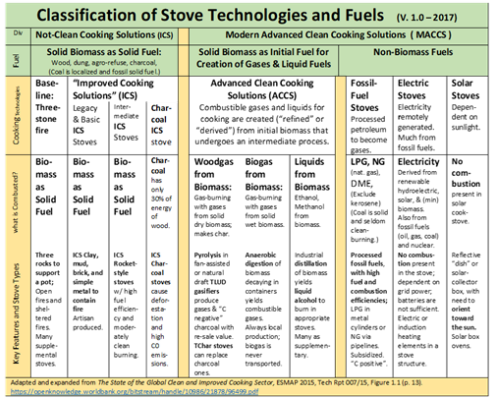
- **My ETHOS 2022** presentation was "**Cookstoves and Climate: A Comparative Analysis**"
  - Available as 21-slide deck and as presented as a 14-minute video at www.woodgas.com
  - Summarized here in the next three slides:

ESMAP Overview of Improved and Clean Cooking Technologies

http://www.drtlud.com/wp-content/uploads/2017/04/Stove-Classification-2017-04-10.pdf

2015 Original

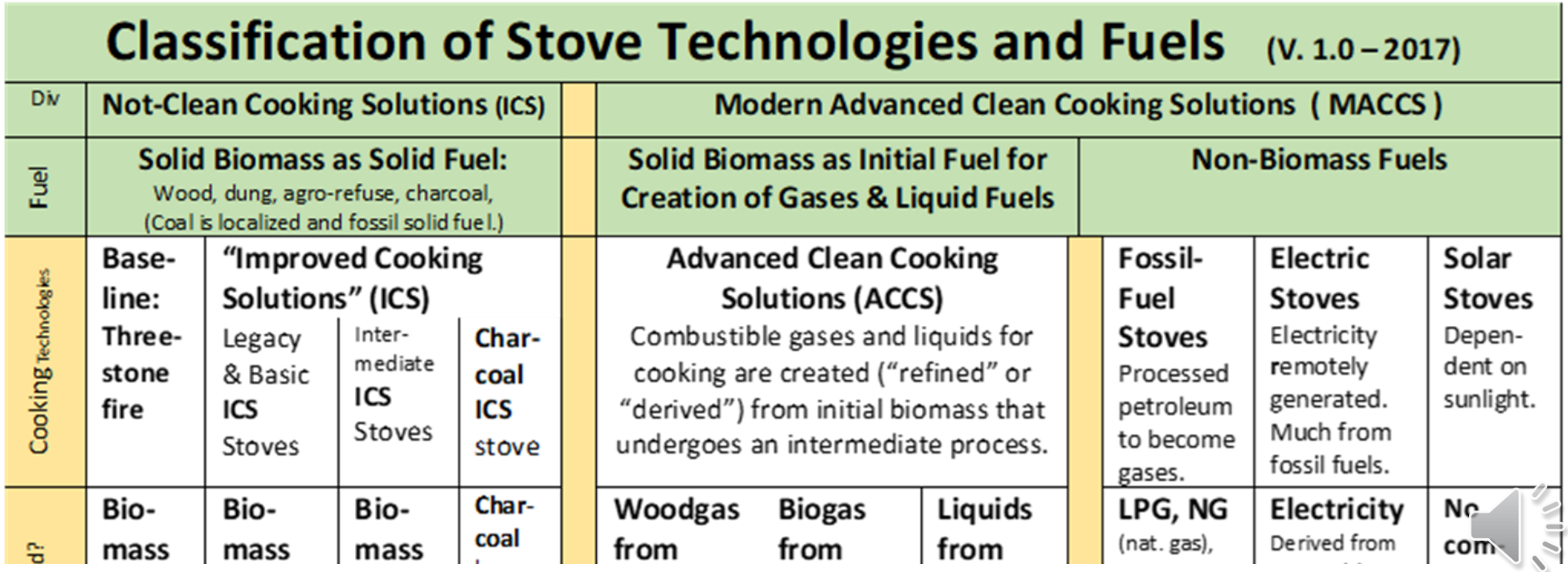
2017 Rearranged by Anderson



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).
https://openknowledge.worldbank.org/bitstream/handle/10986/21878/964990.pdf



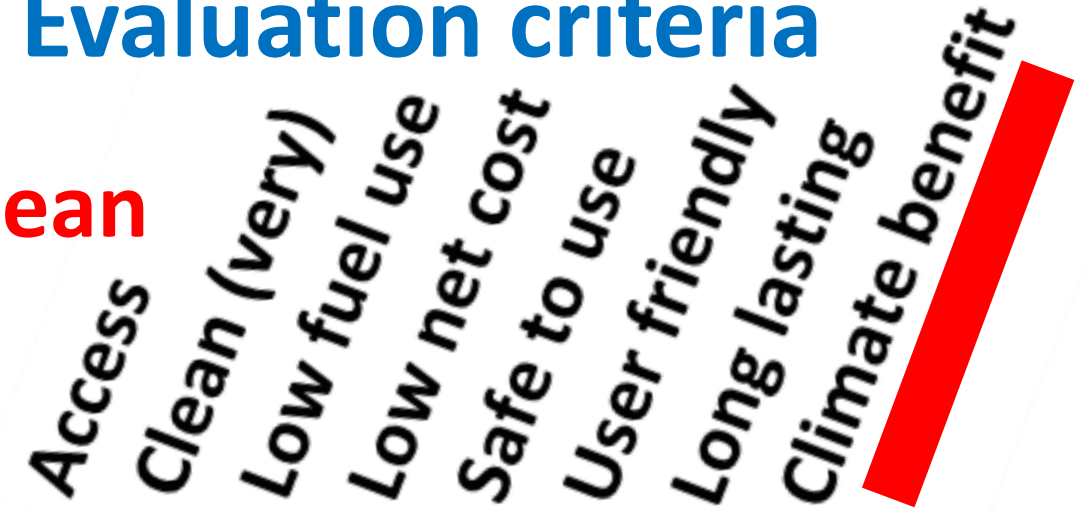
Classification of Stove Technologies and Fuels (V. 1.0 – 2017)

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.
d?	Bio-mass	Bio-mass	Bio-mass	Char-coal	Woodgas from	Biogas from	Liquids from	LPG, NG (nat. gas),	Electricity Derived from	No com-

Stove types

Solid Biomass for 3SF and ICS	
3-Stone	
Traditional / Legacy ICS - Basic	
ICS – Intermediate	
ICS- Charcoal	
Solid Biomass for Advanced	
Woodgas TLUD-ND	
Woodgas TLUD-FA (Fan)	
Biogas (Anaerobic digestion)	
Liquids – Alcohols (Distillation)	
Non-biomass fuels- Advanced	
LPG & NG (Processed fossil fuel)	
Electricity (Much is fossil-based)	
Solar (Limited by daylight hours and weather)	

Evaluation criteria



- **ICS fail on Clean and fail on Climate.**
- **These are super clean and also are the only stoves that are carbon negative.**
- **These are nice but limited by economics**
- **These are clean but will increasingly have very significant limitations.**

Electricity has issues of supply and high cost. **Concerns about LPG/NG for health and terrible for fossil fuel emissions.** **Will be banned.**

How much benefit can come from TLUD stoves?

- **For society:** Significant contributions toward **meeting eight of the UN's Sustainable Development Goals**. [SDG's 1, 2, 3, 5, 6, 7, 13, and 15]

- **For family:** **Monetary benefits** (based on 7 years of experience in WB, India):
  - an average household can **save about US$110 per year on fuel purchases,** and
  - **the woman of the house receives about $40 per year income from the sale of the biochar** that she produces when cooking the family meals. That is women empowerment.

- **For climate:** The World's poorest 500 million families could help **sequester 0.5 Gt CO2/yr** by using TLUD cookstoves to prepare daily meals.

- **By 2050, increasingly advanced TLUD stoves will be used for cooking meals in middle-income homes, sequestering an additional 0.5 Gt CO2/yr.**

CDR of >1 Gt CDR/yr via TLUD biochar + ER credit for energy.

How is this financially sustainable? What Business model?

- Unlike any other type of cookstove, **TLUD stoves can have INCOME streams.**
- The incomes are **associated with the production of biochar,** the valuable co-product of pyrolytic production of woodgas for cooking.
- And the incomes are **possible only through the management of biochar businesses with sufficient numbers of TLUD stoves.**

Bias, Conflicts of Interest, and Money

- I am Paul Anderson, a **79 year-old**, retired university professor.
- **Since May 2001**, I have been dedicated to **micro-pyrolysis**, with 20 presentations to ETHOS. I am an "expert" on the topic. Nickname: "Dr TLUD"
- **I am biased** favoring TLUD technology. But bias does not mean being wrong.
- Conflicts of Interest: (Not really)
  - Not much chance to make money equal to my personal financial investment thus far.
  - My donation of 20 years in retirement cannot be recovered.
  - A little bit of recognition would help promote the TLUD efforts.
- I frequently say: **"If something better is found, I will endorse it."**
- **There is nothing better than TLUD stoves for what our world needs now and for the future !!**

Roadmap to 10 t CDR/yr via biochar

- **Biochar (TLUD) stoves can remove 1.5 Gt CDR/yr by 2050**

Projections for CDR via BC&E (Version 2023-01-27) Units = Gt of CO_2 removal (CDR) per year

Service used to produce biochar	2030	2040	2050	Cumulative to year 2100
Cookstoves -TLUD	0.1 – 0.2	0.5 – 1.0	1.0 – 1.5	75 – 105
Crop residue	0.2 – 0.5	1.0 – 2.0	1.0 – 2.0	90 - 220
Subtotal ALIA	*0.3 – 0.7*	*1.5 – 3.0*	*2.0 – 3.5*	*165 - 325*
Forest safety	0.1 – 0.2	0.5 – 1.0	1.0 – 1.3	75 – 95
Urban tree waste	0.1 – 0.1	0.2 – 0.8	0.5 – 1.0	38 – 75
Subtotal	0.2 – 0.3	0.7 – 1.8	1.5 – 23	113 -170
Elect. power gen.	0.1 – 0.1	0.2 – 0.3	0.5 – 1.1	38 - 80
Home heating	0.1 – 0.1	0.2 – 0.4	1.0 – 1.8	75 - 140
Process heat	0.1 – 0.2	0.2 – o.4	0.6 – 1.3	38 - 110
Subtotal	0.3 – 0.4	0.6 – 1.1	2.1 – 4.2	151 - 313
TOTAL	**0.8 – 1.4**	**2.8 – 5.9**	**5.6 – 10.0**	**429 - 808**

Notes:
1. All numbers are "best estimates" and are subject to increases or decreases of 50%.
2. Abbreviations: ALIA = Areas of Labor-Intensive Agriculture
3. In 2020, all the BC&E amounts were virtually zero.
4. No double counting. Example: do not count as crop residues or urban tree waste what is collected and counted for cookstove fuel or other heating.
5. If used to offset continued new emissions, it is not drawdown.

CDR via TLUD stoves is now the relatively easy 15% of the 10 Gt goal.

Paul Anderson now spends most of his efforts on the other 85% of the 10 Gt goal and to establish credible CDR verification methods.

Five Goals for CDR/yr Explained in "Roadmap ... Biochar"

Five Goals for CDR via Pyrolytic Biochar and Energy (BC&E)

All measurements refer to tonnes per year of carbon dioxide removal and storage.

The First Goal has been proposed by the multi-nation Mission Innovation Launchpad in Sept and Nov 2022.

Goal	Weight per year		Expressed as:	Target date
(Prove viable)	100 t		2 tonnes per week	(Currently operational)
First Goal	1000 t	1500 stoves	1X = 1 thousand t = 1 k t	December 2023
Second Goal	10,000 t		10X = 10 thousand t = 10 k t	2025 - 2027
Third Goal	1,000,000 t		1000X = 1 Million tonnes	2030
Fourth Goal	1,000,000,000 t		1000 Million tonnes = 1 Gt	2040
Fifth Goal	10,000,000,000 t		10 Gigatonnes = 10 Gt	2050

Eight (8) orders of magnitude of increase in 27 years!!! *And how to do it.*

Example: 1500 Champion TLUD stoves in one project area. (per year, so it is sustainable)

- Use of TLUD stoves **produces good quality biochar**
  - **CDR value** of 1000 t CDR @ $100/t = **$100,000.** (could be @$200/t = $200,000)
  - **Physical biochar** (~750 t) is sold for soil enhancement @ $200/t = **$150,000**)

- The project could have **$250,000 to $350,000** to cover its operational costs and revert money back to the community. **That is $167 to $233 per HH.**

- There are costs (MRV, admin, maintenance, etc.). But with a chance of sustainability.

- **Add in ER carbon credits** from energy savings and replacing NG and LPG.

- Add creation of **viable businesses of fuel supply and biochar markets.**

Method for success. Why thiswill work?

- The TLUD stove projects must purchase the **initial stoves (@ ~US$40 each x 1500 = $60,000**) to be distributed to the project households, and there need to be **buyers for the CDR credits and physical biochar for ~$250,000.**

- This will work because **the threat of the coming devastation of Climate Change literally compels payments** by affluent societies, businesses, governments, and concerned citizens for CDR and physical biochar.

Perhaps the only good result that could be caused by disastrous Climate Change is if it forces the affluent societies to provide appropriate clean CDR cookstoves to the World's three billion poorest people. -- PSA

- The worldwide community for clean cookstoves is prepared to do the on-site work to progressively place 500 million TLUD stoves into use.

Title

Transition to TLUD Stoves for CO_2 Removal (CDR)

with Biochar and Climate Benefits

Transition is both

a noun: as in "The transition to TLUD stoves..." and

a verb: declaring that "You transition to TLUD stoves..."

Conference Theme: "*Don't just talk about the great things you're doing –*

share insights so that others can do great things."

Our planet and societies need all "stovers" to do great things.

Our futures in 2030, 2040, 2050 and 2100

- Paul Anderson will likely be dead before 2040. But my grandchildren and many of you and your children could be alive until 2100.

- Do you make or promote Rockets or charcoal burners or other ICS stoves? What should be your stove business in 2030 and later?

- Do you make or promote fossil-burning stoves? Please stop.

- Are you influential with the CCA and tow the line of current policy? Sorry. To be favoring fossil-fuel stoves should not be continued.

- Are you advancing TLUD pyrolytic energy and biochar production in cookstoves? Praise you. You are on a justifiable pathway that helps.

What if we fail to accomplish CDR via TLUDs?

- **If we cannot accomplish this task that has so many co-benefits and is the "low hanging fruit" of CDR,** there is probably not much hope for other forms of CDR to be successful. **Eventually it will be too late to be helpful.**

- In 2050, without massive (and disruptive) emission reductions (ER) and many gigatonnes of CDR at least by biochar, the **World will not be a pretty place.** A hostile climate will be just one of many problems. The World is facing the consequences of social disruption from natural disasters, mass migrations, wars, and food shortages. On top of that is the economic disruption that hurts everyone.

- Sorry to bring bad news. I hope that you will not ignore or forget this soon. And **please consider some actions.**

What can you do?

- **1: Spread the word to bring in financial support for major CDR impact.**
  - Especially tell others until one of the ultra-rich sees the opportunity to have major impact with some **seed money** to put the TLUD stoves into use with CDR benefits. It is extremely difficult to reach MacKenzie Scott, Melinda French Gates, Bill Gates and Jeff Bezos.
- **2. Become more informed.**
  - **Example: "Advanced Biomass Cooking" (ABC) or "Green Cooking"** is coordinated by Christian Rakos, President of the Biomass Energy Association, based in Austria.
  - Analyze your situation and begin preparations. Tell Paul Anderson of your plans.
- **3. Transition your activities to include TLUD stoves.**
  - **Become actively involved to bring CDR stoves and biochar into your projects.**
  - Analyze your objectives and resources and possible timetable.

Contact Information:

Paul S. Anderson, PhD

(a.k.a. Dr TLUD)

- Email: psanders@ilstu.edu Skype: paultlud
- Phone: Office: 309-452-7072 Mobile & WhatsApp: 309-531-4434
- Website: www.woodgas.com
  - On the woodgas.com/resources page, see:
  - White paper (with biosketch on page 50) and (soon) the "Roadmap...Biochar"
  - TLUD Quick Picks (includes ETHOS 2022 and 2023 materials and a dozen key documents and videos about TLUD stove technology)
  - Biochar production (documentation about RoCC kilns)
  - Pages for each country with associated biochar CDR activities

Be a climate hero. Support TLUD stoves.