This slide deck was presented during about 45 minutes (excluding time for Dr. Kumar's section) on a Zoom webinar of Biochar Crusaders (India) on 9 June 2021. The session was not recorded, so each slide is lacking important explanatory information. [And some notes have been added in brackets.] Some RE-presentations or expanded explanations will be made available in future materials.

Producing Biochar at Farms using Agri Waste: RoCC Kiln Capabilities

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Biochar is in its "Wild Wild West" Stage

- Exciting
- Unknown
- New Technologies
- Dynamic
- Boom and Bust
- Urgency for World Issues
- WEST, as in West Bengal, western Kenya, western world and everywhere.
- Today's presentation is at the frontiers of biochar, so do not expect to receive all the answers.
- But it is also very real, based on years of efforts.

RoCC kilns work well!!

Four Sizes of RoCC Kilns (as of June 2021)

[Introductory slide; will be shown again.]

23-inch diameter (590 mm), (200 L or 55-gallon Barrel-size kiln) In Kenya, rear viewer (not in the normal operational position.)

100 to 1000 kg/day biomass input

32-inch (800 mm) Diameter x 48-inch (1220 mm) Length unit in India.
Front view at right.
Rear view below.

Below: 48 inch (122 cm diameter) x 60 inch length. In California, Feb 2020.

Above and below: 72-inch (6-ft, or 1.8 meter) RoCC kiln inside a 20-ft shipping container
w/ mechanical rotation

Latest RoCC Kiln Innovation – "H-Frame"

- **Named for the "H" where the axle stub is supported.**
- **Full details by the end of this presentation.**

Strong, easy to make, inexpensive, scalable, versatile, mobile.

Major Issues and Topics: (Outline for this presentation.)

- Size of pyrolyzer units and related aspects
- Pyrolysis technologies
- Biomass types
- Design options for fabrication
- Experiences and Results
  - India — banana plants; rice straw; tea refuse — Manish Kumar
  - Kenya — cut grass; cleared shrubs; rice husks — Gilbert Mwangi
  - Mexico — coconut shells; bamboo — Kennon Reeves
  - USA — waste wood; hemp stems; misc. biomass — Paul Anderson
- Business possibilities
- Carbon financing for CO_2e <u>removal</u> (including field burning)
- Conclusion
- Q & A

Major Issues: Size, Technology, Biomass and Results

- Size of pyrolyzer units and related aspects
  - Too small or too large, but mostly missing the middle sizes
  - Costs
  - Mobility
  - Through-put (biomass in and biochar out per hour or day)
    - 5 to 1 ratio by weight (dry)

- Pyrolytic technology
  - Retort: Lab scale and Adam Retort and giant sizes
  - TLUD (Top-Lit UpDraft) Cookstoves or barrels
  - Flame cap (a.k.a. "cavity kilns") Open top or partially covered --- RoCC™
  - Gasifiers that are tuned to produce char
  - Furnaces that leave char in the ashes

Major Issues: Size, Technology, Biomass and Results

- **Biomass types**
  - **Physical size: Rice husks, chips, straws, twigs, branches, trunk/cord wood**
  - **Origins: Agriculture residues, forest refuse, fuel crops, MSW**
  - **Location / distribution / availability**
  - **Moisture content (MC)**

- **Results**
  - **MANY combinations to evaluate**
  - **Results from:**
    - **India**
    - **Kenya**
    - **Mexico**
    - **USA**

RoCC kilns can be adapted for many biomass types, sizes and shapes

(E = Easy, R = Reasonable, P = Problematic, D = Difficult)

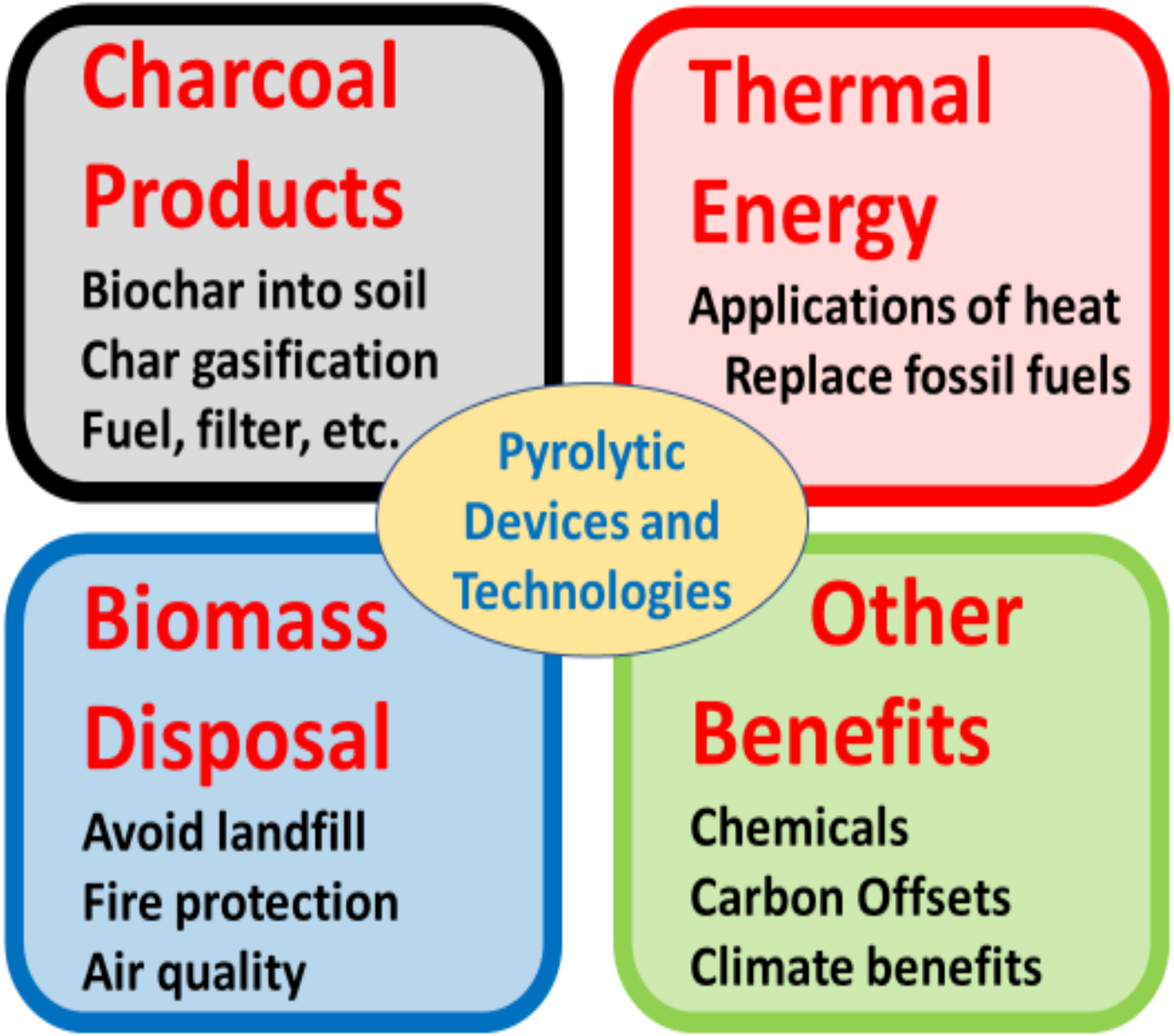
- **Sawdust and rice husks (P)**
- **Mulch (R)**
- **Chips and Pellets(R)**
- **Reeds and stems (E)**
- **Brush and small branches (E)**
- **Arm-size branches (R)**
- **Cordwood (R)**
- **Slab wood and bamboo (E)**
- **Whole trunks (P) (Allow sufficient time for pyrolysis)**
- **Full size root balls of trees (D).**

The ability to handle so many different forms of biomass can mean **substantial savings on current pre-processing** of biomass to be disposed.
Example: Eliminate grinding and chipping whenever possible.

Financial Issues:

Four ways for pyrolysis to be "profitable."

Best if two or more ways are used.



Sizes for Pyrolytic Biochar Production

Classified by Orders of Magnitude of input of biomass per 10 hrs of operation

- Laboratory (< 1 kg)
- Micro (1 to 10 kg.)

- Small (10 to100 kg)
- Midi (100 kg to 1 ton)

- Medium (1 t to 10 t)

- Large (10 ton to 100 t)
- Industrial (> 100 t)

Seven Orders of Magnitude !

From a full slide deck and presentation that is available at:
https://woodgas.energy/wp-content/uploads/2020/12/Small-and-medium-pyroysis-BC-Week-10-minutes-2020-12-08.pdf

Sizes for Pyrolytic Biochar Production

Classified by Orders of Magnitude of *input of biomass* per 10 hrs of operation

	Objectives
• Laboratory (< 1 kg)	R&D /testing
• Micro (1 to 10 kg.)	Cooking
• Small (10 to100 kg)	Making Biochar
• Midi (100 kg to 1 ton)	
• Medium (1 t to 10 t)	To be determined
• Large (10 ton to 100 t)	Char/chem/power
• Industrial (> 100 t)	CHP (char secondary)

Not today

Yes my topic if low cost

NOT my topic

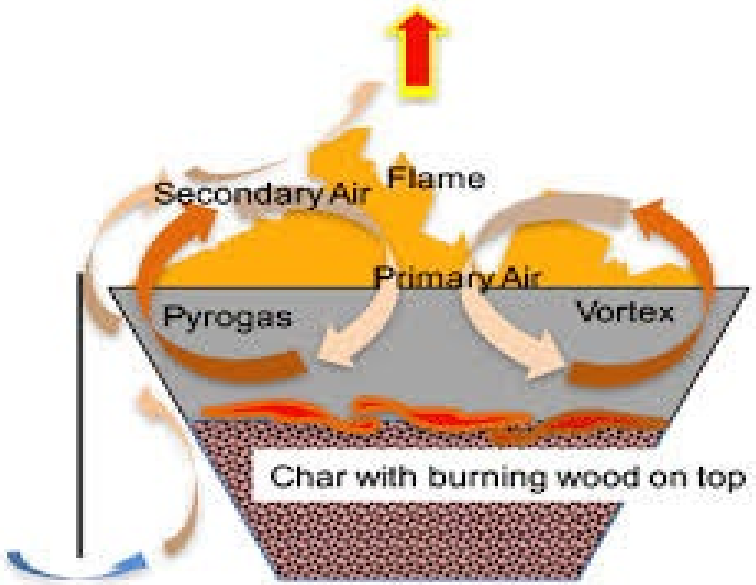
Pyrolytic Technologies for Dry Biomass Fuels Are NOT Specific to Sizes of Devices

Without oxygen	Limited oxygen	Much oxygen
Retort	Gasifiers (various types)	"Conservation burn"
Laboratory	Glowing pyrolysis (TLUD)	Air curtain machines
Adam retort	Flame cap (Cavity kilns)	Industrial furnaces
Rotary kilns	*Open top:* Pit; trench; trough; pyramid; cone; Kon Tiki	Incinerators
	Covered top: "4C kiln" and RoCC kiln	Forest fire

Technical Note:
Not referring to the oxygen that is in every hydrocarbon molecule of biomass.

Flame Cap Pyrolytic Biochar Production

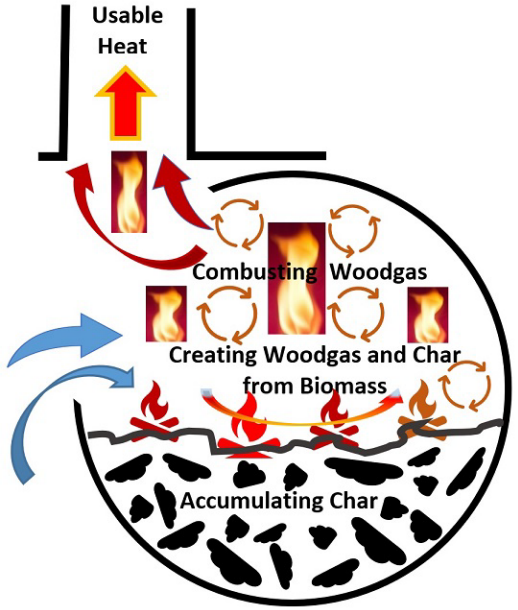
(*open top* cavity kilns): Pit; trench; cone; pyramid; trough; Kon Tiki



"4C Kilns" that did not rotate (Discontinued)

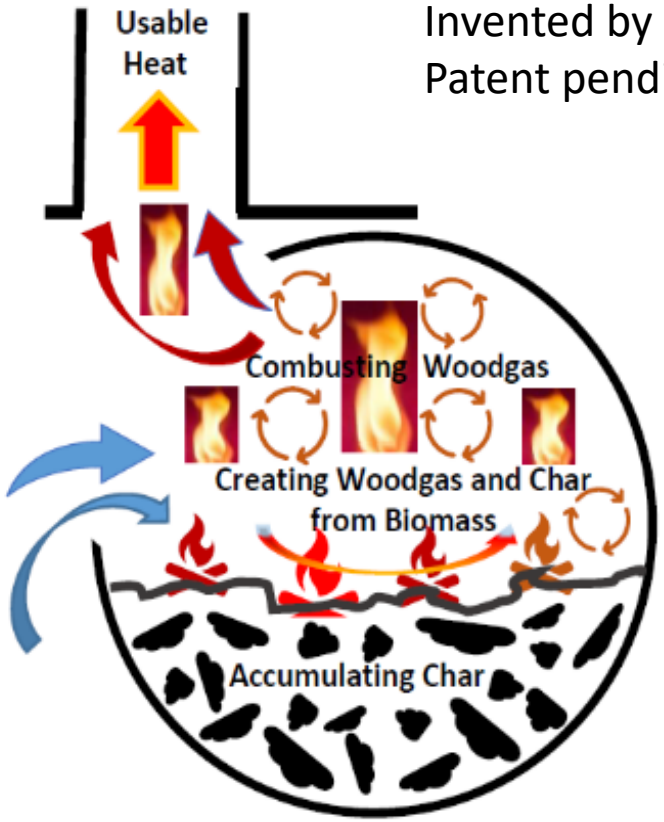
Flame cap (*covered* cavity kilns):

- Small (10 to100 kg)
- Midi (100 kg to 1 ton)



RoCC kilns for making biochar

Rotatable Covered Cavity Kilns



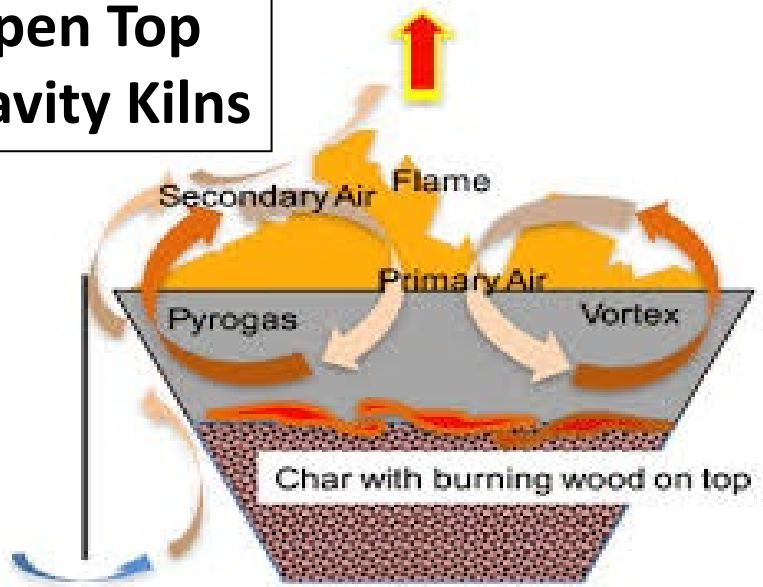
Flame Cap Processes in Covered Cavity Kilns

Invented by Paul Anderson.
Patent pending.

Evolution of the RoCC kiln

- **Flame Cap** (aka Flame Curtain) pyrolysis technology is accomplished in cavities with closed bottoms and **open** tops.
- **"4C kilns"** were **covered** cavity kilns that were not rotatable. [~ 8 made between 2014 and 2019.]
- **Rotatable Covered Cavity (RoCC) kilns from 2019.**

Open Top Cavity Kilns

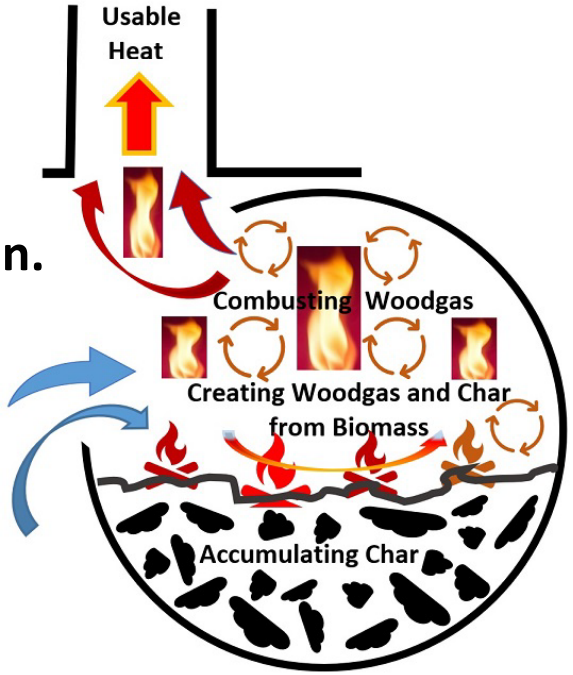


Shared Flame Cap Features

- Heat, flames and emissions rise away from the flame cap.
- Combustion of pyrolytic gases occurs with turbulence.
- Pyrolysis of biomass occurs because of the heat of the cap of flames.
- Char accumulates in the lower areas where oxygen cannot reach because of the cap of flames.

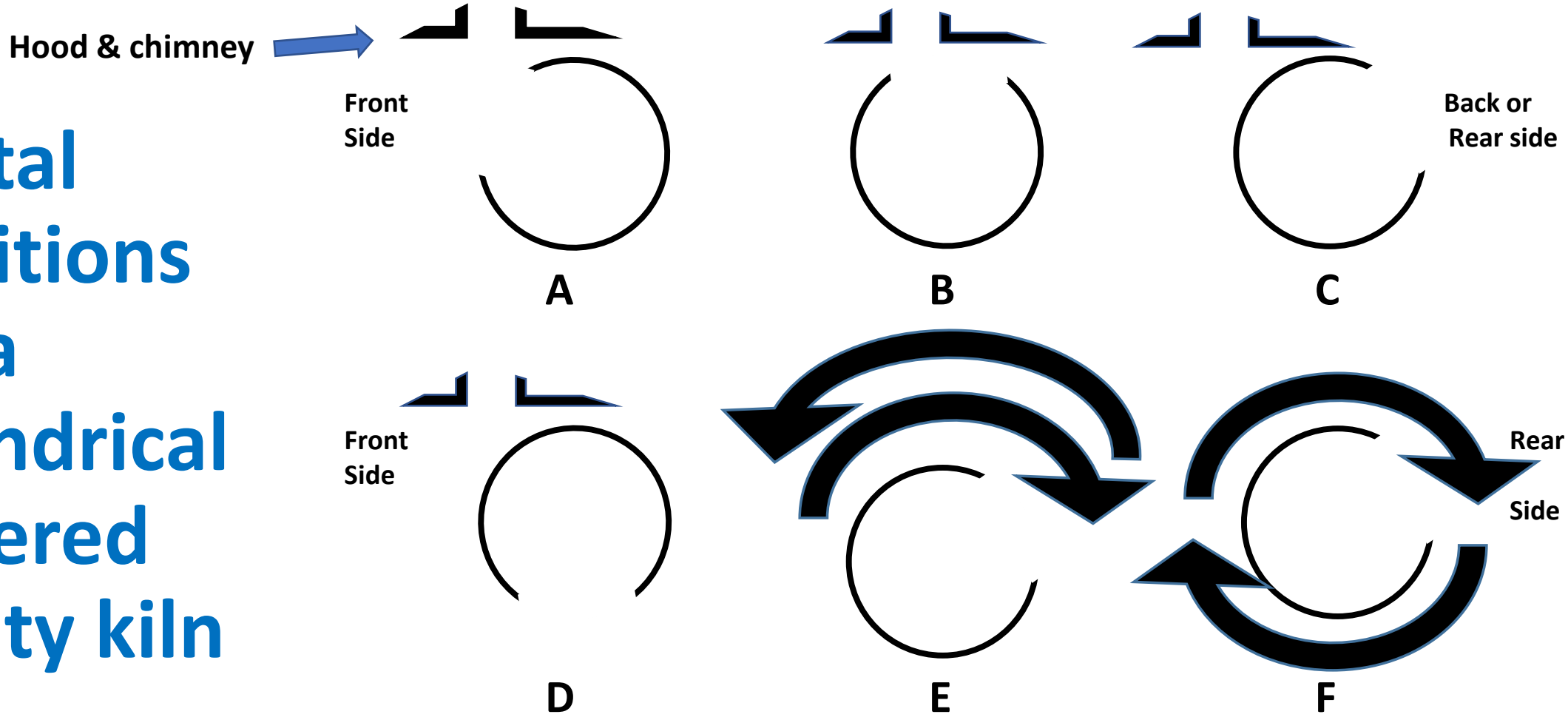
Advantages of RoCC:

- Flame is protected from wind & rain.
- Longer heat retention in the combusting gases.
- Created heat can be directed to uses via chimneys.
- Chimneys can assist with draft.
- Rotation mixes the char to assure that all the biomass is pyrolyzed.
- Rotation to easily empty the char.



Covered Cavity Kilns

Portal positions on a cylindrical covered cavity kiln



Portal position	Position Name	Purpose	Observations
6A 270 to 350	Shelf fuel feeding	Slide in fuel on shelf	“Normal” position; best flame cap.
6B 320 to 40	Straight up	Slow the fire	Least air entry; “simmer”.
6C 10 to 90	Bulk fuel feeding	Drop in fuel	Short time only; lacks draft.
6D 140 to 220	Straight down	Unloading	Used sparingly for brief times.
6E Roll 240	Rocking back and forth	Tumble w/o dumping	Use common sense; varies w/ fuel type.
6F Roll 360+	Full rotation	Mixing extensively	Subject to conditional limitations.

Four Sizes of RoCC Kilns (as of June 2021)

23-inch diameter (590 mm), (200 L or 55-gallon Barrel-size kiln) In Kenya, rear viewer (not in the normal operational position.)

100 to 1000 kg/day biomass input

32-inch (800 mm) Diameter x 48-inch (1220 mm) Length unit in India.
Front view at right.
Rear view below.

Below: 48 inch (122 cm diameter) x 60 inch length. In California, Feb 2020.

Above and below: 72-inch (6-ft, or 1.8 meter) RoCC kiln inside a 20-ft shipping container
w/ mechanical rotation

Many Options for Cylindrical Pyrolyzer

- **Standard 55-gallon (200 L) steel drum**

- **Cylindrical steel tanks of various sizes** (including RR tank cars)

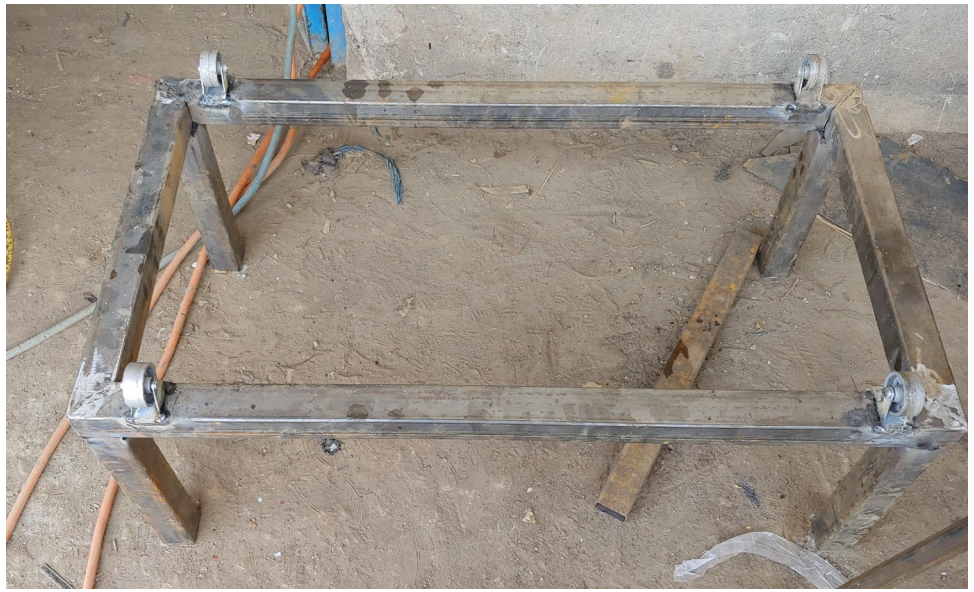
- **Corrugated steel pipe (CSP)**
  - Strong, economical, industrial product
  - 3 ft to 18 ft diameters; Lengths up to 40 ft.

Three Arrangements for Rotation

- **Rack with support wheels / casters**
- **Rails for rolling**
- **Axle / Axle stubs for rotation and support**

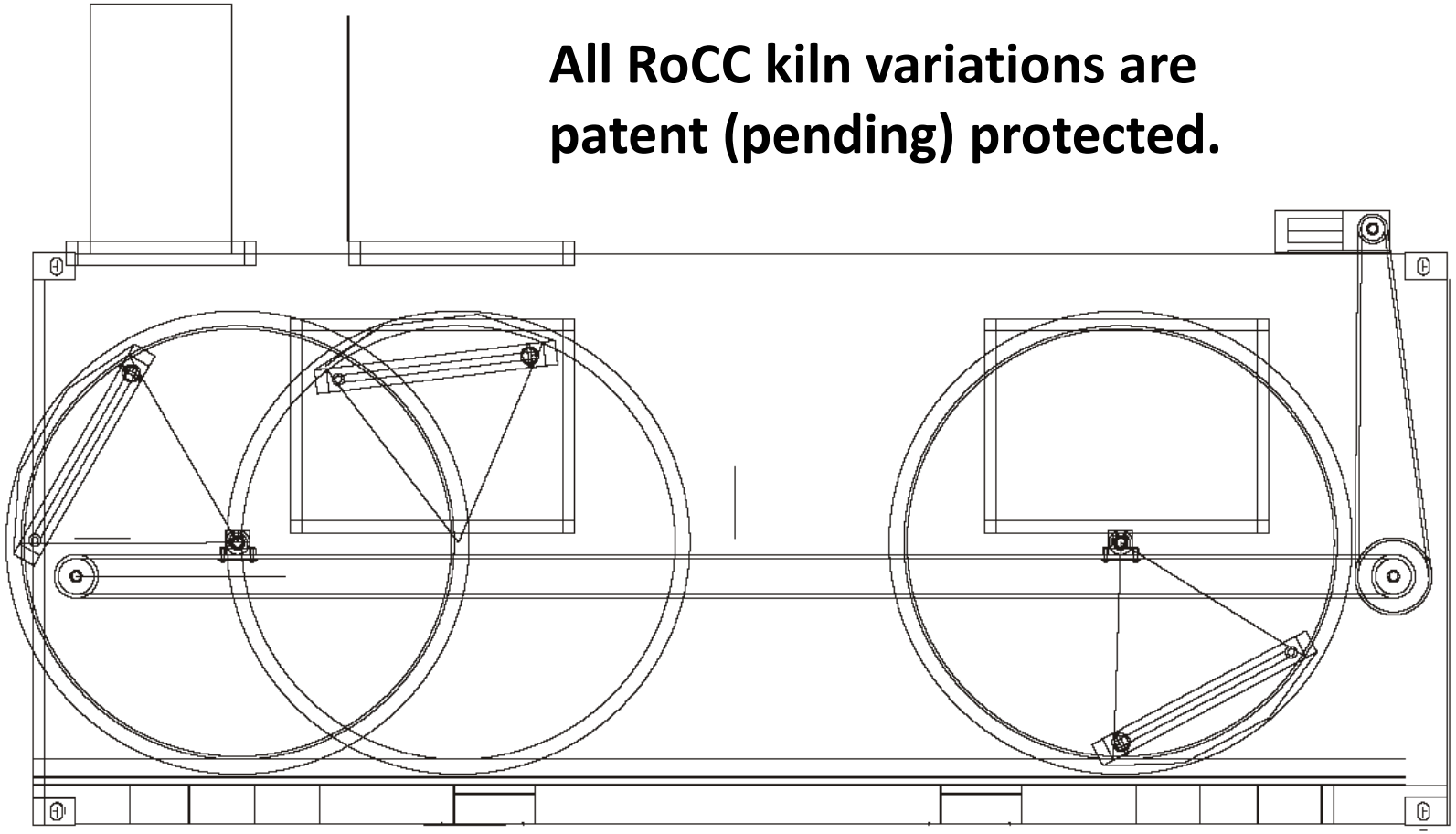
Rack with Support Wheels for Pyrolyzer

- **Welded rectangular tubing with four legs and four steel casters/wheels. ➔**



- **Welded cross bars and casters on improvised legs of concrete blocks. ➔**

RoCC Kiln in Construction: 6 ft D x 7 ft L Inside a 20- ft Shipping Container on rails for rolling



All RoCC kiln variations are patent (pending) protected.

- Constructed in central Illinois with several test runs by May 2021.
- Scale to larger sizes will depend on results and future funding / sales / business associates.
- If interested, write to Paul S. Anderson at: psanders@ilstu.edu

Rails for Rolling

Weight is supported totally on the rails.

The hole in the floor is for dumping the hot char at the discharge end. N.B. The char is not yet ready to dump in these photos.

Axle / Axle Stubs

Having a full-length axle through the cylinder is NOT as good as having only axle stubs which are pipes welded to a firm end-plate that is welded to the ends of the barrel / cylinder.

Support Structure Options

- Racks (shown previously)
- Large side wheels "RoCC n' Roll" (Discontinued and Superseded)
- X-Frames (works well but is no longer the best choice)
- H-Frames (recommended for simplicity, flexibility and size changes)

RoCC n' Roll kiln

- Designed for "residential," woodlot and educational use.
- Shown is number four of the five experimental versions thus far.
- Latest design and further information will be given at the webinar on Thursday December 10, 2020.

- **Discontinued and superseded by H-Frame Design**

RoCC n' Roll barrel kiln processes approximately 25 kg per hour, or a quarter ton in 10 hours of operation, yielding about 50 kg of biochar.

Availability of product or construction plans is not yet determined. Seeking associates for development and/or business.

RoCC X-Frame Kilns

(An option to compare with the H-Frame designs.)

This slide will be shown again and discussed during the Kenya segment of this presentation.

Latest RoCC Kiln Innovation – "H-Frame"

- **Named for the "H" where the axle stub is supported.**
- **Full details by the end of this presentation.**

Strong, easy to make, mobile, inexpensive, scalable, welded or bolted, versatile, ...

Pieces to make an H-Frame RoCC kiln

The cross-bar of the H has adjustable positions.

Wheels are optional, removable and can be of various sizes for different terrain and heights.

Many options for the handles. The blue pair was borrowed.

Q: What is the big difference between these two H-Frame RoCC kilns?

A: Same kiln, but the frame is rotated 90 degrees to change the height of the portal from the ground for loading different types of biomass.

Both positions can have wheels for moving through fields.

Some Lessons Learned (thus far)

- No need for door to cover the portal (doorway).
- No need for hood and chimneys in most circumstances, but hood and chimney remain an option especially if emissions control or use of heat is desired.
- No need for the grate / bars that can swing into place over the portal. The relative cost is high, they can warp, and too hot to actually use.
- Use scrap materials when possible for great savings.
- Learn with mild steel; stainless steel is not necessary when learning and might not be needed for your application.
- No insulation.
- Protective paint and galvanizing do not last.

Experiences and Results

- India
- Kenya
- Mexico
- USA

India --- Comments by Dr. Manish Kumar

Kenya --- Comments by Gilbert Mwangi

[Success with rice husk biomass depends on continual feeding in small quantities.]

RoCC X-Frame Kilns

(An option to compare with the H-Frame designs.)

[Note the different types of biomass from fields.]
[On wheels the RoCC kiln is easily moved to the biomass.]

Kenya

[11.6 kg of biochar]

Mexico --- Video by Kennon Reeves

Video (30 seconds) of RoCC X-Frame in Mexico with coconut shells

By Kennon Reeves on June 6, 2021

USA ---- Comments by Paul Anderson

One RoCC barrel-size kiln processes approximately 25 kg of woody biomass per hour, or a quarter ton in 10 hours of operation, yielding about 50 kg of biochar.

50 kg of biochar represents approximately 125 kg CO2 long-term removal and storage (CDRS), which is approximately US$12 gross income from sales of CDRS @ $100 per tonne CO2e to companies that are stimulating CDRS (Microsoft, Shopify, etc.).

$12 per day can pay an agricultural worker in many countries.

Business possibilities

- You cannot gain from the RoCC kiln technology if you do not embrace it. There are no restrictions to prevent anyone from starting to use the RoCC kiln technology. It is recommended that you stay in contact with Paul Anderson to save your time and money.

- When you (or others) do gain from the RoCC kiln, then part of that gain is to be provided back to Dr. Anderson who holds a patent (pending).

- No RoCC kilns are sold; their production and use are authorized via agreements (such as licenses) that advance the RoCC kiln impacts.

- Dr. Anderson is seeking and expects to identify appropriate associates and partners in numerous countries to maximize the beneficial impacts of RoCC kiln pyrolysis so that all can gain.

- (Continued)

Business possibilities (Continued)

- The business possibilities are available for fabrication of units, management of units (including in projects), any use of RoCC kilns, and the resultant carbon-related benefits that include carbon markets.
- Dr. Anderson seeks impact more than financial gain.

- Contact Information:

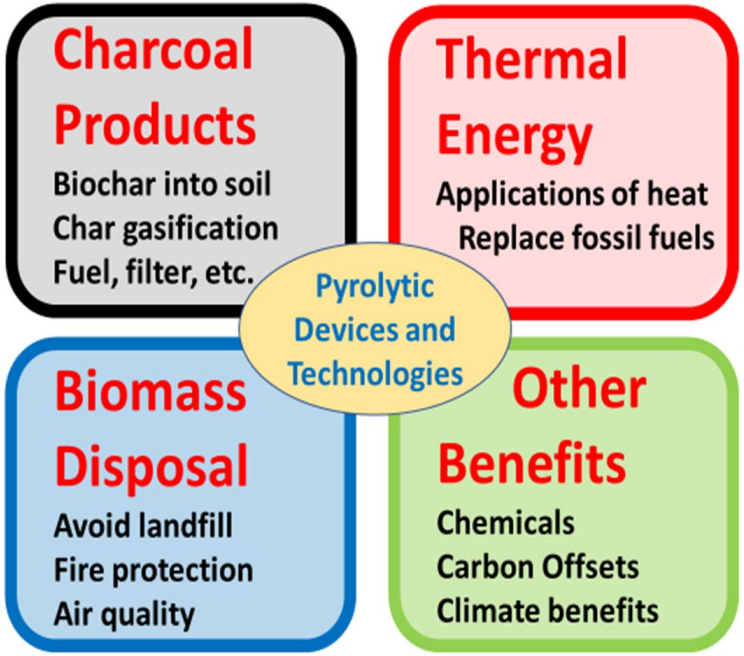
Paul S. Anderson, PhD

Email: psanders@ilstu.edu

WhatsApp & Mobile Phone: +1 309 531 4434 (Central Time USA)

Website for RoCC kilns and biochar white paper:
www.woodgas.energy/resources

Examples of RoCC kiln Business Prospects



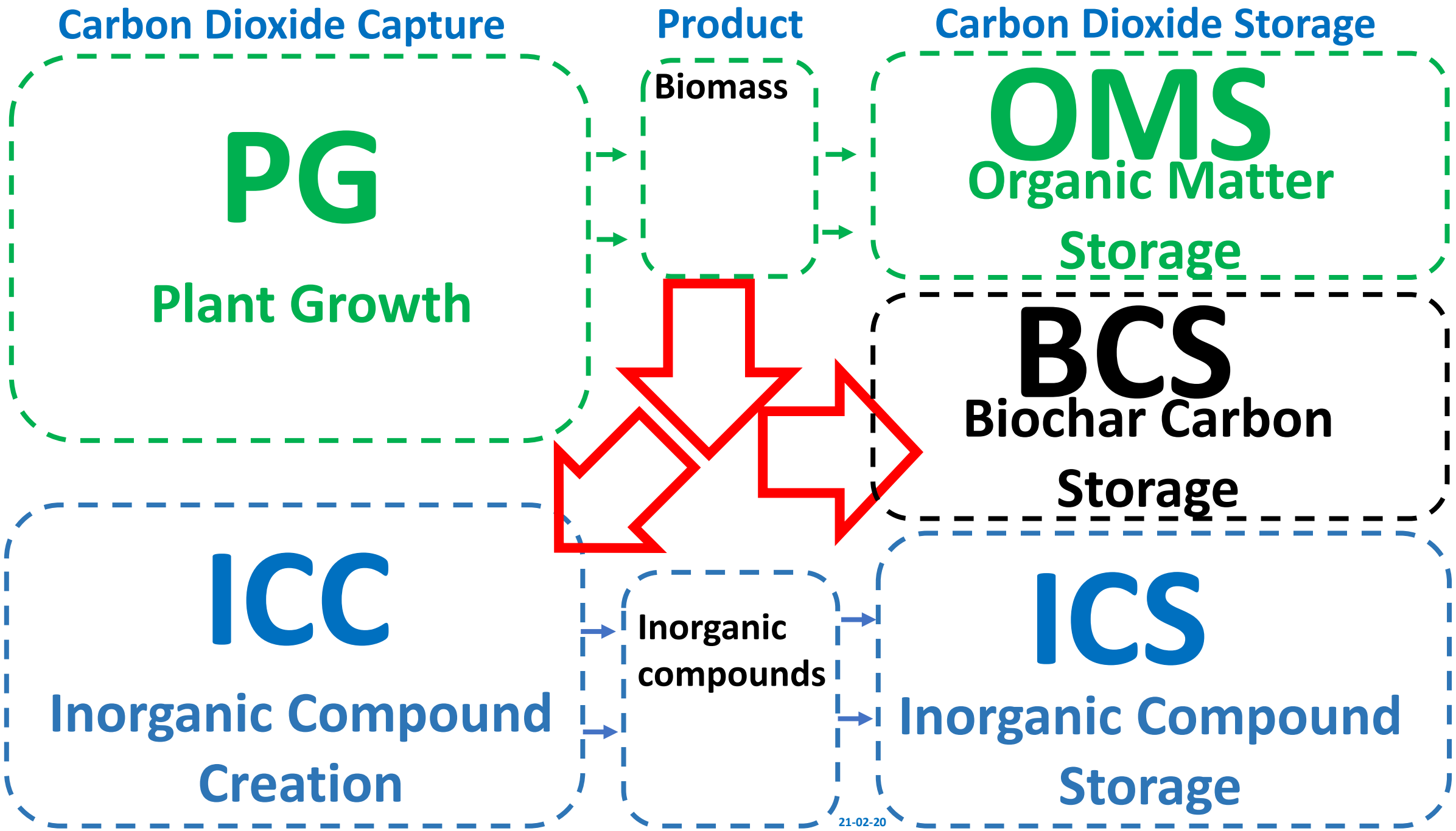
- **Manufacturing** of RoCC kilns
  - Incl. future units for thermal energy
- **Research** paid for by outside funding
  - Put Dr. Anderson on your team
- Operate business with RoCC kiln **char production**
  - Produce biochar more efficiently with RoCC kilns
- Collection of RoCC biochar to produce **commercial products**
  - The focus is on final sequestration of the biochar, never to be burned.
- Transactions with carbon units for **carbon markets**
  - Dr. Anderson will use carbon markets to increase the cash flow for growth
- **Other activities** linked to RoCC kiln capabilities

The climate crisis and biochar

- **Biochar and stable carbon removal (sequestration) are in a TRILLION-dollar sector of the world economy in coming years.**

- **Carbon tracking that is necessary for receiving carbon funding for CDRS (on the voluntary carbon markets) is accomplished with CharTrac™ carbon accounting system. Dr. Anderson has arranged this for the RoCC kiln usage that places biochar into soil. (If interested, contact him for further information.)**

The remaining slides were shown but not discussed.


Carbon Dioxide Capture
Product
Carbon Dioxide Storage
PG
Plant Growth
Biomass
OMS
Organic Matter Storage
BCS
Biochar Carbon Storage
ICC
Inorganic Compound Creation
Inorganic compounds
ICS
Inorganic Compound Storage
21-02-20

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

Nature-based capture

Plant Growth (photosynthesis) PG

SOMG

- Forest & woodland growth FWG
- Agricultural crop growth AGG
- Weeds and wild growth WWG
- Ocean biomass growth OBG
- Soil organic matter growth SOMG

[Suffix "G" = Growth and Suffix "S" = Storage]

Biomass

- Woods
- Crop residues
- Invasive weed
- Seaweeds
- Soil organisms

TREES

- Standing trees TREES
- Wood structures WOODS
- Soil Organic Matter Storage SOMS

Organic Matter Storage OMS

Prevent decay

Redirected biomass

Burn to CO_2

Pyrolyze to biochar

BCS

- Biochar in soil BC-SOILS
- Biochar in structures BC-CONS
- Biochar into mines BC-GEOS

Biochar Carbon Storage BCS

Elemental Solid Stable Carbon

Engineered capture

Inorganic Compound Creation ICC

- Concentrated chimney emission capture **CCE** CCE
- Direct air capture **DAC** DAC
- Enhanced weathering **EW** EW
- Carbon concretions in oceans: CCO

Inorganic compounds

- Super-critical Liquid CO_2
- Carbonates

OCS

- Deep geologic storage GEOS
- Constructed structures CONS
- Incorporation into soil SOILS
- Ocean carbon sinks OCS

Inorganic Compound Storage ICS

Engineered inorganic chemical storage

The objective is CO_2 Removal <u>and</u> Keeping it removed.

Long-term Sequestration

Clear winners are plants with Biochar !

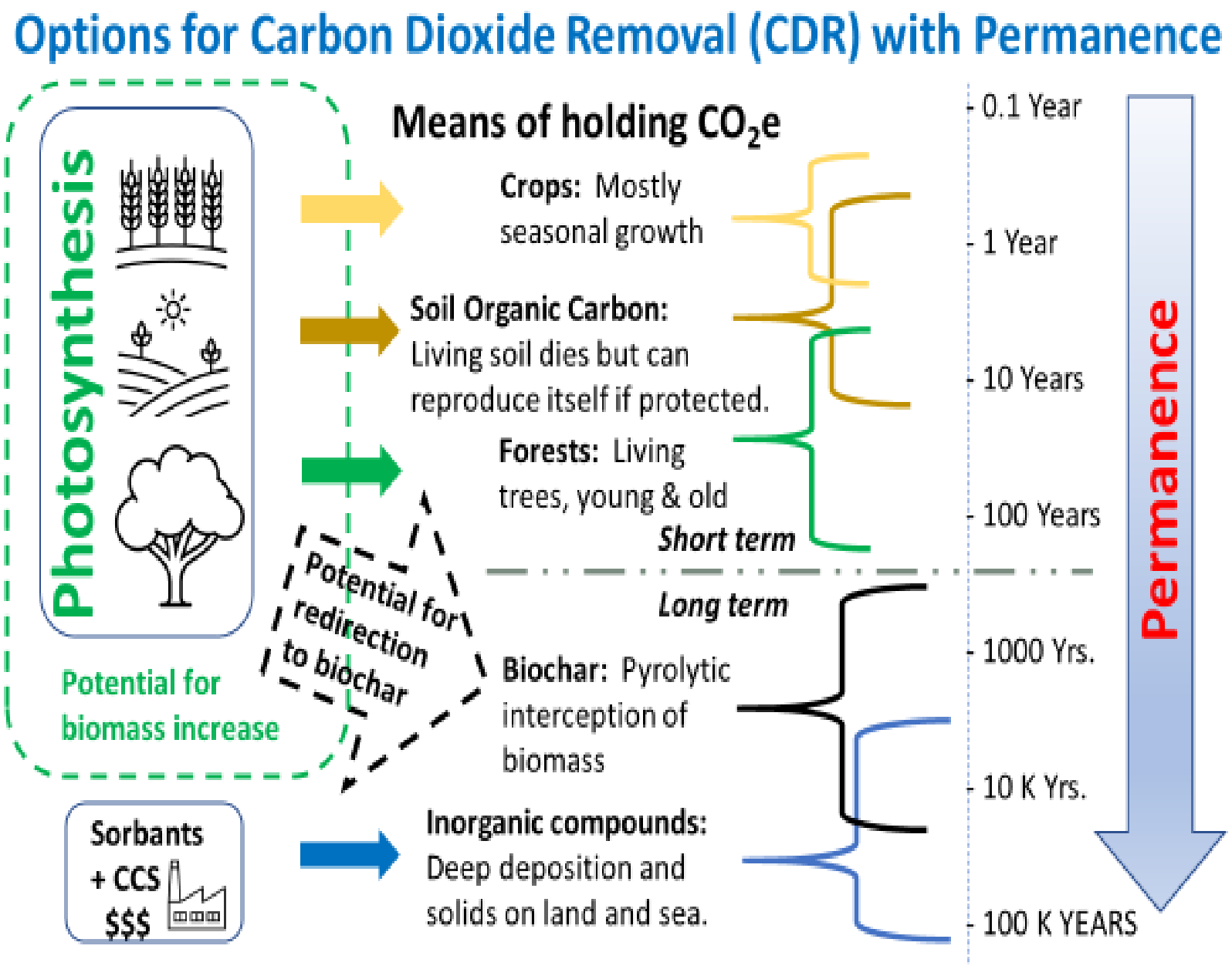


Table of sizes of RoCC Char makers

(New version 2020-02-15; Draft still in need of refinement; Some rounding)
(Based on cylinders; Extrapolations from Column B; Estimated variability of +/- 50%)

	A	B	C	D	E	F
	Size >>>> Issue (below)	55 gallon (Barrel)	~140 < 180 gallon	464 gallon (4x5 ft) (8 barrels) (1.7 m3)	750 gallon (4x8 ft) (14 barrels)	1500 gallon (~ 20 barrels)
a	Dimensions (Diameter x Length)	(D) 2 x 3 ft = 9 ft3	3 x 4 ft (28 ft3) (210 gal)	4 x 5 ft (62 ft3) (464 gal)	4 x 8 ft = 100 ft3 (2.8 m3)	4 x 16 ft= 200 ft3 (~5.6 m3)
b	Fuel input (kg/hr) (extrapolation from Col B)	~25 kg ~50 lbs (~3 - ~2.5 kg/ft3/hr)	~84 kg/hr	180 - 200 kg/hr	250 – 300 kg (Quarter ton)	500 kg 1000 lbs (Half ton)
c	Char output (kg/hr @ 20% yield) [CO2e reduction per hour]	5 kg 1 wheelbarrow (WB) [18 kg]	~16 kg/hr [58 kg]	40 kg [146 kg]	50 kg [~ 183 kg]	100 kg [366 kg]
d	Thermal energy output as 70% of total (30% in char) 12 MJ/kg/hr 8 BTU/lb/hr	300 MJ 83 kW-h 284 K BTU	Almost 1 M BTU (Under EPA interest threshold)	2400 MJ 666 kW-h 2.3 M BTU	3000 MJ 830 kW-h 2.8 M BTU	6000 MJ 1660 kW-h 5.6 M BTU
e						
f						

	A (repeated)	F (with new units)	G	I	J	K
	Size >>>> Issue (below)	1500-gallon 200 ft3 4x16 ft; 5x10 ftf; 6x7 ft	3000-gallon 400 ft3 11.3 m3	7500-gallon 1000 ft3 28 m3 = 20 ft container	15,000 gal 2000 ft3 56 m3 = 40 ft container	30 K gallon 4000 ft3 113 m3 (RR tank car)
a	Diameter / Length	4 x 6 x 8ft = 200 ft3 (~5.6 m3)	6 x 14 ft or 7 x 10 ft 8 x 8 ft	**8 x 20 ft** 10 x 13 ft 12 x 9 ft	12 x 18 ft 14x 13 ft 16 x 10 ft	10 x 52 ft (RR tank car) 16 x 20 ft
b	Fuel input (estimate per hr) (extrapolation from Col B)	500 kg (Half ton)	1000 kg ~ One ton per hour	2.5 tons per hour	5 tons per hour (~3 - ~2.5 kg/ft3/hr)	~10 tons/hr
c	Char output (w/ 20% yield) [CO2e reduction per hour]	100 kg [0.36 kg]	200 kg/hr [0.73 kg]	500 kg/hr [1.8 t]	1 t/hr [3.6 t]	Estimate 2 tons/hour [7.2 t/hr]
d	Thermal energy output as 70% of total (30% in char) 12 MJ/kg 8 K BTU/lb	6 GJ Gigajoules 1.66 MW-h 5.6 M BTU	12 GJ Gigajoules 3 MW-h 10 M BTU	30 GJ 8 MW-h 28 M BTU	60 GJ 16 MW-h 57M BTU	~120 GJ 33 MW-h 114 M BTU
e						
f						

Selected Sizes of RoCC Char Makers

(**Revised version 2020-06-22**; Draft still in need of refinement; Some rounding)
(Based on cylinders; Extrapolations from Column B; Estimated variability of +/- 50%)

	A	B Midi Scale	D Medium Scale	E Medium Scale	G Large Scale	I Large Scale
1	**Name & Size >>>>**	**Barrel (Home)** **2 D x 3 L (ft)**	**Utility - A** **4 D x 5 L (ft)**	**Utility - B** **4 D x 8 L (ft)**	**Bulk Service** **6 D x 14 L (ft)** **8 D x 8 L (ft)**	**Container (20 -ft)** **8 D x 20 L (ft)** **12 D x 9 L (ft)**
2	**Volume**	9 ft3 = 0.25 m3 (55 gallon)	62 ft3 = 1.7 m3 (464 gallon) (~ 8 barrels)	100 ft3 = 2.8 m3 (750 gallon) (~ 14 barrels)	400 ft3 =11.3 m3 (3000 gallon)	1000 ft3 = 28 m3 (7500 gallon)
3	**Fuel input (kg/hr)** (Extrapolation from Col B) (Based on volume; less if based on horizontal area of flame cap pyrolysis.)	~25 kg ~50 lbs (~3 to ~2.5 kg/ft3/hr)	180 - 200 kg/hr	250 – 300 kg Quarter ton /hr **~ 5 t / workday** or > 2 cords.	1000 kg ~ One ton / hour **~ 10 t / workday**	2.5 t/hr **~ 25 t / workday** (Probably is high, but certainly at least 10 t/ day)
4	**Char output (kg/hr @** 20% yield) [CO2e reduction per hour]	5 kg ~1 wheelbarrow [18 kg]	40 kg [146 kg]	50 kg [~ 183 kg] (~1.8 tCO2e/day)	200 kg/hr [0.73 t] (~7 tCO2e/day)	500 kg/hr [1.8 t] (~1.8 tCO2e/day)
5	**Thermal energy output** as 70% of total (30% in char) 12 MJ/kg/hr 8 BTU/lb/hr	300 MJ 83 kW-h 284 K BTU	2400 MJ 666 kW-h 2.3 M BTU	3000 MJ 830 kW-h 2.8 M BTU	12 GJ Gigajoules 3 MW-h **10 M BTU**	30 GJ 8 MW-h 28 M BTU

	A	E
1	**Name & Size >>>>**	**Utility - B** **4 D x 8 L (ft)**
2	**Volume**	4 x 8 ft = 100 ft3 (2.8 m3) 750 gallon (~ 14 barrels)
3	**Fuel input (kg/hr)** (Extrapolation from Col B) (Based on volume; less if based on x-sectional area.)	250 – 300 kg **(Quarter ton / hour)**
4	**Char output (kg/hr @** 20% yield) [CO2e reduction per hour]	50 kg [~ 183 kg]
5	**Thermal energy output** as 70% of total (30% in char) 12 MJ/kg/hr 8 BTU/lb/hr	3000 MJ 830 kW-h 2.8 M BTU

Hypothetical scenario with utility-size RoCC Kiln

- Abundant biomass
  - Slabs / refuse wood; urban wood waste
- Need for heat and hot water
  - Apt complex; school; small industry
- Replace fossil fuel
  - Avoid carbon tax;
- Biochar for agriculture
  - Increasing value
- Carbon sequestration
  - Increasing importance

Patents and Business Prospects

- The RoCC kiln invention has international patent pending status with likely coverage until 2040. This protects your interests as well as those of the inventor.
- When there is financial gain based on the RoCC kiln production or use or other activities such as gained carbon credits, some small share should come to the inventor.
- Therefore, there are at this time (06/2021) no up-front fees to become involved with RoCC kilns and receive expert assistance.
- All options are open for business arrangements to be made so that the RoCC technology can become the basis of business for biochar, energy, climate benefits, and more.
- You are encouraged to become informed about how you or your geographic area or field of activities could benefit with RoCC kilns.

Costs of RoCC Kilns (in affluent societies)

- **Barrel size (such as 55-gal drum and cylinders up to 3-ft diameter & < 4-ft long):**
  - **Do-It-Yourself (DIY)** for your own use can be **essentially free** if you use scrap, found, or hardware store items.
  - **Purchase ready made (or hire the work) for a few hundred dollars** from a supplier (who is in business for profit and needs a written agreement with the inventor).
  - [NOTE: The H-Frame design needs about US$100 for new materials in America. But labor for preparation (cut, drill, and weld) will cost hundreds more.]
- **Utility size (from 3 to 4-ft diameters and up to 10 ft long):**
  - Many variables, but likely to **cost from 2 to 8 thousand dollars,** but without mechanical operation. The inventor can assist you to locate a supplier (and save).
  - Special arrangements for those making units with features not previously included, such as for heat capture and use.
- **Bulk service size and larger:**
  - Contact Dr. Anderson for special assistance. Consider doing joint research and/or business efforts. Probably used for a heating or biomass reduction project.

In-field RoCC Kiln for Crop Refuse (Design only)

[A better design in H-Frame is coming soon.]