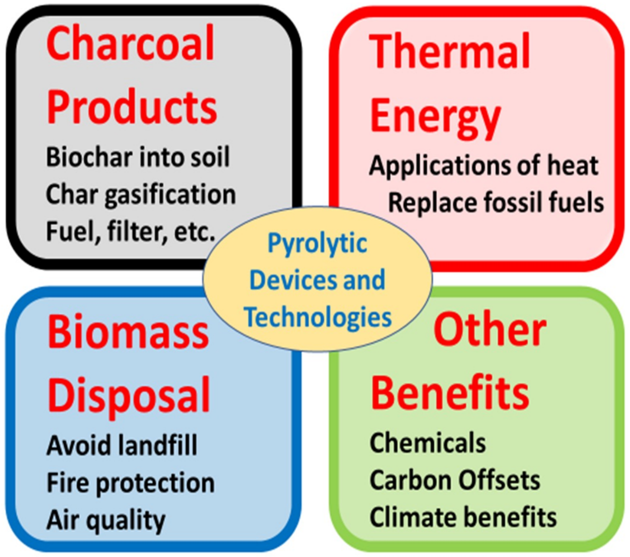
Low-Cost Timber Stand Improvement (TSI) via RoCC kilns, Biochar and Carbon Markets

or

Financially Viable Biochar Production in Forestry

Paul S. Anderson, PhD, and Gary Gilmore, Forester

A presentation to the 2022 USBI Conference, Morgantown, West Virginia, 9 – 11 August 2022



Track / Category: Climate Smart Agriculture and Forestry

- Part 1: Background: 8 slides assumed to be known
- Part 2: Operations and financial outcomes
- Part 3: Conclusions and projections

Available at Website of Woodgas International: https://woodgas.com

Structure of the presentation and slides:

The full deck of 30 slides contains far too many details and words to be covered in a 15-minute oral presentation. Instead, I will present ~10 SUMMARY SLIDES that are followed by the detailed slides.

Part 1: Background:

The next 8 slides are for review. The content has been presented previously and most is available at https://woodgas.com . Please contact the authors for details and support for your activities with RoCC kilns.

Start of Part 1: Background - Abstract (revised):

Through two proposed grants for USDA Climate Smart Commodities, **we intend to establish that biochar production from low-value forest biomass has sufficient financial value to cover much of the substantial costs of Timber Stand Improvement (TSI) in American forests.**

The projects are on thousands of acres of the Seneca and Maidu tribal lands in Northern (Allegany) and Pacific (Sierra Cascade) forests, respectively.

Biochar is a new 21st Century Climate Smart Commodity. The biochar produced in the project is used 1) to conduct demonstration projects and 2) to help establish market values of biochar as a physical soil-amendment commodity and as a CO2 removal (CDR) commodity.

The financial benefits are from four sources:

A. Increased forestry income from forest growth from essentially free TSI.

B. Value of produced physical biochar.

C. Value of the long-term CO2 REMOVAL (CDR) sold for carbon credits.

D. Payment for perceived benefits for habitat, biodiversity, watershed protection, fire hazard reduction, scenic beauty, etc.

Our project is uniquely innovative in seven (7) ways:

1) use of **patented RoCC kilns** for biochar production onsite in forests,
2) use of **CERCS Web3 apps**, featuring CharTrac for innovative MMRV for CDR,
3) use of **Baseline Biochar Metrics (BBM)** for improved product quality analyses,
4) use of safe (controlled) **pyrolysis within burn scars** to reduce fire hazards even during fire bans,
5) use of **“standing firewood”** in TSI for reducing costs and improving drying and storage,
6) showing how 50% of short-term CDR forest growth becomes **long-term CDR via biochar**,
7) establishing **new profitable and beneficial forestry businesses** focused on TSI and biochar that can scale.

Sizes for Pyrolytic Biochar Production

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

Details are in the Green Carbon Webinar of 25.06.2020.
https://www.youtube.com/watch?v=tdpqx_bzT20

Objectives

- Laboratory (< 1 kg) — R&D /testing
- Micro (1 to 10 kg.) — Cooking

TLUD cookstoves

- Small (10 to100 kg)
- Midi (100 kg to 1 ton) — Making Biochar
- Medium (1 t to 10 t) — Various

Major gap in available technology now filled by RoCC kilns

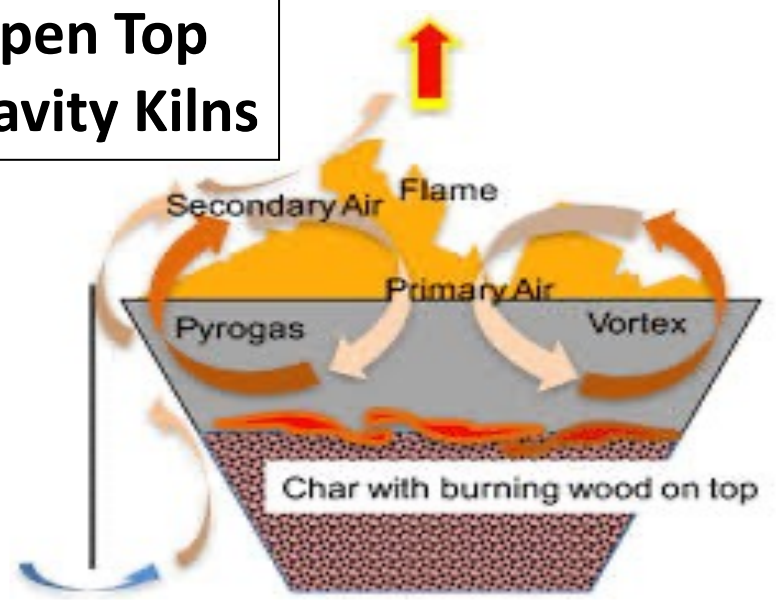
Different Diameters of **RoCC kilns**

- Large (10 ton to 100 t) — Char/chem/power
- Industrial (> 100 t) — CHP (char secondary)

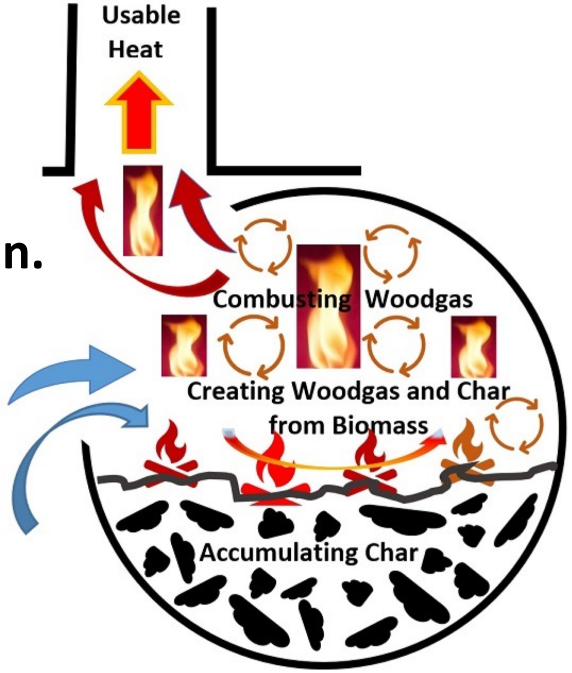
Not my topic

The RoCC Kiln Technology

Open Top Cavity Kilns



- **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.**



Covered 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.

Four Sizes of RoCC Kilns (as of August 2022)

Approximate diameters are 2 ft, 3 ft, 4 ft and 6 ft.

[All of these are pre-H-Frame designs. They are discussed in other presentations.]

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

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.

100 to 1000 kg/day biomass input

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

Commercial production of biochar: Kenya

- Two-barrel RoCC kiln with "H-Frame" w/ wheels.
  - Instructions are at woodgas.com
- Note: Newer models / designs of supports and wheels are preferred.
- Easiest way to gain experience is small-scale actual usage.

- Challenges in Kenya:
  - Biomass supply
  - Funding

Implementation partner: Biochar Pamoja, Gilbert Mwangi. Contact Paul Anderson

Forestry biochar:

- Forestry "residues"
- Large RoCC kilns
- Current largest is 6 ft diameter x 7 ft length
- Biochar production approx. 0.5 tonne per day
- Will enlarge to 8' x 20' for logs. Largest size is not yet known.
- Challenges:
  - Funding. Seeking investor(s)
  - More R&D participation

Implementation partners: Seneca (NY) and Maidu (CA) Tribal Nations (Pending USDA funds)

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

Part 1: Background:

The previous 8 slides were for review. The content has been presented previously and most is available at https://woodgas.com .

Part 2: Operations and financial outcomes:

Also with summary slides for faster presentation. Detailed slides are for slower, individual viewing.

Summary of Assumptions for Discussion

- **Assume abundant biomass with appropriate conditions of equipment, labor, management, etc.**

- **Details are on the next slide.**

- **The following calculations assume 1 tonne of biochar per 2-person work crew per day, derived from about 5 t of reasonably dry biomass ready for pyrolysis.**

Assumptions for discussion

- **Abundant biomass** on reasonably accessible land. (Start with easy cases.)
- **TSI cutting only** (which must be done). No chipping and no transport from area, but the biomass is arranged for drying and later pyrolysis.
- **"Standing firewood"** of girded trees for vertical drying of stored biomass that is available at any later time. Remove ladder fuel and crowns.
- **Improved forest access** via planed TSI actions will aid biochar production.
- **TSI biomass yield** is impacted by MANY variables including forest type, terrain, time, objectives, budget and forestry equipment.
- **RoCC kilns numbers**, sizes and features are controllable variables.
- **The following calculations assume 1 tonne of biochar per work crew per day, derived from about 5 t of reasonably dry biomass ready for pyrolysis.**

Summary of Expenses:
Labor, equipment, kiln, & other (very rough)

- **Labor:** Two workers per crew with benefits = **$500/workday/t-biochar.**

- **Forestry equipment:** Financed (or leased) estimated as **$200 /workday.**
  (The financing of equip & kilns is a major issue.)

- **RoCC kilns** leased or financed for **$100 /workday** ($2000/mo = $24,000 /yr).

- **Services and admin** for supervision, MRV, maintenance, fuel. Est. **$100/day**

- Subtotal: $500 + 200 + 100 + 100 = **$900/day to obtain 1 t biochar.**

[Next slide has more details.]

Expenses: Crew, equipment & other (very rough)

- **Labor** is expensive; try to reduce. With benefits, perhaps US$30/hr (?); becomes $250/day/worker. Two workers per crew = **$500/day/t-biochar.**
  - More investment in equipment can reduce labor costs.
- **Forestry equipment:** 4-wheel-drive/skidsteer with bucket and/or backhoe with grapple claws. One to service 2 to 4 RoCC kilns near the biomass. Plus chainsaws, water tank (safety mainly), misc. Financed (or leased), so estimate of $200 /day (?). ***(The financing of equip & kilns is a major issue.)***
- **RoCC kilns** leased or financed for $100 /workday ($2000/mo = $24,000 /yr).
- **Services and admin** for supervision, MRV, maintenance, fuel. Est. **$100/day**
- Subtotal: $500 + 200 + 100 + 100 = **$900/day to obtain 1 t biochar.**
- NOTE: Numbers could be higher or lower and will change in the coming years. We want an initial "target of expenses" for our discussion.

The financial benefits are from four sources.

Two are "voluntary" and difficult to capitalize.

A. **Improved forest growth** will give increased forestry income (not known but projected) from **Timber Stand Improvement (TSI).**

B. Payment for **perceived socio-environmental benefits** for habitat, biodiversity, watershed protection, fire hazard reduction, scenic beauty, etc.

Two are market-based with fluctuating values.

C. Value of produced **physical biochar**.

D. Value of the **long-term CO_2 REMOVAL (CDR)** sold for carbon credits.

[The next 4 slides give supporting details.]

A. Increased forestry income from improved forest growth from lower cost Timber Stand Improvement (TSI).

- TSI includes resolving:
  - Canopy competition | Understory growth | Thinning of plantation forest
  - Invasive species | Unhealthy trees | Fire hazard reduction
  - ALL yield small diameter forest stems & branches that accumulate or cost transport $.
- **TSI requires on-time payments, but growth has delayed payback.**
- We are considering how to finance TSI with biochar production.
- If TSI is not sufficient initial motivation, seek another client.

B. Financing with perceived benefits

- **Perceived benefits** can be for habitat, biodiversity, watershed protection, fire hazard reduction, scenic beauty, etc.
- VALUE is in the eye of the beholder. And all the markets are **"voluntary"** and can pay whatever is the agreed price.
- Example 1: What is the value of significantly **reducing the fire hazard** of an overgrown forest that is up-wind of residences and businesses? And what is that value in terms of premium rates on fire insurance?
- Example 2: The groves of redwoods / Sequoias in Yosemite National Park are beautiful, **irreplaceable and priceless**.
- Question: Should government bodies that have responsi-bilities of the environment and already pay billions for fighting forest fires contribute to what we are discussing?

C. Value of produced physical biochar.

- The prices of physical biochar are highly varied and influenced by many variables:
  - Supply and demand
  - Type of biomass feedstock
  - Temperature of pyrolysis
  - Char characteristics
  - ???
  - ???

- Estimated value of **$300 per tonne** (FOB edge of the forest).

- **Value of biochar into forest soils for improving tree growth** has not been determined but could be an important factor to influence forest owners.

D. Value of the long-term CO2 REMOVAL (CDR) sold for carbon credits.

- **CDR = Carbon Dioxide Removal** ("removal" implies long-term storage; it could be called **CDRS** to emphasize that such storage is accomplished.)
- CDRS units = **1 tonne CO_2e** securely sequestered for at least many hundreds of years. **400 kg biochar = ~1 t CO_2** (Ratio 1:2.5)
  - Quite different from "Carbon Offset Credits" that refer to emission reductions.
- After adjustments, **1 tonne biochar = ~2.5 t CO_2**
- **Price of 1 t CO_2 that is truly removed as CDRS** is **not** well established.
  - Purchase prices are often not disclosed. **Estimated to be $80 to $180.**
  - Technology stimulation funding pays US$100 to >$600 per t in some cases.
- If we assume $100 / t CO_2e, then **receipts would be $250 for 1 t/day.**

Summary #1 of TSI finance estimates:

based on 1 t biochar per crew/day

- "Income"
  - Physical biochar: +$300
  - CO2 removal: +$250
  - Subtotal: +$550
- "Expense" -$900 =

Labor	$500
Equipment	$200
Kiln expense	$100
Admin	$100

- Net operations cost: **-$400** **to be offset by other values (below)**

Other Income that is not included:

- **Firewood value:** Ready for extraction; minus transport costs.
  - By 2050 with "Net Zero" requirements, heating with biomass could be crucial. [Pyrolytic space heating with biochar production is another topic; see me.]
- **TSI increased value:** Owner could pay something (or should).
- **Perceived social value:** Fire hazard reduction or natural value.
- **Heat/chemicals value:** This is a goal for R&D. And it will come.

Summary #2 of TSI finance estimates:

based on 2 t biochar per crew/day

- "Income"
  - Physical biochar: +$600
  - CO2 removal: +$600
  - Subtotal: +$1100
- "Expense" -$1200
- Net operations cost: **-$100**

Income is doubled to $1100

=

Labor is the same	**$500**
Equipment is doubled	**$400**
Kiln expense is doubled	**$200**
Admin is the same	**$100**

Other Income that is not included:

- **Firewood value:** Ready for extraction; minus transport costs.
- **TSI increased value:** Owner could pay something (or should).
- **Perceived social value:** Fire hazard reduction or natural value.
  - "Maybe some amount, if the benefit is close to me."
- **Heat/chemicals value:** A goal for R&D. And it will come.

Further considerations:

- We have still not factored into the discussion:
  - All values are based on **initial estimates.**
    - Labor is very high; could be lower in many areas.
    - Used or underused forestry equipment.
  - Too many variables to be representative of many actual cases.
  - Some variables can and will increase and others decrease, and we are only getting started to work on solutions to whatever else might arise.
- **Is this representation close enough to merit some consideration and some funded projects?**

Your comments will be appreciated!!

Part 3: Conclusions and projections:
National numbers:

- America has **over 800 million acres of forests** in four main regions.
- Northern, Southern, Mountain and Pacific forests have distinct needs.
- If there were **5 tonnes of low- or no-value biomass per acre of TSI**, that would be 800 million t biochar or 2 billion t CO_2 removal potential.

Part 3: Conclusions and projections:
Bring it down to operational sizes:

- **Per 100 M acres (of the 800 M), and if on a 10-year rotation schedule,** that would be 10 million acres /yr. Assuming 200 acres /yr per crew, then 50,000 crews (100,000 jobs) are needed. And could be 5 to 8 times bigger.

- **Per 10 M acres/yr under TSI-Biochar programs**, sequestration would be 25 M tonnes of CO2e per year, with CDR value of $2.5 billion per yr, and $5 B / yr for physical biochar at only $200/t. CDR is REMOVAL, not reduction.

- **Per 10,000 acres/yr under TSI-Biochar programs**, sequestration would be 25,000 tonnes of CO2e per year, with CDR value of $2.5 million per yr, and $5 M / yr for physical biochar at only $200/t. Need 50 crews of 2 persons.

What could possibly go wrong?

- Everything!!!
- With numerous innovations in equipment and methods to be trialed, the biochar production capacity **could be only half, or could be double.**
- The financial estimates of biochar values could be half or double the projections. This is the wild wild west of biochar.
- **The climate crisis will drive all factors to favor this TSI-biochar model.**
- The world is slow to respond to the climate crisis. An appropriate trial will be useful, but funding is crucial.
- We await the decision soon on **two separate proposals** of $3 M each to the USDA Climate-Smart Commodities program. One in NY is with the Seneca Nation in Northern hardwood forests. One in CA is with the Maidu Summit (Tribal) Consortium in the Sierra-Cascade forests where we will trial biochar production in recent burn scars.

Personal comments If interested, please see me.

- 1. If you have not looked at my white paper ***"Climate Intervention with Biochar"***, please see it at https://woodgas.com/resources
- 2. I am not a **forester nor an economist** nor business manager. All such help and more is greatly needed.
- 3. I am **focused on small and mid-size pyrolysis devices at lower costs.** Gary Gilmore and I invented the RoCC kilns that are now available.
- 4. Next month I will be 79 years old. **RoCC kilns need some younger talent.** I am seeking associates, partners, licensees, project developers, etc.
- 5. [Say whatever else comes to mind.]

The next two slides have some notes about business issues.

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.

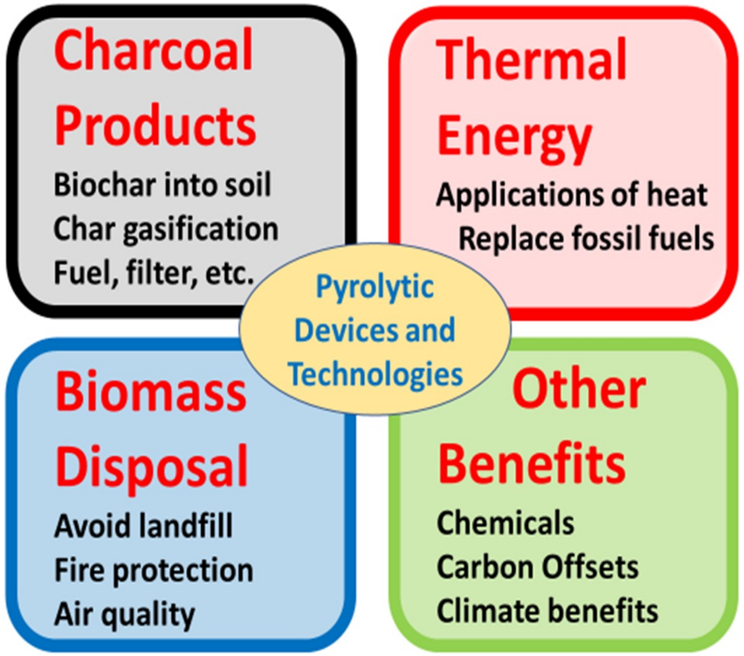
- When you (or others) do gain from the RoCC kiln, then part of that gain is to be provided back to Dr. Anderson who holds a patent.

- 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)

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 char production business** with RoCC kiln
  - Produce biochar more efficiently with RoCC kilns
- **Commercialize biochar products** with char produced in RoCC kilns
  - The focus is on final sequestration of the biochar, never to be burned.
- **Carbon market transactions** with carbon units from RoCC kilns
  - Dr. Anderson will use carbon markets to increase the cash flow for growth
- **Other activities** linked to RoCC kiln capabilities

Questions?

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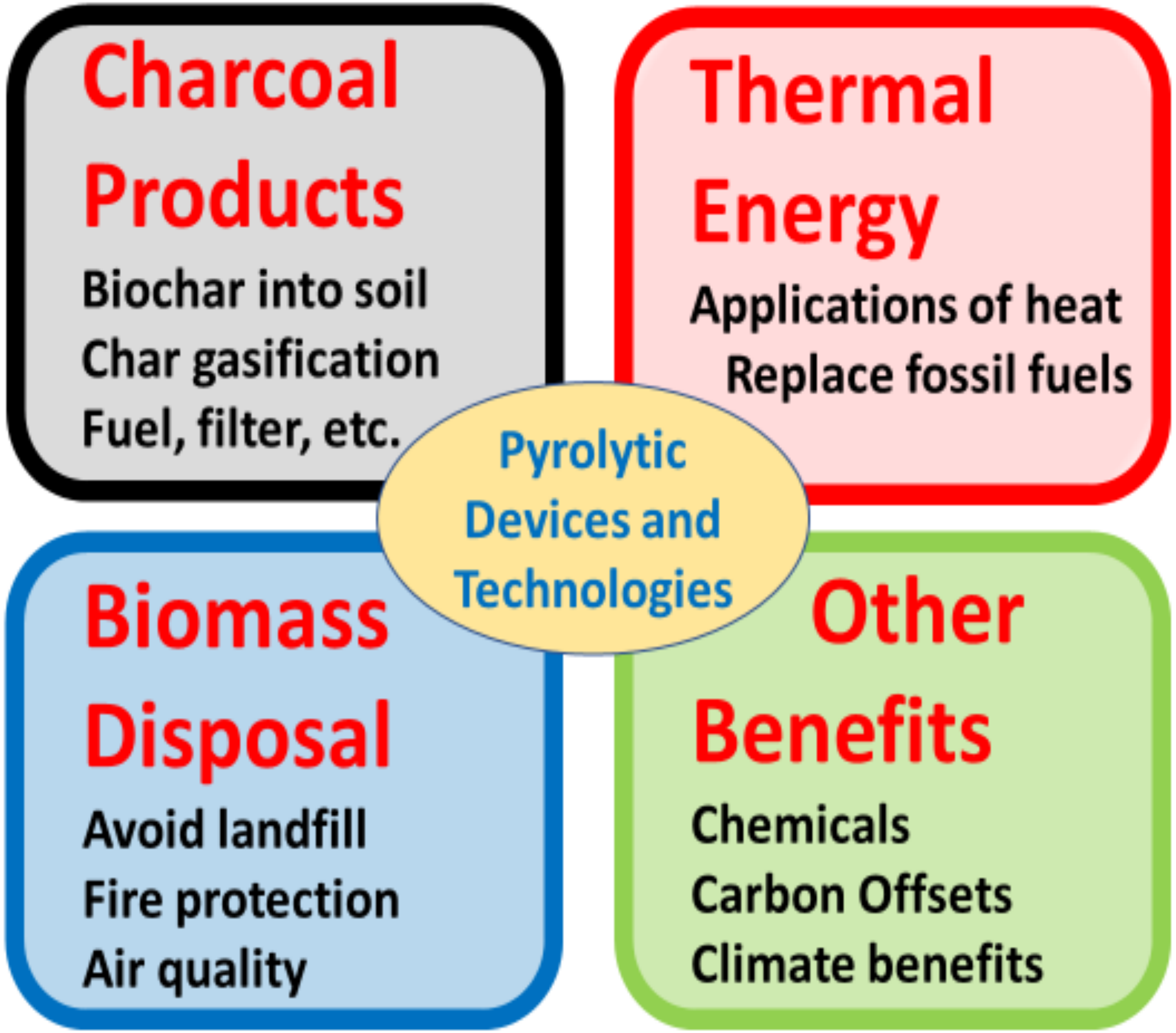
This presentation plus RoCC documents and more are available at the website:

www.woodgas.com



See Paul Anderson's white paper:
"Climate Intervention with Biochar"