October 27, 2022, Meeting

Clean Fuel Standard: Agriculture and Forestland Carbon Capture & Sequestration Advisory Panel (AF-CCSAP)

MEETING SUMMARY

PARTICIPANTS

Advisory Panel Members:

- Abbey Brown, Washington Dept. of Ecology
- Cherie Kearney, Columbia Land Trust
- Chris Covert-Bowlds, Dr., Washington Physicians for Social Responsibility
- Csenka Favorini-Csorba, Washington Department of Natural Resources
- Dryw Jones, US Forest Service Pacific Northwest Research Station
- Harrison Pettit, Pacific Ag Biofuel
- Jim Amonette, Washington State University & Pacific Northwest National Laboratory
- John Henrikson, Wild Thyme Tree Farm
- Karen Sowers, Pacific Northwest Canola Association
- Max DuBuisson, Indigo Agriculture
- Mary Catherine McAleer, Weyerhaeuser
- Paul Buckland, Inland Empire Paper Company
- Stephanie Celt, Washington Department of Commerce

Other Participants:

Department of Ecology: Debebe Dererie, Janée Zakoren, Rebecca Sears, Joel Creswell

Opening

Rebecca Sears (Ecology) welcomed Advisory Panel members and provided an overview of the meeting agenda and objectives. Biochar is a big topic – we expect to have future meetings on further biochar topics. How came to focus on biochar. First two were about introducing to backgrounds, interests, expertise, rough out a work plan create a shared understanding of CFS and LCA. We know some places we'd like to go – how do we get there. Meeting three we worked on possible practices, which might be greater priority, and the criteria by which we might evaluate. Biochar was one of several practices, and with the expertise of the panel and the experts on the panel and recommend biochar great place to start. Future meetings on biochar, shaped by interests of this group. When learning and engaging in biochar today, helpful to consider draft criteria: efficacious, quantifiable, verifiable, sequestration size, reliability, durability, readiness, and avoidance of negative impacts.

Abbey provided an Ecology update. The panel is tied to the long-term of the Clean Fuel Program. The short term – nearing the end of the rulemaking process (since July 2021), and planning to adopt in the end of November. The rule will provide much more detail about how the program will work. Preparing for program launch January 1. CCS practices will not be incorporated into the program January 1, but we are thinking about the longer term, how we can quantify, account for and incentivize these practices. That is something that we're working on the panel in the long-term.

The members shared what they hoped to learn on biochar during the meeting. Interests included: fundamentals of biochar; the scale of sequestration opportunity; market opportunities; feedstock types; processes; co-benefits; human health effects and relative benefit to carbon benefits in general; longevity under different applications; avoided emissions to agricultural burning; bi-products; barriers and limitations and incentives; incorporating into landscape for agriculture, combined with food, fish waste, long term soil, nutrient, water retention – is it scalable and economical to produce; production process; lifecycle benefits; learning current science; how biochar fits into a fuel pathway; how long does it stay around, confidence in measurements; how feedstock components effect the carbon component and how that effects the credit; where processes take place and how biochar impacts people and communities.

The meeting transitioned to the carbon capture and sequestration practice presentation provided by Jim Amonette. Jim Amonette holds a joint appointment with the US Department of Energy's Pacific Northwest National Laboratory and Washington State University's Center for Sustaining Agriculture and Natural Resources. He has more than forty years' experience in research related to soil chemistry, and more than twenty years' experience focusing on carbon sequestration by soil systems. The last 17 years he has devoted a major part of his work to biochar, with a focus on assessing the potential impact that biochar technology can have in drawing down carbon from the atmosphere. Currently, he is working on several biochar projects involving climate and economic life cycle assessments and the integration of biochar with other carbon drawdown/storage approaches.

The AF-CCSAP presentation format consisted of 3 biochar topics, with each topic having a 15-minutes presentation followed by a 15-minutes Q&A, for a total of a little more than 90-minutes presentation total.

Part 1: Biochar basics

Presentation

The term biochar has been around since late 1990s. It can be made from a variety of feedstocks. The focus is on residues that might otherwise be wasted, or not utilized in productive manner as opposed to having plantations and cutting down trees. If it's done sustainably it is used to convert biomass residues.

Produced by different allied processes– pyrolysis or gasification. What goes on as we make biochar? Initially, we have well-ordered system, whatever our biomass is, and there's no char, but once raise temperature, we're going from one system where we have chemical compounds of one kind, and when we get done, we have a totally different set of chemical compounds. It's primarily carbon (80%), a little bit of oxygen, little hydrogen, and with the chemicals entirely rearranged. Depending on how far you go, and temp, you end with a stable carbon, quite a bit less of original biomass. At same time, a lot has gone to atmosphere, so may have half of the carbon started with up ends up in atmosphere, and the remaining gets increasingly more stable.

There's no single way to produce biochar. There's slow pyrolysis, and fast pyrolysis. The difference has to do with the heating rate. Slow is made with larger biomass chunks. Fast pyrolysis needs a small particle size, requiring biomass to be sawdust size, to enable pyrolysis to happen quickly when encounters heat. Slow pyrolysis gets biochar and some gases in hydrogen and carbon dioxide, so syngas if chose to collect. Fast pyrolysis ends with some biochar, but lots of other things, like bio-oils that can be refined. Depending on what trying to do, you might go with slow or fast pyrolysis.

The higher the carbon content, the more stable it is. Increase water holding capacity.

Q&A

You mentioned biochar is stable for centuries – under what conditions?

Essentially when combined with soils, so it's dependent on the soil temperature, to some extent as to its stability. At 10C a typical biochar would have a half-life ~1,000 years. If you go to 15C, it's on the order of 300 years. For the biochar, there's typically a fraction that comes off in the first few years, and there's the highly stable fraction more like graphite in its structure.

Carbon sequestration and carbon emission net cost/benefit analysis?

We'll cover during third part of presentation. Briefly, I don't think you'll make money making biochar just by itself. The carbon credits at this point are not at a level to support that. You must get smart and combine the biochar production with other uses of biochar – co-composting operations, combining with concrete as a substitute, things like that, you'll have to combine with some other process to get carbon credits.

What qualities of the biochar determines the carbon sequestration credit value?

We'll cover during third section. Basically, the production itself – how clean, efficient, what fraction of biomass made into biochar, how much methane or soot emitted in process, part is the stability of the biochar when get into question of how stable it is.

What is the relationship between the type of production (slow vs fast) and use?

Talking about using biochar itself, if focus is only on biochar probably go with slow, avoid the extra process of bio-oil and cleaning it up. If on other hand, the question is how to pay for itself, and bioenergy is one way to make it pay, can generate energy by syngas, or bio-oil. In the Iowa example they have 3 products – biochar, a substitute for asphalt, a feedstock for bio-oil. They pay for biochar production, and the carbon credits make it appealing.

Economic analysis of efficiency between fast vs. slow pyrolysis? Related to feedstock processing cost?

Fast is more complicated and is going to be more expensive. The only one I'm aware of that seemed to be profitable is this Iowa example. Generally, gasifier type systems or slow pyrolyzer, with minutes to hours instead of seconds of biomass residence time, are more profitable to operate.

What are the ideal sizes for biochar production systems? I'm thinking you want bigger if you want sequestration benefits, but then presumably you begin needing to transport materials longer distances which may add lifecycle emissions?

Generally, we think of a fuel shed as a 50-mile radius and under those conditions the transport emissions are negligible compared to the benefits of the process. The economic side is more expensive. So, the economics are affected before the emissions. It depends how much biomass you have. Everyone wants a 100t a day but there are some places where it's hard to get the transport, and it's easier with the portable systems. Like the containerized systems that are small enough to move, if you need more capacity, they are sophisticated, clean, and lower emissions. Portable systems for smaller fuel sheds coupled with the large single bioenergy facility for the larger fuel sheds are the way to go.

Do we have long term (century? Multi-decadal?) studies that support the half-life of hundreds of years? Or is that based on shorter term studies?

Based on shorter term studies. We have several abandoned charcoal production sites, from 100-150 years ago, and now they have tools to study the types of carbon present. What we don't know is how much biochar they started with. They seem to confirm that you have this first couple three years, the less stable stuff comes off, but then slows down the rate of release. It's a concern, but not too concerned, things seem to agree.

What is the most common use of biochar currently?

Market wise, until last couple years, marijuana growers were the biggest consumers of biochar, as it's a high value crop and could make it pay. Generally, seen as a soil amendment. It's not paying as an amendment for commodity crops yet, so it will need to be subsidized. Now it's put in soil as a storage medium. Concrete would be more durable. Industry still trying to figure out what the best place to put this stuff is.

Are you familiar with Charm Industrial's program?

Yes, while I haven't seen the hard data, I understand generally what they're trying to do. It's analogous in a sense to geologic sequestration, where you drill a well each time you inject. So, wonder if they're going to run into issues with how many sites they have, and don't know the capacity for each storage well. Nothing inherently wrong with the process, difference with biochar is that it doesn't have some of the co-benefits of biochar associated with soil amendments.

Part 2: Biochar applications

Presentation

Biochar and Washington are a good match – large ag land area for incorporating, moderate soil fertility (e.g., soils that have received lots of nitrogen and are acidic and can benefit from biochar).

If biomass is sustainably procured, forestry residues account for 70-90% residues total.

Western states in general. As the price one is willing to pay for biomass increases, the amount of available biomass increases. Right now, about 34 – 40 dollars per ton, about ¼ the potential biomass available. In 17 western states there is more ag residue relative to forest residues found in Washington state.

What can biochar do in ag:

1. Soil amendment: liming agent, increase porosity and water holding capacity, promotes soil organic matter formation
2. Livestock feed additive (some evidence, hard to reproduce in temperate climes, don't know if it's a big player)
3. Manure disposal (may not be best use of manure, if don't have another market for it, may be one thing one could do with it)

Agriculture applications – wheat and pea application. Wheat cultivars already designed to grow at lower pH. So not much impact on wheat.

Water holding capacity – Looked at Quincy sand, almost doubling of water holding capacity, so there's potential in irrigated regions for increased productivity. Could help with flood events.

Forestry applications – Washington has a great deal of forest biomass particularly in Grays Harbor. So, end up hauling the char to the eastside of the state to use the biochar. Why want to do biochar:

1. Thinning for fire hazard reduction
2. Slash during timber harvest
3. Worst thing to do with slash pile is burn from a climate perspective

Forestry applications:

- Mobile air curtain burners (struggle to get past 15% carbon efficiency—meaning that 85% of the biomass carbon is put into the atmosphere immediately)
- Containerized gasifiers, slow-pyrolysis kilns, large bioenergy facilities have best climate impacts (45% efficiency) best options forward
- Flame cap kilns when need to clear, remote rough terrains, small wood lots, climate impacts not as robust

Linking forestry and agriculture—With forest managers wanting to reduce fire risk, could utilize mobile biochar units convert to high quality biochar, and transport to apply to acidic croplands

Organic waste management applications:

- Clean woody biomass in municipal waste streams
- Composting operations – lowers odors, speeds process, decreases methane emissions, but more data needed to optimize these results

Environmental filtration applications – roofing systems, roadway strips, road salt, remediations of spills, mine reclamation

Risks:

- PAH – small molecules are of most concern. Biochar itself is not a prob, but to get to that point, there are PAHs associated with all biochar, need to test to make sure it's not a problem.
- Decreases efficacy of pesticide and herbicide
- Uncontrolled preparation is the big one – need clean efficient methods, byproducts of fast pyrolysis often a problem
- Uncontrolled application – match biochar to specific soils and crops
- Quality control – diverse range of biochar properties possible, need certification programs

Benefits:

- New industry – boost to rural and urban economics
- New equipment/technological development
- Improve soil health (sometimes crop yields)
- Fire risk mitigation and cost – if it's made cleanly, we avoid the particulate issue
- Water management improving holding
- Way of storing carbon in an easily verifiable form. Can put in soil, measure in 5 years, measure 5 years again.

Q&A

Sounds much better than selective burning to reduce wildfires.

I think there is a cost issue, Dryw might be good to answer too, if only concerned about PM and methane, then yes, it is better. But there are also the economics and the ecosystem health issues. From the emissions, and the soot, you'd be better off avoiding open fires of any kind.

If you're talking about pre-commercial thinning and leaving slash on the ground all the carbon gets emitted on the floor over decade, or 10 % hangs around for 100 years. The co-benefit of generating energy is a huge untapped potential.

To optimize the forestry uses, does that mean setting up biochar facilities within 50 miles of sites? Are they mobile?

I can see they are mobile but is that the built-in assumption. Yes, but there is bioenergy that have been around for decades that have plenty biomass within 50 years. Often, they use a site for 2-3 years, so site and biomass dependent. There's a niche for mobile, a niche for stationary too.

You mentioned accumulation of SOC with biochar soil amendments – is that SOC accumulation through the soil profile or concentrated in the upper horizons? In other words, is the total SOC in the soil column increasing or just concentrating in the upper portions?

It's generally in the upper horizons, but biochar will breakdown and filter down where it can stimulate native soil carbon accumulation in the deeper horizons. The native soil carbon will accumulate over time.

You talked a bit about why biochar might not mean increased yields for wheat…in general is the potential for yield increases on a crop-by-crop basis, or are there other factors that influence whether it can mean increased yields?

It's pretty much crop by crop, but depends on the biochar, the soil. Talk about designer char for soil situations. The soil might be more important than the crop itself. Wheat just happens to be adapted for low soil pH.

Is there a relationship between stability in the soil and depth in the soil profile? Follow-up: does biochar migrate up/down the soil profile over time?

Th answer is yes – the deeper the more stable the carbon. That's why a deeply rooted crop puts a lot of carbon deep down. Largely has to do with temperature. Get to 55 F, that slow rate of oxidizing. Most of biochar stability data is correlated with temperature. You tell me temperature and I can tell roughly how stable it is. We don't know exactly how long it is before it breaks down – still more to be learned here.

Can you go over the technical potential for forestry residues graph again? $/BD tonne?

If we didn't care about market price, that max amount we could do is the top of the graph. Question is how much it takes to dry that down. The fact that it's free helps, but if it's 60% moisture content, you'd want to do an LCA on climate and finance side.

How would assess the feasibility of a free feedstock that is 60% moisture content?

Are there monitoring data on soil carbon over a decade or two period, at different depths?

There are a few studies out there, particularly in Australia, they first applied 15 years ago, and they monitored at depth. I've taken data from that study, looked at how fast the native non-pyrogenic increases over that, they all follow the same response curve. You're touching on a subject – we don't have all the research to answer all the questions that everyone would like to see. We know if a good thing is, but we need a long-term research program to answer that. The resources have not been brought to bear. If we can USDA and DOE to work together to get some long-term field trials that are adequately monitored in 10 locations around the country.

Part 3: Biochar climate change impacts and LCA approaches

Presentation

In regular carbon cycle, almost all the carbon returns to the air. The simple biochar cycle concept, we intercept the decomposition by converting to biochar, up to about 50% of the carbon, the rest is syn-gas or bio-oil, so about half of carbon ends in biochar, half in the atmosphere. The idea is that reduces amount put in atmosphere right away. Lifetime of high-quality biochar is ~20x higher than wood in soil, and ~200-500x greater than straw. Carbon efficiency and quality of man-made biochar exceed those of natural charcoal from wildfire.

This schematic shows the whole picture – other cereals in WA and felling losses for WA. Pyrolysis completely restructures the carbon. Part of the output is biochar, bio-oil, syngas, pr. Benefits – energy, avoided soil emissions, soil amendment. Climate impact – avoided some Co2, avoided some CH_4, NOX,

I haven't talked about is enhanced primary productivity. Between 5-10% enhancement to plant productivity – BUT most studies in tropics. More productivity pulls down more CO_2 from the atmosphere.

Key LCA parameters:

- Starting materials Carbon – most of biomass is about 50% carbon. The higher the lignin content, the more biochar you get out the other end. Lignin is the brown material from which they make corrugated cardboard. Don't have a good use for it otherwise.
- Alternative pathways for biomass – what would happen if didn't make biochar? The control option.
- Bioenergy production – Energy is going to be released, are you using it to offset ff emissions for example
- Carbon efficiency – carbon in biochar/carbon in biomass theoretically can't get much above 50%
- Production GHG/A emissions – do you have GHG and aerosol emissions? Methane has GWP20 which equals 91. First year is 134.and soot20 is 3300(xCO2). That absorbs radiant energy. In the first year it's 36000. This is why it's so important how it's made, cleanly, to reduce methane and soot emissions.
- Biochar quality – good correlation between ratio of hydrogen content to organic carbon content; lower the ratio, the more stable the biochar
- Impact on soil properties – The native carbon stocks, does it increase or decrease? Has impact on soil GHG emissions.

Biomass fates:

- Beetle killed trees – only half carbon goes up in wildfire, lose big chunk at outset, then slows
- If left biomass there and no fire, decay around 20–50-year half life
- Convert biochar, big chunk up in atmosphere away, then relatively stable

LCA side:

- Biochar v wildfire: It's always a better option to make biochar or controlled burn than let a wildfire burn
- Biochar vs. biomass decay: Takes a while to catch up
- We want a carbon payback period of 10 years or less

In WA state, the largest single contributor to the mitigation offset from biochar technology is from the carbon stored in biochar. There are small soil carbon losses due to crop residue removal, and to the slow oxidation of biochar carbon over time. Net of about 400million tons net avoided. Technical potential, biochar can offset 8-19% of WA state GHG emissions, largely from carbon accumulation and storage in soils.

Predicted 3x increase in soil carbon stocks in Washington agricultural soils over 100 years with maximum sustainable biochar production – needs on the ground reality check. Shows potential scope of storage.

How much biochar can WA soils accommodate? Will we run out of space? Aggressive timber harvest (facility + field) would take 60 years, then other options – concrete, asphalt, shift to fast pyrolysis. Tells us it's not infinite sink.

Biochar is twice as effective as bioenergy in WA due to the already low C intensity of primary energy production (hydropower).

A lot of carbon is buffered in the oceans and will return to the atmosphere as we remove atmospheric CO2. We need to remove about twice as much in the atmosphere, to drawdown the amount of C02 that we want to.

Back to the future -

To return our climate to the 'safe' zone (~350ppm CO2) we will need to draw down at least 1000Gt of CO2 over next 1-2 centuries. Half is in atmosphere now. The other half is in the ocean and will be released as we draw down atmospheric CO2. Will cost tens of trillions of $. Biochar can sustainably draw down about a third of the amount needed (ca. 333 Gt CO2). Building native soil C stocks (regenerative agriculture) and enhanced weathering of calcium and magnesium silicates can get us close to 500 Gt

Q&A

Sounds like WA state could lead the world in this. Return on investment argument for WA legislature?

I did a calculation per unit land mass this number is just about our share of what needs to be done. Yes, WA, CA, OR, CO, and a few places back east, these places are leading the charge. CA with their LCFS is a couple of years ahead and are throwing money at getting the biochar things started. China has invested heavily in biochar, and Australia. In the US, WA could be a leader.

What kind of facility would need to be sited (likely in central WA) to process thinned forest residues?

By central WA, the central basin including Yakima. Most of biomass is on westside. If processing woody biomass, it makes sense to process as close to trees as can, then ship across the mountains. If you site facilities on the west edge or north edge of the Columbia Basin where you have ponderosa pine and fire danger. Yakima, Okanogan, Colville great place. There it's just what kind of facility – probably enough thinning for that site. You'll also need places that will need more mobile. I'm a fan of combined bioenergy biochar facility. But it's hard to compete with electricity in WA.

On the forest density map in the earlier presentation for the state of Washington, curiously Skamania and Wahkiakum counties were a light color – yet Skamania is completely forested. Why is this? US National Forest coverage? Can we assume biochar on National Forest as well?

Yes, we can assume biochar on national forest. The map is not accurate in that section in terms of standing biomass (rather it measures available biomass). National parks are not included. None of the tribal areas are included, except Yakama Nation.

If you show the slide on the net carbon reduction impact graph. Turquoise color. What is the maximum biochar per unit area assumed?

We're assuming 50 tons of biochar carbon per hectare. If assume biochar has 80%, carbon, then look at 60 tons biochar/hectare. Convert to acres divide by 2.47.

AF-CCSAP Work plan – future biochar topics for exploration

Panel members generated ideas on possible future topics and/or questions of exploration for the Advisory Panel, including:

- Economics of biochar production and value (to present to legislature)
- Economics and climate LCA of biochar integrated with other systems (compost, concrete, etc.)
- What is the cost of applying production of biochar – what is the low hanging fruit for Washington?
- How to present to legislature: compare/contrast current forest thinning/selective burns vs. this: health emissions, jobs, costs/benefits…
- Exploring what the magic $$ amount is to incentivize uptake of biochar
- Coproduction of biochar and bioenergy/biofuel. This could include LCA for these processes. Bioenergy and biofuel are most directly related to our overall goals.
- LCA comparison of several relevant scenarios (feedstock, production method, county of location)

Next steps, wrap-up, and closing

Rebecca closed out the meeting by thanking members for their ongoing participation and contributions. She also shared the team's contact information and encouraged panel members to email the team with any ideas, suggestions, or questions that arise before the next panel meeting, February 15, 2023.