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EXECUTIVE SUMMARY

Madhu Khanna, Draft of 7-22-15

Biogenic carbon emissions are generated during the combustion or decomposition of biologically-based material. Biogenic feedstocks differ from fossil fuels in that they may be replenished in a continuous cycle of planting, harvesting and regrowth. The same plants that provide combustible feedstocks for electricity generation also sequester carbon from the atmosphere. Plants convert raw materials present in the ecosystem such as carbon from the atmospheric and inorganic minerals and compounds from the soil and make the elemental nutrients available to other life forms. Carbon is returned to the atmosphere by plants and animals through decomposition and respiration and by industrial processes, including combustion. Biogenic CO2 is emitted from stationary sources through a variety of energy-related and industrial processes. Thus, the use of biogenic feedstocks results in both carbon emissions and carbon sequestration.

The EPA has returned to the SAB for its advice on a revised science-based framework for accounting for biogenic carbon emissions. EPA's November 2014 *Framework for Assessing Biogenic CO2 Emissions from Stationary Sources* (Environmental Protection Agency, 2014) is a sequel to its 2011 Framework (Environmental Protection Agency, 2011) which the SAB reviewed and reported on in September 2012 (Science Advisory Board, 2012). The goal of 2011 Framework was to provide the analytical foundation for making determinations about the estimated net atmospheric contribution of biogenic CO2 emissions from the production, processing and use of biogenic feedstocks at stationary sources. The goal of the 2014 Framework is to evaluate biogenic CO2 emissions from stationary sources that use biogenic feedstocks, given the unique ability of biogenic material to sequester CO2 from the atmosphere over relatively short time frames through the process of photosynthesis.

Policy Context

In its 2011-2012 review, the SAB was given a policy context for the biogenic carbon accounting framework. The SAB was told that the 2011 Framework was intended to guide the determination of CO2 emissions from regulated stationary sources under the Clean Air Act, specifically those facilities receiving a prevention of significant deterioration permit (PSD) air permit that were required to conduct a best available control analysis (BACT) for CO2 emissions. The question before the Agency and hence, the SAB, was whether and how to consider biogenic greenhouse gas (GHG) emissions in determining thresholds for permitting and decisions about BACT for CO2 emissions from bioenergy.

The Agency has removed this policy context from its 2014 Framework and this hampered the SAB's deliberations. Many answers about the design of the framework depend upon the features of the specific policies whose implementation would rely on this framework. The 2014 Framework and the charge questions left it to the SAB to either imagine various policy contexts within which this framework could be applied or to craft its responses in a void without

information on parameters and boundaries that are appropriate to a specific program or policy. A policy context is particularly relevant for defining the scale of demand for biogenic feedstocks and the appropriateness of including/excluding upstream and downstream emissions and leakage effects due to the use of biogenic feedstocks. It would have also been useful to know more about the regulated entities that would be responsible for emissions associated with these effects. A broadly defined policy context (that could include policies established by other agencies) is also relevant for specifying sustainable land management and feedstock production practices that could influence their impact on the carbon cycle. Thus there remains significant confusion as to whether and how the Agency plans to utilize the SAB's recommendations. We offer this Advisory with a strong caveat that nearly every response to EPA is "it depends."

Future Anticipated Baseline Approach

In order to compare change in any system over time, there has to be a baseline against which to assess changes so that two distinct scenarios can be compared. EPA's reference point baseline approach simply assesses the estimated net change in land-based biogenic CO2 fluxes and/or carbon stocks between two points in time. In our 2012 SAB report, we stated that the reference point baseline approach was not adequate in cases where feedstocks accumulate over long time periods because it does not estimate the *additional* effect of a stationary facility's combustion of biomass on carbon emissions over time. We note that EPA has acknowledged this limitation in its 2014 Framework and conducted a future anticipated baseline analysis to ascertain the *additional* effect of increased biomass harvesting on emissions over time.

The SAB's 2012 advice on the anticipated baseline approach recognized (then and now) that sophisticated modeling would be needed to capture the interaction between the market, land use, investment decisions, emissions and ecosystem feedbacks. In the case of long rotation feedstocks, bioenergy demand can affect carbon stocks in many ways including the harvest ages of trees, the diversion of forest biomass from traditional forest product markets to bioenergy and rates of afforestation and deforestation. Estimating the net effect of these changes on carbon stocks requires a model that integrates market demand and supply conditions with biophysical conditions that determine growth of forest biomass, carbon sequestration and fluxes due to harvests and land use change and incorporates the spatial variability in these effects across the US.

Also consistent with our 2012 recommendations, EPA has now moved toward a "representative factor" approach that would include an assessment of the biogenic landscape attributes (type of feedstock, region where produced) as well as the process attributes (based on the stationary source process and types of biomass handling) that could be calculated using various spatial and temporal scales. EPA has initially considering calculating a Biogenic Assessment Factor (BAF) for an individual stationary facility however the data needs for a facility-specific approach were quite daunting. This approach would require case-specific measurements and calculations of carbon stocks and fluxes and chain-of-custody carbon accounting while ignoring land use

changes at a broader landscape level that may mitigate or exacerbate the effects within a "fuel-shed."

Some of our 2012 statements bear repeating because they remain relevant. We recognized (then and now) the tradeoffs between simplicity, scientific rigor and policy effectiveness. We recognized the difficulty of undertaking an anticipated baseline approach and we said that practical considerations must weigh heavily in the agency's decision making. We said that any method that might be adopted should be subject to an evaluation of the difficulties of implementation and costs of compliance against any savings in carbon emissions and we maintain that caution in this Advisory.

In the 2014 Framework, EPA has undertaken this daunting task, offering simulations of future biophysical and economic conditions employing the Forestry and Agricultural Sector Optimization Model (FASOM) to determine the incremental greenhouse gas emissions of increased biomass feedstock demand compared to a "business as usual" scenario. EPA is to be commended for its skillful use of FASOM-GHG to accomplish this complicated modelling. EPA's case studies are based on 9 regions of the country which is a reasonable spatial scale that strikes a balance between the onerous data needs of a facility-specific calculation versus a country-wide scale where facilities' demands for increased biomass cannot be linked to net carbon emissions. As we stated in 2012, for long rotation feedstocks, a regional scale (larger than the facility-specific scale), has the following advantages: it captures indirect (market) effects, it's less cumbersome than a chain-of-custody accounting; it offers greater data availability. The EPA's case studies applied the future anticipated baseline approach on a regional basis to Southeastern roundwood, Corn Belt corn stover and Pacific Northwest logging residues, however none of its charge questions were feedstock or model-specific.

Given that the carbon consequences of increased demand for biogenic feedstocks is likely to depend on the model selected to evaluate those consequences, a more robust discussion of the choice of modeling platform and its underlying assumptions and parameters would have been useful. Instead, EPA posed very detailed charge questions to the SAB about the temporal scale and spatial scale for the anticipated baseline modeling.

Below, we've highlighted our responses to EPA's charge questions followed by our more general comments and recommendations.

EPA's Charge Questions:
Part 1: Future Anticipated Baseline Approach and Temporal Scale

Part I of EPA's charge questions pertain to the temporal scale and the anticipated baseline approach to calculating a BAF. The 2014 Framework is a great improvement over the 2011 Framework with respect to the treatment of temporal issues. The 2014 Framework very clearly recognizes the intertemporal tradeoffs inherent in various timescales for examining emissions over time (Environmental Protection Agency, 2014, pp. B-1 to B-22).

With respect to selecting a temporal scale, the most important criteria is whether it captures effects over time, i.e. the terrestrial effects, both positive and negative, stemming from a change in the demand for biogenic feedstocks. Similar to EPA's concept of an "emissions horizon", we recommend defining the time horizon as the period of time over which all terrestrial effects occur, both positive and negative. The temporal scale for positive and negative terrestrial effects may differ across feedstocks but the longest of these, as measured for any given feedstock production system, should set the end point of the temporal scale used for all feedstocks. We do not support changing the temporal scale to fit a policy horizon (EPA's so-called "assessment horizon"); rather the time scale should be chosen to capture all effects.

We are proposing an alternative framework based on the differences in carbon stocks on the land in contrast to EPA's framework which is based on carbon emissions. Our proposed alternative framework in Appendix A: Alternative Framework Based on Carbon Pools offers a prototype equation with terms for the net change in live stores, the net change in dead stores, the net change in soil stores, the net change in product stores and the net change in waste stores. A key feature of using land carbon stocks is that all terms can be readily aggregated or disaggregated and are still subject to mass balance. The new stock-based framework presented in Appendix A would be scale and process invariant as it could be used for a stand, plot, fuel shed or region. It would comport with the current conventions in carbon accounting which essentially use input-output tracking of carbon throughout the system with well-defined boundaries.

We are also proposing a modification to the Biogenic Accounting Factor (BAF) formula that departs from any of EPA's approaches. Our modified BAF formula takes account of "residence time" of CO2 emissions, i.e. the length of time emissions are resident in the atmosphere. To take account of residence time, our proposed approach would accumulate the annual differences in carbon stocks on the land over the entire time horizon. By contrast, EPA's approach to a cumulative BAF would simply account for the difference in carbon stocks at a single point in time. By cumulating annual differences across the entire projection period, our modified BAF formula would yield something like the notion of "ton-years" to account for differences in carbon stocks *each year*. By taking the time path and residence times of emissions into account, we are proposing a measure that provides a more plausible indicator of the contribution of biogenic emissions to radiative forcing or the overall balance between incoming solar radiation and energy radiated back to space.

Part II: Scales of Biomass Use When Applying Future Anticipated Baseline Approach

Part II of EPA's charge questions was entirely devoted to very technical considerations concerning how to select model perturbations in biomass demand ("shocks") for the anticipated future baseline simulations to estimate the net atmospheric contribution of biogenic CO2 emissions. We found these questions to be narrow and difficult to answer in the absence of a policy context, programmatic goals, information about legal boundaries and implementation details. The charge question in Part II, in particular, would have been better framed by specifying policy scenarios that may either have an explicitly stated scale of biomass demand

changes or that could be used to simulate a scale of demand for biomass. Noting these limitations, our responses are highlighted below.

EPA asked for our general recommendations on the scale of demand change that should be used in a model for the future anticipated baseline approach. Typically, biomass demand changes should be modelled in response to particular policy scenarios like the Clean Power Plan. Failing that, potential demand changes can be ascertained from the economic modeling itself by simulating a specific policy. In the absence of a policy context, they could be modelled incrementally, e.g. 1 million tons, 2 million tons, 3 million tons, to see how the Biogenic Accounting Factor responds to changes in demand. In general, the market and resource impact of a small marginal change would likely be insignificant thus a data-driven approach would define the size of the shock by the ability of available data to provide a basis for a significant change in the BAF (at the one decimal level). Demand changes should be bounded, of course, by historical data on resource use to eliminate shocks that lie far outside historical trends. Going from a 1 million ton shock to 10 million tons overnight would, of course, not be advisable if such an increment lies outside historical trend lines, however. Modeling exercises could also be undertaken to determine BAF thresholds for different levels of the size of the total change in demand.

For any given change in total demand for biomass, the demand for individual feedstocks should be determined endogenously so that it is economically viable and constrained by the joint production function. BAFs should be the same for a feedstock irrespective of which policy induces the demand for them. An ex post evaluation would allow revisions to EPA's estimates of feedstock demand changes based on updated data. To evaluate the performance of a BAF retrospectively, quantities of biomass feedstock used by stationary sources could be updated and predictions about biomass demand at stationary facilities could be tested against actual outcomes. While a BAF may be calculated with a 100 year time horizon, assuming that forest and land management practices will be maintained over that period, they need to be updated periodically to incorporate changes in market conditions, land use and land cover and policies over time.

Other Issues:
Alternate Fate Approach for Waste-Derived Feedstocks

In 2012, the SAB said that EPA should consider the alternate fate of waste-derived feedstocks diverted from the waste stream, whether they might decompose over a long period of time, whether they would be deposited in anaerobic landfills, whether they are diverted from recycling and reuse, etc. In the 2014 Framework, EPA has conducted extensive alternate fate calculations in Appendix N however EPA drew a narrow boundary around point source emissions and neglected other significant considerations that affect the greenhouse gas footprint of alternative municipal solid waste (MSW) management alternatives. Specifically, the EPA neglected to quantify the benefits of electrical energy recovery from both landfills and combustion, and neglected to quantify carbon storage associated with landfills. Moreover, the landfill baseline that was selected is inconsistent with regulatory practice. Under the Clean Air Act New Source

Performance Standards, EPA requires landfills above a certain size to, at a minimum, collect and control (e.g., flare) landfill gas. This standard was written to apply to more than half of the waste disposed in landfills. As such, a baseline of direct venting is misleading. Finally, some states regulate gas collection more strictly than the federal standard and this too must be recognized. The relative rankings in the 2014 Framework would change considerably if energy recovery were considered (Environmental Protection Agency, 2014, pp. N-9). The 2014 Framework clearly includes methane associated with municipal solid waste feedstocks, while neglecting to quantify the benefits of electrical energy recovery from both landfills and combustion, and neglected to quantify carbon storage associated with landfills.

Choice of Model

EPA did not ask for feedback on its choice of model or any general criteria for choosing a model but given that the choice of model can determine results, we think this was an oversight. It should be pointed out that FASOM is an intertemporal optimization model that assumes perfect foresight. Economic agents are forward-looking and expectations about future market conditions drive management decisions in the present. Because of this assumption, landowners and firms automatically engage in "anticipatory planting" in response to increased biomass demand. In Appendix J, EPA provided a detailed discussion of models in general and FASOM in particular, but there was no discussion of how FASOM's assumption of anticipatory planting affected the estimates of biogenic accounting factors (BAFs). For Southeast roundwood, FASOM projected that an increase in the use of Southeastern roundwood would result in a net reduction in biogenic CO2 emissions relative to a "business as usual" scenario, a result that is somewhat counterintuitive. As a deterministic, dynamic simulation model, FASOM assumes that agents operate with perfect foresight and know, with certainty, all relevant information for all future years. While expectations about future prices certainly drive investment behavior, this assumption implies that any increase in demand for biomass feedstocks automatically translates into investments that perfectly satisfy that demand in the future. This strong assumption virtually guarantees a particular outcome (a low BAF for feedstocks for long time horizons) because investment behavior will always compensate for any removal of carbon from the land. This "anticipatory planting" assumption should be examined along with other assumptions in the FASOM model, such as feedstock yield functions, rates of growth of yields and their soil carbon effects (particularly for non-forest feedstocks).

Summary of Conclusions and Recommendations: TO BE DISCUSSED

EPA's 2014 Framework has advanced biogenic carbon accounting and offered vast improvements over its 2011 Framework. As captured in the 2014 Framework, the anticipated baseline approach to calculating BAFs, while subject to implementation difficulties and all the uncertainties associated with modeling the future, represents an advance in biogenic carbon accounting and EPA is to be commended for its heroic efforts. In the hopes of further advances in biogenic carbon accounting, the SAB offers the following summary of our conclusions and recommendations.

1. For full evaluation of a biogenic carbon accounting approach, EPA should specify its policy context and legal authorities over upstream and downstream emissions. EPA's Framework should be evaluated for its use in a specific policy context.

2. The appropriate time scale for considering climate impacts from biogenic feedstocks is the time period over which all terrestrial effects occur in response to a policy induced shock in demand for bioenergy.

3. A biogenic carbon accounting approach based on carbon stocks (terrestrial pools such as live, dead, soil, products, material lost in transport and waste) is preferred over an emissions (flux-based) approach because it comports with conventional carbon accounting, has well-defined boundaries and follows conservation of mass as well as mass balance.

4. A Biogenic Accounting Factor method that take into account the time path of changes in terrestrial carbon stocks *over the entire time period* as well as the residence time of emissions is preferred to a BAF based on the difference in cumulative stocks *at any single point in time* to account for the full effect of biogenic feedstock use on the atmosphere.

5. EPA should evaluate its model choices as well as the assumptions, elasticities and parameters embedded in each model.