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TO: EPA Science Advisory Board (SAB) Panel on Biogenic Carbon Emissions

FROM: Caroline Gaudreault and Reid Miner (NCASI)

DATE: August 5, 2015

SUBJECT: ***Comments on SAB Panel Draft Responses to Charge Questions 1***

On July 22, the SAB Panel posted revised responses to charge questions 1 and 2 related to its review of EPA's November 2014 Framework for Assessing Biogenic CO_2 Emissions from Stationary Sources. The National Council for Air and Stream Improvement (NCASI) appreciate this opportunity to provide comments on these responses, focusing on charge question 1. More specifically, we will address the following topics: type of baseline, the proposed stock-based determination of Biogenic Assessment Factors (BAFs), and temporal scales for computation of BAFs.

Our comments highlight the following points.

- The result of any BAF calculation is only as accurate as the stock change information used in the calculation. Because the BAF approach proposed by the SAB Panel uses an anticipated future baseline, there are inherent and large uncertainties associated with the stock change information used in the BAF calculations. These uncertainties need to be explicitly addressed and understood by policy makers.

- Furthermore, given the inherent uncertainties associated with anticipated future baselines, one should not ignore regulatory approaches that, while being informed by the insights from studies based on anticipated future baselines, are more robust to uncertainties about the future. In this context, it is too early to dismiss the use of reference point baselines in a regulatory framework intended to implement policies on biogenic carbon.

- Within the context of BAFs based on anticipated future baselines, the Panel's proposal to base the calculation on the changes in stocks of carbon in terrestrial pools is helpful in that it is conceptually simpler than the equation in the draft Framework which, as the Panel points out, is based on "a mixture of net fluxes and correction terms". In addition to being conceptually simpler, the approach proposed by the SAB Panel is better suited to the types of data available for making such calculations.

- Within the context of BAFs based on anticipated future baselines, in a range of *idealized examples* examined by NCASI the tonne-year method proposed by the SAB Panel yielded reasonable estimates (generally within 10%) of the net cumulative radiative forcing associated with the increased use of wood for energy. There is a need, however, to examine the response of the proposed method to a range of real-world situations, such as (a) the use of thinnings and (b) various demand scenarios superimposed on a variety of starting age-class distributions.

- Within the framework of BAFs based on anticipated future baselines, the tonne-year method *does not yield reasonable estimates* of net cumulative radiative forcing impacts for cases where the amounts of methane are significantly different in the reference and policy scenarios. Where the methane emissions in the reference scenario are significantly higher than those in the policy scenario, the tonne-year method produces BAFs that are far greater than those produced using calculations based on net cumulative radiative forcing, *even when the tonne-year method is adjusted for methane emissions using 100-year global warming potentials (GWPs)*. Thus, it is not only important to account for methane, but it must be done in a way that adequately characterizes the radiative forcing impacts of methane emissions over time.

- In using the proposed SAB approach, or any approach, on manufacturing residuals it will be important to properly characterize the reference case. In the draft framework report, EPA correctly finds that for black liquor, because the carbon in liquor would return to the atmosphere at the same time in the reference and policy scenarios, the BAF will be zero (or less for some reference scenarios). For woody mill residuals, the SAB Panel appears to suggest, however, that in a reference scenario involving landfilling "…wood waste carbon is generally not subject to loss via methane…" We would point out that while the amounts of methane generated may be open to debate and appear to be far less than the amounts produced by municipal solid wastes, methane is produced when woody mill residuals materials are disposed in mill landfills. In addition, mill landfills do not capture and burn methane emissions nor do they use them for energy. Accordingly, while methane emissions are produced in landfills containing woody mill residuals, the capture of, and production of energy from, methane should not be included in the reference scenario for woody mill residuals.

- The SAB Panel suggests that the temporal horizon extend to a point where the difference in terrestrial stocks between the reference and policy scenarios is constant. This does not work for some types of systems (e.g., where there are on-going additions to stocks of permanently stored carbon). Also, in some cases, the difference in stocks may approach, but never reach, an asymptote of zero. A different rationale for selecting a temporal horizon in these cases should be developed.

Type of Baseline

The SAB Panel's general recommendations and the proposed BAF calculation method involve the use of anticipated future baselines. Analyses based on anticipated future baselines are important when one is trying to understand how the emissions from a system will respond to a perturbation, and how these emissions are different from those expected to occur without this perturbation. These analyses, by necessity, are based on projections of future carbon stocks. To be realistic in the context of the U.S. these projections must reflect landowner and market responses to increased demand for wood. Consequently, there are significant uncertainties associated with projections of forest carbon stocks and more importantly, in projections of how markets and landowners will respond to changes in demand.

The appendices to the draft response to the SAB Panel charge examine the effect different scenarios on the BAFs. Specifically, Table 1 of Appendix C presents the results shown in Table 1, below. Depending on the scenario being modeled, the calculated $BAF_{\Sigma 90yr}$ ranges from -0.337 to 0.344. This information, while helpful, begs the question of how one knows which future scenario is appropriate.

Table 1. Summary of Scenarios Examined the SAB Panel

Scenarios	$BAF_{\Sigma 90yr}$
Case 1: Increased demand results in reduced carbon stocks while stocks are stable in reference scenario	0.334
Case 2: Increased demand results in increase in carbon stocks while stocks are stable in the reference scenario	-0.337
Case 3: Increased demand first results in a decrease in stocks followed by a period where stocks recover and eventually exceed those in the reference case, where stocks remain stable	-0.112
Case 4: The reference scenario involves carbon stocks that are increasing while the increased demand scenario also results in stocks that are increasing, but more slowly than in the reference scenario.	0.344
Case 5: The reference scenario involves carbon stocks that are decreasing while the increased demand scenario also results in stocks that are decreasing, but more rapidly than in the reference scenario.	0.326

The real-world dilemma can be illustrated with the following thought experiment. Imagine that, in 1950, an analyst is charged with estimating the $BAF_{\Sigma T}$ for the year 2000 associated with a doubling of demand for roundwood for energy from private pine forests in the U.S. South. The range of reasonable future scenarios in 1950 might have encompassed those shown in Table 2. Indeed, in 1950, it seems likely that it would have been possible to develop reasonable arguments for many, if not all, of these alternative futures. Yet the estimated BAFs developed for these scenarios range from well above zero (0.667) to well below zero (-0.333). Choosing one of these to represent the future would have involved a significant gamble. As it turns out, carbon stocks on privately owned pine forest land were about the same in the 1990s as they were at mid-century in spite of a doubling of harvesting on these lands (albeit, not for energy). Of course in 1950, the odds were low that a policy maker would have been lucky enough to base policy on the specific modeling study yielding what we now know to be the correct prediction.

Alternatively, a policy maker might have examined the results of these various analyses as well as other information regarding existing and expected land use policies, demographic trends, etc. and settled on a policy that was informed by the insights from all of these sources. For instance, just for illustrative purposes we might imagine a situation where a policy maker gleaned the following lessons from the projections, modeling, and other information available at the time.

- Looking at the results of studies using anticipated future baselines, the policy maker might have decided that it is clear that markets are important. Greater demand for wood is expected to result in more forest area, and unlikely to result in serious long-term, permanent drawdowns in forest carbon stocks.

- The policy maker might have determined that there is the opportunity for policies, not focused on carbon, (e.g., the Conservation Reserve Program) to help mitigate the impacts of increased demand for wood on forest carbon stocks.

- The policy maker may have understood that the pace and intensity of landowner reactions to increased demand for wood for energy are uncertain. At the same time, the policy maker might have seen that returns to forest owners are largely driven by returns to wood for home construction. Therefore, given demographics and projected household formation, the policy maker might have decided that in the years following 1950 the U.S. was going to see a significant increase in demand for housing. This would have had the side effect of producing more small wood for pulp and energy as well as more manufacturing residuals that can help serve these markets.

- The policy maker might have found that anticipated future baseline studies suggested that the net impact of increased use of biomass for energy on atmospheric CO_2 may not be zero but for the types of material likely to be used for energy, the net impact is relatively small, especially compared to fossil fuel. It might also have been clear that over successive rotations, as more wood is produced from land remaining in forest, the BAFs associated with wood would become even smaller and the benefits of displacing fossil fuel with biomass-based energy would continue to accrue.

- While the policy maker might have decided that there is a need for diligence, because the future is always uncertain, it might also have been clear that there was no reason to expect that the market would respond to increased demand in a way that had significant adverse carbon and warming consequences. Indeed, the policy maker might have found that it was reasonable to assume that market and landowner responses would help mitigate carbon and warming impacts associated with increased demand.

- Finally, the policy maker might have concluded that attaching a GHG emissions liability to biogenic CO_2 could have unforeseen impacts on markets and landowners that would be counterproductive to the objectives of keeping land in forest and limiting atmospheric GHGs.

As a result of these, or different, insights gleaned from an examination of all available information, a number of different policies might have been considered in 1950, including, we would suggest, ones based on reference point baselines.

The problems with predicting future carbon stocks for developing anticipated future baselines are not just theoretical. Bucholz et al. (2014)[1] considered what anticipated future baselines would have looked like had they been based on projections done by the Department of Agriculture for its Resource Planning Act (RPA) Assessments. The Bucholz et al. analysis focused on "surplus wood", which is growth minus mortality and removals, and represents a reasonable surrogate for forest carbon. Bucholz et al. found that "a constant reference baseline approach assuming constant levels of annual growth and removals would have been closer to observed actual data for every assessment since 1965 compared with an anticipated future or BAU baseline approach [based on the projections in the RPA Assessments]." They concluded that "selecting appropriate baselines depends on the policy or program goal, in particular whether the baseline will be used as a planning/scenario evaluation tool or whether it will be implemented in a regulatory scheme with potential legal implications. Given the challenges in predicting the future status of forest resources, anticipated future baselines might be best suited for planning and policy development, while constant reference baselines might be more appropriate for monitoring and regulatory frameworks."

Given the value of many different types of scientific and economic information, it is prudent to consider all types of available information when developing forest carbon policies and regulations. Using a flexible and inclusive process, policy makers can take into account the strengths and limitations associated with each type of information and decide how best to apply it. Until such a process is undertaken, it is premature to rule out the use of reference point baselines in regulations implementing forest carbon policies.

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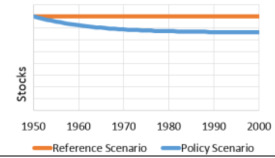
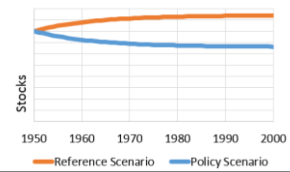
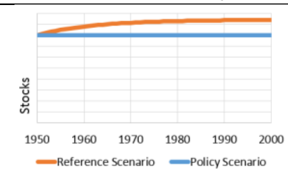
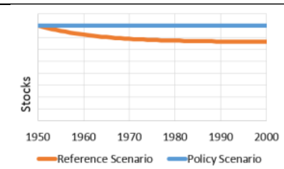
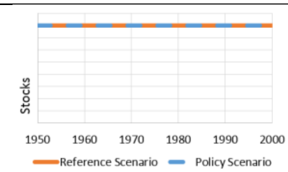
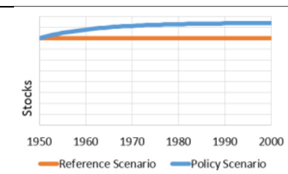
[1] Buchholz, T., S. Prisley, G. Marland, C. Canham and N. Sampson (2014) *Uncertainty in projecting GHG emissions from bioenergy*, Nature Climate Change Vol 4., pg. 1045-1047, December 2014

Table 2. Possible Baseline and Policy Scenarios in 1950 in Anticipation of a Doubling of Demand for Roundwood

	Reference scenario: Demand remains constant: 1950 to 2000	**Policy scenario: Roundwood removals double, 1950-2000**	**Graphical depiction of stocks**	**$BAF_{\sum T}$ from 1950 to 2000**
Case A	Forest carbon stocks remain stable, with losses due to land conversion being offset by increased in stocks in remaining forests	Forest carbon stocks decrease to a new stable level due to conversion of higher carbon density forests to more productive but lower carbon density forests		0.333
Case B	Forest carbon stocks increase to a new stable level associated with the current demand and existing age-class distribution	Forest carbon stocks decrease to a new stable level due to conversion of higher carbon density forests to more productive but lower carbon density forests		0.667
Case C	Forest carbon stocks increase to a new stable level associated with the current demand and existing age-class distribution	Forest carbon stocks remain stable due to an investment response that offsets the impacts of additional harvesting via additional forest area and more productive management		0.333
Case D	Forest carbon stocks decrease due to land conversion to non-forest uses	Forest carbon stocks remain stable due to an investment response that offsets the impacts of additional harvesting via additional forest area and more productive management		-0.333
Case E	Forest carbon stocks remain stable, with losses due to land conversion being offset by increased in stocks in remaining forests	Forest carbon stocks remain stable due to an investment response that offsets the impacts of additional harvesting via additional forest area and more productive management		0.000
Case F	Forest carbon stocks remain stable, with losses due to land conversion being offset by increased in stocks in remaining forests	Forest carbon stocks increase due to an investment response that more than offsets the impacts of additional harvesting via additional forest area and more productive management		-0.333

Stock-Based Determination of BAFs

We would first observe that the most recently proposed Biogenic Assessment Factor (BAF) formula, based on stocks, represents a helpful conceptual simplification of the originally-proposed calculation formula, which was based on carbon flows and correction factors. In addition to being conceptually simpler, the stock-based framework is better suited to the types of data available to make these calculations, especially at the regional-scale.

However, there are several features of the SAB's BAF formula that warrant comment. These features are best illustrated using the results of calculations NCASI has performed on a range of scenarios of potential interest to EPA and forest-based industries.

Applying the Proposed BAF Formula to Idealized Roundwood-Based Systems

The panel recommends using the accumulation of annual differences in carbon stocks on the land rather than using the difference in carbon stocks at the end of the temporal horizon. In other words, the Panel recommendation is to use a tonne·year approach (or weighted average impact of carbon storage, $BAF_{\Sigma T}$[2]) rather than an endpoint approach (BAF_T). Its rationale for doing so is that this approach is an approximation of the actual radiative forcing (dynamic approach) from the differences in carbon stocks.

To test the ability of the tonne-year approach to approximate results based on net cumulative radiative forcing, NCASI has examined a number of idealized scenarios involving an increase in demand for roundwood. The scenarios are idealized in that they are based on simple landscape-scale spreadsheet models that assume smooth and gradual changes in stocks over time, or in some cases, steady state stocks. Thus, they are conceptually the same as the examples presented in the appendices to the draft response to the SAB charge (by Harmon and Skog) but sometimes involve stock accumulation curves of different shapes than those in the SAB Panel's draft appendices.

NCASI has compared the BAFs obtained using the $BAF_{\Sigma T}$ approach proposed by the SAB Panel to the BAFs obtained by computing, over time, the cumulative radiative forcing impact of the difference in carbon stocks between the reference and policy scenarios. The radiative forcing impacts have been determined using a dynamic radiative forcing calculator produced by École Polytechnique in Montreal (http://pubs.acs.org/doi/abs/10.1021/es9030003). For the idealized scenarios examined, we found the BAFs obtained using the $BAF_{\Sigma T}$ approach proposed by the Panel were

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[2] Where T is the length of time it would take for the effect of increased demand for a feedstock on the carbon cycle to reach a state in which the difference in carbon stocks between the policy case and the reference case is no longer changing.

reasonable approximations of the BAFs computed using net cumulative radiative forcing (i.e., generally within 10% although larger differences were sometimes found when the absolute magnitude of the BAF was small). We can provide additional information on these calculations if helpful.

In the process of examining these idealized scenarios, however, it became clear that more work is needed to consider a range of real-world situations. These situations will require attention to, for instance, allocation – as in the case where thinnings are used for energy while larger roundwood is used for building products. It will also be important to understand the reasonableness of the $BAF_{\Sigma T}$ estimates in cases involving a range of different starting age class distributions in combination with different demand scenarios.

Applying the Proposed BAF Formula to Systems Involving Woody Mill Residuals

As recognized in Appendix A of the response to charge questions 1 and 2 (by Harmon and Skog) but not in the draft response to the charge itself, methane is a greenhouse gas significantly more potent than carbon dioxide and this is not reflected in the pools of carbon. For some feedstocks, the reference case may involve releases of methane (e.g., decay in landfills) with important implications for climate change, which do not occur in the policy case. Although the stock formula proposed by the Panel correctly accounts for the carbon mass balance, it does not account for the differences in radiative forcing or fate in the atmosphere of different biogenic GHGs. It is therefore necessary to apply other methods to understand the impacts of methane releases.

Although Appendix A suggests that “wood waste carbon is generally not subject to loss via methane…”, we would point out that while the amounts of methane generated may be open to debate and appear to be far less than the amounts produced by municipal solid wastes, methane is produced when woody mill residuals materials are disposed in mill landfills. Indeed, companies must estimate and report these emissions to EPA under the greenhouse gas reporting rule[3]. While there is at least some methane produced in landfills containing woody mill residuals, the amounts are small enough that it is very rare for a mill landfill to have a methane capture system. Likewise, it is extremely rare for a mill to produce electricity from methane captured from its landfills. The reference scenario for woody mill residuals should reflect these observations.

To demonstrate the importance of appropriately accounting for methane, NCASI applied the tonne-year approach proposed by the panel to the case of woody mill residuals that would be landfilled if not used for energy[4]. It was assumed that 1000 kg of carbon in residuals would be diverted from landfills and used for energy every year from the moment the policy was implemented and stocks and emissions were calculated year by year. The BAF obtained using the approach proposed by the Panel ($BAF_{\Sigma T}$) was

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[3] Code of Federal Regulations (CFR) Section 98, Subpart TT. Federal Register 75(132):39736-39777
[4] Assuming 77% of the carbon in residuals is non-degradable and a decay rate of 0.038 yr^{-1}. Additional details can be found in http://onlinelibrary.wiley.com/doi/10.1111/jiec.12225/abstract.

compared to that obtained by 1) adjusting Net Biogenic Emissions (NBE)[5] to account for methane using 100-year GWPs and then applying the SAB tonne·year approach and 2) evaluating the net cumulative radiative forcing on a dynamic basis and calculating the endpoint BAF (given that the intent of the tonne-year approach is to approximate this dynamic approach that yields the net cumulative radiative forcing). In the dynamic approach, it was also necessary to calculate the Potential Gross Emissions (PGE)[6] based on radiative forcing.

To perform the calculations, the differences in annual CO_2 and methane emissions between the policy and reference scenarios were calculated each year. These annual emissions differences, in units of kg of each gas, were entered into the dynamic radiative forcing calculator (see above), yielding the cumulative radiative forcing associated with the cumulative emissions differences as a function of time. The annual PGE emissions were then also entered into the calculator, yielding the cumulative radiative forcing associated with cumulative PGE_{Dyn} as a function of time. At any time, BAF_{Dyn} is equal to the cumulative radiative forcing associated with NBE_{Dyn} divided by the cumulative radiative forcing associated with PGE at that same time. The results are presented in Figure 1, Figure 2, Figure 3 and Table 33. The figures and table illustrate several important points.

As shown in Figure 1, for this system it is not possible to determine the length of time it would take to reach a state where the difference in carbon stocks between the policy case and the reference case is no longer changing (i.e., T is when $NBE_{\Delta t} = 0$) because, on an ongoing basis $NBE_{\Delta t}$ does not approach an asymptote of zero like it does in many cases involving roundwood. This is discussed in greater detail below.

[5] NBE represents the net atmospheric biogenic CO_2 contributions associated with biogenic feedstock production, processing, and use at a stationary source.
[6] PGE represents emissions equivalent to the carbon content of the biogenic feedstock used.

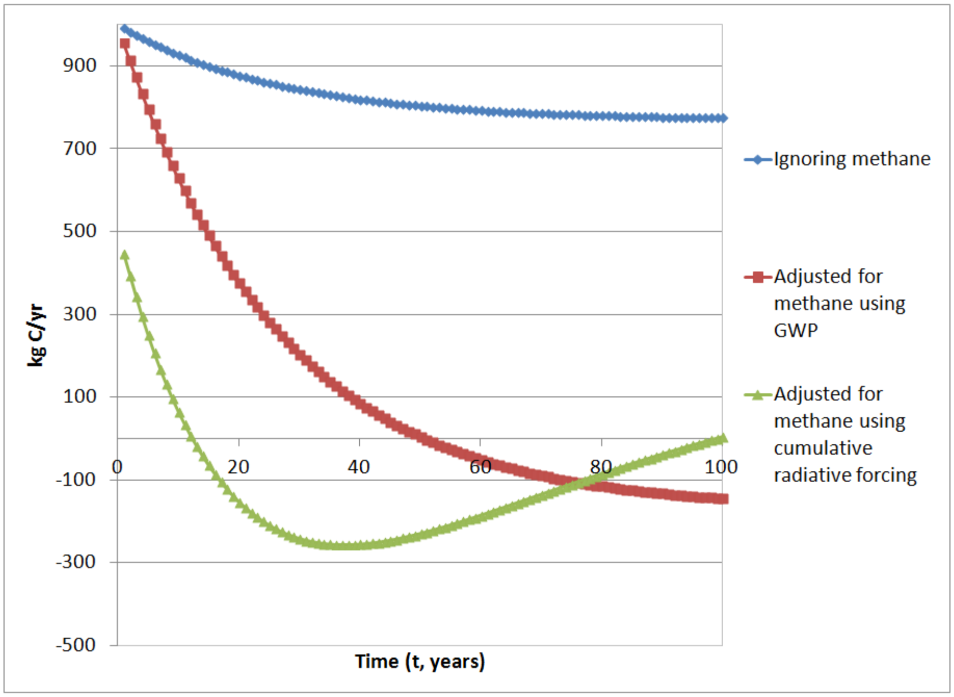

Figure 1. $NBE_{\Delta t}$ as a Function of Time With and Without Adjustment for Methane in the Case Where Woody Mill Residuals Are Used for Energy Instead of Being Landfilled

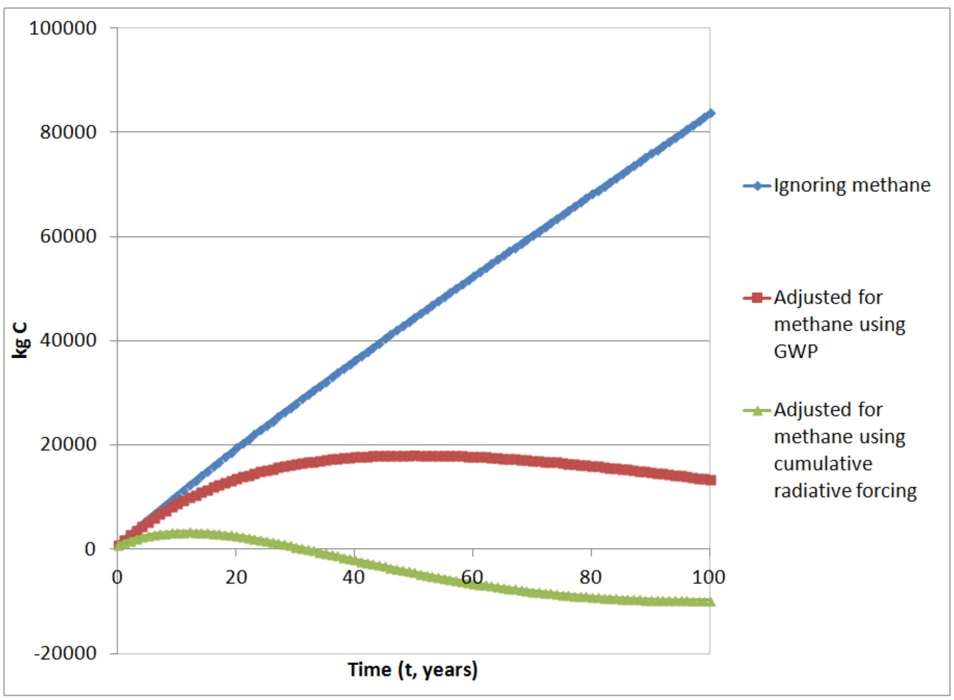

Figure 2. NBE_t With and Without Adjustment for Methane in the Case Where Woody Mill Residuals Are Used for Energy Instead of Being Landfilled

Figure 2 shows that NBE_t is significantly affected by methane adjustment and the method used to do so. Using GWPs to make this adjustment results in a significant over-estimation of NBE_t relative to the result obtained using dynamic modeling of radiative forcing. Estimates of NBE_t made without adjusting for methane are far higher than those obtained using either of the methods to adjust for methane.

Different methods for calculating the BAF give different results, as illustrated in Figure 3 and Table 3. For cases where methane is involved, the tonne-year approach proposed by the panel generates poor estimates of the avoided radiative forcing (i.e., $BAF_{\sum T}$ is not a good approximation of $BAF_{Dyn,T}$), with $BAF_{\sum T}$ being considerably larger than $BAF_{Dyn,T}$. Properly considering methane is clearly critical in understanding the climate change implications of using materials for energy where the amounts of methane associated with the reference and policy scenarios are significantly different.

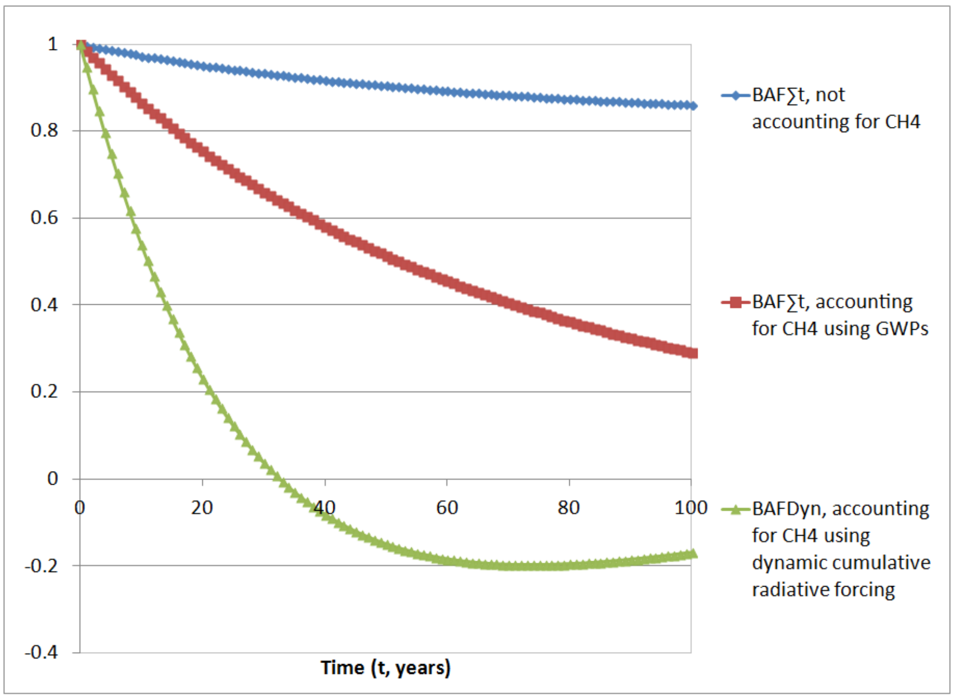

Figure 3. Comparison of Different BAF Calculations Over Time in the Case Where Woody Mill Residuals Are Used for Energy Instead of Being Landfilled

The values in Table 3 clearly demonstrate (a) the shortcomings of the $BAF_{\sum T}$ approach when methane is ignored and (b) the shortcomings of using 100-year GWPs to correct the $BAF_{\sum T}$ approach for methane.

Table 3. Comparison of Different Methods for Calculating the BAF for woody mill residuals used for energy where the reference case is disposal in a landfill

T	Ignoring Methane	Considering Methane	
	$BAF_{\Sigma T}$	$BAF_{\Sigma T}$*	$BAF_{Dyn,T}$
50 years	0.90	0.52	-0.15
100 years	0.86	0.29	-0.17

**Computed using GWPs.*

Applying the Proposed BAF Formula to Systems Involving Black Liquor

In the revised November 2014 draft framework report[7], EPA correctly notes that if black liquor was not used for energy (and as a source of recovered pulping chemicals) it would likely be managed in a way that caused the carbon to return to the atmosphere essentially immediately. If it returned as CO_2, the $BAF_{\Sigma T}$ would be zero**.** If a significant fraction of the black liquor carbon in the reference scenario returned to the atmosphere as methane, the $BAF_{\Sigma T}$ would be less than zero.

Temporal Scale for Computation of BAFs

From a technical perspective, it is conceptually appropriate to use a temporal scale for biogenic carbon accounting that is based on the time horizon over which effects are expected to occur. The panel specifically recommends that the temporal horizon for a given feedstock be set to the length of time it would take for the effect of increased demand for a feedstock to reach a state in which the difference in carbon stocks between the policy case and the reference case is no longer changing (when $NBE_{\Delta t} = 0$) and that the longest of these horizons, as measured for any feedstock production system, be selected as the temporal horizon used for biogenic carbon accounting for all feedstocks. We would make several observations regarding these two recommendations.

First, because some of the models used in developing the scenarios involve functional relationships that yield results that are asymptotic to zero, in theory the difference may never be equal to zero. We assume that this would require an arbitrary non-zero value be used to represent steady state. The SAB Panel should consider options and rationales for the approach to be used in selecting this value for these cases.

Second, some systems may never reach a point where the difference in stocks between the reference and policy scenarios is no longer changing (i.e., NBE will never approach zero). An example of this is where annual additions are being made to pools of non-degradable carbon (e.g., disposal of woody mill residuals in anaerobic landfills). This may also be the case in other situations. This means that the proposed approach for

[7] Appendix D, Section 6: Addendum: Spent Pulping Liquor—Overview of Processes and Possible Alternate Fates

determining T will not always be possible to apply and a different method for determining T will be needed.

Also, it should be made clear that the decision to apply the longest temporal horizon to all feedstocks, as proposed in the draft response to the SAB charge, is a policy choice. That choice begs the question of how the SAB Panel would recommend limiting the scenarios to be examined by EPA as the Agency attempts to determine the longest temporal horizon.

We appreciate the opportunity to provide these comments to the SAB Panel and would be happy to provide additional information on any of the points raised above.