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October 18, 2011

Dr. Holly Stallworth
Designated Federal Officer (DFO)
SAB Staff Office
United States Environmental Protection Agency

Dear Dr. Stallworth:

Thank you for the opportunity to provide written comments on the EPA report, "Accounting Framework for Biogenic $CO_2$ Emissions from Stationary Sources", dated September 2011. In addition to the written comments below, we have separately requested an opportunity to appear before the EPA Science Advisory Board Panel at its meeting next week in Washington D.C.

NCASI is a non-profit environmental research organization focused on the environmental and forestry issues facing the forest products industry. We receive most of our funding from companies that own forests or manufacture forest products, but we also receiving funding from, and have been involved in collaborations with, a range of government and non-governmental organizations.

We encourage the panel and EPA to let us know if any questions arise regarding the materials below.

Best Regards

Reid Miner

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Comments submitted on October 18, 2011 by NCASI on<br>“Accounting Framework for Biogenic $CO_2$ Emissions from Stationary Sources”<br>Dated September 2011<br>Prepared by the<br>U.S. Environmental Protection Agency<br>Office of Atmospheric Programs<br>Climate Change Division<br>Washington DC

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<tr><td>General</td><td>

The report does not give adequate attention to four important facts.<br><br>First, forest carbon stocks are growing at the national and global level (see Pan et.al., “A Large and Persistent Carbon Sink in the World’s Forests”, <u>Science</u>, Vol. 333, 19 August 2011) indicating that the net flux of biogenic carbon is from the atmosphere into forests. The biogenic $CO_2$ emissions to the atmosphere from stationary sources, together with all other fluxes of forest-derived biogenic carbon to the atmosphere (including deforestation), are more than offset by forest growth. Regarding the specific situation in the United States, the Pan et. al. 2011 study confirms data published by EPA in the U.S. Inventories of Greenhouse Gas Emissions and Sinks that consistently show that U.S. forest carbon stocks are not declining, but growing. While this cannot continue indefinitely, the data provide important evidence that biomass use is not causing forest carbon stocks to decline that additional biomass could be removed from forests without causing forest carbon stocks to decline.<br><br>Second, it is broadly agreed that a strong market for forest products provides an incentive to keep forest land in forest, thereby avoiding losses in carbon stocks associated with converting land to non-forest uses. (See, for instance, Wear and Greis, “The Southern Forest Futures Project: Summary Report”, May 12, 2011, U.S. Forest Service, Southern Research Station) A forest carbon policy that treats harvesting as a threat to forest carbon stocks (e.g.by focusing on biomass consumption) rather than as an important driver helping to prevent losses of forest is risking significant unintended consequences such as encouraging conversion of forest land to non-forest uses.<br><br>Third, the process of calculating, allocating and tracking forest carbon impacts attributable to specific producers and users of biomass is going to be difficult, costly, complicated and controversial. Biomass producers may supply multiple users over multiple years. They often draw from sites that are managed over multiple growth and harvest cycles and supply a number of different types of biomass products. The sites encounter various natural disturbances and are managed to address a range of sustainability objectives. In addition, biomass users commonly obtain biomass from multiple suppliers, many of whom are small private non-industrial land owners with very limited financial or technical ability to generate the data needed by the framework. Allocating forest carbon impacts (a) with limited data, (b) to multiple users (or suppliers), (c) to multiple biomass products produced by the forest, (d) to anthropogenic vs. natural factors and (e) to outputs other than biomass, will require allocation decisions that are unlikely to be made consistently across the country. This will introduce a level of uncertainty and arbitrariness that is inappropriate for a program intended to yield consistent outcomes when applied to different stationary

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| | sources.<br><br>Fourth, while the report focuses on the narrow question of adjusting estimates of forest carbon emissions, it is important to understand that this exercise takes place against backdrop of years of research and experience documenting the long-term benefits of using biomass to directly and indirectly displace fossil fuels. Ignoring this fact introduces a risk that policies flowing from the framework may focus on the narrow question while jeopardizing the ability to gain the maximum benefits via displacing fossil fuel in the future. It would be helpful if the report took more time to explain this important context.<br><br>Given these facts, it would seem unnecessary, and potentially counterproductive, for programs like the PSD and Title V programs to rely on a complex and expensive-to-implement framework that departs so dramatically from the conventional practice (i.e. simply recognizing the favorable balance in the forest carbon cycle via use of a zero emission factor for biogenic $CO_2$). |
| General | The accounting framework begins with calculation of "Potential Gross Emissions" (PGE) (i.e., the carbon content of biomass delivered to a facility expressed as $CO_2e$). Using PGE as the point of departure is inconsistent with EPA's GHG reporting rules and has the effect of maximizing the potential liability of bioenergy facilities for greenhouse gas emissions. It would have been equally valid to start the accounting with a presumption of net zero emissions from biomass (a presumption consistent with the observation of increasing forest carbon stocks in the U.S. and globally), with any needed subsequent adjustments based on metrics of carbon stock change and other factors. |
| General | There are several important mistakes, inconsistencies and gaps in the framework that require attention. Several of these are highlighted in the following bulleted items. These, and others, are highlighted in the detailed comments below.<br>• The question of how to address situations where regional carbon stocks are declining has been left largely unaddressed, yet if regional accounting is selected (e.g. instead of national accounting or a categorical exclusion) these are precisely the situations where the framework is needed.<br>• A conceptual approach for dealing with site-level changes in land use and land management has been proposed that is unworkable in its scope and fails to address threshold questions regarding time frames and allocation. For instance, the framework uses several equations to "adjust" PGE to create an estimate of Net Biological Emissions (NBE). The equations used to adjust PGE include several parameters (e.g., LEAK, SITE_TNC, SITEEMIT, SITESEQ) that, in all but the simplest of situations, would be difficult (or impossible) to estimate in practice.<br>• The draft framework includes special accounting for Land Use Change and Land Management Change but not for other factors that affect forest carbon stocks. This special accounting has potential to cause "double counting" of the effects of Land Use Change and Land Management Change. The draft report's rationale for NOT including special accounting for fuel treatments (page 44) is relevant here (i.e., if fuel treatments are effective, "the increase in forest carbon stocks will be reflected in subsequent years' analyses of standing stocks."). |
| General | In applying this framework to PSD and Title V programs, EPA will need to carefully consider the workability of the framework. As presented, the framework assumes the |

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| | availability of data that do not exist in many circumstances and would be far too costly to develop. It is important to understand that data availability and quality become far greater problems as the spatial scales for the calculations become smaller. As a result, the aspects of the framework that require plot- or site-level data are especially problematic. This can be ameliorated by performing the assessments for the parameter "GROW" at as large a spatial scale as possible and by limiting the scope of calculations for SITE_TNC to truly significant changes whose impacts can be reasonably approximated without extensive site-specific data (e.g. conversion of forest land to non-forest uses). |
| General | It is appropriate that the report recommends using a "Reference Point" baseline for assessing net flux of biogenic carbon attributable to biomass combustion activities at stationary sources. Significant uncertainties would be introduced by attempting to characterize these fluxes against "business-as-usual" or alternative scenarios. While it may be important to consider counterfactual scenarios to address certain types of questions, comparisons to counterfactuals are unnecessary and inappropriate for characterizing the actual, current (existing source) or projected (new source) impacts of biomass combustion, at a given time and place. |
| General | It is appropriate that the report recommends limiting the analysis to biogenic $CO_2$ and to life cycle stages that involve biogenic carbon and biogenic $CO_2$. While, in some applications, it is important to understand the full life cycle emissions of all greenhouse gases, this information is not relevant to the question being addressed by EPA (i.e. How should biogenic $CO_2$ emissions associated with the combustion of biomass at stationary sources be adjusted to account for other fluxes of biogenic carbon to and from the atmosphere attributable to that biomass?). This is not to say that other greenhouse gas emissions along the life cycle are unimportant. Only that they should not be included in the assessment of stationary source emissions of biogenic $CO_2$. |
| General | The report observes that "The decision on whether to adjust biogenic $CO_2$ emissions from a stationary source in any particular program is a policy decision, and this study does not provide any recommendations or judgments about that issue."<br>It is important that the report recognizes that it may be necessary to use different accounting frameworks for different purposes and in different programs. An accounting framework focused on the determination of net biogenic carbon emissions attributable to biomass combustion may not be appropriate, for instance, for examining the implications of policies to incentivize low-carbon technologies. |
| Page iv and elsewhere | Here and elsewhere, the report cites the 1996 IPCC Guidelines for National Greenhouse Gas Inventories. Some of the text describing the rationale and methods for biomass carbon accounting has been modified in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The report should be relying on the updated Guidelines. If certain text does not appear in the 2006 Guidelines, one should assume that it was removed from the 1996 Guidelines for a reason and not refer to it. |
| Page 3 | The report identifies the following six criteria that the framework is intended to meet.<br>1. Accurately reflects the carbon outcome.<br>2. Is scientifically rigorous/defensible.<br>3. Is simple and easy to understand.<br>4. Is simple and easy to implement.<br>5. Is easily updated with new data.<br>6. Uses existing data sources. |

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| | As a general matter, we would observe that the framework described in the report fails to satisfy criteria 2 through 5 in all but the simplest of circumstances. The analysis will not be simple or easy, for instance, (a) in any situation where multiple biomass users are located in regions where carbon stocks are decreasing or under threat of decreasing, (b) for any biomass users relying on multiple sources for wood, or (c) for any biomass producer required to give site-level scrutiny to the carbon impacts of a range of normal forest management activities. |
| Page 7 | At the end of the paragraph at the top of the page, the report should add information on the forest carbon balance at the global level. In specific, the report should note that Pan et al (2011) have determined that, at the global level, the world's forests are a net sink for atmospheric $CO_2$ (Pan et.al., "A Large and Persistent Carbon Sink in the World's Forests", Science, Vol. 333, 19 August 2011). After accounting for forest carbon gains via growth and expansion of forests as well as carbon losses due to deforestation, harvesting and all other factors, the net removals of $CO_2$ from the atmosphere accomplished by the world's forests amount to $1.1 \pm 0.8$ Pg C $year^{-1}$. |
| Figure 2-2 | "Wildfire on unmanaged land" is shown in the "natural origin" half of the figure. But there are many situations where the lack of management is dictated by policy or law, so that the lack of management is not "natural" and neither, therefore, are the fire-related losses of carbon that can be attributed to such lack of management. |
| Page 12 | The report uses a quote from the IPCC web site to represent that body's view on the question of biomass carbon accounting for biomass fuels. This is inappropriate because the statement has not been peer reviewed. Indeed, to our knowledge, it has not even received broad review within IPCC. In the accounting Guidelines themselves, IPCC avoids the use of the term "carbon neutral" and it is surprising to see it being used on the IPCC website. |
| Page 13<br>Under "C." | The second paragraph indicates that under the IPCC framework, "…no entity actually is assigned the emissions or bears responsibility for the emissions of $CO_2$ resulting from the use of biologically based feedstocks at stationary sources."<br><br>In fact, there is an entity that is assigned these emissions and bears this responsibility. It is the national government. In its annual inventories, the U.S. must report the net flux of forest carbon into or from the nation's forests as an emission. Governments have a range of policy options to influence the net flux of forest carbon to the atmosphere. To our knowledge, however, no government in the world has pursued a policy that attaches an emission liability to stationary sources based on releases of biogenic $CO_2$. |
| Page 14<br>Under "1." | The report states that a categorical exclusion "rests on the assumption that because it is theoretically possible to harvest and consume biologically based feedstocks in a way that does not add net biogenic $CO_2$ to the atmosphere, it is reasonable to assume that that this equilibrium state always exists and does not need to be tested." This is not necessarily true. It can also be based on an understanding of the markets for and supplies of biomass, of the factors affecting land use decisions, and a judgment that market forces and policy instruments are in place that will ensure that the demand for biomass will not cause national forest carbon stocks to decline. |
| Page 14<br>Under "2." | The report is justified in rejecting the categorical inclusion approach as it ignores the widely recognized difference between the carbon in biomass and the carbon in fossil fuels, with respect to the impact of ongoing use of the respective materials on |

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| | atmospheric $CO_2$ levels. |
| Page 15<br>Under "E." | At noted above, it is appropriate that the report limits the analysis to biogenic $CO_2$ and to life cycle stages that involve biogenic carbon and biogenic $CO_2$. While, in some applications, it is important to understand the full life cycle emissions of all greenhouse gases, this information is not relevant to the question being addressed by EPA (i.e. How should biogenic $CO_2$ emissions associated with the combustion of biomass at stationary sources be adjusted to account for other fluxes of biogenic carbon to and from the atmosphere attributable to that biomass?). This is not to say that other greenhouse gas emissions along the life cycle are unimportant. Only that they should not be included in the assessment of stationary source emissions of biogenic $CO_2$. |
| Page 15 | While we agree that LCA options are too complex for use on a case-by-case basis, it would be appropriate for the report to include substantive discussion of the LCA literature regarding the GHG mitigation benefits of bioenergy. In future deliberations regarding the framework, EPA may wish to consider circumstances in which there may be advantages in using a "categorical LCA" approach to carbon accounting similar to that being used in the Agency's RFS2 program to measure the carbon footprints of bioenergy technology options. |
| Page 16<br>Under "3.1:" | It is appropriate to limit the analysis to biogenic $CO_2$. The objective of the framework, at least in the context of the report is, to address the question; How should biogenic $CO_2$ emissions associated with the combustion of biomass at stationary sources be adjusted to account for other fluxes of biogenic carbon to and from the atmosphere attributable to that biomass? Given this question, GHGs that do not contain biogenic carbon need not be included. To the extent that some non-$CO_2$ GHGs might contain biogenic carbon (e.g. biogenic $CH_4$) the framework should not adjust for global warming potential, but should focus on the fate of the carbon as it affects the forest carbon cycle. |
| Page 17<br>Under "3.3"<br>and elsewhere | We would note here, and will repeat later, that the report needs to clarify that the calculation of transport and processing losses should be based on the point where PGE is determined. In other words, in the calculations, the adjustment of PGE for losses in order to calculate TFP should include only losses that occur upstream of the point where PGE is determined. Losses that occur downstream of this point are treated differently in the calculations. |
| Page 19<br>Under "3.7"<br>and elsewhere | The report justifies inclusion of land-use and management changes in the framework based on the observation that "land-use change emissions (which are primarily biogenic) are responsible for about 30 percent of total anthropogenic emissions since 1850." Deforestation is, indeed, a significant contributor to increased $CO_2$ in the atmosphere, but the report provides no evidence that other less obvious land management changes are significant contributors to observed increases in atmospheric GHGs. While it is possible to measure site-specific impacts associated with a range of land management activities, these impacts are (a) almost always small compared to the impact of converting forest land to non-forest uses (or the reverse), and (b) highly variable, depending on the specific management changes in question, and thus require significant cost and effort to estimate accurately. For these reasons, it would seem reasonable to limit the scope of the assessment of land use impacts to those associated with major changes, primarily the conversion of land into, or out of, forest.<br><br>Another issue that will need to be addressed is the potential double counting of carbon |

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| | flows in the GROW parameter and in SITE_TNC. This issue becomes more acute as the spatial scale for determining GROW becomes smaller. |
| Page 20<br>Under "B."<br>and elsewhere | Attempts to characterize leakage are bound to yield very uncertain results. In addition to being uncertain, the results will depend on the method used to determine them. It does not seem appropriate to introduce this level of uncertainty into calculations intended to influence stationary source emissions permit conditions. The report, therefore, should be less encouraging of attempts to include indirect land-use change and leakage into these calculations.<br><br>The report should also include an expanded discussion of the relationship between leakage and spatial scales of analysis. In specific, one must be concerned that harvesting activity might be driven from one region to another as the result of a determination that biomass from one region carries a $CO_2$ liability that is not attached to the biomass from another region. Again, this points to the need to make regions as large as possible, with national-scale assessment seeming to be the most appropriate scale to address this issue.<br><br>A related issue is the potential for international leakage that could be caused by applying an emissions liability to biogenic $CO_2$ in the U.S. when such a liability is not applied elsewhere in the world. The calculation framework in the report does not account for the leakage that could be associated with a shifting of wood production or forest products manufacturing across national boundaries in response to the costs (direct and indirect) attributable to emissions limits on biogenic $CO_2$. |
| Page 21 and 22<br>Under "C." | The report is correct to steer the framework away from the "carbon debt" concept employed by Fargione (2008) and Manomet (2010). EPA's objectives are different than those addressed by these two studies, and it is reasonable that the report should select an accounting framework best suited to EPA's needs: i.e. adjusting biogenic $CO_2$ emissions associated with the combustion of biomass at stationary sources to account for other fluxes of biogenic carbon to and from the atmosphere attributable to that biomass.<br><br>If, at some point, EPA encounters the need to employ a framework that relies upon counterfactual scenarios (for instance, the "carbon debt" approach), we would encourage EPA to (a) construct the counterfactual scenarios in a way that reflects all important, direct and indirect economic impacts of the forest carbon policies being studied, and (b) examine multiple counterfactuals. Given the uncertainties inherent in calculations involving counterfactual scenarios, it is critical that sensitivity analyses be performed using different scenarios to ensure that resulting policies are robust in the face of a range of possible futures. |
| Page 22 and 23<br>Under "3.8" | For reasons noted above, we see no reasons in science why the accounting should be based on spatial boundaries smaller than the national boundaries of the U.S. In any event, the spatial boundaries should be as large as possible. The problems encountered as spatial scales become smaller include (a) data become less available and lower in quality, (b) estimation errors are greater, (c) the risk of leakage becomes far greater, and (d) the risk of artifacts due to double counting in the GROW and TNC_SITE terms is greater. |
| Page 22 and 23 | The temporal scale for determining trends in forest carbon stocks needs to be selected so as to allow consideration of transient conditions that may not be reflective of |

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| Under "3.8" | longer-term trends. In a cyclical industry, both harvesting and planting intensity go through cycles that can manifest themselves in short- term trends in forest carbon stocks that are very unlikely to be sustained over the longer term. |
| Page 22 and 23<br>Under "3.8" | The report is correct to note the problems associated with using state boundaries for determining "regions" for purposes of establishing the stability of forest carbon stocks. The markets for wood do not respect state boundaries. Artificially limiting the forest carbon accounting to state boundaries would not provide an accurate assessment of the potential impacts of an activity on forest carbon stocks. The risk that the calculations will be affected by leakage is very high when spatial boundaries this small are used. As noted above, for various reasons, it would seem that national-scale assessment is the most appropriate. |
| Page 22 and 23<br>Under "3.8" | The report notes the potential importance of international flows of wood, as they might impact the assessment of potential impacts on US forest carbon stocks, and also the difficulties associated with addressing these impacts in the accounting framework. This is a potentially significant limitation of the proposed framework. In some regions, the cross border flows of forest carbon could be important and the framework should provide a means for addressing these. |
| Page 24 | For a number of reasons, it would be most appropriate to perform the assessment of carbon stocks over a land base that includes all rural land in a region, inclusive of all private and public timber stands, reserved forestlands, and agricultural lands. First, a comprehensive approach is required to detect and quantify leakage and other indirect land use effects. For example, when harvest levels are restricted on certain categories of forestlands, other lands may experience increased harvest levels. In addition, it is the net change in carbon stocks over the entire land base that determines what the atmosphere sees. |
| Page 25 | The draft report identifies some important considerations regarding appropriate uses of estimated changes in forest carbon stocks in the accounting framework. Most notably, footnote #29 (page 23) and Section 4.9.B.1 (page 43) demonstrate that forest carbon stocks can decline for reasons unrelated to use of forest biomass for energy production. Nevertheless, it is asserted on page 25 that if a decline in carbon stocks is observed in an area, then "stationary sources using biologically based feedstocks from that area are likely contributing to that decline and related net emissions." This statement is questionable and should be revised. A measured reduction in carbon stocks in a region should be characterized as indicating a need to assess whether and to what extent the reduction is attributable to biomass consumption by stationary sources or to other factors such as natural tree mortality (e.g., due to storms or wildfire) and conversion of forests to non-forest uses. |
| Page 26<br>Top of page | The report is correct to observe that a significant problem associated with performing the needed assessment at small scales is the large errors associated with the estimates. This further reinforces the importance of conducting the analyses at as large a spatial scale as possible. |
| Page 26 and 27<br>Under "3.8" | The report correctly identifies a number of difficulties associated with using what it calls "anticipated future baselines" and "comparative baselines." Both of these approaches require the development of speculative counterfactual scenarios which introduce a large amount of uncertainty into the assessment and make the results not only uncertain but prone to manipulation. In addition, as complex and difficult as the "reference point baseline" approach is to apply, the anticipated future and |

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| | comparative baselines are far more complex and difficult. Finally, and perhaps most important, the reference baseline approach is the one best suited to answering the question important to EPA, namely: How should biogenic $CO_2$ emissions associated with the combustion of biomass at stationary sources be adjusted to account for other fluxes of biogenic carbon to and from the atmosphere attributable to that biomass? |
| Page 32<br>Under "2." | The report indicates that "leakage should be considered for those biomass feedstocks that are currently marketed elsewhere as a commodity". While this exercise may have value in theory, in practice, the estimation of leakage is subject to significant uncertainty and introduces another opportunity for manipulation of the results. Unless the leakage is direct and amenable to accurate estimation, the disadvantages of including leakage in the calculations are likely to outweigh the advantages.<br><br>This does not mean that leakage is unimportant, however. And because of this, the spatial scales of the analysis should be as large as possible, with national-level assessment seeming to be most appropriate. |
| Page 38<br>Under "4.1" | As noted above, it is appropriate to limit the analysis to biogenic $CO_2$. The objective of the framework, at least in the context of the report is to address the question; How should biogenic $CO_2$ emissions associated with the combustion of biomass at stationary sources be adjusted to account for other fluxes of biogenic carbon to and from the atmosphere attributable to that biomass? Given this question, GHGs that do not contain biogenic carbon need not be included. To the extent that some non-$CO_2$ GHGs might contain biogenic carbon (e.g. biogenic $CH_4$) the framework should not adjust for global warming potential, but should focus on the fate of the carbon as it affects the forest carbon cycle. Given that we know that the carbon fluxes (not adjusted for GWP) associated with these non-$CO_2$ biogenic GHGs are small compared to fluxes attributable to biogenic $CO_2$, it is reasonable to ignore them altogether. |
| Page 38<br>Under "4.2" | In the discussion of methods for determining direct emissions of $CO_2$, the report should include the use of emission factors and information on fuel consumption (i.e. activity data). |
| Page 39<br>Under "4.4" | In the first paragraph on this page, when the report discusses the importance of considering, in the mass balance, the carbon in products, it should also mention carbon in by-products that are sold and exit the facility (not just the "carbon stored as byproduct of combustion…". In the following paragraph, the opening sentence should likewise be modified to say, "As described in Section 3, a variety of products and co-products may be produced…". |
| Page 40<br>Under "4.7" | The attempt to separately account for carbon stock impacts due to land use change and land management change introduces a risk of double counting because, if these practices have impacted forest carbon stocks, the impacts are, presumably, already included in the regional estimates of stock changes and therefore accounted for in the determination of net carbon uptake in growing feedstock (i.e. the GROW parameter). The smaller the spatial boundaries for determining the balance between growth and drain, the greater the risk that the double counting is a significant issue in the analysis. |
| Page 40<br>Under "4.7" | The report suggests that a wide range of possible activities might be considered to be land use change or land management change and might, therefore, have to be addressed at the site level to estimate the net impacts of the production of the biomass on atmospheric $CO_2$. The carbon stock changes associated with many of the activities potentially within the scope of this assessment are small, especially when |

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| | compared to the impacts related to converting land into or out of forest. There is uncertainty inherent in the estimates of these impacts and for small impacts the potential estimation errors can exceed the size of the impact under study. Therefore, if EPA determines that it is necessary to include site-level land use change impacts in the assessment, it would be reasonable to limit the scope of such analyses to the truly significant changes; in specific, the conversion of land into or out of forest. |
| Page 40<br>Under "4.7" | The report fails to recognize that in a significant fraction of cases, the process of attributing and allocating land use and land management change-related impacts is going to be difficult and complicated (and potentially controversial). A site may supply multiple users over multiple years, encompassing multiple growth and harvest cycles, supply a number of different types of biomass products, encounter various natural disturbances and be managed to address a range of sustainability objectives. In addition, biomass users commonly obtain biomass from multiple suppliers, most of whom are private non-industrial land owners with very limited financial or technical ability to generate the data needed by the framework. Allocating site-level stock changes (a) to these multiple users and biomass products, (b) to anthropogenic vs. natural factors and (c) to outputs other than biomass will require allocation decisions that are unlikely to be made consistently across the country. This will introduce a level of uncertainty and arbitrariness that is inappropriate for a program intended to yield consistent outcomes when applied to different stationary sources.<br><br>The report should also acknowledge the potential impacts of the program on small land owners. The monitoring and recordkeeping implicit in the framework may be enough to discourage small landowners from continuing to use the land to produce wood. In these cases, the primary options to use land productively will often involving converting the land to purposes other than forestry, resulting in large losses of carbon (e.g. another potential source of leakage). |
| Page 40<br>Under "4.7" | Again, we would observe that although determining leakage and other indirect effects may have value in theory, in practice, the estimation of these factors is subject to significant uncertainty and introduces opportunity for manipulation of the results. Unless the leakage is direct and amenable to accurate estimation, the disadvantages of including leakage in the calculations are likely to outweigh the advantages. This also holds true for other indirect effects.<br><br>Yet, leakage is real and potentially important. Harvesting might shift from regions producing biomass having a biogenic $CO_2$ burden to regions (or countries) where biomass is without such burdens without actually affecting overall net transfers to the atmosphere. The best way to limit this is to use national-level spatial scales for the accounting. |
| Page 41 and beyond<br>Under "4.8" | Again, we would note that the spatial scales should be as large as possible. This will reduce estimation errors associated with limited data availability at smaller scales, reduce the potential significance of double counting the effects of land use change, limit the effects of leakage on the calculations, and better reflect what the atmosphere actually sees with respect to net fluxes of biogenic carbon. |
| Page 41 and beyond<br>Under "4.8" | Again we would suggest the need for considerable flexibility in setting the temporal scales for determining the stability of forest carbon stocks. There are a range of circumstances that can cause transient trends in carbon stocks that can obscure the more relevant long-term picture. |

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| Page 42<br>Under "4.8" | Again, we note that the report acknowledges the potential importance of international flows of wood but does not address the question of how these should be addressed in the framework. This is a potentially significant limitation of the proposed framework. In some regions, the cross border flows of forest carbon could be important and the framework should provide a means for addressing these. |
| Page 43<br>Under "1." | The report notes that, under the proposed framework, as long as carbon stocks are increasing, the problems associated with attribution are not important. It then indicates that "the decision about how to handle attribution in situations where carbon stocks are declining is critical but not resolved within this framework." This is a major limitation in the proposed framework. Indeed, the problems with attribution are daunting, not only when regional carbon stocks are declining, but also often when attempting to address site-level land use and land management-related impacts. Yet, it is precisely when these issues arise that the framework is most needed.<br><br>Given this critical limitation, we must again ask why such a complex and problematic framework is needed when (a) national and global forest carbon stocks are increasing and (b) policies aimed at keeping forests in forest will be of far greater benefit in maintaining stable forest carbon stocks than complex accounting exercises focused on biomass use. |
| Page 43<br>Under "fuel treatments" | The report suggests that it is not important to give separate attention to fuel treatments because the effect of these treatments will be reflected in the assessment of carbon stock changes. Yet, the report fails to apply this logic to impacts due to land use change and land management changes that are also reflected in the assessment of carbon stock changes. |
| Page 46<br>Table 5-1 | In the definition of PGE, the table incorrectly states that PGE is the carbon content in the biogenic feedstock used for energy at the stationary source…". Given the calculation framework described, and the definition of NBE (also in the table), the definition of PGE should be based on the carbon in the feedstock delivered to facility, not the amount combusted. Otherwise, there would be no need to adjust the feedstock carbon (PGE) to account for carbon in products. |
| Page 47<br>Table 5-1 | Here and elsewhere, it should be made clear that the various losses described in the table are those that occur upstream of where PGE is determined. Losses that occur downstream of this point may be manufacturing residuals or wastes but for purposes of the calculations, they are not included in the calculation of losses (as reflected in the parameter "L"). |
| Page 47<br>Table 5-1 | To be consistent with the calculations, the definition of LAR should be expanded to clarify that it is also includes the proportion of PGE that is offset by virtue of the emissions having been avoided. |
| Page 47<br>Table 5-1 | The definition of leakage is too narrow and should be expanded to include all changes in emissions not addressed in the calculations that are attributable to the activities being analyzed in the calculations. |
| Page 47<br>Table 5-1 | Given the calculations, it appears that TFP is not the "Total site production necessary to provide the feedstock used by the stationary source" but instead, the "Total site production necessary to provide the feedstock used by the facility where the stationary source is located." Otherwise, there is no need to adjust for carbon in products (for instance). |
| Page 47 | Definitions of GROW and AVOIDEMIT are confusing, especially to the extent that both |

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| Table 5-1<br>And in the calculation framework in general | show up in the calculation of LAR in the framework. It would probably be more easily understood and internally consistent if both GROW and AVOIDEMIT were expressed as fractions of the carbon in the TFP.<br><br>GROW would be the fraction of the carbon in the TFP that was assumed to be offset by growth of feedstock in the region (ranging from zero to one) and AVOIDEMIT would be the fraction of the carbon in the TFP that would have returned to the atmosphere even if it has not been burned in the stationary combustion source(s) (again ranging from zero to one).<br><br>The first term in the NBE equation would then have to be changed to "PGE x (1 + L) x (1 – LAR – PRODC)", with the constraint that (1-LAR-PRODC) not be less than zero. |
| Page 49<br>Top of page and throughout the framework | It is stated that PGE is based on the $CO_2$ content of the biogenic feedstock required at the stationary source for energy and indicates that it is determined at the point of combustion. This is incorrect. PGE includes all carbon delivered at the facility, including that destined for products sold by the facility. Otherwise, there would be no need to adjust PGE for carbon in products (i.e. because, in almost all cases, none of the carbon in the feedstock at the point of combustion ends up in product). |
| Page 54<br>Under C. | The first sentence is incomplete. It fails to include AVOIDEMIT as a part of the LAR calculation. |
| Pages 56 and 57<br>Under "F." | The report needs to anticipate a circumstance where land conversion has occurred in a one year, there is a delay of over a year before energy crops are produced on the converted land, and then these crops are produced annually for many years. The report simply says that the net emissions/sequestration needs to be "adjusted to a per year basis" but no guidance is provided on how this is done. Is there a "look back" period? Over how many cycles of crops should the land use change impact be allocated, or does the first year's crop bear the entire load (meaning that the year-1 crop would have an enormously different BAF than the same crop produced the following year). These are the types of questions that need to be addressed when attempting to include land use change and land management change into the framework. The lack of a method for addressing these challenges is a key shortcoming of the framework. |
| Case Study 3 | We have prepared a revised Case Study 3 (see below), more accurately reflecting the flows of biogenic carbon into and through a kraft pulp and paper mill. The revised case study also clarifies that the BAFs for the biogenic $CO_2$ from burning black liquor and bark, and from managing a number of other manufacturing residuals, are not dependent on the source of the wood. These emissions from these manufacturing residuals would have occurred anyway, and are addressed in the framework as "anyway emissions".<br><br>In addition, the revised Case Study 3 corrects several errors found in the original. |
| New Case Study | Given the interest in using forest harvest residuals for energy, it would be helpful to include a case study focused on this practice. The case study would draw attention to several facts, including the following.<br>• "If harvest residue is not removed for bioenergy, it would have decayed or been burned in the forest." [From page 33 of the report.]<br>• As a result, emissions from burning forest residues are specifically included in |

| | |
|---|---|
| | the definition of "AVOIDEMIT", as noted in table 5-1 of the report and in the definition of AVOIDEMIT at the top of page 55 of the report. |

## Case Study 3: Calculating Net Biogenic Emissions for a Pulp and Paper Mill Harvesting Roundwood in the Pacific Northwest

### Description

This case study provides an illustration of net biogenic $CO_2$ emissions for a biomass cogeneration plant at a pulp and paper mill in the state of Washington. This case study illustrates how biomass energy may play a subservient role in the facility. In the case of pulp and paper mills, woody biomass is purchased for the production of paper products for printing, packaging, or other markets. The process of making pulp and paper from wood and wood residue feedstock requires the removal of parts of the wood in order to produce wood fibers suitable for making paper or other products. This results in the generation of manufacturing residuals of various types (e.g. black liquor solids, bark, rejects), some of which are used as fuels to help satisfy the energy demands of the pulping and papermaking process. Mills usually produce a substantial portion of their energy needs through biomass burning. The results for this case study are shown in Table 6.

### Essential Features

- The pulp and paper mill in this scenario purchases wood from two sources: forests (300,000 short tons per year) and byproducts such as chips and sawdust from other wood-processing facilities such as sawmills (100,000 short tons per year).

- Both feedstocks are sourced from within the state of Washington.

- From the 2007 RPA assessment (Smith et al., 2009), Washington State had net growth of 1,638,148 thousand cubic feet of forest and removals of 899,047 thousand cubic feet. This equates to net growth of 32.1 million dry tons biomass and removals of 17.6 million dry tons biomass. Thus, harvest of 0.3 million tons of biomass for paper and energy production in this case study is replaced by growth in this region. This assumes the entire state is the sourcing region for the mill; while clearly this would not be the case, the excess growth statewide is so high that these statewide numbers make the case that harvests will not put forest carbon stocks in the region into decline. These two feedstocks provide the wood fiber needed for all mill operations. These feedstocks are blended in the mill prior to manufacture of pulp and paper and energy production, so they share common factors such as losses, product proportions, etc.

- The mill uses this purchased wood biomass for production of pulp and paper as well as byproducts, such as turpentine and soap. Much of material that must be removed from the wood biomass to produce pulp becomes black liquor solids that are burned in a recovery boiler that recovers pulping chemicals for reuse and produces steam for electricity generation and to provide heat for the pulping process.

- The electricity generation from biomass is equivalent to about 35 MW. Fossil fuels are also used in the mill for energy, but are not included in these calculations.

- See Table 7 for additional information about the parameters used in this case study.

### Overview

The following sections describe calculation of Net Biogenic Emissions (NBE) and the Biogenic

Accounting Factor (BAF) in six steps:

Step 1: Potential Gross Emissions (PGE), feedstock carbon lost along supply chain (L), Level of Atmospheric Reduction (LAR), and carbon leaving the accounting framework as products (PRODC)
Step 2: Carbon storage resulting from incomplete utilization (SEQP)
Step 3: Carbon Emissions/Sequestration at the Feedstock Production Site (SITE_TNC)
Step 4: Leakage (LEAK)
Step 5: Net Biogenic Emissions (NBE)
Step 6: Biogenic Accounting Factor (BAF)

**Overview**

As presented in Section 4 of the accounting framework, the complete formula for estimating Net Biogenic Emissions (NBE) is:

$$\begin{aligned} NBE = & [PGE \times (1 + L) \times (1 - LAR) \times (1 - PRODC)] \\ & - [PGE \times SEQP] \\ & + [SITE\_TNC \times (1 - PRODC)] \\ & + [LEAK \times (1 - PRODC)] \end{aligned}$$

In each of the Steps 1 through 4, we work through the calculations required for the square bracketed terms.

**Step 1: Potential Gross Emissions (PGE), feedstock carbon lost along supply chain (L), Level of Atmospheric Reduction (LAR), and carbon leaving the accounting framework as products (PRODC)**

In Step 1, the difference between what could potentially be emitted if all of the feedstock produced is consumed, and what is actually emitted as a result of the feedstock processing or combustion process is calculated. It is then adjusted for the amount of carbon contained in products that ultimately leave the source and thus occur outside the accounting framework. This Step corresponds to the following term, which appears first in the full Net Biogenic Emissions (NBE) equation above:

$$[PGE \times (1 + L) \times (1 - LAR) \times (1 - PRODC)]$$

The calculation begins with the carbon that is contained in the feedstock as it leaves the production site (e.g., farm, forest). Note that PGE is calculated with reference to the feedstock that is used by the facility. The proportion that is lost in transport, storage and handling upstream of the facility (L) is added, in order to find the actual quantity of feedstock that must be produced at the production site to provide feedstock for the facility.

***i. Calculating Potential Gross Emissions (PGE)***

Potential Gross Emissions (PGE) refers to the metric tons of $CO_2e$ contained in the feedstock as it enters the mill - in other words, it is the total $CO_2e$ that could potentially be released. PGE is the product of the mass of feedstock used by the facility and its carbon content. Conversion factors are used to express the final PGE as metric tons $CO_2e$. See Table 3 for default values for each of the coefficients. Note that in this case, the feedstock input to the source is measured in English units, so the conversion from English to Metric is necessary.

$$\begin{aligned} PGE = & (\text{Feedstock needed}) \\ & \times (\text{Carbon content of feedstock}) \\ & \times \text{English\_to\_Metric} \\ & \times \text{Carbon to } CO_2e \end{aligned}$$

Wood from forests:

$$PGE = 300{,}000 \text{ short tons per year} \times 0.5 \times 0.9072 \times (44 / 12) = 498{,}960 \text{ tCO2 per year}$$

Residues from mills:

$$PGE = 100{,}000 \text{ short tons per year} \times 0.5 \times 0.9072 \times (44 / 12) = 166{,}320 \text{ tCO2 per year}$$

Combined:

$$PGE = 498{,}960 \text{ tCO2 per year} + 166{,}320 \text{ tCO2 per year}$$

$$PGE = 665{,}280 \text{ tCO2 per year}$$

- ***Calculating Proportion of Feedstock Lost (L)***

Feedstock Lost (L) is the proportion of additional feedstock production needed to overcome loss in conveyance, storage, and plant handling. The following equations give the amount of potential emissions in the feedstock that must be produced (TFP) at the feedstock site. This case study assumes that 1% of the mass of carbon removed from the forest is lost in transport and handling of the material before it is delivered to the pulp and paper mill. The losses associated with processing and transporting wood from the forest to the sawmill (which generates the residual chips) are assigned to the sawmill and not considered in these calculations. It is assumed that losses from the saw mill to the pulp mill are zero. The losses that occur within the pulp and paper mill are not considered in calculating TFP because they occur after the point where PGE is determined (i.e. after the wood is delivered to the mill).

TFP = (Feedstock needed)
× (1 + Plant Losses occurring upstream of the point where PGE is determined)
× (1 + Storage Losses occurring upstream of the point where PGE is determined)
× (1 + Losses during handling and transport occurring upstream of the point where PGE is determined)

and

L = [(TFP / Feedstock needed)] – 1

But the fraction we are given (1%) is the fraction of TFP that is lost.

0.01 = (TFP – Feedstock needed) / TFP

Or

Feedstock needed = TFP - (0.01 × TFP) = 0.99 × TFP

Substituted above

L = [(TFP/(0.99 × TFP)] – 1 = (1 / 0.99) -1 = 0.0101

For wood delivered directly to the pulp and paper mill, 1% of the TFP is lost,

TFP = 300,000 × (1 + .0101) × (1 + 0) × (1 + 0) = 303,030

and

For residual chips delivered from the saw mill (upstream transport losses from the forest to the saw mill are assigned to the saw mill and it is assumed that the losses from the saw mill to the pulp mill are zero)

TFP = 100,000× (1 + 0.0) × (1 + 0) × (1 + 0) = 100,000

So, in total

L = [(303,030 + 100,000) / (400,000)] -1

L = 0.007576

- ***Calculating Level of Atmospheric Reduction (LAR)***

Level of Atmospheric Reduction (LAR) is the proportional atmospheric $CO_2e$ reduction that is associated with either: (a) feedstock growth, which sequesters atmospheric $CO_2$ (GROW), or (b) avoided emissions

(AVOIDEMIT) from the biogenic feedstock (e.g., from decomposition or combustion of manufacturing residues), which would otherwise have contributed to atmospheric $CO_2e$.

When LAR equals one all the emissions are offset. When it equals zero none are offset. A term between 0 and 1 means some proportion is offset. The following equation gives the amount that is offset by growth or avoided emissions.

$$LAR = (GROW + AVOIDEMIT) / (Feedstock\ needed \times (1 + L))$$

In applying this equation to a facility that uses forest biomass to manufacture pulp and paper, it is helpful to first understand the flows of carbon from the feedstock production site through the production of the paper product. For purposes of this example, information from Côté et al. (2002) has been used to estimate these flows.

In the study by Côté et al. (2002), losses in processing and transport upstream of the mill were not stated, but in this example, they are assumed to be 1% of the material shipped from the feedstock production site (as noted above in the calculation of L). Because the incoming wood at the mill in the Côté et al. study contained 641,000 tons of carbon, the amount of feedstock removed from the forest contained 647,475 tons of carbon. The mill's incoming annual feedstock (641,000 tons carbon content) was subject to losses of 87,000 tons of carbon in debarking and processing, 58,000 tons of which are burned and 29,000 tons of which are sent to the mill's landfill. Of the remaining 554,000 tons of carbon in wood, 302,000 were removed during pulping to produce 252,000 tons of carbon in unbleached pulp. These 302,000 tons of removed carbon consisted of 287,000 tons of carbon in black liquor solids, which were burned in the kraft recovery process to recovery pulping chemicals and to produce energy, and 15,000 tons of carbon in turpentine and soap by-products, which are sold. Although the calculation framework is not intended to characterize the life cycle benefits of recovering black liquor solids, it is worth noting that these benefits are considerable, both due to the efficiency with which the black liquor solids are used to produce new pulping chemicals and due to the amounts of energy recovered for use in the process. (See Gaudreault et. al. 2011 for more information) The unbleached pulp was then bleached. The bleaching process removed another 21,000 tons of carbon, which were sent to the mill's waste treatment operations, leaving 231,000 tons of carbon in the bleached pulp used to make paper. The Côté et al. (2002) study did not estimate the losses of fiber incurred in the production of paper from pulp, so for this example, it will be assumed that 2% of the bleached pulp is lost during paper production, representing losses of 4,620 tons of carbon which are sent to the mill's waste treatment operations.

In the following table, the carbon flows described above are used to derive factors (equal to the fraction of carbon removed from the incoming material to each process) for estimating various flows in the example mill.

**Table 1: Development of Factors to Estimate Carbon Flows for Example Kraft Mill (Largely derived from Côté et al. (2002))**

| Material | Tons C | fraction of C coming into each process that is removed through that process |
|---|---|---|
| Carbon in total feedstock produced at the feedstock site, or TFP | 647,475 | |
| Carbon in wood lost in upstream processing and transport | 6,475 | 0.010 |
| Carbon in wood delivered to mill | 641,000 | |
| Carbon in residuals generated in debarking not suitable for burning but sent to mill's waste management operations | 29,000 | 0.0452 |
| Carbon in bark removed and used as fuel | 58,000 | 0.0905 |
| Carbon in wood sent to pulping | 554,000 | |
| Carbon removed in pulping which is contained in black liquor solids, burned to recover pulping chemicals and energy | 287,000 | 0.5181 |
| Carbon removed in pulping which is converted into turpentine and soap sold as by-products | 15,000 | 0.0523 |
| Carbon in unbleached pulp sent to bleach plant | 252,000 | |
| Carbon removed in bleaching sent to mill's waste management operations | 21,000 | 0.0833 |
| Carbon in bleached pulp | 231,000 | |
| Carbon removed in papermaking sent to mill's waste management operations | 4,620 | 0.020 |
| Carbon in paper product | 226,380 | |

These factors derived above are then used to develop estimates for the example mill of the fate of carbon removed from the two sources of feed stock as they are processed for pulp and paper production. The estimates are shown in the following tables. Note that the units are metric tons of $CO_2$.

### Table 2: Flows of Carbon from Roundwood through the Example Kraft Pulp and Paper Mill

| | Tons $CO_2$ |
|---|---|
| Carbon in total feedstock produced at the feedstock site, or TFP | 504,000 |
| Carbon in wood lost in upstream processing and transport | 5,040 |
| Carbon in wood delivered to mill | 498,960 |
| Carbon in residuals generated in debarking not suitable for burning but sent to mill's waste management operations | 22,574 |
| Carbon in bark removed and used as fuel | 45,148 |
| Carbon in wood sent to pulping | 431,238 |
| Carbon removed in pulping which is contained in black liquor solids, burned to recover pulping chemicals and energy | 223,403 |
| Carbon removed in pulping which is converted into turpentine and soap sold as by-products | 22,539 |
| Carbon in unbleached pulp sent to bleach plant | 185,297 |
| Carbon removed in bleaching sent to mill's waste management operations | 15,441 |
| Carbon in bleached pulp | 169,855 |
| Carbon removed in papermaking sent to mill's waste management operations | 3,397 |
| Carbon in paper product | 166,458 |

### Table 3: Flows of Carbon from Residual Sawdust and Chips through the Example Kraft Pulp and Paper Mill

| | Tons $CO_2$ |
|---|---|
| Carbon in total feedstock produced at the feedstock site, or TFP | 166,320 |
| Carbon in wood lost in upstream processing and transport | ? |
| Carbon in wood delivered to mill | 166,320 |
| Carbon in residuals generated in debarking not suitable for burning but sent to mill's waste management operations | 0 |
| Carbon in bark removed and used as fuel | 0 |
| Carbon in wood sent to pulping | 166,320 |
| Carbon removed in pulping which is contained in black liquor solids, burned to recover pulping chemicals and energy | 86,162 |
| Carbon removed in pulping which is converted into turpentine and soap sold as by-products | 8,693 |
| Carbon in unbleached pulp sent to bleach plant | 71,465 |
| Carbon removed in bleaching sent to mill's waste management operations | 5,955 |
| Carbon in bleached pulp | 65,510 |
| Carbon removed in papermaking sent to mill's waste management operations | 1,310 |
| Carbon in paper product | 64,200 |

Combining these two provides information on the overall flows of carbon into and through the mill. These results are shown in the following table.

**Table 4. Flows of Carbon from All Sources through the Example Kraft Pulp and Paper Mill**

| | Tons $CO_2$ |
|---|---|
| Carbon in total feedstock produced at the feedstock site, or TFP | 670,320 |
| Carbon in wood lost in upstream processing and transport | 5,040 |
| Carbon in wood delivered to mill | 665,280 |
| Carbon in residuals generated in debarking not suitable for burning but sent to mill's waste management operations | 22,574 |
| Carbon in bark removed and used as fuel | 45,148 |
| Carbon in wood sent to pulping | 597,558 |
| Carbon removed in pulping which is contained in black liquor solids, burned to recover pulping chemicals and energy | 309,565 |
| Carbon removed in pulping which is converted into turpentine and soap sold as by-products | 31,231 |
| Carbon in unbleached pulp sent to bleach plant | 256,762 |
| Carbon removed in bleaching sent to mill's waste management operations | 21,397 |
| Carbon in bleached pulp | 235,365 |
| Carbon removed in papermaking sent to mill's waste management operations | 4,707 |
| Carbon in paper product | 230,658 |

Having clarified the flow of biogenic carbon into and through the manufacturing process, the appropriate calculation framework for the various flows must be determined. The following table identifies the attributes of each flow in the context of the calculation framework described in this report.

**Table 5. Accounting Attributes of Various Flows of Carbon through the Example Kraft Pulp and Paper Mill**

| | Accounting Attribute |
|---|---|
| Carbon in total feedstock produced at the feedstock site, or TFP | TFP |
| Carbon in wood lost in upstream processing and transport | L |
| Carbon in wood delivered to mill | PGE |
| Carbon in residuals generated in debarking not suitable for burning but sent to mill's waste management operations | Manufacturing residual* |
| Carbon in bark removed and used as fuel | Manufacturing residual* |
| Carbon in wood sent to pulping | Intermediate product |
| Carbon removed in pulping which is contained in black liquor solids, burned to recover pulping chemicals and energy | Manufacturing residual* |
| Carbon removed in pulping which is converted into turpentine and soap sold as by-products | By-product |
| Carbon in unbleached pulp sent to bleach plant | Intermediate product |
| Carbon removed in bleaching sent to mill's waste management operations | Manufacturing residual* |
| Carbon in bleached pulp | Intermediate product |
| Carbon removed in papermaking sent to mill's waste management operations | Manufacturing residual* |
| Carbon in paper product | Product |
| * These are classified as manufacturing residuals because they must be removed from the feedstock in order to make pulp and paper. Once separated from the feedstock, the carbon in these materials is destined to return to the atmosphere whether the materials are burned for energy or not. They therefore fall within the definition of Avoided Emissions as elaborated in the report in section 5.2 (C)(2). | |

The Level of Atmospheric Reduction (LAR) can now be calculated.

As noted above, LAR is the proportional atmospheric $CO_2e$ reduction that is associated with either: (a) feedstock growth, which sequesters atmospheric $CO_2$ (GROW), or (b) avoided emissions (AVOIDEMIT) from the biogenic feedstock (e.g., from decomposition or combustion of manufacturing residues), which would otherwise have contributed to atmospheric $CO_2e$.

The table above indicates that there are five materials contributing to PGE that need to be considered and all are manufacturing residuals. Other than these five flows, all of the carbon entering the mill leaves the mill in products or by-products. In these five cases, however, the carbon releases from these materials are classified as Avoided Emissions, as noted in the footnote to Table 5. Therefore LAR = 1.

In other words, these manufacturing residuals must be removed from the feedstock to make pulp and paper, and had they not been burned (to recover energy and, in the case of black liquor solids, to recover pulping chemicals) or otherwise managed, the carbon would have returned to the atmosphere anyway. This will be a common situation for mills that purchase woody biomass only for the primary purpose of producing forest products (e.g. lumber, panels, pulp and paper).

- **Calculating Carbon in Products (PRODC)**

Carbon in Products (PRODC) is the carbon content in products, in $CO_2$e, made from processing of the biogenic feedstocks, including energy products like ethanol that are combusted (or used) elsewhere releasing their sequestered $CO_2$e to the atmosphere. This serves as a mass balance calculation which ensures that the sum of the carbon content in the products equals the carbon content in the feedstock. The mass of each product or co-product is multiplied by the carbon content and summed up and divided by the Potential Gross Emissions (PGE) to estimate the proportion of carbon that leaves the stationary combustion facility in the form of products. Normally, analysis of the carbon content for various types of paper or other manufactured products would be combined with production quantities to estimate the $CO_2$e captured in the products. For this example, we use the information provided in the table above, based largely on the relative proportions as reported by Côté et al. (2002). The table indicates that there is one by-product and one product.

The formula for PRODC is:

$$PRODC = CO_2e \text{ content of Products} / PGE$$

Using data from the table above

$$PRODC = (31{,}321 + 230{,}658) / 665{,}280 = 0.3937$$

- **Step 1: Conclusion**

In the first step, the PGE from the feedstock are adjusted for feedstock losses (L), Level of Atmospheric Reduction (LAR), and any products that leave the facility (PRODC). The resulting term in overall equation is calculated as:

$$[PGE \times (1 + L) \times (1 – LAR) \times (1 – PRODC)]$$

$$[665{,}280 \times (1 + 0.007576) \times (1 – 1) \times (1 - 0.3937)] = 0$$

**Step 2: Carbon storage resulting from incomplete utilization (SEQP)**

Step 2 calculates the difference between what could be emitted by utilization of the feedstock (PGE) when combusted fully and what is actually emitted as a result of the production of a Sequestered Fraction in the form of post-combustion material. This term can include carbon sequestered in residuals like ash or carbon sequestered through carbon capture technology. Note that if these materials are sold for use outside the stationary source rather than disposed of, they should be counted in PRODC.

The Sequestered Fraction (SEQP) is the proportion of the feedstock carbon content that is contained in the derivative products that remain after biogenic feedstock combustion at the stationary source. In some production technologies, virtually all of the carbon in the feedstock is emitted as $CO_2$. In that event, Sequestered Fraction would be 0 or very close to 0. In other technologies, unburned carbon is left in the ash.

$$SEQP = CO2e \text{ sequestered from stationary source} / PGE$$

This case study assumes full combustion (of all feedstocks used for energy) and consequently no Sequestered Fraction, and thus, For wood from forests:

$[PGE \times SEQP] = 0$ tCO2e

For residues from mills:

$[PGE \times SEQP] = 0$ tCO2e

In total:

$[665{,}280 \times 0] = 0$ tCO2e

**Step 3: Carbon emissions/sequestration at the feedstock collection site (SITE_TNC)**

In Step 3 we calculate the annualized difference in the stock of land-based carbon (above- and below-ground), other than feedstock growth, which results from implementation of biogenic feedstock production. This value may be zero, or it may be positive (indicating that additional emissions from land take place as a result of biogenic feedstock production) or negative (indicating that additional sequestration on land takes place as a result of biogenic feedstock production). As in Step 1, this term is then adjusted to account for carbon in feedstock that is ultimately removed from the accounting framework in products that leave the facility.

For forestry case studies, since several products are removed from the same piece of land, specific sequestration effects of feedstock removal and land-use change need to be distributed among various feedstock uses. All of the effects cannot be assigned to just the bioenergy feedstock. For example, if 100 acres are harvested for roundwood and residues, and only the residues go to bioenergy with the roundwood going to saw mills, it would not be appropriate to have all of the emissions from land-use change attributed to the residues only. Some emissions need to be attributed to this harvested roundwood even if it is used for non-energy purposes. In this scenario, if SITE_TNC were to have a non-zero value, a proportion should be assigned to the pulp and paper mill.

However, SITE_TNC for this case study is zero since it is assumed that the harvest does not lead to changes in carbon stocks of non-feedstock carbon pools (like dead biomass).. This implies the annualized carbon stock of site sequestration is the same and site sequestration loss (or gain) is zero.

**Step 4: Leakage (LEAK)**

In Step 4 of the NBE formula, we incorporate the effects of leakage or indirect land-use change. LEAK is the leakage of biogenic carbon emissions generated outside the supply chain induced by market reactions to biogenic feedstock use for bioenergy (i.e., replacement of diverted crop, livestock or forest products due to a change in land use from conventional products to biomass feedstocks). The term is expressed as net emissions of tCO2e that occur when producing the feedstock volume needed for stationary combustion. This value will only be calculated if a commercial market exists either for the feedstock being used or for the previous land use. LEAK may be estimated from previous published work, or it may be an assumed value, or it may come from another analysis.

In the current case study, all biomass purchases are for the production of pulp and paper, and the energy production therefore involves no effects on the biomass markets that could potentially lead to leakage. In other words, because no feedstock (roundwood or residues) was harvested solely for energy (it was harvested for paper or other forest products), the consumption of biomass for energy does not impact the market; essentially in a paper mill, all of the wood burned for energy is residual wood (or black liquor, also a byproduct). Hence, there is no demand for more roundwood or residues to be produced elsewhere and no market effect from this feedstock consumption, so thereis no leakage.

LEAK = 0

**Step 5: Net Biogenic Emissions (NBE)**

Once all the various parts of the NBE equation are calculated in Steps 1 through 4, they are combined together to estimate the Net Biogenic Emissions (NBE). In this case study, the Net Biogenic Emissions associated with the conversion of wood to electricity at this facility are found by first calculating the potential emissions from the feedstock itself, adjusted for any feedstock material that is lost between the point of harvest and the point of combustion. This value is then adjusted to account for growth in the feedstock itself or avoided emissions from residue decomposition, and is further adjusted to account for the carbon embodied in Sequestered Fraction (SEQP) (e.g., ash) and Carbon in Products (PRODC) (e.g., paper). Finally, terms that account for sequestration at the point of feedstock production and leakage are added.

$$
\begin{aligned}
NBE = & [PGE \times (1 + L) \times (1 - LAR) \times (1 - PRODC)] \\
& - [PGE \times SEQP] \\
& + [SITE\_TNC \times (1 - PRODC)] \\
& + [LEAK \times (1 - PRODC)]
\end{aligned}
$$

$$
\begin{aligned}
NBE = & [665{,}280 \times (1 + 0.007576) \times (1 - 1) \times (1 - 0.3937)] \\
& - [665{,}280 \times 0] \\
& + [0 \times (1 - 0.3937)] \\
& + [0 \times (1 - 0.3937)]\ tCO_2e
\end{aligned}
$$

$$NBE = 0\ tCO_2e$$

**Step 6: Biogenic Accounting Factor (BAF)**

The last step in applying the accounting framework for this case study is to calculate the Biogenic Accounting Factor (BAF). This number is the value that would be used by a facility to determine “net biogenic $CO_2$ emissions” from the source, given a particular feedstock and gross emissions value. It is typically between 0 and 1, though values >1 or <0 are possible in certain cases. The Biogenic Accounting Factor is calculated using the equation below (see Section 4):

$$BAF = NBE / PGE$$

$$BAF = 0\ tCO2e / 665{,}280\ tCO2e = 0$$

The results for this case study are summarized in Table 1 below.

Table 6: Numeric results of the Net Biogenic Emissions equation variables

| Variable | Value | | | Units |
|---|---|---|---|---|
| | Wood from Forests | Residues from Saw Mills | Combined | |
| Net Biological Emissions (NBE) | 0 | 0 | 0 | $tCO_2e$ |
| Potential Gross Emissions (PGE) | 498,960 | 166,320 | 665,280 | $tCO_2e$ |
| Level of Atmospheric Reduction (LAR) | | | 1 | Proportion (no units) |
| Carbon in Products (PRODC) | | | 0.3937 | Proportion (no units) |
| Sequestered Fraction (SEQP) | | | 0 | Proportion (no units) |
| Net emissions gain on site (SITE_TNC) | | | 0 | $tCO_2e$ |
| Leakage (LEAK) | | | 0 | $tCO_2e$ |
| Proportion of Feedstock Lost (L) | | | 0.007576 | Proportion (no units) |
| Biogenic Accounting Factor (BAF) | | | 0 | Proportion (no units) |
| Total Feedstock Produced (tons) | 303,030 | 100,000 | 403,030 | Dry tons per year |
| Land needed (ACRES) | N/A | N/A | N/A | Acres |

**Summary**

This case study portrays a situation in which biomass energy production is not the primary function of the plant. Pulp mills purchase wood to produce pulp which is used, in turn, to make paper. The process of pulp and paper production requires the removal of a significant fraction of the incoming wood in order to obtain fibers suitable for paper making, resulting in the production of a number of different manufacturing residuals. Pulp and paper mills are often able to produce substantial quantities of heat and electric power through burning of these manufacturing residuals, generally using this energy in the internal functions of the mills. In such cases, biomass purchases are not for energy production, and would have occurred anyway (i.e. they are "anyway emissions" and can be treated as avoided emissions in the calculations). At kraft pulp mills, much of the residual organic matter removed from wood in order to make pulp is contained in black liquor solids, which are burned to recover pulping chemicals and to generate steam. The use of black liquor solids in the kraft recovery system has been shown to have substantial life cycle greenhouse gas and energy benefits (although these types of life cycle benefits are not the focus of the calculation framework discussed in this report). Because the biomass used by most pulp and paper mills is not purchased primarily for energy production, the leakage and emissions from indirect land-use change are not applicable. Mills, such as the one in this case, will often have relatively high proportions of PRODC. The NBE will depend largely on whether any of the material purchased by the mill has been purchased for purposes other than production of pulp and paper. Where all of the material purchased is for of pulp and paper (or wood product) production, the NBE and BAF are likely to be zero.

**Additional Information**

Additional information about this case-study scenario is provided below. Table 7 contains information about the biogenic emission system and Table 8 contains key data inputs and assumptions.

**Table 7: Information about the case study parameters**

| | |
|---|---|
| Feedstock type | • Purchased roundwood and chips: 300,000 dry tons/year<br>• Wood residues from other wood processing facilities: 100,000 dry tons/year |
| Feedstock source | • Region: State and private forests in western Washington state and residues from nearby sawmills. |
| Facility description | • Energy fate: heat and electricity co-generation<br>• Example Facility size: 35 MW electricity generation<br>• Example Facility location: Puget Sound region, Washington |
| Land-use change | • Prior and current land use: no land-use change; all biomass procurement operations are justified for manufacture of paper, not for energy production. |
| Feedstock loss | • Conveyance/Haulage upstream of where PGE is determined: 1% of feedstock produced at production site<br>• Storage losses: upstream of where PGE is determined of feedstock produced: 0% of feedstock produced<br>• Mill losses associated with making pulp and paper, occurring downstream of the point where PGE is determined: Variable depending on the source and type (See Table 4.) |
| Sequestered Fraction /Carbon in Products | • Products and by-products: 230,658 $tCO_2e$ in paper product and 31,231 $tCO_2e$ in turpentine and soap by-products |
| Feedstock Characteristics | • Carbon content of feedstock entering mill: 200,000 short tons per year<br>• Weight of feedstock entering mill annually: 400,000short tons |
| Baseline | • Mill's manufacturing residuals would have decayed or been burned anyway.<br>• Because all of the feedstock is brought into the mill to produce pulp and paper, the emissions associated with the combustion of black liquor solids, bark/wood materials and other manufacturing residuals are "anyway emissions" |
| Years for annualizing growth and sequestration changes | • Not Applicable because all emissions as associated with Avoided Emissions (or "anyway emissions") |
| Leakage | • Market not affected/leakage not applicable |

**Table 8: Key inputs and relevant assumptions for case study analysis**

| Key Inputs | Values | | | Units | Notes |
|---|---|---|---|---|---|
| | **Round-wood** | **Sawmill Residuals** | **Combined Feedstock into Mill** | | |
| Feedstock needed | 300,000 | 100,000 | 400,000 | Bone dry short tons | |
| Carbon content of feedstock | 0.5 | 0.5 | 0.5 | Carbon content/dry content | |
| Transport and handling losses | 5,040 | 0 | 5,040 | Metric Tons $CO_2e$ annually | Includes only losses upstream of where PGE is determined (at entrance to mill) |
| Process losses | 41,412 | 7,266 | 48,678 | Metric Tons $CO_2e$ annually | In the mill, after the point where PGE is determined. Consists of various losses sent to waste managment |
| Carbon in Product and By-Products (i.e. paper, turpentine and soap) | 188,997 | 72,892 | 261,889 | Metric Tons $CO_2e$ annually | |
| **Key Inputs** | **Notes** | | | | |
| Calculating PGE | Standard calculation where carbon is 50% of a dry ton of woody material | | | | |
| Calculating SEQP | Assumes complete combustion of biomass that is burned | | | | |
| Calculating SITE_TNC | No land-use change; set to zero | | | | |
| Calculating LEAK | No market effects from energy production; set to zero | | | | |

**References**

The data used in this case study are based on the carbon balance illustrated in Côté et al. (2002), which is for a Kraft mill in Texas, scaled to reflect average mill conditions reported for the state of Washington in Smith and Hiserote (2010). Sources include:

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