Graphical Illustration of the Terms Used in the New NBE Formulation

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The following figures graphically illustrate the terms used in the new NBE formulation that is based on the difference in carbon stores between two scenarios (the reference and the policy). This particular analysis is at the landscape level. In Figure 1, the theoretical time trace for the two scenarios is illustrated for the case in which the policy scenario involves a 20% increase in forest harvest intensity at the landscape level to meet a biogenic carbon need. Once the policy is implemented the store of carbon decreases in the policy scenario and the difference with the reference scenario grows until about 75 years. This cumulative difference, sometimes referred to as the "wedge" represents the NBE_T term.

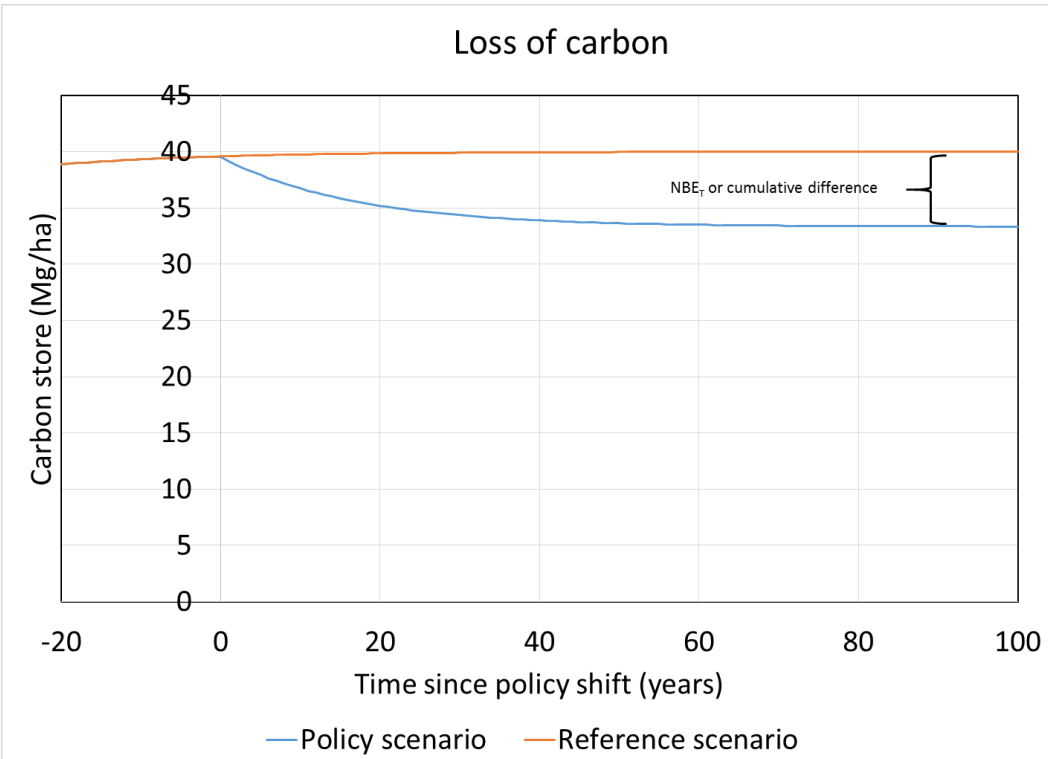

Figure 1. Hypothetical example of how a policy and reference scenario can diverge at the landscape level and how that relates to NBE_T.

One can also plot how the difference in the two scenarios (i.e., the wedge) grows as illustrated in Figure 2. There are two ways this could be portrayed: as the sum of the annual changes in the differences or as a straight line function based on the average difference over the time period T. The average is easier to conceptualize and compute, however, the growth of the difference in scenarios tends to be curvilinear and not particularly well represented by a constant. To represent these changes in the rate that the difference grows one can determine the annual increase in the difference as represented by NBE_t where t is a given year as opposed to a period as represented by T. NBE_t can also be referred to as the marginal growth rate in NBE.

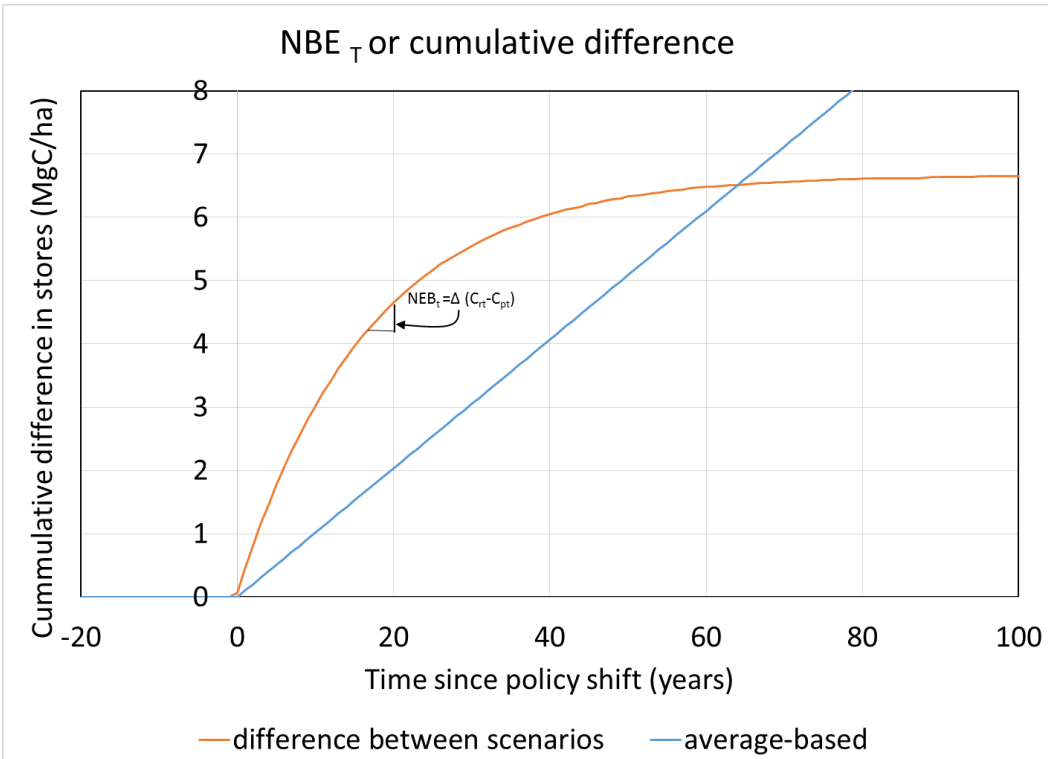

Figure 2. The difference in two scenarios over time at the landscape level and how that relates to the annual change in the difference (NBE_t) or the so-called marginal change.

The rate at which the annual change in the differences between the scenarios can be represented by an average or as a marginal change or essentially "instantaneous" rate of change as illustrated in Figure 3. The average is simpler to apply, however, it does not represent the timing of the emissions to the atmosphere and that given enough time the difference between the two scenarios does not grow. In contrast, NBE_t indicates whether there is a pulse of emissions (or in other cases uptake) and when the marginal increase in NBE_T approaches zero at the landscape level. One possible way to define T is when NBE_t averages zero.

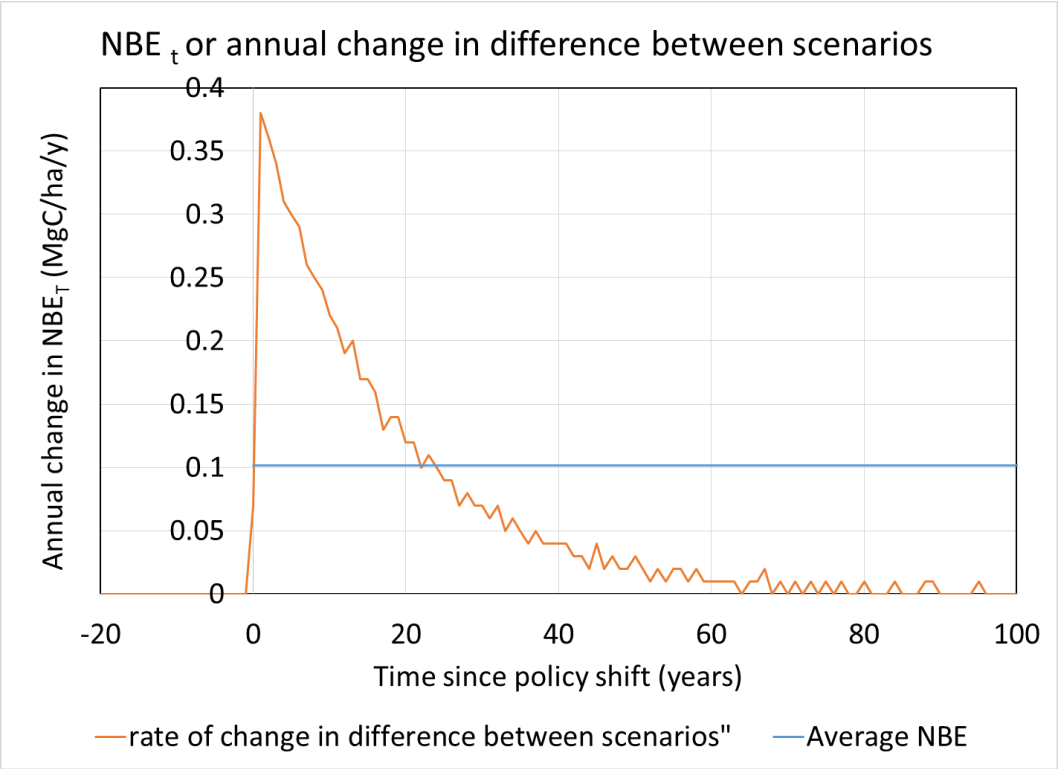

Figure 3. The rate at which the difference in scenarios grows over time at the landscape level as represented by the "instantaneous" or marginal rate versus the average difference.

Using the example case in which biogenic fuel harvest causes a 20% increase in the proportion removed from a forest we can see how the various NBE terms can be used to derive the BAF.

In Figure 4 the cumulative difference between the reference and the policy cases (NBE_T) as well as the cumulative potential emissions (PGE_T) is shown. Because the difference between the two cases does not expand forever (i.e., it ceases to expand much after 75 years), the NBE_T term asymptotes. In contrast, emissions occur each year and hence PGE_T increases in largely a straight line fashion and it continues to increase after NBE_T asymptotes.

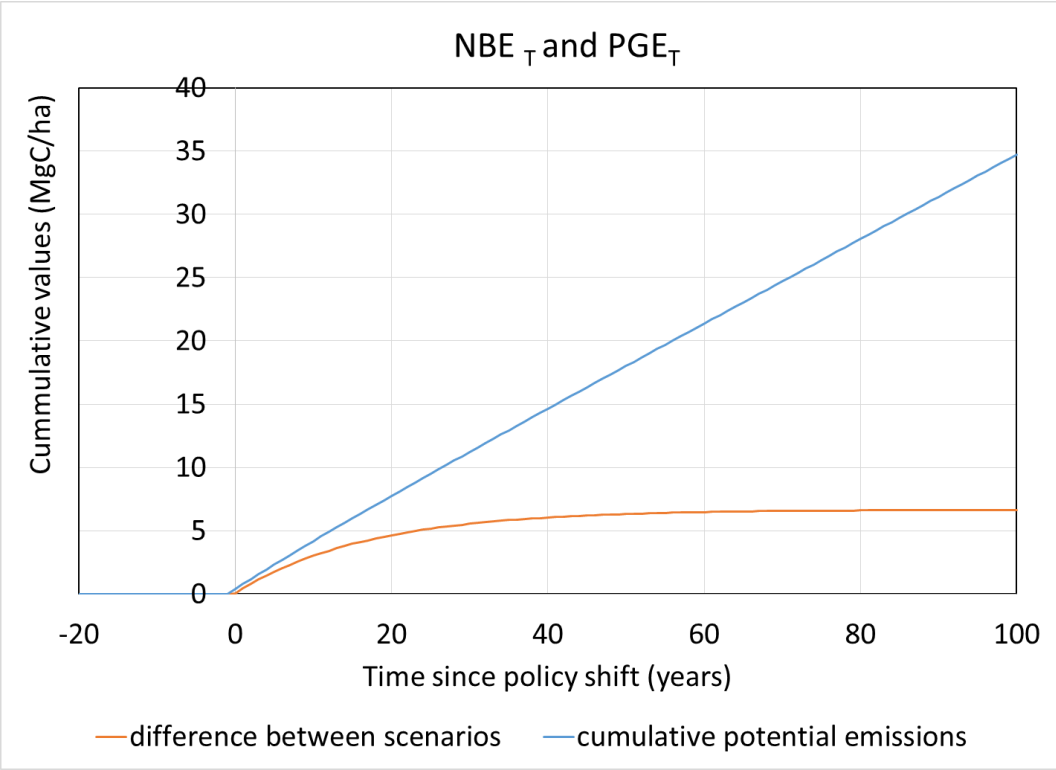

Figure 4. The cumulative difference between scenarios (NBE_T) and the cumulative gross potential emissions (PGE_T) caused by the policy scenario.

In Figure 5 the annualized versions of these variables is shown. For NBE this represents the annual change in the difference between the two scenarios and indicated by the subscript t. When the difference between the two cases ceases to increase, then NBE_t is equal to zero. The annual potential emission from the biogenic energy plant is PGE_t and it declines slightly to an asymptote because the removal of biogenic fuel stock decreases the stores in the policy case and since the proportion being removed stays constant, the absolute amount declines.

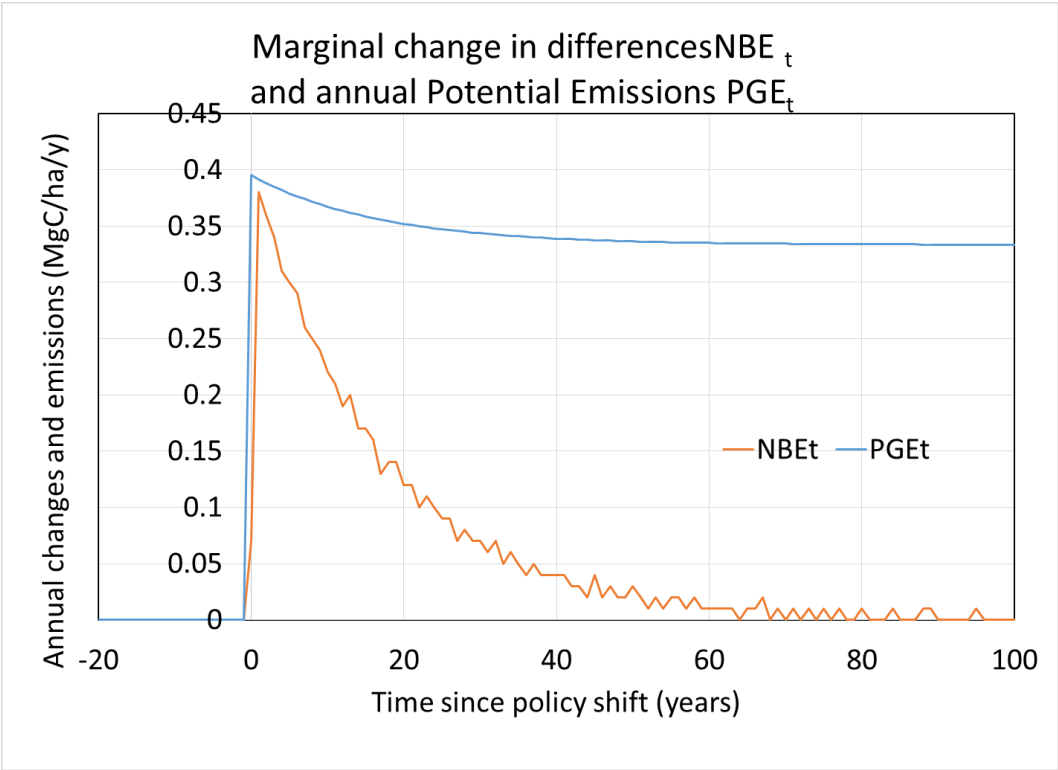

Figure 5. Annualized changes in the difference in stores between the two scenarios (NBE_t) and the annual gross emission (PE_t) caused the burning of harvested biogenic carbon in the policy scenario.

If the cumulative versions are used to calculate a cumulative BAF, that is PGE_T and NBE_T, then this variable changes over time as shown in Figure 6 as the BAF_T term. It rises and then declines and if T is large enough it approaches zero. Alternatively one can sum all the differences in stores until time T and divide that by the sum of PGEt to determine BAF2 (described in Appendix X). This results in BAF values that higher than BAF_T after 7 years.

If the annualized version of NBE and PE, that is PGE_t and NBE_t are used, then one is computing the BAF for a given year t (BAF_t). While this indicates the amount of carbon emitted by biogenic energy generation that is recaptured by the forest each year, the more policy relevant term would involve averaging these values. This is shown as the BAF running average (which is average of BAF_t from year 0 to T). This averaging provides a number slightly lower to that using the cumulative approach.

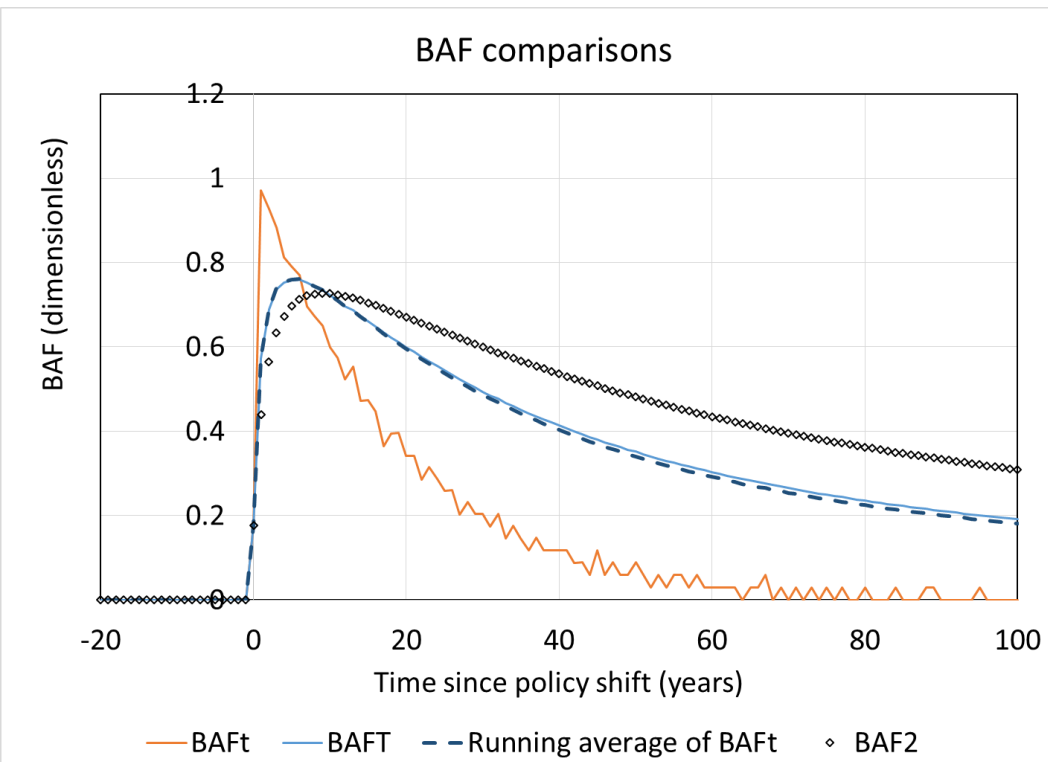

Figure 6. Comparison of the annualized-based BAF (BAF_t), the cumulative-based BAF (BAF_T), sum of store differences/ sum of potential emissions ratio (BAF2), and the running average of the annualized-based BAF.