Framework for Assessing Biogenic CO_2 Emissions from Stationary Sources

Presentation to EPA Science Advisory Board
Biogenic Carbon Emissions Panel

March 25, 2015

Overview

- Welcome
- Overview of the Framework Process
  - Purpose
  - 2011 draft Framework and 2012 SAB recommendations
- Revised Framework components
- SAB Panel peer review focus
- Questions and clarifications

What is the original purpose of this study?

- To conduct a "*detailed examination of the science associated with biogenic CO_2 emissions and to consider the technical issues that the Agency must resolve in order to account for biogenic CO_2 emissions in ways that are scientifically sound and also manageable in practice.*" (Letter from EPA Administrator to Members of Congress, January 12, 2011)
- To answer the question:
  - How to account for stationary source onsite biogenic CO_2 emissions, taking the biological cycling of carbon into consideration?
- Biogenic CO_2 emissions are defined as CO_2 emissions related to the natural carbon cycle, as well as those from the production, harvest, combustion, digestion, fermentation, decomposition, and processing of biologically-based materials.

2011 Draft Framework and 2012 Peer Review

- Technical report on considerations for accounting net biogenic CO_2 associated with stationary sources; flexible to be adapted for different applications.
- Described an accounting methodology on the basis of the carbon cycle (including biogenic feedstock growth and/or emissions avoidance).
- SAB peer review: 18 expert panelists; 1 year review with public meetings; 17 member consensus, 1 separate opinion
  - *A priori* "carbon neutrality" is not supported by the science.
  - 17 found IPCC inventory approach not adequate for less than all sector coverage.
  - Preferred a specific policy application to evaluate or a larger scope of analysis.
  - Captured main factors to assess offsite carbon cycle dynamics associated biogenic feedstock use; especially for certain feedstocks (i.e. waste and short-rotation agricultural feedstocks; Reference point baseline approach is not adequate (additionality is important).
- Recommendations
  - Future anticipated baseline approach
  - Alternative fate approach (waste-derived feedstocks, decay rates for forestry/ag residues)
  - Consideration of tradeoffs between different temporal scales
  - Default factors by feedstock and region

Incorporating SAB Feedback into Revised Framework

- Improved framework equation representation
  - Removed aggregate term “LAR”, repeating terms (like “1-PRODC”)
- Added future anticipated baseline approach analysis
- Evaluated implications of different temporal scales
- Added alternative fate approach for waste-derived feedstocks and industrial byproducts with no current alternative markets
- Added illustrative case studies and regional biogenic assessment factors using different baseline approaches and temporal scales to demonstrate the functionality of the framework equation

Not able to address all recommendations

- Flexible to be adapted within various types of programs and stationary sources
- Not specific to any policy or program
- No final BAFs

Revised Framework Overview

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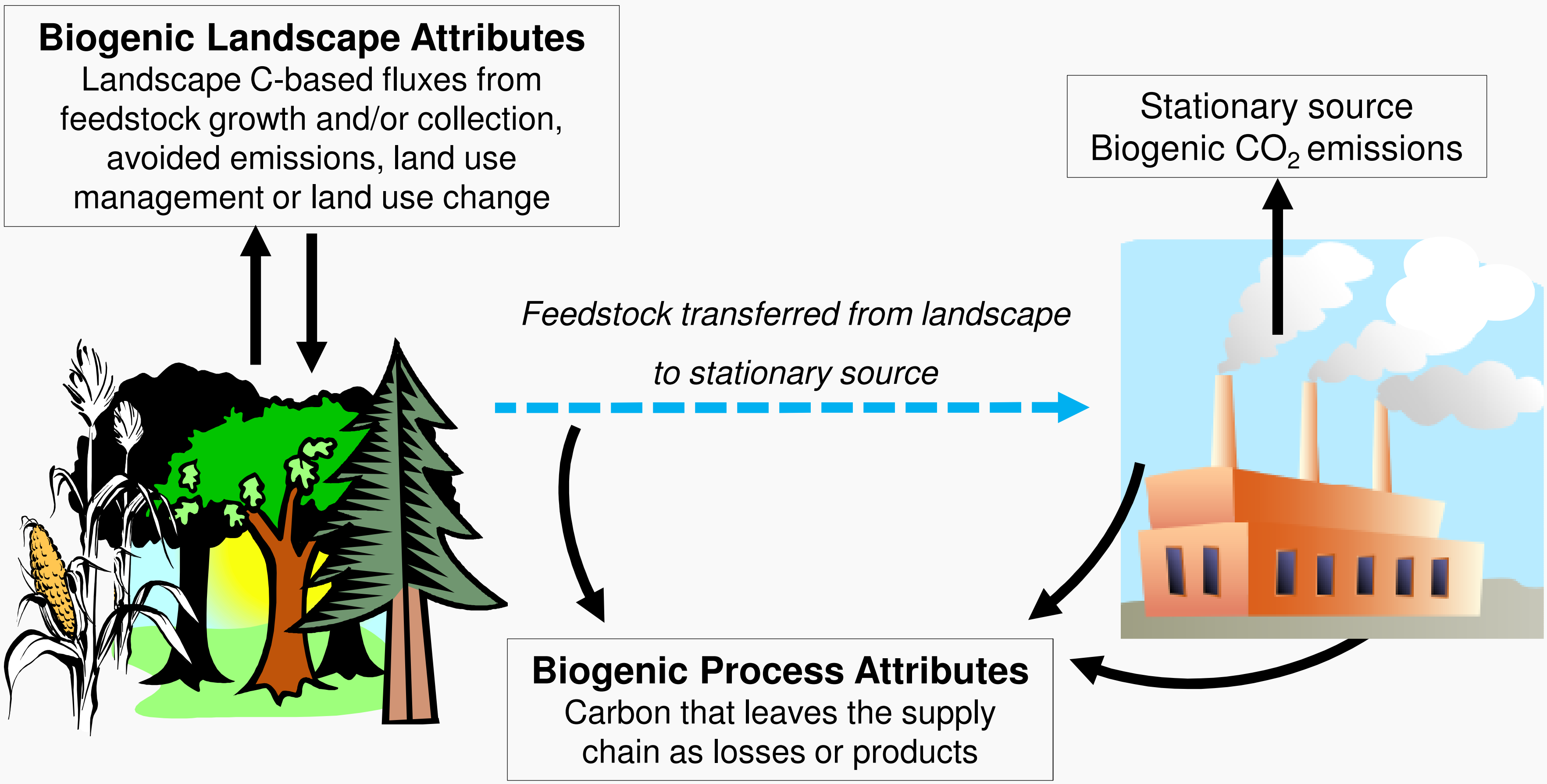
Technical Appendices to this Report

Framework Scope



Technical Considerations

As discussed in the Framework, there are a variety of technical elements that should be considered when assessing biogenic carbon-based emissions from stationary sources using biogenic feedstocks:

- Baseline
- Temporal Scale
- Spatial Scale
- Leakage
- Feedstock(s) Used

Equation Terms

- Biogenic Landscape Attributes
  - Net growth **(GROW)**: net biogenic carbon sequestered or emitted through feedstock growth and removals on the feedstock production landscape
  - Avoided emissions **(AVOIDEMIT)**: avoided landscape emissions associated with feedstocks that would have eventually decomposed or been burned on the production site if not removed
  - Total net change at production site **(SITETNC)**: net biogenic carbon emissions or sequestration from non-feedstock biogenic carbon pools on the production landscape associated with land management or land use or land management change
  - Leakage **(LEAK)**: emissions associated with leakage, such as indirect land use change from displaced feedstock or feedstock substitute production
- Biogenic Process Attributes
  - Losses **(L)**: represents losses of biogenic feedstock carbon during transportation, storage, and processing (e.g., via decomposition)
  - Products **(P)**: represents carbon embodied in process products (e.g., lumber, ethanol, biochar, ash) that pass out of the supply chain prior to or exit the stationary source through forms other than as stack emissions

New Equations

$$BAF = \frac{NBE}{PGE}$$

$$NBE = (PGE)(GROW + AVOIDEMIT + SITETNC + LEAK)(L)(P)$$

Therefore:

$$BAF = (GROW + AVOIDEMIT + SITETNC + LEAK)(L)(P)$$

- The equations above are designed to transform a measurable or estimated quantity (carbon content of biogenic feedstock used at the point of assessment) into a quantity that cannot be directly measured (the net atmospheric biogenic CO_2 contributions associated with different stages of biogenic feedstock production, processing, and use at a stationary source).
- The Biogenic Assessment Factor (**BAF**) is a unitless factor that represents the net atmospheric biogenic CO_2 contribution associated with using a biogenic feedstock at a stationary source, taking into consideration biogenic landscape and process attributes associated with feedstock production, processing, and use at a stationary source, relative to the amount of biogenic feedstock consumed.

$$\mathbf{NBE} = (\mathbf{PGE})(\mathbf{GROW} + \mathbf{AVOIDEMIT} + \mathbf{SITETNC} + \mathbf{LEAK})(\mathbf{L})(\mathbf{P})$$

Net Biogenic Emissions (**NBE**):

- The net atmospheric biogenic CO_2 contributions associated with different stages of biogenic feedstock production, processing, and use at a stationary source.
- The terms in the *NBE* equation each play a specific role in this transformation.

$$\boldsymbol{NBE} = (\boldsymbol{PGE})(\boldsymbol{GROW} + \boldsymbol{AVOIDEMIT} + \boldsymbol{SITETNC} + \boldsymbol{LEAK})(\boldsymbol{L})(\boldsymbol{P})$$

Potential Gross Emissions (**PGE**):

- The carbon content of the biogenic feedstock used by a specific entity or generally consumed.
- This is a quantity that could be measured or estimated at different points of assessment (e.g., at the boiler mouth, stationary source gate, feedstock production site, or at the stack: wherever the point of assessment needs to be).
- Thus, this term can have different values indicated by subscripts, representing different points along the supply chain.
  - For example: PGE_0 could be the feedstock source (farm/forest), PGE_1 the boiler/fermenter mouth, PGE_2 the stack emissions.

$$NBE = (PGE)(GROW + AVOIDEMIT + SITETNC + LEAK)(L)(P)$$

L

- A unitless adjustment factor greater than or equal to 1 that represents biogenic feedstock carbon leaving the supply chain between the feedstock production site and input into the stationary source conversion process (e.g., via transit, decomposition, deviated for use as a product).
- *L* scales *PGE*, as measured at the point of assessment, up to account for any feedstock carbon deviated from the supply chain.
- *PGE* times *L* is the carbon content of the biomass grown/harvested to achieve the delivered quantity of feedstock measured at the point of assessment.

P

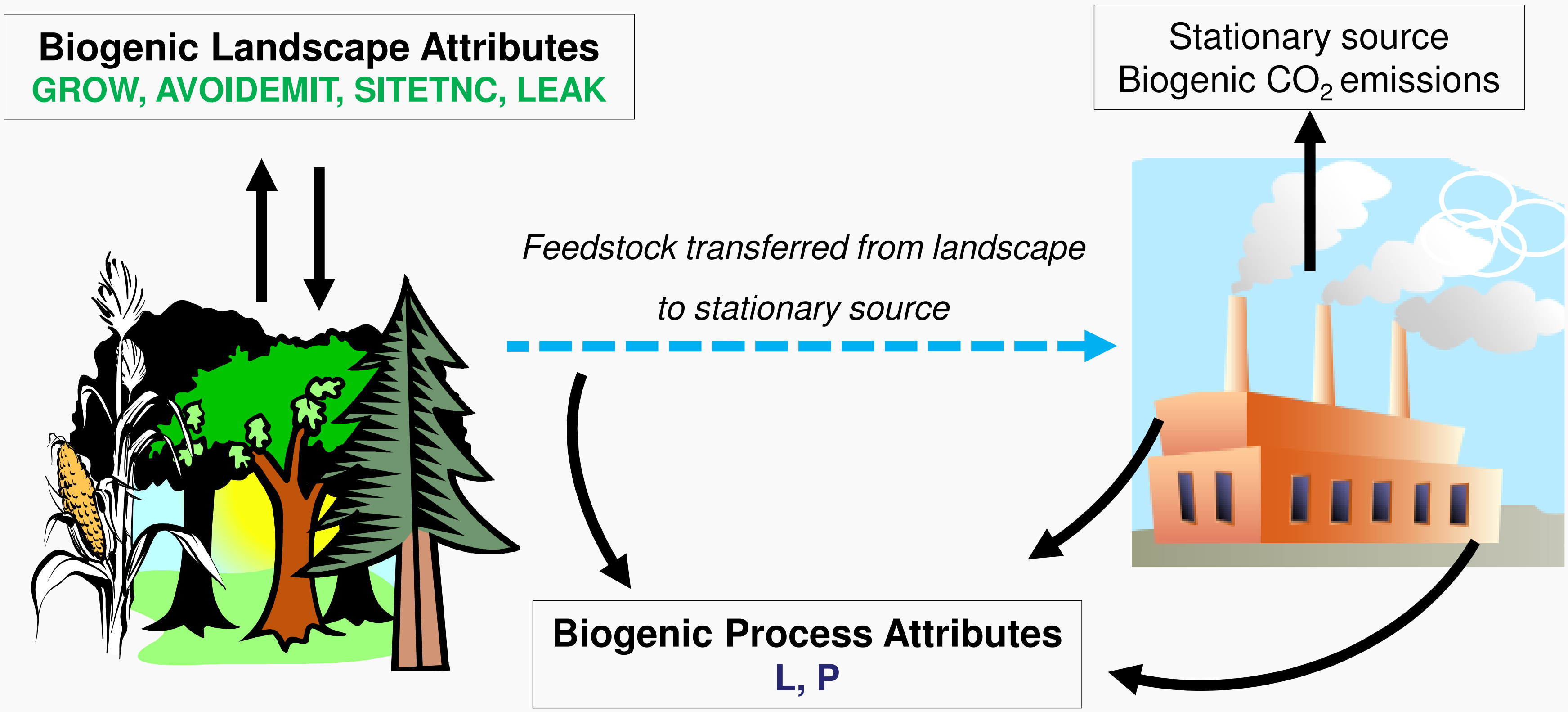
- A unitless adjustment factor between 0 and 1, equal to the share of feedstock carbon content at the point of assessment that is emitted to the atmosphere by a stationary source.
- In effect, this term also reflects the share of carbon that remains in products, that is either not emitted to the atmosphere or is sold and eventually emitted to the atmosphere by a downstream user.

$$NBE = (PGE)(GROW + AVOIDEMIT + SITETNC + LEAK)(L)(P)$$

- The landscape emissions effect: the sum of four unitless factors that relate the total biogenic carbon content of the feedstock grown at the feedstock production site, i.e. *(PGE)*(L)*, to related landscape biogenic carbon pools.
- *(GROW + AVOIDEMIT + SITETNC + LEAK)*(PGE)*(L):* the estimated net biogenic carbon atmospheric contribution from growing, harvesting, processing, and using the feedstock as measured at the point of assessment (multiplied by *P* to determine share that is actually emitted by specific entity).

Term	Reflects	Definition
GROW	Feedstock growth	Net feedstock growth (or removals) on the production landscape.
AVOIDEMIT	Avoided emissions	Avoidance of estimated biogenic emissions that could have occurred on the feedstock landscape without feedstock removal (e.g., avoided decomposition or burning) or per an alternative management strategy.
SITETNC	Production site total net change	Estimated total net change in feedstock production site non-feedstock carbon pools due to land use management and/or change associated with feedstock production.
LEAK	Leakage	Biogenic emissions associated with leakage, such as indirect land use change from displaced feedstock or feedstock substitute production.

Framework Scope with Equation Terms



Technical Appendices

- Appendices provide detailed discussion of technical considerations (e.g., temporal scale in App. B, anticipated baselines in App. J) and illustrative calculations showing how the framework equation and its terms could be applied using future anticipated baselines (Apps. K-L).
- SAB mentioned a few potential models that could be used
  - "to capture both the market, landscape and biological responses to increased biomass demand, a bioeconomic modeling approach is needed with sufficient biological detail to capture inventory dynamics of regional species and management differences as well as market resolution that captures economic response at both the intensive…and extensive margins…"
- Used one of these models, FASOM-GHG, with current feedstock consumption estimates and regional energy market projections, to generate:
  - Six alternative future anticipated baseline scenarios with different demand trajectories, and related cumulative landscape emissions associated with each baseline's biogenic feedstock consumption (Appendix K)
  - Illustrative factors per alternative biogenic feedstock production scenarios per specific feedstocks and specific regions, and to the individual case study parameters and assumptions (Appendix L)
  - No final values: illustrative results per case study parameters and assumptions

SAB Panel Charge

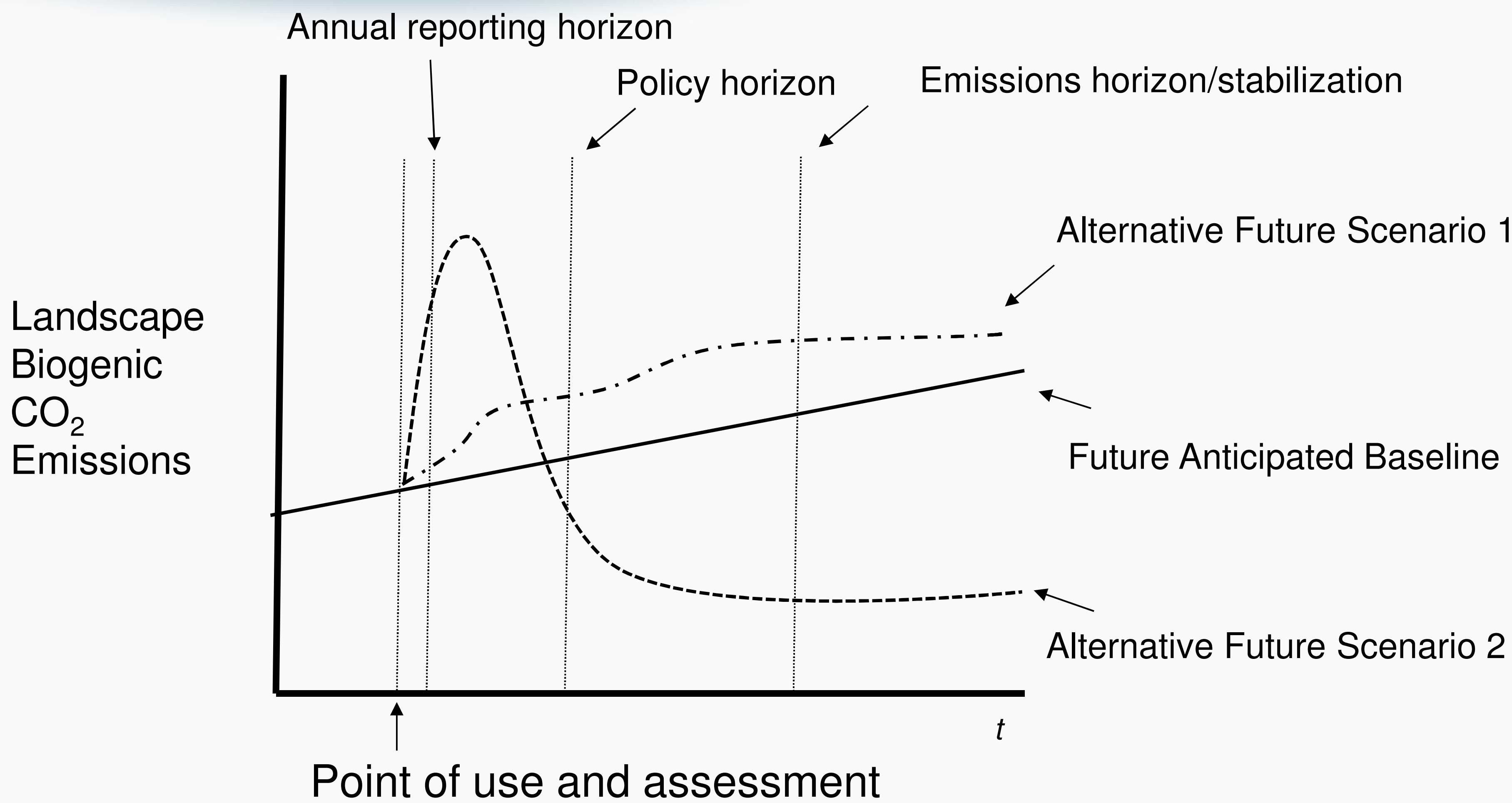
Targeted Technical Focus

- During the 2011-12 peer review, the Panel thoroughly reviewed key elements of the draft Framework and was definitive in many of its findings and recommendations. EPA incorporated many of these elements into the revised report.
- The charge questions therefore focus on specific areas of the framework that were not addressed and where EPA would like further guidance (versus a review of the Framework in its entirety).
- EPA requests that the Panel examine and offer recommendations *on future anticipated baseline specification issues* in the context of assessing the extent to which the production, processing, and use of *forest- and agriculture-derived biogenic material* at stationary sources for energy production results in a net atmospheric contribution of biogenic CO_2 emissions.
  - *Considerations for choosing appropriate temporal scales*
  - *Considerations for choosing appropriate scales of biogenic feedstock usage (model perturbations or 'shocks') for analyzing future potential bioenergy production changes.*

Part 1: Future anticipated baseline approach and temporal scale

- Different possible treatments of time: different choices have different implications and impacts on results when applying an assessment framework to long-term and short-term emissions assessments.
- There are different elements of time to consider when using a future anticipated baseline approach, including:
  - Emissions horizons vs. assessment, policy or reporting horizons: fluxes related to feedstock production may occur over many years to decades, whereas policies may cover only a few years or decades or reporting may be the current year.
  - Differences in temporal characteristics of different feedstocks (i.e., annual crops, short rotation energy crops, and longer rotation forestry systems).
  - Changes in biophysical and economic conditions over time may affect or differ from those in future anticipated baseline and scenario estimates.

Example Landscape Emissions Projections



Part 1: Future anticipated baseline approach and temporal scale (2)

- Per SAB recommendation, the revised Framework identifies various temporal scales and considers tradeoffs in choosing between them (as seen in Section 4 of the main report, Appendix B on temporal scale and subsections in other Appendices).

- Though there may not be a single scientifically correct answer when choosing a time horizon (Advisory, page 16), for Part 1 EPA seeks guidance on

  What criteria or tools could be used when considering different temporal scales and the tradeoffs in choosing between them in the context of assessing the net atmospheric contribution of biogenic CO_2 emissions from the production, processing, and use of biogenic material at stationary sources using a future anticipated baseline.

Summary: Key points of Part 1 charge questions

a. Should the temporal scale for computing biogenic assessment factors vary by policy, feedstocks, and/or other metrics?
   - If yes to any of the above, what goals/criteria might support choices between shorter and longer temporal scales?
   - Would the criteria differ when generating default biogenic assessment factors versus crafting policy specific ones?

b. Consider emissions within the policy horizon or emissions horizon?

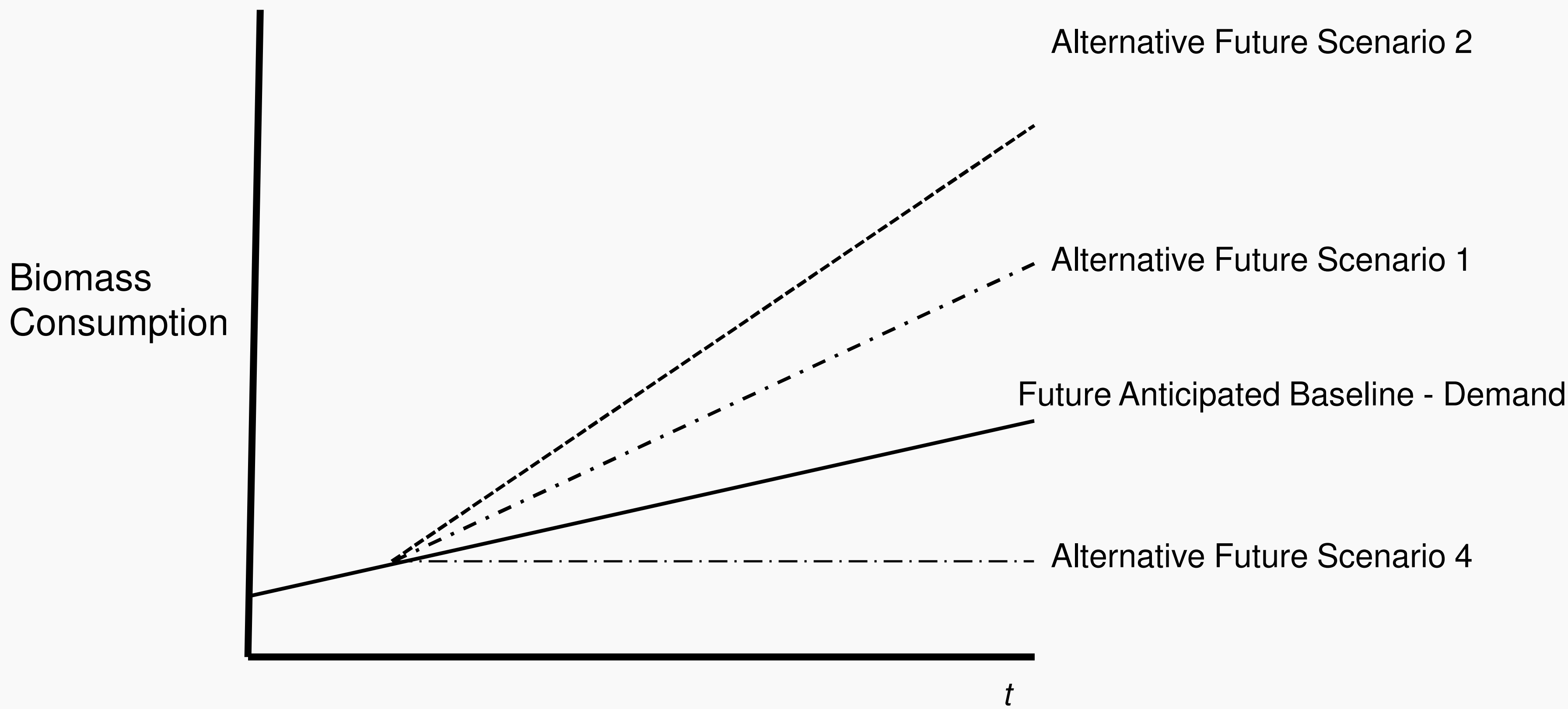
c. Include all future fluxes into one number applied at time of combustion (cumulative, as in one time application of factor) or a default biogenic assessment schedule of emissions to be accounted for in the period in which they occur (marginal, as in apply emission factor each year reflecting current and past biomass usage)?

d. Considerations when looking at the performance of a future anticipated baseline application versus observed data ex post?

Part 2: Scales of biomass use with future anticipated baseline approach

- Future anticipated baseline approach modeling typically starts with an identified initial equilibrium baseline condition.
- After establishing the baseline, analysts employ different ‘shocks’ or changes to one or more coefficients or variables within the model to simulate different market, policy or biophysical conditions, and a new equilibrium is reached.
- This technique is used often to test sensitivity of the results to specific variables and different expectations of future market or other conditions.
- In the context of this charge, the shock refers to changing the scale of biomass demand or usage to simulate related biogenic feedstock production market and land use effects, including the biogenic carbon-based emissions profile.

Example Biomass Demand Scenarios



Biomass scenarios can vary in the quantity of future feedstock demand, the portfolio of feedstocks consumed or changes to other variables.

Part 2: Scales of biomass use with future anticipated baseline (2)

- Per SAB recommendation, the revised Framework includes detailed discussion of and illustrative case studies using anticipated baselines (as seen in Section 4 of the main report and Appendices J-N).
- In the context of modeling future anticipated baselines for forest- and agriculture-derived feedstocks, EPA seeks guidance on technical considerations concerning how to select model perturbations ('shocks') for future anticipated baseline simulations estimating the net atmospheric contribution of biogenic CO_2 emissions from the production, processing, and use of biogenic material at stationary sources.
  - As the SAB Panel recommended developing default assessment factors by feedstock category and region that may need to be developed outside of a specific policy context, and as the framework could be also be used in specific policy contexts, the questions below relate to the choice of model shocks both within and outside of a specific policy context.

Summary: Key points of Part 2 charge questions

a. Reflect small incremental increases in feedstock use (marginal impact) or large increases to reflect all users (average impact)?
b. General increment of the shock: tons, as percentage, other?
c. From business as usual baseline, or from a baseline that includes increased usage of the feedstock?
d. Should shocks for different feedstocks be implemented in isolation, in aggregate, or something in between?
e. For feedstocks produced as part of a joint production function, how should the shocks be implemented?
f. How should scale of the policy be considered, particularly for default factors?
g. Would the answers to any of the above questions differ when generating policy neutral default factors, versus generating factors directly tied to a specific policy?
h. Considerations when looking at the performance of a future anticipated baseline application versus observed data ex post?

Thank you!

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