

Methodology to Integrate Algae Wastewater Treatment Technologies to Avoid Emissions from Grey Infrastructure Wastewater Management Systems v1

External R1 Review Round

Reviewer #2

Date: April 6, 2025

CONTENT referenced by reviewer's comment <i>e.g. Section number + paste exact text</i>	REVIEWER'S COMMENT <i>Please paste the comment from the reviewer</i>	AUTHOR'S RESPONSE <i>Please describe how the comment was addressed and include new content in quotations</i>	Reviewer's Conclusion [PASSED/ REJECTED WITH COMMENTS]
<i>e.g. 2.1 - "approximately 25%</i>	e.g. Replace with "adequate"	<i>e.g. This was changed to "The majority of the material must have a moisture content of 25% or less, as measured in the field."</i>	PASSED
Section 6.1, 3: Electricity Use Monitoring	Consider adding guidance that requires emissions associated with electricity use be calculated wherever possible with utility-specific emission factors, which are readily	Thank you for this valuable comment. We agree that the use of utility-specific emission factors, where available, can significantly improve the accuracy of electricity-related	Passed

	<p>available in some geographies and are becoming more widely so. This will avoid over- or under-estimation of avoided emissions by using grid averages, which can vary significantly from the electricity being delivered.</p> <p>During the baseline study, if the data is available, including a comparison of utility-specific emission factors for the facility to the grid emission factors in the LCA could be valuable as part of the uncertainty analysis, recognizing these are subject to change and the NREL Cambium resource is acceptable for future-looking analysis.</p>	<p>GHG estimates especially in regions where the grid mix differs substantially from national or regional averages. To reflect this, the methodology has been updated to recommend the use of utility-specific emission factors when they are publicly available and verifiable. This was in the original methodology “Project Proponents are required to incorporate geographically specific data, including local energy grid emissions factors, regional emissions factors for chemical production, and applicable water quality and environmental regulations.” but more specific direction has been added in section 3.1.1.3</p> <ul style="list-style-type: none"> ○ Changes to methodology: more detailed direction has been added to section 3.1.1.3: “Project proponents are encouraged to use utility specific grid emissions factors 	
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<p>Section 2</p>	<p>Consider clarity on project boundary/scope - the project boundary bullets list physical and operational sources of emissions, but the following paragraph says it includes upstream and downstream activities. Please clarify what delineation you are referring to, and how the GHG reduction is attributed directly to the physical and operational boundary if the net reduction is a comparison of full life cycle impact of the two systems.</p> <p>In section 3.1.1.1, #2. Establishing the Scope, system boundaries are referred to as direct emissions, operational energy use, and material use. In 3.1, #4, construction and decommissioning are referenced. In 3.1.1, #1, construction, operation and maintenance are listed. Please clarify which sources of emissions/activities are considered in the net reduction between the baseline and algal systems.</p>	<p>Thank you for the comment. We agree that clearer delineation of boundaries is needed and have revised the methodology accordingly.</p> <p>The methodology now distinguishes between:</p> <ol style="list-style-type: none"> 1. The Project Boundary, which refers to the physical and operational scope of the treatment facility and defines the core monitoring and reporting framework; and 2. The LCA System Boundary, which includes upstream and downstream processes such as material production. <p>While monitoring occurs within the project boundary, GHG emissions reductions may be credited based on life cycle accounting even when those reductions occur outside the facility as long as they are transparently modeled, verifiable, and directly attributable to the project activity. This is consistent with ISO 14040-compliant comparative LCAs, and such reductions must not be double-counted under other crediting mechanisms.</p> <p>We have updated Sections 2, 3.1, and 3.1.1 to ensure consistent use of boundary definitions</p>	<p>Passed</p>
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		<p>and emission source inclusions across the methodology.</p> <p>Updates to the methodology:</p> <p>Section 3.1.1.1 #2: We have clarified that direct emissions are referring to an attributional LCA and that indirect or consequential emissions cannot be considered under this methodology.</p> <p>Section 3.1#4: No change here as this is defining the system boundary for LCA which must include construction and decommissioning.</p> <p>Section 3.1.1#1: Fixed this to be consistent with the other section and have included decommissioning and removed maintenance as this is including in operational.</p>	
Section 3.1, 2. site analysis	<p>Is there a carbon cost of early retirement of existing gray infrastructure? Is it assumed that replacement with algae-integrated system only occurs when the original infrastructure is at end-of-life? Expanding on necessitation of new infrastructure investments</p>	<p>Thank you for this important observation. We agree that early retirement of existing gray infrastructure carries a carbon burden that must be accounted for. Specifically, the embodied carbon associated with early decommissioning can be estimated as the fraction $(1 - \text{actual life} / \text{expected life})$ of the total embodied carbon of the original infrastructure, including</p>	Passed

	<p>could clarify whether early decommissioning should be included in the scope of the reduction assessment.</p>	<p>end-of-life impacts such as deconstruction and disposal. Alternatively, this burden can be represented as the amortized embodied and end-of-life emissions (using the original expected lifetime) multiplied by the number of service years forgone due to early decommissioning.</p> <p>In our analysis, algae-based treatment is not assumed to replace existing infrastructure, but rather to serve as an alternative or substitute for new gray infrastructure that would otherwise be constructed to address water quality requirements or system capacity expansion.</p> <p>When evaluating either the algae-integrated scenario or the business-as-usual gray infrastructure scenario, early decommissioning—if applicable—is considered within the scope of the LCA and should be included in the assessment.</p> <p>This issue has now been addressed by adding a new section (3.1.1.10) to the protocol, which defines how to quantify and include the carbon burden of early decommissioning of gray infrastructure when applicable. The section clarifies that this burden is only considered when early retirement occurs and provides two acceptable methods for calculating its impact within the LCA framework.</p>	
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Section 3.2, Temporal Resolution	What happens in the event the algae system is decommissioned early and the emissions then need to be amortized over a shorter life span? Is this captured in the buffer pool?	<p>Emission reductions under this methodology are credited in real time based on monitored and verified system performance. In the event that an algae-integrated treatment system is decommissioned prior to the end of its assumed service life, the embedded emissions from capital inputs (e.g., construction, equipment) must be amortized over the actual operational period.</p> <p>To maintain the environmental integrity of the credits, the methodology includes a buffer pool mechanism. A percentage of credits is withheld to account for non-performance risks, including early project termination. If early decommissioning occurs, the remaining unamortized emissions liability is covered by the buffer pool, ensuring that no net over-crediting occurs even though credits were issued during active system operation.</p>	Passed
Section 1.2	Line items 5 and 6 should have full sentence descriptions to match the other definitions in that list.	We agree and have updated the methodology to include full sentence descriptions.	Passed
Section 1.1, line item 2	Replace “hit” with “meet”	replaced	Passed
Section 1.1, line item 3	Add “compared” to sentence: “Reduction in direct GHG emissions (nitrous oxide	added	Passed

	(N ₂ O) and methane (CH ₄) from reduced N loading compared to conventional treatment processes, and reduced biosolids generation and subsequent end-of-life emissions due to reduced organic loading compared to anaerobic digesters and landfills”		
Section 1.3, line item 12	Add “a process that” at the beginning of the definition so it reads “a process that involves...”	added	Passed
Section 1.3, line item 13	Add “a process” at the beginning of the definition so it reads “a process also known...”	added	Passed
Section 1.3, line item 14	Add “a process that” at the beginning of the definition so it reads as “a process that targets...”	added	Passed

Reviewer's Blind Review Comments regarding Protocol/Methodology

Kindly enter your comments based on these questions in the table below. Also, if referencing specific text, please include text excerpt or row/page number from the protocol/methodology for ease of reference by the authors. All reviewer comments will remain anonymous unless you choose to be named.

Is the protocol/methodology clearly written with adequate detail for implementation?	The guidance could use more precise detail on project boundaries being considered for carbon reduction and credit generation (sections 2 and 3, see specific notes above). If those boundaries are clarified, the rest of the guidance has adequate detail.
Is the underlying foundation of the protocol/methodology clear?	Other than the boundary questions noted above, the foundation is clear.
Is the protocol/methodology feasible?	Yes, it seems the protocol has been written with feasibility in mind, reflected by instances where project context and data availability are taken into account for decision making (e.g., Section 2: Uncertainty Quantification Methods).
Are there any alternative or additional points that should be considered?	Temporal resolution considerations noted above, specifically around potential early decommissioning of the algae system or early decommissioning of the existing infrastructure.
Will the proposed guidelines and regulations achieve the results defined in the protocol/methodology?	Yes

Do you want to be named in the review? (Expert Reviewers will be named after review is completed unless you choose to be anonymous)	No, prefer to remain anonymous
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Recommendation

Kindly mark with an X

Accept As Is:	
Requires Minor Revision:	X
Requires Moderate Revision:	
Requires Major Revision:	
Reject and Re-submit:	
Rejection: (Please provide reasons)	

General/Additional Comments: