

Health & ecosystem impact assessment for biomass carbon removal deployments

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Context

Frontier seeks to support promising carbon removal projects that can be done responsibly and maximize benefits to communities and ecosystems while minimizing potential harms. As a part of purchasing diligence, we assess the project's approach to legal and regulatory compliance, ecosystem safety and distribution of community benefits.

We have built mechanisms into Frontier's purchasing diligence and contracting to (1) minimize the potential known risks of projects; and (2) establish processes for adaptive management over time to ensure that projects stop if negative impacts are identified.

In some cases, existing regulations (OSHA, MSHA, EPA's Underground Injection Controls, etc.) will be sufficient to manage project risks. For the specific safety risks where applicable regulatory regimes do not exist or don't fully retire the risks, Frontier uses the rubric below to inform whether to purchase from the project. This analysis also helps Frontier identify additional controls that should be added into the project contract to ensure safe, responsible deployment.

This assessment rubric

This rubric was developed by environmental, safety and health sciences firm <u>Ramboll</u> to help reviewers for Frontier's offtake purchasing program assess whether a biomass carbon removal project (1) is set up for safe deployment and (2) has a best-in-class approach to monitor and mitigate any potential ecosystem and health and safety risks.

We do this by selecting for projects with low substantive risk and strong procedural controls across key risk categories:

- Low substantive risk Risks are inherently lower because of the nature of the approach and the way the company has designed a deployment. For example, a project that uses a particularly well-characterized biomass feedstock.
- <u>Strong procedural controls</u> A project has appropriate instrumentation and processes in place to monitor ecosystem interactions along with governance controls that trigger deployment shifts if any negative impacts are observed. For example, a project has a comprehensive plan to monitor geologic well parameters and processes to halt injection if variation is observed.

Pre-Deployment assessment rubric

Assessment Category		Assessment		Relevant BiCRS		Assessment Rubric		
As	sessment Category	Туре	Assessment Description	Pathway	High pass	Low pass	Needs improvement	Guidelines for advanced monitoring & mitigation
1-0	1 - Overall Project Governance							
а	Regulatory Compliance	Procedural	Project has controls in place to comply with local, state, and federal regulations	All projects	Proponent has a regulatory compliance expert and has a plan for compliance Planning prioritizes hazard elimination where practical	Proponent has a regulatory compliance expert and has a plan for compliance	No regulatory compliance expert engaged and no plan for compliance	In the U.S., potentially applicable regulations include: • Local, State and federal permitting for injection wells and CO2 transportation • Local, State and federal environmental regulations associated with air, water and waste. • OSHA worker exposure, safety data sheet requirements • Federal or state permitting for potential releases to water (storm runoff), plant wastewater discharge, air (fine particulates), or waste disposal (depending on wastes generated by energy production) and chemicals used for gas scrubbing (ethanolamine)
b	Compliance with ongoing, transparent monitoring and reporting	Procedural	Project has established requirements for project reporting and auditing	All projects	Proponent will receive regular, independent audits of environmental and safety outcomes for this project Proponent plans to transparently report audit findings and safety data to relevant project stakeholders, including communities	Proponent will receive regular, independent audits of environmental and safety outcomes for this project	No plans for third party review or transparent reporting	
с	Compliance with project-specific plans and objectives	Procedural	Project clearly demonstrates climate benefits versus counterfactual	All projects	Proponent robustly demonstrates estimated carbon dioxide removal (CDR) benefit compared to counterfactual scenario, GHG baseline based on life cycle analysis (LCA) is assessed	CDR benefit, GHG baseline, and additionality demonstrated with low confidence level	Proponent does not accurately assess additionality or determine impact compared to baseline	 Ensure biomass was not destined for other CDR activities and publish vetting process The GHG baseline considers the baseline relative to each feedstock used, if projects utilize more than one feedstock type Specific project objectives will vary
2 - 1	Local Ecological Imp	acts						
a	Organic biowaste	Procedural	Project has a plan to source biowaste that has been sufficiently characterized	All projects	Proponent has committed to follow the requirements for organic waste sourcing in "Guidelines for advanced monitoring & mitigation. Plan to publish findings is encouraged for High Pass rating.		of organic waste is assumed without basis, no verification	 Plan to partner with industrial biomass processors who provide biomass with consistent composition, or sample frequently enough to determine composition Collect representative samples of selected biomass and analyze for pathogens, forever chemicals, hormones, pharmaceuticals, or other harmful components, to prevent future adverse environmental issues. Source biowaste responsibly so as to avoid nutrient-depletion at scale where it competes with land application of biowaste. Plan to only use the amount of organic biowaste proven to be sustainable that would not be otherwise applied (e.g. through biosolid land-application) Develop a plan to mitigate risk of subterranean methanogenesis, migration or leakage Develop robust monitoring, reporting & verification (MRV) and sourcing policies within the project protocol

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b	Geologic carbon sequestration (GCS) injection well-induced impacts	Substantive	Project demonstrates understanding of safe injection well practices and has controls in place to minimize potential for GCS-induced seismicity, leakage, or caprock fracturing, and to minimize freshwater/land-use impacts	All projects geologically injecting processed biomass	Proponent has committed to follow the requirements for biomass injection in "Guidelines for advanced monitoring & mitigation." Plan to publish findings is encouraged for High Pass rating.	Negative GCS impacts not adequately evaluated, no expert engaged	 Conduct site screening and site selection, ensure that identified well(s) have desired storage capacity and appropriate supportive geology. Projects where biomass feedstock, bioenergy production and carbon storage are co-located have potential for lower environmental, safety and health impacts. Conduct site characterization (including social characterization) Establish pre-injection baselines and assemble data for permitting (EPA Class VI or V Permit and locally applicable permits). Plan to monitor before, during, and after injection (robust MRV/surveillance plan) to confirm that the well is adequately constructed and prevents subsurface fluids from leaking into drinkable groundwater, and that subsurface pressure is actively managed to avoid seismicity
с	CO2 transport-induced impacts	Substantive	Project has assessed and mitigated environmental and social and health impacts of CO2 or biomass transportation If carbon storage is not co-located with biomass		Proponent has committed to follow the requirements for biomass injection in "Guidelines for advanced monitoring & mitigation." Plan to publish findings is encouraged for High Pass rating.	Negative CO2 and biomass transportation impacts not adequately evaluated, no expert engaged	If carbon storage or biomass processing is not co-located with biomass, develop a CO2 transportation plan that minimizes the CO2 transportation impacts, which may include considering biodiversity, traffic patterns, or other local health and safety impacts.
d	Surface water and groundwater protection	Substantive	Project presents minimal risk to groundwater and surface water	All projects geologically injecting processed biomass	Proponent has committed to follow the requirements to mitigate groundwater impact within "Guidelines for advanced monitoring & mitigation." Plan to publish findings is encouraged for High Pass rating.	Surface and groundwater protection not adequately evaluated	 Determine whether surface and groundwater water protection is relevant to the project site based on proximity of water bodies and aquifer to CO2/ biomass feedstock/injection area and federal/local regulations Assess risk of fertilizer runoff in case of purpose grown feedstock use and implement stormwater pollution prevention plan, as applicable If necessary, develop surface water and groundwater monitoring plan Ensure sequestered organic biowaste is below the water table
e	Waste management and hazardous spent amine disposal	Procedural	Project has plans for safe waste testing, risk assessment for potential employee exposure and disposal protocols	BECCS	Proponent has committed to follow the requirements in "Guidelines for advanced monitoring & mitigation." Plan to publish findings is encouraged for High Pass rating.	No plan to address spent amines or wastes	Wastes and spent solvent must be managed in accordance with Federal, State, and federal, state and local regulations as a hazardous waste.
f	Soil health protection	Substantive	Project has characterized the impacts of selected biomass harvesting and production on soil health/nutrients and has a clear plan to balance soil fertility and control nutrient runoff (if using woody biomass/ag residues)	All projects	Proponent has committed to follow the requirements for biomass sourcing in "Guidelines for advanced monitoring & mitigation." Plan to publish findings is encouraged for High Pass rating.	No plan to address soil nutrient balance, no consideration of ash application/fertilizer runoff, no plan to minimize soil erosion, no plan to mitigate soil carbon loss	Suggested guardrails that may be relevant depending on the biomass inputs: 1. Determine amount of forestry or ag residue that can be removed from soil without negative soil carbon or erosion impacts, gather baseline information about soil nutrients 2. Perform standard agronomic soil analysis with recommendations for appropriate soil inputs for maintenance of soil organic carbon, and define appropriate fertilizer inputs. 3. Plan to monitor soil quality with standard agronomic analyses over time 4. Plan to apply best management practices to control fertilizer/ash runoff and maintain stormwater pollution prevention plans 5. Plan to apply best forest management practices or engage an expert to control soil carbon loss from land conversion and soil erosion 6. For agricultural residues: collect evidence that cultivation practices on acreage where biomass is sourced is sustainable

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3 - Macro Ecological Impacts								
a	sourcing	Substantive & procedural	Sourcing of biomass for this project presents minimal risk to furthering land use change and disrupting communities. This may depend on: • Whether selected biomass is a by-product of existing waste or residue pathway • Whether the biomass source was a result of forest thinning for forest fire control • Whether biomass can be grown or managed from non-arable land or land already disrupted by human activities • Whether/how much additional treatment is required to process the biomass into energy • Distance from source to bioenergy plant, and subsequently to injection site	All projects	selected biomass does not displace existing utilization by local communities. See Frontier's Sustainable Biomass Sourcing Principles for details.	impact assessment and assess acceptability of environmental and socioeconomic tradeoffs. If using waste from purpose growm crops or from managed forests, assess risk of competing for waste and contributing to land use change.	environmental/social impacts, or environmental tradeoffs have not been adequately assessed	 Biomass used should avoid substituting above ground durable carbon stocks for geologic storage and ensure that sourcing biomass from a managed system does not reduce the stock of carbon in that system over time. (a) For agricultural residues: demonstrate that rate of biomass harvest on the acreage from feedstock source does not exceed the sustainable rate of removal; the feedstock is not a dedicated energy crop that competes with food production, (b) For woody/biomass: biomass should be sourced from a regulated forestry management project/activities in historically stable or increasing carbon stocks, or where carbon stocks may be decreasing but forest management had to be carried out regardless. Utilize existing waste and residues over purpose grown biomass, whenever possible Use feedstocks with sustainable sourcing certification from well-regulated jurisdictions while avoiding sourcing from primary forests or supporting forest conversion. (a) Woody feedstocks are ideally sourced from forests that are Forest Stewardship Council (FSC) certified (or other robust sustainability certification) and follow the Roundtable on Sustainable Biomass (RSB) Requirements for Woody Biomass 5. Undertake a comprehensive accounting of project lifecycle emissions for biomass sourcing Encourage biomass governance and supply chain transparency.
Ь	Water footprint	Substantive & procedural	Project presents minimal risk of depleting water resources. Determine water usage required for biomass irrigation and conduct water vulnerability assessments to identify potential risk and identify corrective actions that can reduce or mitigate the risk	All projects	Biomass is not grown in an area experiencing water scarcity, and selected biomass does not have a large water footprint	Biomass does not have a large water footprint	Irrigation or water footprint concerns have not been addressed, selected biomass will impose water stress on local environment/community	 Select biomass feedstock that does not require large water inputs/any additional water input Develop plan to mitigate freshwater stress if using purpose-grown feedstocks/biomass energy crops Source biomass in areas not impacted by drought conditions

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¢	Biodiversity and land-use protection due to feedstock	Substantive	Assess and understand competing uses for land (both social and environmental)	All projects	Selected biomass is derived from waste biomass feedstocks; selected land is not currently supporting communities or providing high-quality natural habitat Any additional ecosystem benefits are clearly demonstrated	waste biomass feedstocks or is sustainably purpose-grown; selected land is not currently supporting communities or providing high-quality natural habitat	Biomass material impacts have not been assessed or justified, land-use conflicts have been identified, no plan to protect biodiversity, no additional ecosystem benefits	 Assess conflicts associated with biomass sourcing - removal of habitats, increased land demand, land-use change and other environmental/social impacts Plan to apply best forestry/land management practices to avoid competition between food production, biodiversity, and growing forests For forestry residues: land use, land-use change, and forestry (LULUCF) emissions do not exceed carbon removals in the forestry sector of the location of the harvest (country/state/province) Demonstrate that the biomass does not threaten protected areas or impose negative impacts on Indigenous Peoples, workers, or communities, or distort agriculture/forestry product markets. Land rights are clearly demarcated and the project will not disrupt utilization by local communities
C	Biodiversity and land-use protection due to bioenergy plant	Substantive	Project presents minimal risk of land use change due to physical facility footprint	BECCS	The bioenergy plant is located on existing developed land and there are no biodiversity impacts associated with the construction of the bioenergy plant Any additional ecosystem benefits are clearly demonstrated	Selected land for the construction of the bioenergy plant is not currently supporting communities or providing high-quality natural habitat	impacts have not been assessed or justified, land-use conflicts have been identified, no plan to	 Conduct field studies to determine potentially suitable BECCS sites Assess conflicts associated with increased land demand or land-use change and other environmental/social goals if using pastureland or cropland If possible, include biodiversity enhancement and ecosystem benefits as part of development plan
4	- Worker Wellbeing							
đ	Amine use for carbon capture and noxious emissions	Procedural	Plan to protect workers' health and broader community from amine vapors and aerosols if using post-combustion scrubbing technology	BECCS	Worker health & safety risk assess amine solvent use, hazard commu			 Conduct health & safety risk assessment Prepare site-specific health and safety plan which includes routine monitoring of amine vapors, an Emergency Action Plan, a Spill Response Plan and safety training Require personal protective equipment for personnel working with amines
ľ	Plant corrosion from amine solvent use	Procedural	Plan to prevent and monitor corrosion from amine solvent use	BECCS	Amine corrosion risk is assessed at the plant design stage and all machinery and fixtures / metal parts are made of stainless steel or material that is not susceptible to corrosion due to amine vapors.	A plan exists to evaluate all machinery/equipment and fixtures to assess corrosion risk and replace with corrosion proof material.		 Design and construct the scrubber and amine tank system with materials that are appropriate to withstand corrosive nature of amines. For example, use stainless steel instead of carbon steel for equipment that has potential to come in contact with amines. Use corrosion inhibitors to prevent corrosion of the tanks, pipelines and other equipment. Have a scheduled inspection and maintenance and program plan to monitor corrosion, replace or repair plant equipment over time and ensure the safety and integrity of the amine system and process. Use corrosion inhibitors to prevent of the tanks, pipelines and other equipment.

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С	Particle and NOx inhalation during biomass harvesting, cultivation, pretreatment, combustion, and transport	Procedural	Plan to protect workers' health from: • Inhalation of fine particles (risks heart disease, asthma, etc.) • Inhalation of noxious gases, ash, soot, and heavy metals	BICRS/BECCS	Worker health & safety plan prepa preparation	red for material sourcing and	No health & safety plan	 Mitigate dust exposure through standard dust suppression actions (e.g., wetting, restrictions based on wind speed, etc.). Conduct routine dust monitoring Develop site-specific dust control and health & safety plans which may include requirements for personnel protective equipment and respiratory protection of staff handling ash and biomass.
5	- Community Wellbein	g						
а	Community Engagement	Procedural	Project has a plan and begun early implementation of engagement with the community surrounding the deployment site(s)	All projects	Obtains buy-in and community support for deployment through education, partnership with local leaders, etc. Has a compelling Community Benefits Agreement	Keeps community informed on deployment strategy through one-way communications	Community is not informed	 Inform community of project policies that will be implemented to avoid accidental release of captured CO2 and/or minimize disruptions Accurately evaluate and convey economic, social, and agricultural impacts to proposed community Exemplary projects commit to and display trustworthiness and partnership from project inception through deployment and beyond. Project updates are communicated in a timely and transparent manner
b	Off-site air quality and noxious emissions	Procedural	Project presents minimal risk to air quality from amine use	BiCRS/BECCS/GCS	Minimal potential for community a will mitigate such impacts	ir impacts, or emission control plan	Not assessed or not mitigated	PM10, PM2.5, and emissions monitoring could be planned if necessary, depending on proximity of community and stakeholder concerns
6	- Benefits							
а	Wildfire risk reduction/reduced fuel load	Substantive	Project offers co-benefit of wildfire mitigation	All projects using relevant forest residues	Wildfire vulnerability is clearly reduced and findings are published (or plan to be published)	Wildfire vulnerability is assessed of to produce woody biomass	or reduced, forest only harvested	 Woody biomass is sourced from overstocked locations not classified as old growth forests or forests with high social values Smallest diameter biomass should be removed first until desired stocking level is achieved to preserve potentially merchantable boles; desired stocking level is set by Forest Inventory and Analysis (FIA) program of US Forest Service
b	Controlled/open air burn necessity elimination and air quality improvement	Substantive	Project offers co-benefit of reducing GHGs, particulate and other air contaminant emissions, from controlled burns that would otherwise be required without waste biomass removal	All projects using relevant feedstocks	Biomass removal eliminates necessity for controlled burns, decreased GHG emissions from pile burns or controlled forest burns is demonstrated	Minimal opportunity to reduce cor	ntrolled burns	 Projects should ensure that ash produced as a result combustion is reapplied to the forest for soil enrichment (after appropriate evaluation is conducted).
c	Economic stimulation	Substantive	Project has a clear plan to help local communities benefit economically from projects after obtaining buy-in	BECCS	Lasting community benefits are cli jobs and workforce development community prosperity. Developec encourages prolonged and sustai	waste biomass market	Beneficial economic impacts are short-lived or not clearly defined; no plan for community development or engagement	 After conveying economic, social, and agricultural impacts to affected community, develop job plan in tandem with community

If a project passes the assessment and is selected for a purchase through Frontier, any the 'guidelines for advanced monitoring and mitigation' that are not already sufficiently addressed in existing regulation are incorporated into the project's measurement protocol and included in the purchase contract.

Frontier gates delivery acceptance and payment on the ongoing regulatory compliance and third party verification that a project has delivered on the activities proposed in compliance with the protocol as well transparently and publicly reported relevant ecosystem impact data.