Supercritical

Why biochar feedstock is so contentious

The essential guide for buyers

Image: Waste wood from a sawmill
Cover image: Corn cob stover

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Biochar: A critical climate solution

Biochar has a long history. Used 8,000 years ago by indigenous farming communities in South America, the material has traditionally been added to soil to improve its health, minimize the need for fertilizers, and help plants thrive.

Fast forward to today, and sustainably sourced biochar is playing an increasingly important role in tackling climate change. In a 2023 study, a group of researchers found that biochar has the potential to remove up to three billion tonnes of CO_2 every year—equivalent to the total emissions of 803 coal-fired power plants. The potential of biochar is significant, particularly for carbon credit buyers that want to invest in accessible, scalable, and technology-ready solutions that drive lasting impact. And it's already making a difference. The industry currently produces at least 350,000 tonnes of biochar every year, and in 2023 biochar carbon removal accounted for more than 90% of delivered carbon credits.

Expert opinion

"It's clear that biochar has a tremendous role to play in the climate fight.

To ensure biochar lives up to its promise as an impactful climate tool, it's vital that the feedstocks used to make it are sustainable and don't inadvertently contribute to any negative impacts.

There is no 'one-size-fits-all' feedstock solution, and a variety of factors must be taken into account when investing in a biochar project. Where does the feedstock come from? Does the use of a particular feedstock have adverse—and often hard-to-see—environmental costs? What about social impacts?

At Supercritical, we use a wide range of expertise and data to ensure our biochar suppliers source feedstock from sustainable sources and are committed to responsible practices, environmental stewardship, and the wellbeing of local communities."

Dr Genevieve Hodgins, Climate Scientist, Supercritical

Genevieve is a climate scientist at Supercritical, specializing in biochar and engineered carbon removal technologies. She previously managed the UKRI GGR-D Biochar Demonstrator at the University of Nottingham, leading the UK's largest biochar field trials to evaluate its potential for carbon sequestration and soil health improvement. Genevieve holds an EngD in Carbon Capture and Storage and Cleaner Fossil Energies from the University of Nottingham, where her research focused on post-combustion capture sorbents.

What is biochar feedstock?

Biochar feedstock is the material (or biomass) used to create biochar. This biomass comes in a variety of forms, from animal manure to forestry waste.

To create biochar, feedstocks undergo pyrolysis, where they are heated in an oxygen-limited environment. This can be done in a number of ways, from simple cook stoves to large industrial-scale plants. The quality and permanence of the biochar depends largely on the temperature and duration of the pyrolysis process rather than on the type of feedstock used, although to be viable feedstocks do need to produce a sufficient H/C_{org} ratio (see below). In theory, then, many types of feedstock could be used to create high-quality biochar. But some feedstocks are more sustainable than others, and using an unsustainable feedstock undermines the purpose of biochar as a carbon credit.

For biochar projects to have a net positive climate impact and be commercially viable, they must use sustainably sourced feedstocks that have no unintended environmental impacts. This is why high-quality biochar projects typically use feedstocks that are already classed as waste, rather than using purpose-grown feedstocks that create additional sustainability considerations. For example, growing a field of crops specifically to be used as biochar demands additional resources such as fertilizers and water, and takes away land that could otherwise be used to grow food.

Left: Nut shells can be an ideal feedstock for biochar


Image: Landscape waste including tree prunings, grass clippings, and weeds

The permanence factor: What makes biochar stable?

Biochar's climate benefits hinge on its stability, which is measured by the H/C_{org} ratio—a key indicator of permanence. H/C_{org} ratio refers to the ratio of the number of moles of carbon atoms (C) to hydrogen atoms (H) in biochar. A lower H/C_{org} ratio indicates higher aromaticity and greater stability (and higher permanence) over time. All our current suppliers produce biochar with H/C_{org} below 0.4, as per our vetting requirements.

Biochar: Removal or avoidance?

Biochar projects are sometimes mistakenly viewed as candidates for avoidance credits. Avoidance credits aim to maintain carbon neutrality by protecting long-term carbon sinks—such as forests—from destruction. Biochar, however, represents carbon removal and a net decrease in atmospheric CO_2. When feedstock undergoes pyrolysis, about 50% of the carbon that would otherwise be released from the material is instead converted into biochar, a stable form of carbon that creates a permanent carbon sink to capture further emissions.

At Supercritical, we prioritize projects that use agricultural byproducts or forestry residues rather than purpose-grown crops, which could compete with food production or deplete resources. Typically, biochar feedstocks that Supercritical would consider fall into the following categories:

Agricultural waste and byproducts: Turning waste into opportunity

Feedstocks from agricultural practices typically include animal manure and low-value byproducts from crops and inedible plants, including:

- Bagasse
- Livestock manure
- Poultry manure
- Rice husks
- Stover
- Nut shells

Agricultural byproducts like rice husks, stover, and nut shells can be ideal feedstocks for biochar. However, some byproducts (such as stover) provide essential nutrients when left in the field, so rotation practices are essential for sustainability. Additionally, animal manures may contain contaminants like heavy metals, which need to be carefully managed to avoid soil degradation.

Sustainability considerations

- Agricultural waste and byproducts often have multiple uses, such as biofuels, livestock bedding or animal feed, so we must consider how using this material for biochar impacts the overall resources needed for these applications.
- Animal waste can contain high quantities of heavy metals, which remain present in biochar and can negatively impact soils and crops.
- Byproducts such as stover (crop stalks) are typically left to degrade in the field after harvesting, which provides rich nutrition for soil. Harvesting it for the purposes of biochar may therefore have negative impacts on soil health. As such, high-quality projects using stover will collect feedstock on rotation.
- However, depending on farming practices, some agricultural wastes are burned or left to decompose in the open air—diverting this material to biochar production can be beneficial to local air and water quality.

Waste woody biomass: Scaling up with responsible practices

Woody biomass feedstock comes from wood obtained in forestry management practices, timber production and sawmills.

Woody biomass feedstock, sourced from forestry management, timber production, and sawmills, presents a large-scale, sustainable option for biochar production. However, its use must be carefully managed to avoid diverting material from other essential applications like paper production or animal bedding, which could lead to further deforestation.

Sustainability considerations

- Woody biomass is often available at a very large scale, but it is critical that waste is obtained from responsible and sustainable forestry practices.
- Wood waste has multiple applications, such as paper, animal bedding and chipboard, so we must make sure biochar production isn't diverting material from other uses that then require more forestry to offset.
- In parts of the world susceptible to forest fires, it is necessary to actively protect forestland by felling damaged trees and clearing forest-floor foliage. The production of biochar from this woody mass—and therefore the creation of a revenue stream—incentivises the collection of a waste material that has traditionally had no further use.

Waste from landscape management: From tree pruning to feedstock

This feedstock is made from tree pruning, grass clippings, weeding and other gardening and landscaping activities.

Landscape management waste, including tree prunings, grass clippings, and weeds, can be repurposed for biochar production. However, this feedstock is often used for composting, so its diversion to biochar must be carefully evaluated against the environmental costs of replacing compost materials. Additionally, the high water content in materials like grass clippings can reduce the efficiency of biochar production.

Sustainability considerations

- This material is typically used to make compost, so we need to assess the benefits of making biochar from this material against the demand for composting feedstock and the environmental impacts of other materials subsequently used to make up that demand.
- Some wastes, such as grass clippings, have a high water content and need to be dried before pyrolysis can take place, making the process less efficient.
- Producing biochar requires feedstock in high and consistent quantities, which may prove challenging for this type of material.

Invasive/encroaching species: A high-impact solution?

This feedstock is made from invasive plant species, such as acacia in the Savannah, which can harm natural habitats and environments.

Invasive species can be a viable feedstock, especially when their removal is necessary for ecosystem health. However, the removal process must avoid negative impacts on soil and consider any community reliance on the species for economic purposes. Supercritical ensures these projects are carefully vetted for both environmental and social considerations.

Sustainability considerations

- Invasive species are typically cleared anyway to protect ecosystems, making them a viable waste material.
- However, if clearance allows the land to be used for other purposes we need to consider the carbon impacts of this subsequent use.
- Invasive species must be removed in a way that doesn't negatively impact soil health.
- Local populations may have come to rely on an invasive species for community or economic purposes, so the social impacts of its removal must be considered.
- Depending on the species, there may be alternative uses for the feedstock that yield greater environmental benefits than biochar.

Image: Waste wood
and sawdust from a sawmill

Key challenges for biochar feedstock

01 Leakage

As outlined, every biochar feedstock has its own sustainability considerations. Chief among them is 'leakage'. This is when a project removes or avoids carbon, but as a result that carbon ends up being created—or 'leaking'—elsewhere.

For example, if waste woody biomass is being used to create paper, but is then diverted to biochar, the papermakers now need to find another source of woody biomass. This could create negative environmental impacts (leakage) around deforestation, as well as social impacts by affecting livelihoods if communities are faced with higher costs or obstacles in obtaining materials needed to do their jobs.

Projects must be highly transparent about the origins of their feedstock, ensuring they aren't sourcing material that has an alternative, more beneficial use.

02 Contaminants

Some feedstocks—for example animal manure—are more susceptible than others to contaminants such as heavy metals, dioxins and PAHs, which can harm soil properties and functions. Low-quality pyrolysis processing can also contribute to contamination.

Thoroughly vetting projects, their facilities and processes can help to mitigate contamination risks.

03 Scaling potential

Scalability is a key concern for carbon credit buyers. Biochar is accessible and has a high technology readiness level (TRL) but there are considerations to take into account around feedstocks – namely sourcing and project location. Local regulatory frameworks and standards may also differ between regions.

Again, proper vetting is important to ensure biochar projects are able to scale to required levels. However, buyers will benefit from considering new and innovative opportunities, especially as demand for projects using more traditional feedstocks means credits are likely to face a supply shortage soon. Buyers may not be familiar with invasive species feedstock from the Savannah, for example, but because the area is so vast with a very low population density, it represents a much higher scaling potential.

What's the best feedstock for biochar?

Every feedstock has advantages and disadvantages. For example, forestry residues are often available at very large scales, but we have to ensure this feedstock is obtained by responsible forestry practices, which can be challenging. Similarly, any biomass material currently burnt in the open presents a great opportunity for biochar production as it captures carbon and prevents pollution from being released directly into the air. But if this material is being sourced at a distance from the biochar production site, then benefits may be outweighed by the impact of transport and logistics.

In short, the best feedstock for biochar is the one that's the most sustainable and scalable for the project in question. This will vary greatly depending on the size and location of the project, which is why it's important to enlist expert advice and support before buying biochar carbon removal. Supercritical's climate science team has significant experience researching biochar feedstocks and their sustainability considerations, and can help buyers identify projects that will deliver lasting climate impact.

Below: A farmer burning branches after pruning olive trees, releasing CO_2 into the atmosphere

Case studies

Nuances in feedstock selection

One UK-based company has established a biochar operation in Kenya through which it aims to produce one million CO_2 removal certificates (CORCs) per year by 2030. The company uses macadamia shells and rice husks as two distinct feedstock options for its biochar, and plans to expand into other waste streams in the future. Both feedstocks have little value in alternative applications.

During vetting, Supercritical found that while its rice husk feedstock produced biochar with a suitable H/C_{org} ratio, when using the macadamia nuts as feedstock, the biochar produced fell outside our 0.4 H/C_{org} ratio threshold, potentially impacting the permanence of the biochar. Because of this—and despite these biochar credits being produced by the same project—Supercritical failed the biochar from macadamia nuts but passed the credits using rice husks. We do not believe the macadamia nuts feedstocks would yield the best outcomes for our carbon removal buyers. This case underscores the importance of understanding feedstock nuances, as they directly impact the quality, permanence, and overall effectiveness of the biochar.

Sustainable forestry residues

A wood products company in South America has established a specialized division focused on sustainable biochar production. The company, which exports high-quality wood products such as musical instruments, decking, custom-made furniture, sawn timber, and wood veneers, operates in a region where the strong oil and gas sector ensures cheap, abundant access to electricity, reducing local demand for wood offcuts. Since 2023, this division has been converting these offcuts into high-quality biochar feedstock.

All feedstock is sourced from 34 sawmills located within a five-kilometer radius. This region benefits from a sustainable forestry practice co-developed by the US Agency for International Development as part of the Bolivian Sustainable Forest Management project (BOLFOR), which began in 2004. As a result, the area supports a thriving sustainable forestry industry with minimal deforestation, ensuring a consistent, responsibly sourced supply of feedstock.

Conclusion

There is no one-size-fits-all approach to biochar feedstocks. There are different sustainability considerations for each type of material, and what works for one project may be completely unsuitable for another. Therefore, the feedstocks used within a biochar project must be properly assessed to ensure the project fulfills its carbon removal objectives without causing negative impacts elsewhere, thereby jeopardizing net zero claims.

Every project in the Supercritical marketplace receives a score through our science-driven, commercially-focused vetting protocol. For biochar projects, this includes a deep dive on the feedstocks used, with Supercritical customers getting full access to all this data on our marketplace. This ensures buyers have confidence that the projects they invest in are sustainable, effective and deliver positive impact to people and planet.

Above: Sugarcane bagasse is a fibrous waste product left over after the juice is extracted from sugarcane stalks

Supercritical

Biochar doesn't have to be complicated. Supercritical's carbon removal experts are on hand to guide you through the pros and cons of different projects, identify which are right for you, and help you build a portfolio of credits that meet your strategy aims, risk appetite, and budget.

Request access to the Supercritical marketplace

Speak with one of our carbon removal experts