

Biochar in Construction and Road Infrastructure

LEGEND

Application: Low-carbon or net-zero concrete in buildings and building cladding; Low carbon or net zero asphalt in road infrastructure.

Permanence:

- 50–100yrs for biochar with a hydrogen to carbon (H/C) molar ratio* greater than 0.7.
- 100-1000yrs for biochar with a H/C ratio between 0.4 and 0.7.
- 1,000yrs+ for biochar with a H/C ratio below 0.4.

Infrastructure: Pyrolysis equipment; Biochar processing equipment; Dryers; Shredders; Silos; Analytical testing equipment; Life-cycle analysis; Control software (SCADA); Concrete and Cement Mixers; Industrial Ovens; Digital Monitoring, Reporting and Verification software (dMRV).

Guidance: Identify relevant biomass inputs and an appropriate biochar production technique, calculate carbon sequestration impact, and report changes in the city's emissions inventory. If the practice also leads to reduced emissions across scopes 1, 2, and/or 3, then report those using the [GHG Protocol for Cities](#).

*The H/C molar ratio is an indicator of biochar stability and its rate of decay in the environment. It is a leading measurement method for carbon sink permanence.

PATHWAY

Biochar is made by thermally decomposing biomass in an oxygen-limited environment (pyrolysis). The biochar can be produced from secondary biomass, such as urban green residues and tree clippings, bio-based or wood-based construction demolition waste, end-of-life paper, invasive species, sewage sludge, abattoir waste, and food processing waste.

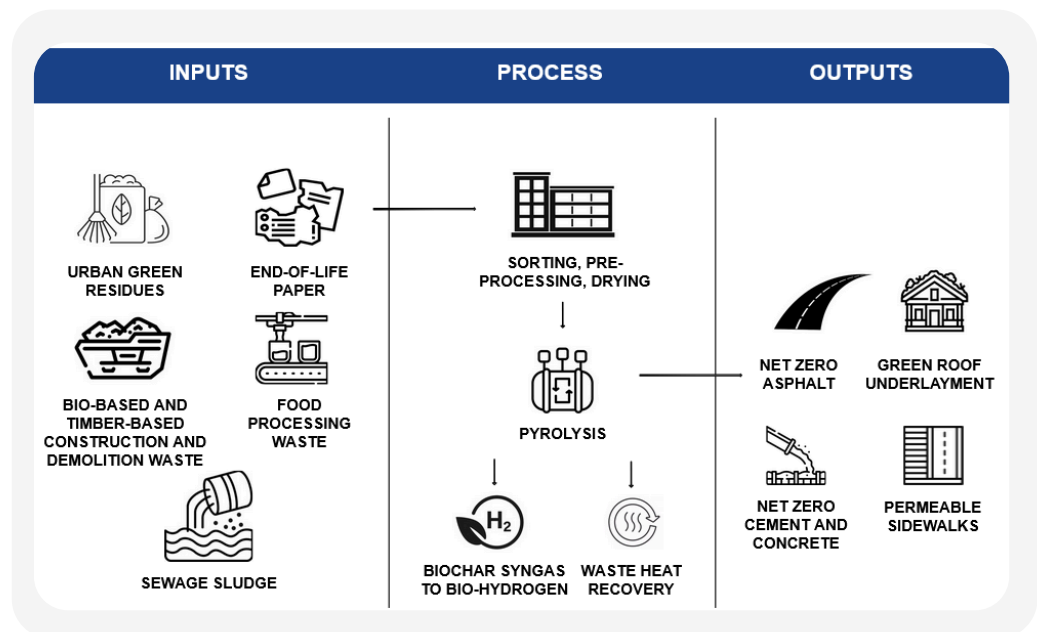


Figure 1: Simplified pathway overview

Biochar is an environmentally friendly carbon rich material that, when treated accordingly, can be used as a filler or as a partial replacement for cement and fine aggregates in cement-based materials, such as concrete and mortar. Biochar can also be used for carbon sequestration in roads, pavements and asphalt/bitumen. Once incorporated, it is locked into the material/matrix. Asphalt and other construction materials are frequently recycled, supporting circularity and permanence aspects. By using biochar as an additive, carbon is physically embedded in long-lived structures, creating a carbon sink and as a result reduces the carbon footprint of buildings and road infrastructure.

ACCOUNTING

Emission risks: Challenges include establishing the baseline waste scenario, traceability of biomass, and contamination exclusion. Methodological inconsistency across carbon market registries further complicates baseline setting. Removal credits in cement, concrete or asphalt are the result of the combined accounting of the amount of carbon sequestered in the biochar, permanence of sequestration, carbon yield, carbon footprint reduction in construction, and degradation pathways in soil versus infrastructure. The amount of carbon stored, pyrolysis emissions, and permanence varies depending on the feedstock, pyrolyzer, and temperature of the biochar production process. It is important to avoid double counting of emissions when calculating across multiple system boundaries (landfill waste, construction and road production processes). Leakage risks, where use of biomass can incentivize other emitting activities, can also occur across multiple boundaries.

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Emission sources to account for:

- Fossil fuel use in transport;
- Processing the biomass materials.
- Energy use and carbon emissions in the pyrolysis process used to produce biochar;
- Emissions from building the pyrolysis reactor;
- Biochar processing and blending into products;
- Consumables.

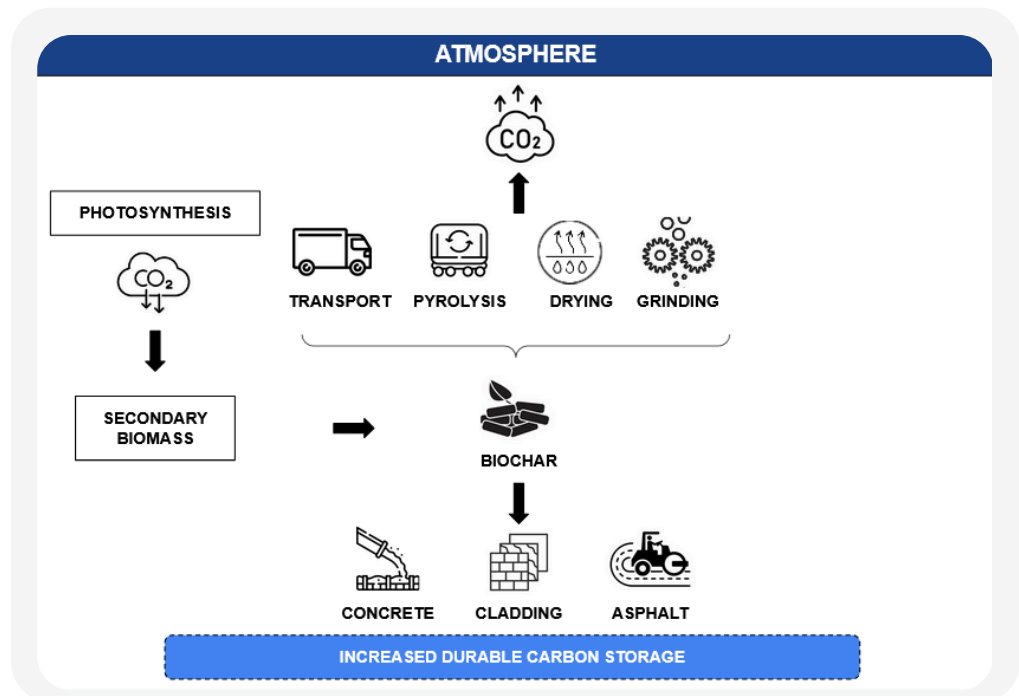


Figure 2: Simplified carbon flow diagram

Mitigation Strategies:

- Use highly efficient system designs allowing for energy recovery;
- Minimize transport distances (build close to feedstock);
- Switch to electric/biofuel/hydrogen logistics;
- Power with renewables, track carbon intensity;
- Automate mixing for optimal biochar dosage, use sealed mixers;
- Recycle process water, minimize inputs;
- Capture off-gases, install CO2 scrubbers; and
- Introduce circular systems for captured gases.

Accounting protocols:

- **Biochar regeneration:** [Global Biochar C-Sink Standard](#), [Puro.earth Biochar Methodology](#), [Isometric Biochar Protocol](#), [VCS Biochar Methodology](#), [Climate Action Reserve U.S. and Canada Biochar Protocol](#), [Rainbow Biomass Carbon Removal and Storage Methodology](#).
- **Concrete production:** [Global Cement & Concrete Association \(GCCA\) Global Low Carbon Ratings for Cement & Concrete](#), [Product Category Rules \(PCRs\)](#), [ISO 14067 Carbon footprint of products](#), [AIA-CLF Embodied Carbon Toolkit](#).

ALTERNATIVE DESIGNS

The urban CDR value chain illustrated in this fact sheet is a reference design based on common infrastructure types and waste streams. However, urban systems differ widely in their spatial form, governance, population density, and resource flows. Therefore, this model should be interpreted as adaptable, not prescriptive.

Possible variations:

- **Centralized vs. Decentralized Systems:** Co-locating pyrolysis reactors at landfill transfer stations or industrial parks is a common approach for biochar production in cities. Some cities may favor **modern, certified mobile pyrolyzers** that can, for example, be integrated into waste collection points. Mobile pyrolysis is not a replacement for stationary systems. It is a complementary, field-validated pathway for scaling CDR across diverse contexts, from agricultural residues to urban biomass streams. Fire safety codes, zoning regulations, and emissions permits need to be adhered to in both centralized and decentralized systems.
- **Feedstock Substitutions:** In areas without sufficient tree clippings or bio-based and timber-based construction and demolition waste (CDW), alternative sources like agro-industrial residues, market waste, or food processing and sewage sludge may be used if inedible and traceable.

OPPORTUNITIES AND GAPS

Acceleration:

- **Job Creation & Skill Development:** Green jobs and new skills are needed for construction retrofits and waste processing.

- **CDR-Ready City Planning:** Urban zoning for biowaste hubs can embed CDR into resilience and adaptation goals.
- **Carbon Market Entry Point:** Verified biochar use in construction and infrastructure qualifies for voluntary carbon credits, helping de-risk project finance.

Gaps:

- **Infrastructure Deficit:** Most cities lack decentralized pyrolysis units or retrofit-compatible infrastructure for biochar integration.
- **MRV Complexity vs Capacity:** Carbon accounting protocols are technically rigorous, but many municipalities and local labs are under-resourced.
- **Regulatory Incompatibility:** Urban building codes, procurement policies, and waste regulations rarely permit circular material use or carbon tracking.
- **Protracted Permitting:** Project developers face protracted permitting approval processes negatively impacting project viability.
- **Sustaining Carbon Integrity:** Long-term storage and leakage risks must be verified consistently, with emphasis on emissions removal.
- **Multi-Stakeholder Alignment:** Synchronizing public works, utilities, and private contractors is operationally complex.
- **Feedstock Variability:** Biomass availability and quality may fluctuate seasonally or as a result of competing uses.
- **Public Acceptance:** Misconceptions about biochar health risks may reduce uptake without clear education campaigns.

CORE RECOMMENDATIONS

- Adjust tender processes to benefit projects that use construction materials that are more sustainable and have a lower carbon footprint.
- Evaluate the availability of residual and waste feedstocks suitable for sustainable biochar production and match make opportunities with project developers.
- Adopt Interim non-construction biochar uses:
 1. Soil moisture retention in parks.
 2. Odor control and organic matter stabilization at waste sites.
 3. Low-carbon filler in non-structural concrete blocks.
 4. Bedding layer for permeable pavement.
- Map the complete materials management requirements, such as logistics, preexisting uses, and departmental needs, for projects to work.
- Launch industry transformation pilot project using biochar for building or road construction.
- Bridge to CDR Readiness with Policy and Training:
 1. Update procurement guidelines and product category rules (PCRs)/environmental product declarations (EPDs) along with chemical safety data sheets (SDS) to allow circular materials
 2. Train public and private sector technicians on MRV protocols
 3. Use tools (for example, [OneClick LCA](#)) to model and track embodied carbon

INNOVATION LANDSCAPE

Innovation needs revolve around the intersection between urban biochar deployment and multiple urban systems, including waste, energy, construction, and water. This requires dedicated platforms for collaboration between cities, biochar production companies, biochar refiners, biochar traders and carbon removal specialists. Cross-disciplinary innovations are also needed, including: certified mobile or district-scale pyrolysis units suited to urban waste flow patterns; biochar-enhanced construction products with verifiable carbon retention; modular MRV systems integrating digital sensors, LCA tools, and community data platforms; and zoning and permitting reforms to allow climate-beneficial material use in urban public works.

LEADING CITIES

- **Ithaca, USA** - [Community-scale kilns](#) integrated into [building materials](#).
- **Helsingborg, Sweden** - Climate neutral concrete with biochar ([reducing embodied carbon in buildings](#))
- **Gloucestershire, UK** - A417 “Missing Link” biochar road/green-bridge ([decarbonising the asphalt repair industry](#)).
- **Grevesmühlen, Germany** - Sustainable road construction ([biochar in asphalt pilot project](#)).

Acknowledgment: This fact sheet is part of a series. The development of the fact sheet was led by the Centre for Science and Technology Innovations (CSTI), a partner in the City CDR Initiative, and received input from partners, cities, and developers associated with the Initiative. The following individuals in particular contributed, either in their organizational or personal capacity: Sue Doward, Francisco Koch, Grant Faber, Aidan Preston, Simone Mangili (CNCA), Lucia Dora Simonelli (CRSI), Kyle Clark Sutton (RMI), Dylan Marks (South Pole), Jan Cihlar (Pyreg), Venna von Lepel (Novocarbo), Jason Aramburu (Applied Carbon), and Micheil Gordon (ecoLocked).