Centre of Excellence
for Decarbonising Roads

GREENPRINT BIOCHAR LIVE TRIAL EVALUATION REPORT

Live Labs 2 North Campus

Department for Transport
ADEPT LIVELABS2 Decarbonising Local Roads
North Lanarkshire Council
Transport for West Midlands
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Contents

STATUS/AMENDMENT	PREPARED	REVIEWED	APPROVED
1.0	Name: Annabelle Farrington Signature:  Date: 05/03/2026	Name: Aditi Subramanian Signature:  Date: 24/03/2026	Name: Matthew Wall Signature:  Date: 26/03/2026

Executive Summary

This report evaluates a live trial of Greenprint Biochar conducted as part of the wider Live Labs 2 project, which aims to test innovative highway solutions to improve road performance, reduce maintenance needs, and enhance safety. This trial focused on the addition of biochar into the asphalt binder mix. The biochar used in this trial was manufactured and sourced from West Sussex County Council (WSCC) and South Gloucestershire Council (SGC) as part of GreenPrint, another Live Labs 2 project. Biochar is a stable, carbon rich material produced through heating organic biomass (such as grass cuttings) in a low oxygen environment through a process called pyrolysis. The addition of biochar to asphalt mixes contributes to carbon reduction through carbon sequestration. The unprocessed biomass absorbed carbon dioxide during photosynthesis. When this biomass is heated without oxygen, the carbon is formed into aromatic molecular carbon structures that are highly resistant to decomposition. Adding biochar to asphalt therefore creates a stable carbon store, as the material does not readily decompose and remains locked within the asphalt layer.

The purpose of this carbon appraisal is to evaluate the carbon performance of Biochar within this live trail. The biochar binder course mix was trialled along 300m^2 stretch of road in Croft head Crescent, North Lanarkshire, within an asphalt concrete (AC20) binder course mix, contributing to 1% of the total asphalt mixture. The findings, limitations, and recommendations presented in this report aim to inform the potential rollout of local council sourced biochar across UK local councils. This will in turn assist evaluation of using waste grass verge cuttings to produce biochar as a viable option for local councils aiming to decarbonise their local road network.

This report assesses carbon emissions across material extraction to construction lifecycle stages in accordance with EN 15804, covering product stages A1-A3 of this standard (raw material extraction, transportation to processing facilities and manufacturing) and construction stages A4 to A5 (transportation of the finished material to site and installation). EN 15804 classifies carbon and establishes a modular, transparent approach to lifecycle assessment that assigns emissions to defined stages. Using EN 15804 ensures that this live trial is in line with the recognised European standard, follows accepted boundaries and allocation rules, and enables results that are comparable, auditable and consistent across products and projects.

GreenPrint is a Live Labs 2 project delivered by West Sussex County Council and South Gloucestershire Council with the aim of exploring the environmental impact of removing grass cuttings produced during conventional local authority maintenance activities. GreenPrint has commissioned the University of Nottingham (UoN) to obtain an Environmental Product Declaration (EPD) for the biochar produced. This certification is currently ongoing and is not expected to be completed until April 2026. As a result, a generic emission factor for biochar has been utilised in this analysis. This will be updated once a third-party verified EPD has been gained.

The findings from the trial show that biochar demonstrated a reduction in carbon intensity when compared to AC20 dense binder, with trial results showing an 44.73% reduction in A1-A5 carbon emissions. The primary driver of the carbon savings can be attributed to the materially lower A1-A3 embodied emissions associated with the biogenic content of biochar.

Introduction

This Evaluation Report provides a high-level assessment of biochar, an emerging sustainable material in highways, construction and maintenance, focusing on its environmental impact, product viability, and alignment with future infrastructure needs. GreenPrint biochar is produced via pyrolysis using waste verge grass cuttings collected by South Gloucestershire and West Sussex County Councils.

Live Labs 2 is a three-year UK-wide programme funded by the Department of Transport (DfT), followed by a five-year monitoring and evaluation period, focusing on how to decarbonise local highways infrastructure and assets. As part of this initiative, North Lanarkshire Council (NLC) are working alongside Transport for West Midlands (TfWM), to establish the UK Centre of Excellence for Materials Decarbonisation in Local Roads.

The Centre of Excellence will act as a central hub for Live Labs 2, supporting research, innovation, and best practices to accelerate low-carbon solutions in road construction and maintenance. By disseminating findings from Live Labs 2 trials, the centre will drive sustainable advancements, enabling Local Authority Highway sectors across the UK to adopt more efficient and environmentally responsible materials and methodologies.

The purpose of this report is to present key findings from a comprehensive evaluation of sustainable materials, including their carbon intensity, potential application, and overall benefits by examining carbon appraisals, lifecycle benchmarks, and various factors such as scalability, compliance, durability and supply chain viability. The aim is to provide decision-makers with valuable insights into the material's capacity to meet sustainability goals while maintaining construction quality and durability. The evaluation will inform ongoing efforts to balance environmental considerations with operational efficiency in infrastructure development.

The carbon profiles of materials have been calculated using the Future Highways Research Group (FHRG) tool Carbon Leadership Profiler Toolkit (previously known as Carbon Analyser), an excel-based tool developed in collaboration with local highway authorities to provide a simple, standardised method for quantifying carbon emissions associated with transport and highways activities, and the OneClickLCA database where embodied carbon data is otherwise unavailable. All carbon profiles have incorporated a local and sector-wide baseline material to benchmark carbon savings. The GreenPrint Biochar trial has been evaluated against AC20 dense binder manufactured/mixed at the same plant in North Lanarkshire.

The carbon evaluation for GreenPrint Biochar considers cradle-to construction lifecycle stages (A1-A5) which include:

- Embodied Carbon;
- Transportation emissions of materials and people;
- Operation of plant and equipment during construction period;
- Operational electricity, fuel and water emissions;
- End of life emissions including deconstruction and waste processing.

Feature	Description	Carbon Intensity	Product Prospects
Material Summary	**Description of material**	**Specific emissions data (CO_2e per unit of material)**	**Brief product potential overview**
Biochar - GreenPrint	Biochar is an asphalt additive produced from biomass. Biomass for this trial has been sourced from waste verge grass cuttings in collaboration with GreenPrint, a Live Labs 2 project. Using biochar from this project allows for the waste stream to be verified and traceable. The biochar additive replaces a proportion of the virgin aggregate, claiming to reduce carbon emissions through the sequestration of carbon and creating a carbon sink within the asphalt layer.	The introduction of biochar into the asphalt mixture at 1% produced 4.88 CO_2e/m^2. This demonstrated an 44.73% reduction in carbon emissions when compared to AC20 dense binder produced at the same Duntilland asphalt plant, North Lanarkshire.	It is considered that, in this trial biochar has demonstrated its potential for use on highway projects in the UK, particularly on projects where carbon reduction, waste circularity and sustainability are key focuses. The additive reduces the reliance on conventional virgin aggregate, promotes circular economy principles, supports the sustainable reuse of locally sourced waste biomass and contributes to carbon sequestration by embedding biogenic carbon into the pavement structure, rather than allowing it to return to the atmosphere during decomposition.

Methodology

Trial Design

The GreenPrint Biochar trail was designed to evaluate the performance, durability, and environmental impact of the material. The asphalt mixture incorporating biochar was applied to 300m^2 of Crofthead Crescent, Bellshill, North Lanarkshire.

Carbon emissions have been assessed based on the whole lifecycle stages A1-A5 (material extraction to construction) in accordance with EN 15804. EN 15804 is the European standard that defines the rules and reporting format for Environmental Product Declarations (EPD) for construction products, providing a consistent, auditable framework for quantifying carbon impacts across a product's lifecycle. These stages cover raw material extraction, transport to and manufacture at the factory, delivery to site and on-site installation, see Figure 1. This clear separation of stages enables precise attribution of emissions to each segment of the supply chain, helping to identify areas for potential reduction measures and ensuring comparability across all trials.

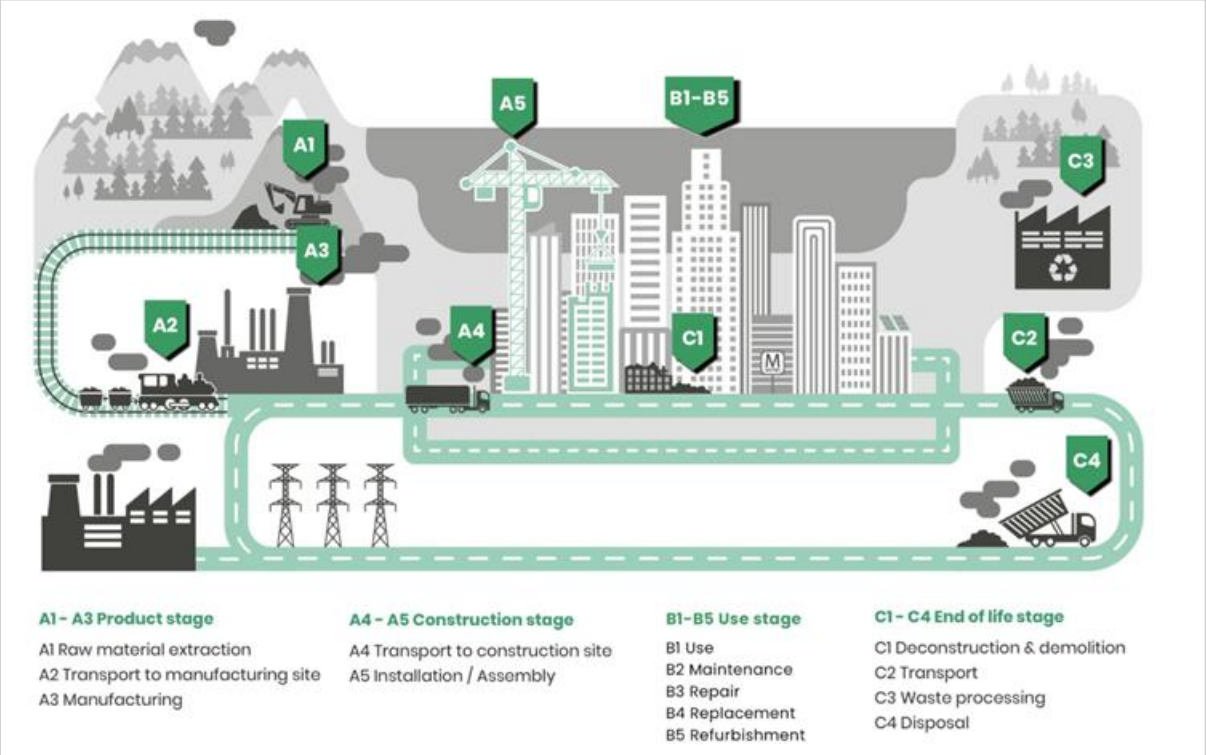

Figure 1: Carbon Lifecycle Stages[1]

[1] https://help.oneclicklca.com/en/articles/275901-life-cycle-stages

Site Selection

The trial sites were chosen based on the following criteria:

- **Traffic Volume:** The site was chosen as it experiences high volumes of both light and heavy vehicles allowing for the assessment of the material's performance under differing stress conditions.
- **Environmental Conditions:** The site was selected due to its varying weather conditions (e.g., temperature, humidity) to evaluate the surfacing material's resilience.
- **Surface Type:** Sites were all originally with hot-rolled asphalt (HRA) and that had deteriorated with use and age to the point where they required maintenance.

Data Collection Plan

The following data items were collected to ensure a thorough evaluation of GreenPrint biochar during site trial:

DATA ITEM	UNIT(S)	RESPONSIBLE	LOCATION OF DATA	PURPOSE
Trial Location	Road name, Coordinates of location of GreenPrint Biochar	Operational Staff	Site Diary	Technical comparisons
Conditions at the time of lay	Temperature (℃) Conditions (rain, dry, etc)	Operational Staff	Site Diary	Operational considerations and technical comparisons
Coring	Pen Softening Point DSR	University of Nottingham	Site Diary	Technical Evaluation
Road Surface Temperature	Temperature (℃)	Inspector	Site Diary	Technical Evaluation
Quantity	m^2 of GreenPrint Biochar used	Operational staff & Carbon Lead	Site Diary	Cost and Carbon Evaluations
Cost	Cost for GreenPrint Biochar Cost for conventional resurfacing	Amey Procurement and Suppliers	SAP	Purchase cost and whole lifecycle cost evaluation
Operational Experience – ease of installation	Subjective – any concerns or benefits experienced by Operations Team	Project Manager to collect on-site data with Operations Team	Case Study in knowledge bank	Scalability Evaluation
Health & Safety	Ease of installation on-site Temperature required for installation	Operational staff and supplier information	Site Diary	Health and Safety Assessment
Operational Data	Time to complete (hh:mm)	Operational Staff	Site Diary	Operational considerations and carbon evaluation
Fuel Usage	Litres of petrol used Type of plant/fleet used (electric, diesel, model)	Operational Staff	Site Diary	Carbon evaluation

Table 1: Data collection plan

Trial Location Plan

The primary aim of the GreenPrint Biochar trial is to undertake a comparison analysis of biochar with the benchmark, conventional AC20 dense binder. In the GreenPrint Biochar asphalt mix, the biochar content was 1% of the total mix. The AC20 dense binder produced by Holcim serves as the benchmark for biochar. The trial and benchmark mixes were manufactured at the same plant at Duntilland Quarry, ensuring energy use and production conditions are comparable. Using this as the baseline provides a clearer comparison and highlights the carbon savings achieved through incorporating recycled materials.

The trial area includes 300m^2 of road as defined in the table below. Preference was given to a location which experience high traffic loads.

TRIAL SITE	ROAD	TRIAL LOCATION
1	Crofthead Crescent	Bellshill, North Lanarkshire

Table 2: Biochar Trial information

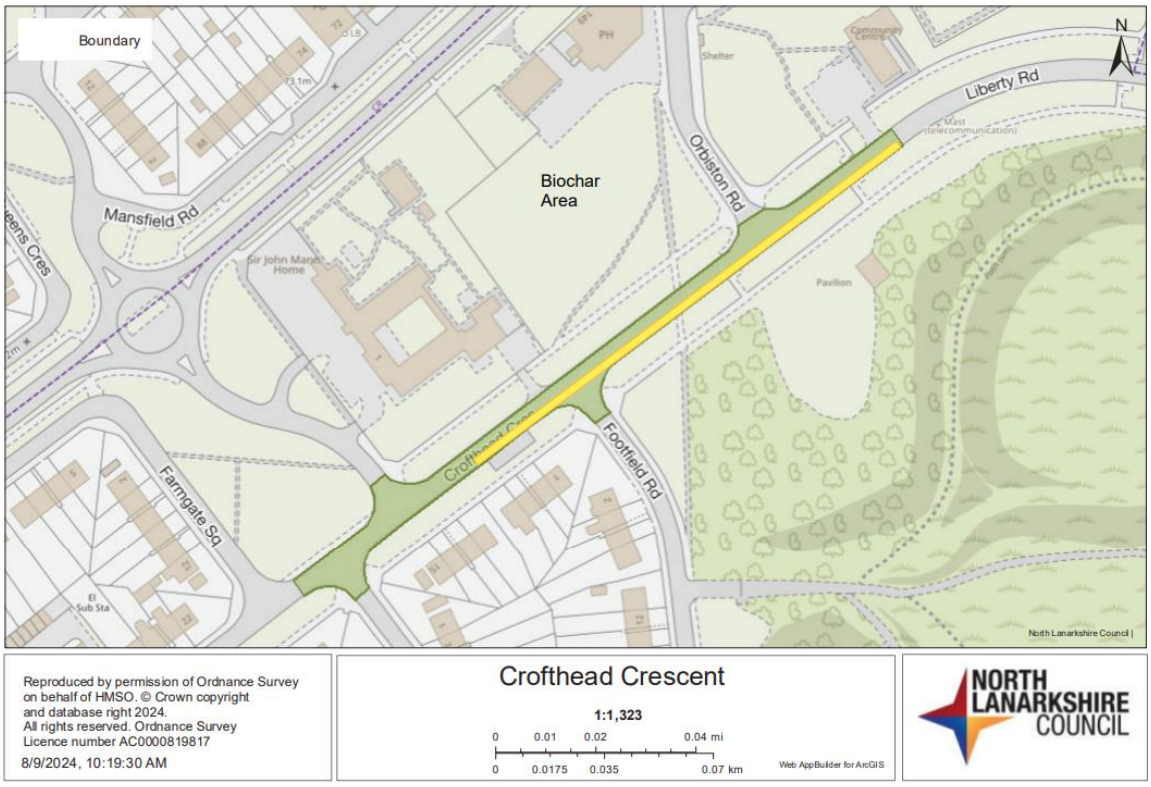

Figure 2: Biochar Trial Extents

Procedure

Site Preparation: The selected sites were cleaned, prepared and planed for the application of the biochar AC20 dense binder mix. Loose debris and water were removed to ensure proper adhesion.

Material Application: Roads were prepped as per manufacturer's instructions prior to product application. The biochar asphalt mix was applied by Luddon Limited on behalf of Hochtief via a paver following conventional asphalt laying processes.

Monitoring and Data Collection: The trial sites will be monitored over a period of 12 months for ongoing durability. Data on surface condition, material performance, and environmental impact areto be collected at regular intervals.

Performance analysis: The performance of GreenPrint Biochar was evaluated based on criteria such as durability, resistance to traffic stress, and environmental impact. Comparisons were made versus conventional AC20 binder to benchmark performance.

Data Analysis

The collected data was analysed to determine the effectiveness of replacing a proportion of the virgin aggregates with biochar in comparison to a conventional AC20 binder course. Data analysis methods were used to evaluate the performance of the biochar mix versus a control section (conventional AC20 binder course) from the same asphalt plant in North Lanarkshire. The analysis focused on:

- **Durability**: Assessing the longevity of the treated site and resistance to traffic and environmental stress;
- **Environmental Impact:** Evaluating the reduction in carbon emissions and use of recycled materials; and
- **Cost- Effectiveness:** Comparing the costs associated with biochar, including material, application, and maintenance costs.

The embodied carbon factors for trialled materials have been developed based on supplier product data and supported from carbon factors sourced from OneClick LCA where required. An Environmental Product Declaration (EPD) had not been produced at the time of this trial. The University of Nottingham (UoN) has been commissioned on behalf of GreenPrint to gain an EPD for their biochar produced from verge grass cuttings. Third party verification from Tunley Environmental for this EPD is currently underway, expected to be finalised April 2026. Tunley Environmental are a sustainability consultancy that verifies to recognised frameworks and standards used in lifecycle assessments, including ISO 14064, PAS 2080, ISO 14040/44 and EN 15804. The addition of a formal EPD will further enhance the level of confidence in carbon analysis.

Holcim have provided A1-A3 carbon value for the manufacturing of the biochar mix at Duntilland Quarry, the third-party verified LCA has been used in the calculation of this value. Holcim provided A1-A3 carbon figures from manufacturing AC20 binder at Duntilland Quarry from works at the same site in North Lanarkshire. This figure has been used as the baseline figures to benchmark GreenPrint Biochar against. As the EPD was not available at the time of this report, a conventional emission factor for biochar has been utilised within A1-A3 carbon emissions. This has been sourced from Holcim's internal carbon tool and incorporates the supplier's declared value as well as all transportation and logistical factors prior to the additive being used in the Holcim asphalt plant.

Holcim's internal carbon tool follows the principles of EN 15804 and has been third party verified by Circular Ecology Ltd. The tool uses primary activity data from Holcim operations, secondary data coming primarily from the UK Government GHG emission factors and Inventory of Carbon and Energy v4.0 by Circular Ecology and University of Bath, with additional data supplied by Carbon Trust.

Carbon Appraisal

Drawing on data collected during the trial; a carbon assessment has been undertaken. Table 3 establishes the parameters of the model, defines assumptions and outlines product specifications.

ASSUMPTIONS	JUSTIFICATION
All transportation is undertaken via diesel HGV.	Based on standard modelling assumptions from similar schemes.
Unit of measurement used is '$kgCO_2e/ m^2$'.	Based on the best available data used to conduct carbon appraisals.
Traffic management activities were not included within this carbon assessment.	Traffic management differs between sites and local authorities so requires separate capturing, as part of standard practice.
Welfare vans and units were excluded from this carbon assessment.	Welfare differs depending on site size and local authority, requires seperate capturing.
GHG-conversion-factors-2025-full-set has been used for delivery vehicle emission factors when the fuel usage is unknown.	Based on the best available data at the time of this carbon appraisal.
This carbon analysis does not incorporate planing out activities within this assessment.	This is a BAU activity therefore is not influenced by this innovative process.
Where specific machine hour carbon emission factors were unavailable emission factors have been selected based on average kW power, sourced from OneClick LCA.	Based on the best information available at the time of the carbon appraisal.
To calculate the CO_2e emissions per tonne of aggregate from each quarry, Holcim utilised the total energy consumption from the quarry over the previous 12 months. Each quarry's energy use was converted to an equivalent CO_2 emission value then divided by the total tonnage of aggregate sold in that same period.	Based on the most up-to-date information Holcim (the asphalt supplier) had available at the time of this carbon analysis.
To calculate the temporary figure for CO_2e emissions per tonne of biochar, Holcim's internal carbon tool incorporates the supplier's declared value as well as all transportation and logistical factors prior to the additive being used in the Holcim asphalt plant.	Based on the most up to date information Holcim had available at the time of this carbon analysis. This figure and carbon calculations will be updated once the EPD for GreenPrint biochar has been independently verified by a third-party organisation.
Holcim utilised Eurobitume's 2025 carbon emission factor for bitumen, $530kgCO_2e$/ tonne.	This figure is the most recent bitumen emission factor and is considered the industry standard.
Fuel consumption of dryers has been calculated by the amount of fuel used divided by the tonnage of asphalt supplied. Giving the CO_2e value per tonne of asphalt mixed can vary plant to plant based on tonnage supplied, fuel type, efficiency etc.	Based on the best available data at the time of this carbon appraisal.

ASSUMPTIONS	JUSTIFICATION
The emission factor used for fibre pellets, a standard aspect of asphalt manufacturing, was sourced from ASPECT.	Based on the most recent emission factors available to Holcim for emission factor calculation. Holcim's internal carbon calculation tool has been externally verified by Circular Ecology and follow the principles EN 15804.
The emission factor used for limestone filler was sourced from ICE v.3 2020.	Based on the most recent emission factors available to Holcim for emission factor calculation. Holcim's internal carbon calculation tool has been externally verified by Circular Ecology and follow the principles EN 15804.
Application rate of bondcoat is assumed to be 0.5/m^2.	Based on application rate given by contractors Luddon Ltd in site records, provided by Hochtief.
Machine hours were assumed based on site records provided by Hochtief.	Based on the best available data used to conduct the carbon appraisal.
Vehicles transporting materials are assumed to travel fully laden to site and return empty.	The assumption that vehicles travel fully laden to site and return empty reflects standard haulage practice for material deliveries. Applying this assumption ensures carbon calculations accurately represent typical operational behaviour and avoid artificially reducing transport-related emissions.
The carbon modelling for AC20 binder assumes equivalent material quantities and construction activities to those recorded for the area covered in the biochar trial, ensuring a like for like comparison.	This approach controls key variables, reducing modelling uncertainty and making the carbon impact of the benchmark directly attributable.

Table 3: Carbon appraisal matrix

Carbon Modelling

The carbon modelling for the trials was conducted using the FHRG Carbon Leadership Profiler Toolkit to collect primary carbon data from the trials, detailing emissions from materials, transport, construction activities and equipment use. Using this information the tool generated carbon profiles that identified emission hotspots. The toolkit's emission database was also used to provide verified emissions factors and improve data accuracy.

One Click LCA was also utilised in modelling to support the FHRG Carbon Leadership Profiler Toolkit due to its large database of emission factors supported by Environmental Product Declaration (EPD). The carbon emission factor for Biochar has been supplied by Holcim. This value was calculated using a third party verified LCA of Biochar and a third-party verified carbon calculator.

Indicative results from carbon modelling for the GreenPrint Biochar trial, expressed in $kgCO_2e/m^2$ and $kgCO_2e/t$ are presented below. This presentation of emissions enables direct comparison across different low-carbon innovations, to highlight carbon-efficient options and support-data driven decision making for reduction strategies. Results are presented graphically in Figure 3, Figure 4 and Figure 5:

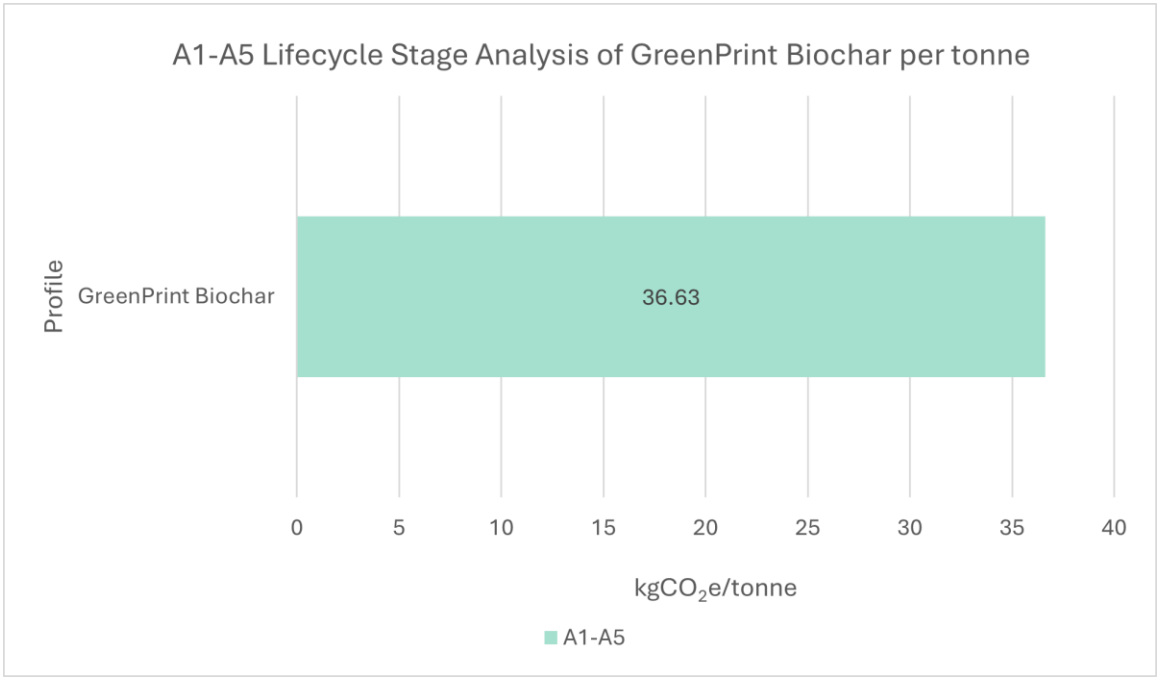

Figure 3: Carbon analysis of GreenPrint Biochar (1% Biochar) per tonne

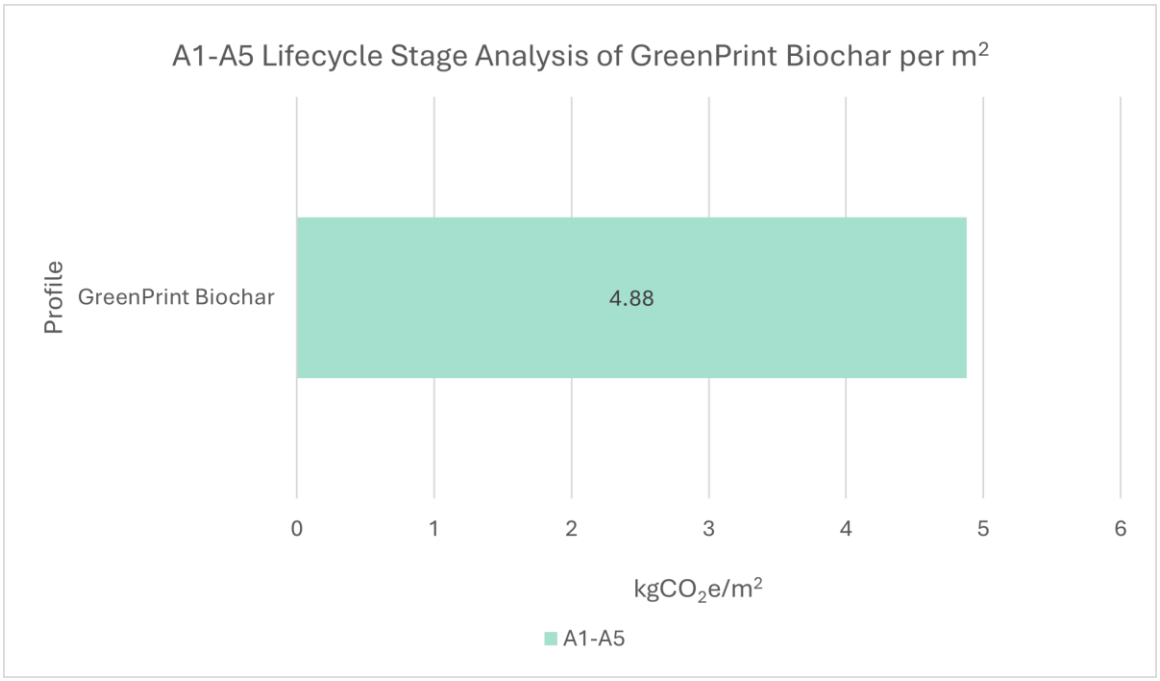

Figure 4: Carbon analysis of GreenPrint Biochar (1% Biochar) per m²

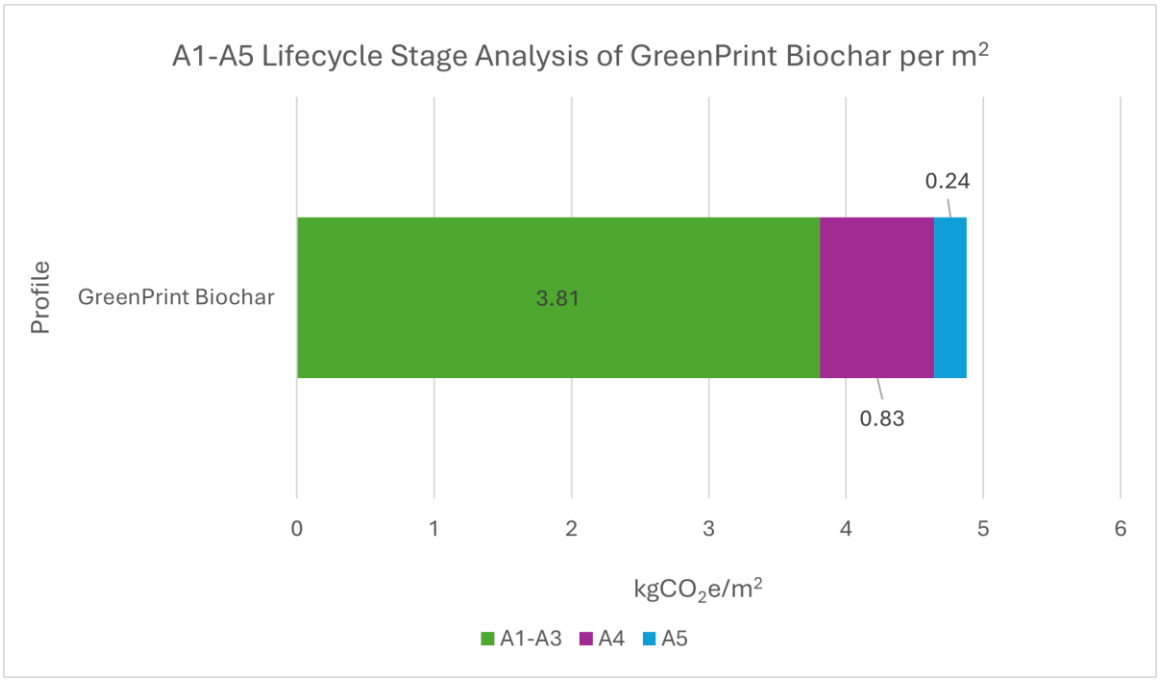

Figure 5: Carbon analysis of GreenPrint Biochar (1% Biochar) lifecycle stages A1-A3, A4 & A5 per m²

Benchmarking

Biochar is yet to be fully evaluated against traditional HRA on terms of performance and long-term viability in North Lanarkshire, as prior to this trial biochar had not been used in North Lanarkshire. These trials are to allow for an analysis of the performance of biochar in comparison to conventional asphalt concrete binder. This would be the traditional option for re-surfacing if the biochar mixture was not used. This allows for comparisons between biochar versus BAU surfacing within the carbon analysis.

A comparative analysis was conducted to assess GreenPrint Biochar the benchmark conventional AC20 binder. The model incorporates A1-A5 lifecycle stages, which represent raw material, transportation to manufacturing, manufacturing, transportation to site and construction associated emissions. This allows for a comprehensive carbon evaluation of biochar.

Indicative comparative analysis results are presented graphically in Figure 6 and Figure 7 :

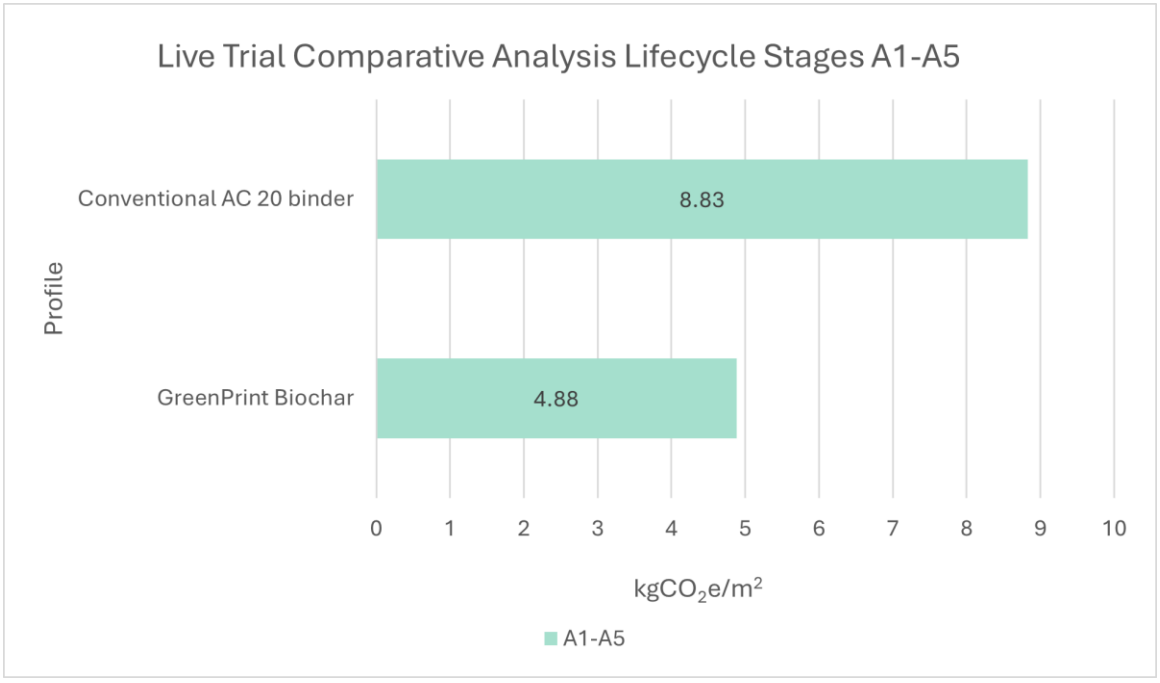

Figure 6: Comparative carbon analysis GreenPrint Biochar versus conventional AC20 per m^2

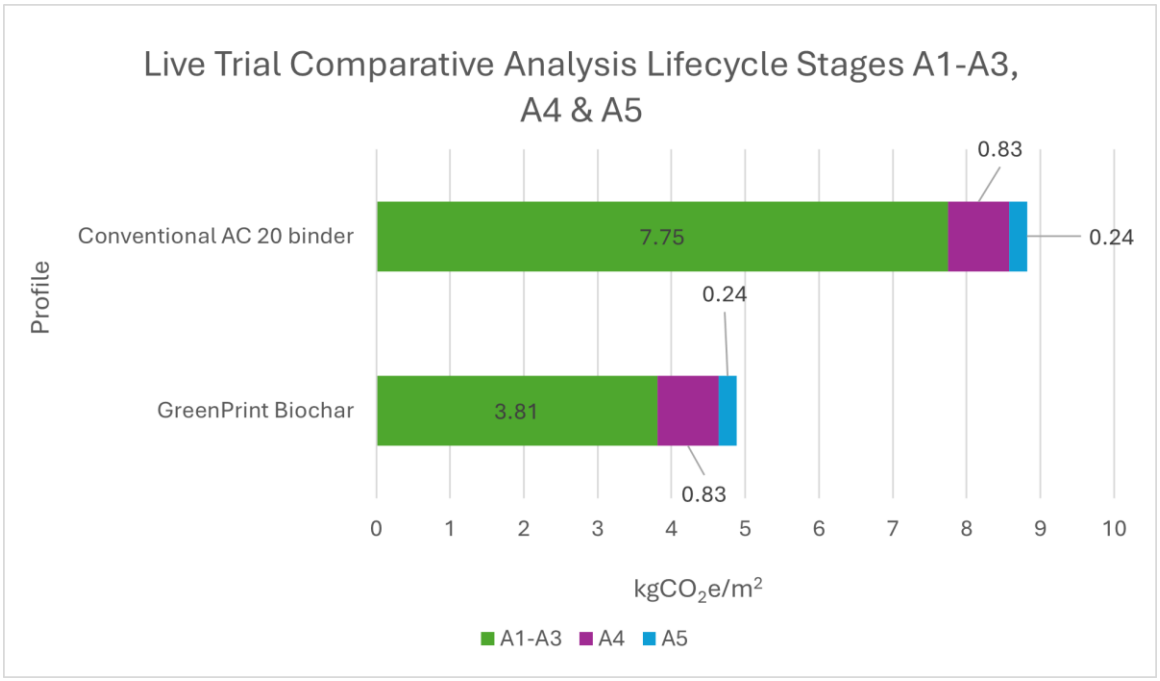

Figure 7:Comparative carbon analysis GreenPrint Biochar versus conventional AC20 A1-A3, A4 & A5 lifecycle stages per m²

MATERIAL	COMPOSITION	APPLICATIONS	PERFORMANCE	INSTALLATION	SUSTAINABILITY
AC20 Binder	A dense asphalt concrete mix with nominal maximum aggregate size of 20mm, designed to bind coarse and fine aggregates with bitumen.	Used as the binder layer between surface and base or sub-base courses in most UK road constructions. Distributes loads and provides structural strength before the laying of the final surface layer. Considered a well-established material with defined performance specifications and widely used in highways.	Provides a well understood balance of stiffness, load bearing and durability suitable the binder course role. Performance depends mainly on correct binder grade and aggregate quality.	Manufactured at an asphalt plant and transported to site, laid with pavers and compacted according to specification. Follows well established laying, compaction and testing routines under UK specification guidance.	Asphalt concrete is generally recyclable but its raw material sources remain primarily virgin materials and fossil based.
Biochar	Biochar is an asphalt additive for use in binder courses. For this trial, the biochar was produced from biomass (grass cuttings) by WSCC and SGC and incorporated in the AC20 mix at a rate of 1%. Biochar is a porous, carbon rich material created through the pyrolysis of organic waste. Typically containing 60-90% carbon along with hydrogen, oxygen and trace minerals, it has a high surface area that enables strong interaction with bitumen.	Intended to be used as an additive to AC20 with the focus on reducing environmental impacts. One of the key objectives of this Live Labs 2 trial is to assess the feasibility and performance of biochar under real traffic conditions, contributing further evidence to the growing body of UK biochar trials.	Previous studies on the use of biochar as an additive has demonstrated that biochar has the potential to: increase high temperature resistance and stiffness and enhance ageing resistance through slowing down oxidative ageing. However, performance depends on the biochar type, particle size, pyrolysis conditions and design mix.	Biochar enhanced mixes are meant to be laid much like conventional AC20 with minimal changes to paving equipment or workflow. Biochar is integrated into the binder during the mixing stage, prior to arriving on site.	The addition of biochar to the binder mix allows for carbon sequestration. The biochar 'locks' carbon that would otherwise been returned to the atmosphere, potentially making the road layer a carbon store. However, the long term permanence of this carbon store is unconfirmed. GreenPrint biochar uses local green waste, reducing disposal carbon emissions and creating value from waste. This supports circular economy principles. Using biochar reduces the demand on virgin binder, reducing the reliance on fossil materials.

*Table 4: Biochar Appraisal**

*All factors assessed as part of the appraisal of GreenPrint Biochar has been built on supplier provided or academic material and are not drawn from the live trial.

Life Cycle Stage	Baseline Carbon Emissions (AC20) ($kgCO_2e$)	Biochar Carbon Emissions ($kgCO_2e$)	Difference (%) (Increase/ Reduction)
A1 – A3	2,325.60	1,142.40	50.88%
A4	249.64	249.64	0%
A5	73.04	73.04	0%

Table 5: Lifecycle Stage Comparison to BAU

Carbon Benefits and Considerations (Matrix)

Table 6 presents the findings of the carbon benefits and considerations matrix for Biochar application as a surfacing material. **All scoring is bold and underlined.**

Technical data used during benchmarking and the carbon benefits and considerations matrix were supplied by the manufacturer and are not derived from the GreenPrint Biochar live trials in North Lanarkshire. While reliance on supplier-provided information may introduce uncertainty in confidence levels, the information and data represents the best available evidence at the time of the appraisal. Data quality has been considered when selecting supplier information and, where possible, supplier values were chosen from manufacturers' standard test reports, specifications and product datasheets that reference recognised test methods and certification.

BENEFIT/LOAD UNDER REVIEW	CONSIDERATIONS	SCORING SYSTEM	JUSTIFICATION
Costs	Transport, operational, material procurement	1 - Significant additional costs **2 - Costs approximate baseline** 3 - Costs significantly lower than baseline	Biochar production from local grass cuttings is now being successfully trialled by WSCC & SGC, reducing transport and procurement cost compared to imported biochar. However, biochar costs vary widely globally and can be higher depending on feedstock and processing, meaning cost neutrality is the most realistic score at this stage.
Maintenance	Design life, maintenance burden, on time for plant	1 – Significantly more maintenance/lower longevity **2- Approximately same maintenance/similar longevity** 3 – Significantly less maintenance/higher longevity	Research has shown that biochar has potential to increase stiffness and rutting resistance at high temperatures, but long-term data remains limited. No evidence yet suggests either a major improvement or deterioration.
Scalability	Manufacturing facilities	1 - Lab testing only **2 - In process of commercialisation w. small scale manufacture** 3 - Already has market presence with developed supply chain	GreenPrint has successfully produced biochar from grass cuttings at trial level, but widespread production facilities do not yet exist.
Compliance with specifications	Requirements for standards departures	1 - Requires significant departure(s) from standard and has not been used before by end client **2 - Requires some departure from standard, but has been used before by end client** 3 - Does not require any departure from standard.	Biochar modified asphalt is not yet part of UK standards, but at field trials exist in the UK and only at small scales.
Environmental	Nature-based solution	1 - Would have significant net disbenefit for environmental factors	Biochar support carbon sequestration, creating a carbon store which would have been released into the atmosphere.

BENEFIT/LOAD UNDER REVIEW	CONSIDERATIONS	SCORING SYSTEM	JUSTIFICATION
		(noise, AQ, biodiversity, landscape etc) 2 - Would have negligible net benefit/disbenefit or no overall change regarding environmental factors **3 - Would have significant net benefit for environmental factors.**	It reduces reliance of virgin materials and utilises waste biomass.
	Road noise	1 - Would have significant net disbenefit **2 - Would have negligible net benefit/disbenefit or no overall change regarding** 3 - Would have a significant net benefit	The addition of biochar to asphalt mixes is not anticipated to cause any changes in construction or operational noise as follows standard asphalt procedures.
	Climate resilience/future proofing	1 - Would have significant net disbenefit 2 - Would have negligible net benefit/disbenefit or no overall change regarding **3 - Would have a significant net benefit**	Early research has found biochar holds potential to improve resistance to high-temperature deformation and slow the ageing of asphalt which enhances climate resilience under hotter summers and extreme weather.
Risk and safety	H&S impacts, safety testing data	1 - Would present increased risk or safety versus BAU option **2 - Would present no overall risk increase or safety impact versus BAU option** 3 - Would present lower risk or safety impact versus BAU option.	Biochar-modified asphalt behaves similarly to conventional asphalt in handling and onsite operations. No additional health or safety risks are anticipated.
Technology Readiness Level	Is it commercially available, is there enough R&D?	1 - Not yet commercially available 2 - Commercially available from worldwide suppliers 3 - Commercially available from European suppliers **4 - Commercially available from UK suppliers** 5 - Commercially available from local suppliers	Biochar is commercially produced in the UK and is available through multiple suppliers for agriculture and environmental applications. GreenPrint is a trial Live Labs 2 project finishing March 2026, however the project has shown the potential for UK-based biochar production from waste biomass.
Constructability	How easy is it to handle on site, install, recover, curing time, specialist equipment/training, storage?	1 - Specialist contractors, time on site and/or equipment required **2 - No considerations required above and**	Biochar can be added directly into asphalt mixing processes without specialist plant and follows standard asphalt laying procedures.

BENEFIT/LOAD UNDER REVIEW	CONSIDERATIONS	SCORING SYSTEM	JUSTIFICATION
		beyond baseline solution 3 - Significant benefits to on-site activity / ease of installation	
Supply Chain	Material availability	1 - Novel materials used **with limited supply** **2 - Materials are available with some supply restrictions** 3 - Materials are readily available	Biochar feedstocks (grass cuttings, organic waste) are abundantly available and renewable. GreenPrint demonstrates a reliable local supply chain for feedstock and production. However, the approach adopted by GreenPrint is not yet widely adopted with GreenPrint being a three-year project finishing in March 2026.
Circular Economy	Recycled content	1 - Virgin materials are used with little or no recycled content 2 - Materials contain a level of recycled content **3 - Materials are predominantly recycled and/or use novel sources of recycled content that would otherwise be discarded as waste**	Biochar is produced entirely from waste grass cuttings in GreenPrint, recycling biomass that would otherwise be discarded and promoting circular economy principles.
	Ease of recycling	1 - Minimal recycling of material possible upon removal **2 - Limited recycling is possible and/or significant reprocessing required** 3 - Reuse/recycling is easy and convenient	The impact of biochar on reclaimed asphalt pavement (RAP) processing and future reuse is not yet broadly evidenced.

Table 6: Carbon benefits and considerations matrix

Long-Term Performance Analysis

The carbon analysis in this report does not include a lifespan analysis. This will be finalised dependent upon the publishing of longevity test results in partnership with the University of Nottingham.

These tests will focus on the following:

- Durability and Aging Resistance,
- Skid Resistance and Surface Integrity,
- Lifecycle Carbon Savings,
- Traffic and Environmental Stress Testing,
- Optimal Reapplication Intervals.

Conclusion & Recommendations

Conclusions

The GreenPrint Biochar live trial has provided early evidence that biochar derived from locally sourced grass verge cuttings can serve as an effective, lower carbon additive within asphalt concrete binder course mixtures. The trial demonstrated that Biochar can be delivered using standard HRA plant and processes, supporting its suitability for deployment in existing surfacing operations. Carbon analysis has demonstrated an 44.73% reduction in A1-A5 lifecycle stage carbon emissions, with the majority of these savings being accounted to A1-A3 lifecycle stage emissions (raw material, transport to manufacturing and manufacturing/processing). These reductions stem from replacing a portion of virgin material with biochar, enabling biogenic carbon sequestration within the asphalt layer and reducing the reliance on fossil derived materials.

Operationally, the trial found that biochar can be used as a polymer additive at 1% of the asphalt mix without special laying procedures. Early operational feedback demonstrated the additive performed well during installation. Confirmation on the biochar's long-term durability, ageing behaviour, stiffness development, and maintenance implications require a longer monitoring period and is dependent on the findings of laboratory tests by the University of Nottingham. Current evidence from similar biochar trials in the UK suggest potential improvements in high temperature performance and ageing resistance however, the absence of long-term performance datasets necessitates cautious interpretation.

Although the GreenPrint Biochar trial has demonstrated promising carbon benefits, it is important to acknowledge uncertainties surrounding the long-term permanence of the carbon store created by the biochar modified asphalt. Biochar is recognised for its ability to stabilise biogenic carbon by converting organic waste into a form that is resistant to rapid decomposition. Embedding biochar within the asphalt binder layer introduces the potential for long-term carbon sequestration however, the durability of this carbon sink over the full-service life of a road is not yet fully understood. Key factors such as the behaviour of biochar during milling and recycling at end of life require further investigation. Until further long-term field data is complete and available the permanency of carbon storage within asphalt layers should be approached as highly promising but not completely verified benefit long term.

Overall, the trial has demonstrated that biochar produced from waste biomass is a promising, practical and scalable pathway to decarbonising the local road network in the UK, particularly where waste management, carbon reduction and circular economy principles are key priorities for local authorities.

Recommendations

It is recommended that robust long-term monitoring (over 5+ years) be implemented at treated sites to comprehensively evaluate performance and verify lifecycle carbon savings. This further long-term monitoring will allow for more expansive carbon modelling to assess end-of-life scenarios to provide a more comprehensive understanding of whole life carbon emissions. Further appraisal should focus on extending beyond A1-A5 lifecycle stage emissions to include field data from operational emissions, maintenance cycles and end of life for the asphalt layer in North Lanarkshire. This would provide a more holistic long-term picture of carbon performance relative to baseline materials.

A further recommendation is to explore a testing framework to assess the long-term stability of carbon stored within road layers and confirm whether biochar remains an effective carbon sink through the pavement's life, including during recycling or planing activities.

Once the University of Nottingham completes the EPD (expected April 2026), carbon modelling for GreenPrint biochar should be updated to reflect independently verified data and to enhance the confidence in the findings of this report.