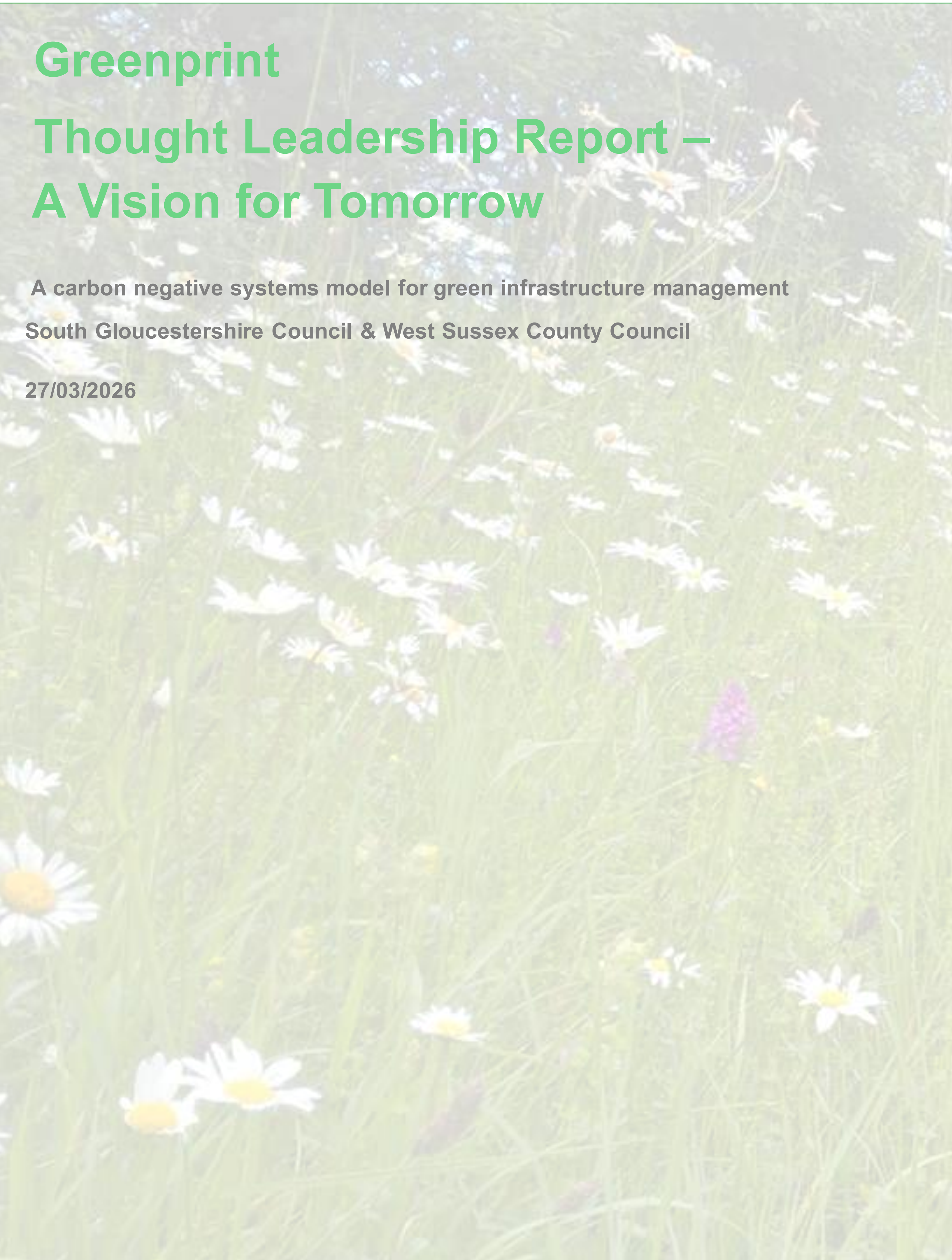

Greenprint

Thought Leadership Report –
A Vision for Tomorrow

A carbon negative systems model for green infrastructure management

South Gloucestershire Council & West Sussex County Council

27/03/2026

Document Control Sheet

Project Name:	Live Labs 2: Greenprint
Project Council:	South Gloucestershire Council & West Sussex County Council
Report Title:	Greenprint: Thought Leadership Report - A Vision for Tomorrow
Report Number:	1

Issue Status	**Prepared by:**	**Reviewed by:**	**Approved:**
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	Date: 20/03/2026	Date: 25/03/2026	Date: 27/03/2026

Executive Summary

The Greenprint project demonstrates that transitioning from traditional cut-and-leave verge management to cut and collect approaches, offer a credible, evidence-based pathway for local authorities to accelerate progress toward net zero, enhance biodiversity, and embed circular economy principles within highways and green infrastructure operations.

The assessment confirms that anaerobic digestion (AD) represents the most feasible and readily deployable short-term decarbonisation solution for verge arisings. AD delivers substantial net carbon benefits through renewable energy generation, with environmental gains significantly exceeding emissions associated with collection and transport. In contrast, pyrolysis becomes operationally and economically viable primarily when verge grass is blended with woody biomass, stabilising feedstock quality and enabling biochar production with long-term carbon sequestration benefits. While traditional cut-and-leave remains the lowest-cost approach in purely financial terms, it performs poorest against carbon and energy outcomes and does not align with longer-term net zero ambitions. The project evidence that recognising verge grass as a recoverable resource, rather than a waste material, unlocks value across decarbonisation, energy generation, and materials recovery agendas (circular economy).

Public acceptance of reduced cut-and-collect regimes was strongly positive, with perceived and observed biodiversity improvements reinforcing the social case for change. Such feedback has translated into South Gloucestershire Council confirming they will be continuing a cut-and-collect approach for the 2026 season. Adjacent to this, effective implementation depends on robust baseline data, adaptive operational management, and secure access to processing capacity. Particular emphasis on the lack of an established biochar market and government environmental constraints are essential factors for developing the project beyond its operational change. For example, revenues are largely confined to small and fragmented voluntary carbon markets, due to no established compliance market or consistent policy mechanisms from the UK Government. Operationally, efficiencies, particularly machinery selection tied to reliability, are fundamental to reducing the cost of the approach, as they have been tied to increased costs.

Looking forward, cost gaps are expected to reduce as technologies mature, collection practices improve, and markets for biomethane, digestate, and biochar develop. Strengthening carbon and biodiversity outcomes will further reinforce the long-term business case, while opportunities to monetise carbon savings through carbon in setting, sponsorship, or partnership models offer additional routes to financial sustainability.

Overall, Greenprint provides clear justification for systemic change in verge management. A phased delivery trajectory, beginning with AD and progressing toward integrated biomass and biochar systems, enables authorities to adopt cut-and-collect in a financially responsible manner while building towards high-value, long-term environmental outcomes. While the transition requires sustained investment and organisational alignment, the combined environmental, operational, and societal benefits present a compelling case for continued adoption and scale-up.

Key Insights

Carbon:

- **Cut-and-leave is the highest emissions option**; cut-and-collect materially reduces emissions by avoiding the decomposition of biomass in the open.
- **AD delivers immediate carbon savings; pyrolysis offers the greatest long-term sequestration** potential via biochar.
- **AD Carbon savings:** 100% grass to AD processing equated to a carbon saving of 5.39 kgCO2 e per 1000m2
- **Biochar CO_2 savings:** for every tonne of biochar produced 2 tonnes of CO_2 could be captured

Cost:

- **Cut-and-collect currently costs ~2.6× BAU (cut and leave),** driven mainly by labour and machinery reliability.
- Clear **pathways to cost reduction** identified through fewer cuts, better equipment, scale and integrated waste logistics.
- Capital investment required for biomass treatment remains high and hard to sustain without an effective means to derive income from the commercialisation of the outputs

Biodiversity:

- **Cut-and-collect is one of the strongest levers available** to improve verge biodiversity by reducing soil nutrient loading.
- Early results are positive, but **long-term- monitoring (5+ years)** is required to evidence full ecological gains.

Behavioural Change:

- **Operational teams and contractors adapted well** to new regimes when involved early.
- **Public support was strong**, supported by proactive communication and visible environmental benefits.

Customer Satisfaction:

- **Positive public feedback**, with no material increase in complaints despite changes to cutting regimes.
- Cleaner verges and reduced litter improved **perceived service quality**.

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Introduction

The UK's move toward a net zero transport system demands bold thinking and closer collaboration across sectors. While national decarbonisation efforts have focused on EV uptake, modal shift and behaviour change, far less attention has been paid to the materials, operations and asset management practices that shape carbon, resilience and social value across the local roads network.

To address this gap, the Department for Transport (DFT) launched Live Labs 2 - a three-year, £30 million programme with five years of follow-up evaluation. Seven projects across four themes are testing scalable, systems-based decarbonisation solutions for highways infrastructure.

Within this national programme, South Gloucestershire Council (SGC) and West Sussex County Council (WSCC) are collaborating on **Greenprint**: a practical, replicable model that reframes highways green assets as a resource rather than a maintenance liability. Instead of the default approach - leaving cuttings in place, which boosts nutrient levels, accelerates regrowth, suppresses biodiversity and increases mowing frequency - the councils are trialling new technologies to collect and process verge biomass across their estates.

By converting grass cuttings into clean heat and power, alternative fuels and low-carbon asphalt additives, the project demonstrates how highways, waste and environmental services can operate as a circular system that cuts emissions, reduces costs and enhances environmental and social value.

Supported by £4 million of investment, Greenprint offers a scalable blueprint for local authorities, one that reimagines the role of green highways assets, strengthens climate resilience and contributes meaningfully to net zero ambitions.

Greenprint's Objectives and Project Aims

The UK's commitment to net zero by 2050 places increasing pressure on the transport sector, which contributes over a quarter of national emissions. Recognising the need for new behaviours, technologies and system-wide approaches, SGC and WSCC set out to explore how highways green assets can contribute to decarbonisation, biodiversity enhancement and operational efficiency.

Developed as a whole-system, circular model, Greenprint transforms verge biomass from a waste stream into a valuable resource. Using data-driven modelling and innovative processing techniques, the project aimed to demonstrate how local highways operations can reduce emissions, lower costs and increase environmental value. Further background is detailed in the Greenprint Outline Business Case (2022).

To achieve this, the project undertook a Whole Life Cycle experimental trial to recycle and add value to verge biomass generated through WSCC and SGC's highways maintenance activities. The work focused on four core aims:

1. **Verify technical and commercial viability** and develop a Business Case to support future scale-up and business-as-usual integration.
2. **Establish repeatable processes and protocols** to create a practical blueprint for other authorities managing green-estate biomass.
3. **Test the Greenprint model with five additional local authorities** to assess scalability across different operational contexts.
4. **Share learning and insights widely** to support sector-wide understanding and accelerate adoption of circular approaches to biomass.

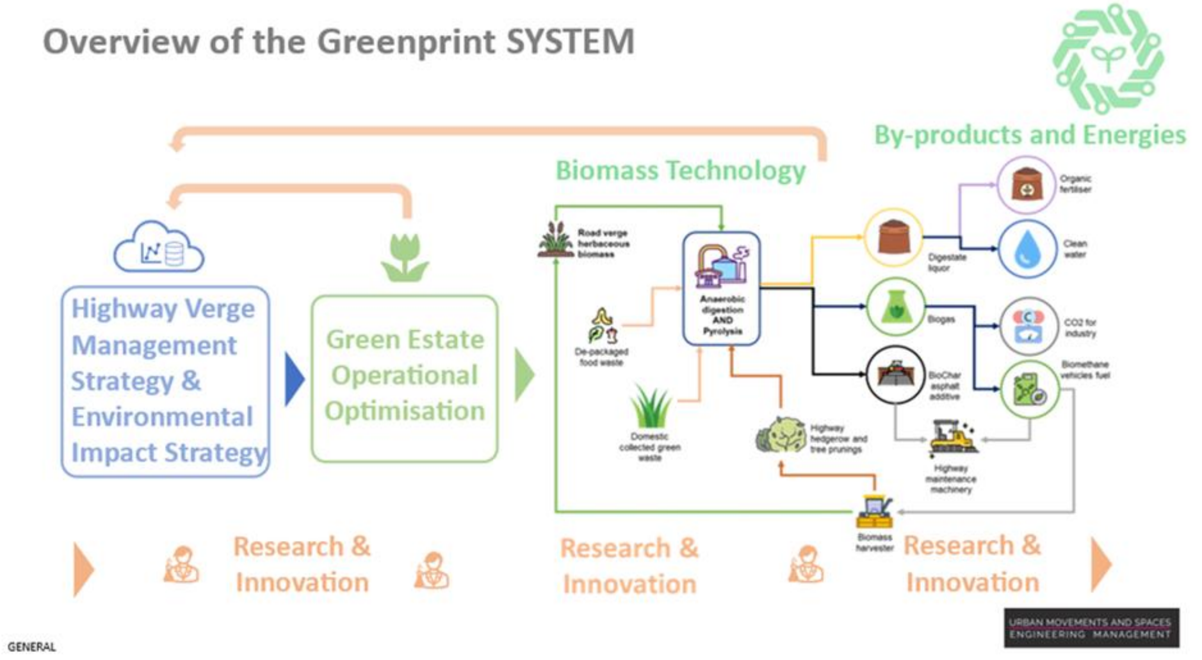
Project's Scope and Outlined Deliverables

During project initiation the partnership involved in Greenprint agreed the following scope and deliverables:

1. Deliver a fit-for-purpose Carbon Model for monitoring the 'Greenprint' trial Whole Life Cycle. Work within the existing WSCC Carbon Monitoring Framework and innovations were needed to produce a credible model of monitoring direct carbon emissions and the potential for 'insetting' emission reductions.
2. Review and restructure the operation for Highway verge management with the view to Whole Life Cycle management including:
   I. Regime, technology and processes
   II. Plants and materials
   III. Infrastructures and logistics, including storage and transport of Bio-carburants and by-products
3. Research and improve the pre-favoured biomass technology (Hydrothermal Carbonisation + Anaerobic Digestion) with the view to derive direct applications in a local circular economy, including:
   I. Confirm and validate the pre-favoured technologies with laboratory and in-situ trials
   II. Identify other 'innovations': Evaluate and undertake trials (this is unknown yet and will be delivered through an Agile process)
   III. Define and evaluate the use of Bio-carburants and by-products
4. Build an economic and benefits case of the Whole Life Cycle of the trial suitable to extrapolate for various pre-defined scenario/options.
5. Produce a fit for purpose Environment Impact Assessment or suitable Environment Assessment.
6. Review and propose legislative temporary or/and permanent changes to remove hindrance against the Whole Life Cycle trial and future applications.
7. Monitor, evaluate, verify and establish a full System for the Whole Life cycle (Blueprint).
8. Produce an Equality Impact Assessment fit for purpose.
9. Communicate and coordinate the trials' progress and results.

Structure and Key Information of the Greenprint "System"

The Greenprint project is designed to test innovative, scalable methods for reducing carbon emissions, improving biodiversity and optimising costs across both urban and rural green-estate management. By examining every stage of the Green Estate system, the project trials more efficient and sustainable practices across four core process areas:



1. Highways Maintenance Strategy

This process defines how often and when the green estate is maintained. It represents one of the largest opportunities for the local authority itself to reduce CO_2 its own emissions and operational costs, particularly when aligned with Plantlife's verge management guidance, which closely supports Greenprint objectives. However, changes to maintenance regimes are highly visible and can be sensitive in terms of public perception. Whether adjustments are gradual or more transformative, they require clear communication, public support and political leadership. Short-term carbon benefits may be reduced if grass cuttings are composted rather than converted into long-term sequestration products.

2. Green Estate Maintenance Operation Optimisation

This process focuses on machinery selection, operating practices, transport logistics and their impact on costs and emissions. Challenges have emerged around machinery efficiency and the complexity of collection logistics, both of which significantly influence viability. If efficiencies or new income streams (e.g., monetised environmental benefits or valuable by-products) cannot offset these costs, the overall model may be difficult to sustain. Transport is particularly critical for both cost and emissions reduction. Mitigation options, such as *in situ* -storage, can be modelled to identify the most efficient approach. Any operational changes must also align with local authority structures, existing contracts and TUPE obligations to ensure smooth implementation.

3. Biomass Technology

This process identifies the most effective technologies for converting biomass into sequestration products, green energy and other valuable outputs. To close the verge/highways loop and streamline delivery, responsibilities were split between the authorities: SGC focused on anaerobic digestion (AD), while WSCC explored pyrolysis and hydrothermal carbonisation (HTC).

4. By-Products and Energy Use

The final process area evaluates how biochar and AD-derived gases and other outputs can be used most effectively to maximise carbon savings and financial return. Greenprint's- priority is to support a circular highways economy, examples include using biochar in road material blends or biomethane to fuel maintenance vehicles. A central requirement is seeking sufficient commercial value to offset the capital and operational costs associated with collection and processing.

Project Review

Process 0: Initiation

1. Strategic Alignment

The council demonstrated strong commitment to Greenprint by submitting the proposal to the Live Labs 2 programme, signalling clear political support for an ambitious innovation project. As delivery began, it became evident that existing governance arrangements and in-house resources were not configured for a programme of this scale. Acknowledging that local authorities are not typically resourced to run intensive innovation projects, a dedicated delivery team was formed to lead the work while integrating closely with existing service teams.

To maintain strategic alignment and secure organisation wide buy-in, we strengthened internal engagement across senior leaders and operational teams. A Project Charter established roles and expectations, while regular updates and concise briefings, kept decision-makers informed and supported the transition towards business-as-usual. Additional- briefing notes were issued to senior managers and local members to ensure continued visibility.

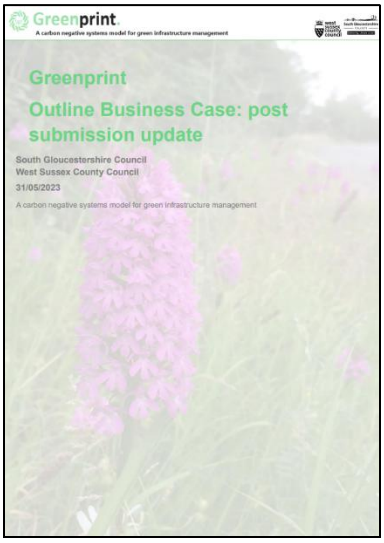
A Project Initiation Document (PID) was approved in December 2023, setting out the project objectives, scope, deliverables and governance. In January 2024 a Partnership Agreement and an Accountable Body were signed between SGC and WSCC, for the purpose of managing, commissioning and delivering the project within their respective administrative boundaries in accordance with the Strategic Outline Business Case approved by DfT. The parties agreed that SGC should act as the project accountable body to receive grant funding and manage distribution of payments to deliver against agreed project costs.

In so doing, WSCC appointed SGC to discharge the functions for this purpose, pursuant to and subject to the provisions of the Local Government Act 1972, the Local Government Act 2000 and the Local Authorities (Arrangements for the Discharge of Functions) (England) Regulations 2012.

2. The Business Case

The business case for the Greenprint Project in both WSCC and SGC was robust, strategically aligned with broader business objectives, and demonstrated clear commercial potential value as a minimum requirement. Although it is challenging to precisely price the entire system, given the complexity of capital investments, internal changes required within the highway team, and potential public perception impacts.

We strongly recommend investing in the development of a comprehensive Business Case to underpin and support the project plans. Additionally, it is essential to incorporate social and environmental values into the overall cost assessment to reflect the full scope of the project's impact. Numerous specialised firms, both large and small, are available in the market to provide expert assistance in preparing a Business Case.


Greenprint.
A carbon negative systems model for green infrastructure management

Greenprint
Outline Business Case: post submission update

South Gloucestershire Council
West Sussex County Council
31/05/2023
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Greenprint Outline Business Case

Process 1: Highways Maintenance Strategy

1. Planning the Change of Highway Verge Maintenance Regime Set Up

To effectively implement a cut and collect maintenance regime, we assembled a team of knowledgeable personnel, including both in-house staff and external contractors.

Engaging recognised specialists, such as Plantlife, can provide valuable guidance throughout this process (see Plantlife's best practice guide: Managing Grassland Road Verges). Operational plans, equipment, labour and contracts must then be developed to reflect the new management regime, incorporating adjusted cutting frequencies, schedules, and specific requirements for the cut-and-collect method. A phased, gradual rollout is advisable, beginning with parishes that support biodiversity initiatives, and expanding through a carefully planned and agreed programme.

It is important to protect areas of high ecological value by adopting bespoke cutting regimes, often involving reduced cutting or no cutting except when beneficial for conservation. Cutting should be avoided during sensitive periods, such as bird nesting seasons, especially when managing scrub areas, and invasive plant species should be properly controlled. Additionally, safety and aesthetic considerations are critical, as cut-and-collect maintenance tends to result in neater verges that are popular with the community, reduce litter, and improve drainage.

1. Site Selection and Characteristics

Before considering moving from a cut-and-drop model to cut-and-collect, it is essential to carry out an inventory of the council-maintained plots to guide selection, along with an accessibility survey to ensure that the selected machinery can operate efficiently in narrow, inclined, or remote locations. Experience shows that such constraints often reduce the proportion of the total area suitable for cut-and-collect operations; in WSCC 100% of the selected maintenance area met these criteria, including a mandatory one-metre safety cut on verges in some locations.

In our case, both authorities established a comprehensive and detailed inventory of the area (plots) to be maintained. There were areas that could be immediately ruled out - for example green spaces used for recreation where frequent cutting is essential. Asset-mapping records categorising the plots should be scrutinised and filtered to enable focus on the most suitable plots. There is no one-size-fits-all approach to plot selection and typical considerations that drives decision-making includes:

- **Accessibility** - ease of access for collection vehicles and machinery.
- **Size of plot** - larger plots are often more viable for cut-and-collect due to economies of scale.
- **Proximity to processing facilities** - sites closer to processing locations reduce transport time and costs.
- **Traffic and safety considerations** - verges near busy roads may be unsafe or require costly traffic management measures.
- **Ground conditions** - Poor drainage or uneven terrain can make collection difficult or damage machinery.
- **Biodiversity value** - Sites with wildflowers or high ecological value typically benefit more from cut-and-collect to reduce soil fertility.
- **Public use and visibility** - High-visibility areas may be prioritised for aesthetic reasons.
- **Partnership opportunities** - some areas may allow for potential collaboration with parish councils or local environmental groups to manage verges and enhance biodiversity.

SGC Site Selection

Before the Live Labs programme, work had already begun in SGC to investigate transition of verge management to a ‘cut and collect’ approach. A project was launched to assess how changes in grass management could enhance biodiversity, deliver carbon benefits, and improve climate resilience. Consultants were commissioned to survey all council-maintained grass between March and May 2022, classifying plots against four key criteria:

- **Operational practicality** (ease of maintenance)
- **Safety requirements** (e.g., visibility cuts)
- **Biodiversity potential**
- **Level of public use**

Only plots scoring 75% or higher for operational suitability were considered for inclusion. Engagement with local stakeholders, including parish or community councils, was critical to confirming final plot selection. An example of the scorecard can be found below:

Road Name	Heath Road Hanham
Parish	Hanham Abbots
Area	262.2842486
Date Surveyed	26/05/2022
Operational Considerations: % Area suitable for changed maintenance	75%
Operational Considerations: H&S restrictions - Are Road Safety Considerations Relevant? (Would changes impact road safety?)	No
Operational Considerations: How would changes impact road safety?	-
Operational Considerations: Width of Verge or Public Open Space Area	Suitable for small machinery
Operational Considerations: Can you access the site with a machine / vehicle?	Yes
Operational Considerations: Is there an area to pull up safely and enter site?	Yes
Operational Considerations: Is there an access gate?	Not relevant
Operational Considerations: Gradient - Could you operate machinery on the terrain?	Moderate gradient (no concern)
Operational Considerations: Are there any on site obstructions restricting operations? (e.g. trees / street furniture / utility cabinets)	Yes
Operational Considerations: Can machinery be operated around the obstructions?	Yes - Small Machinery
Indicators of Biodiversity: Are there any hedges on the site?	No
Indicators of Biodiversity: Are there any ditches on the site?	No
Indicators of Biodiversity: Are there any stone walls on the site?	Yes
Public_Use: Are there any informal footpaths visible on the site?	No
Public_Use: Substantial litter found on the site?	No
Notes	residents park on grass

Figure 1: Example scorecard for a verge in SGC.

Over the course of the Greenprint project, in SGC approximately 36 hectares were trialled under the cut-and-collect model, out of a total of 473 hectares of council-maintained grass. Scaling up will require:

- Continued evidence-based selection of suitable plots
- Early and transparent engagement with local authorities and councillors
- Clear communication of benefits, costs, and maintenance changes

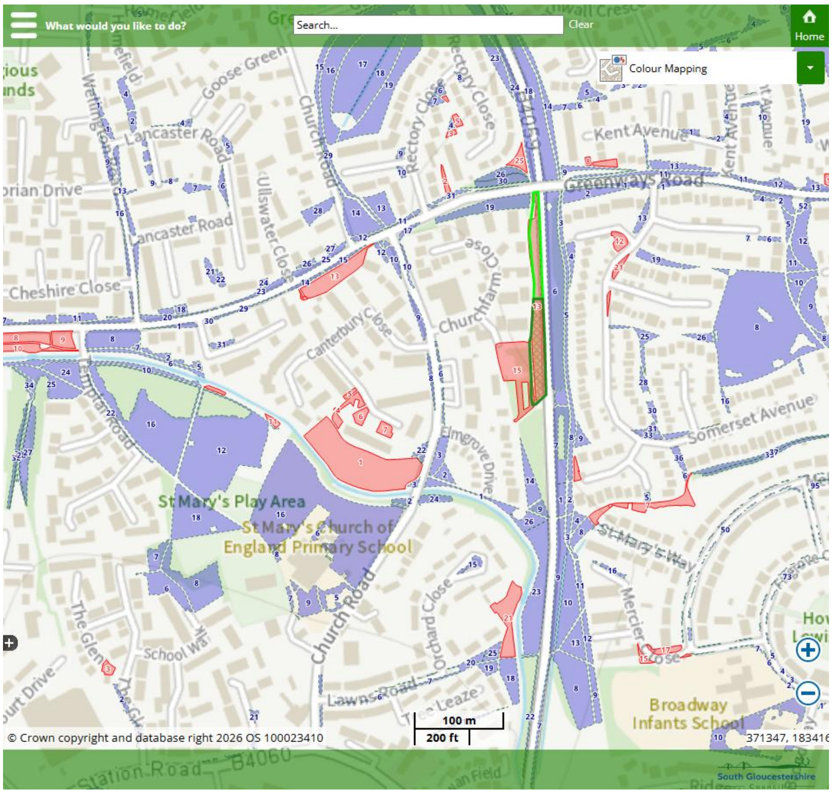


Figure 2: An example of selected area within SGC

WSCC Site Selection

From a WSCC perspective, we selected the Greenprint trial locations by focusing on whole Parish areas rather than individual verges. This approach allowed us to understand how the model operated at a parish scale and ensured consistency across the trial zones.

The Parishes chosen were those closest to operational bases at Drayton and Rudgwick, which helped minimise transportation distances for crews and equipment. This was an important consideration both for efficiency and for reducing the environmental impact associated with travelling between sites.

Selecting locations around these bases also provided the opportunity to test the Greenprint approach in a mix of environments, an inland area around Horsham and coastal areas including Pagham, Bersted and Aldwick. This geographic diversity was valuable in helping us understand how the model performed across differing conditions and community contexts.

Horsham was an especially strong candidate because of its active and engaged environmental community, who were keen to participate in and support the project. Their involvement provided helpful local insight and community alignment with the project goals.

In addition, WSCC already held mapped data for urban verges within asset management system (Confirm) prior to the Greenprint project beginning. This existing dataset meant we could easily identify, validate and integrate the relevant verges within the selected Parish boundaries, ensuring the trial could be mobilised efficiently.

Figure 3: An example of selected area within WSCC

Over the course of the Greenprint project, in WSCC approximately 61 hectares were trialled under the cut-and-collect model, out of a total of 465.88 hectares of council-maintained grass.

Key lessons learned:

1. **Data-driven site selection is essential** - surveying and scoring plots provides an objective basis for decisions and helps reduce disputes.
2. **Operational feasibility can be a limiting factor** - not all areas are suitable for alternative maintenance, even if they score well on biodiversity potential.
3. **Scaling requires political and community support, not just technical evidence** - local adoption depends on trust, understanding, and visible early success.

3. Engagement / Winning Minds Over

Effective public engagement is critical when introducing approaches such as cut-and-collect or reduced-cut regimes. Early, consistent communication builds trust, increases transparency and helps resolve concerns before they escalate, reducing delays, complaints or legal risk. Engagement should be supported by dedicated resource for both proactive outreach and responsive communication, tailored to local community needs.

We recommend appointing a Public Liaison Officer (PLO) for at least six months during the transition period, supported by the wider communications team. The PLO acts as the main link between the project and the public, providing updates, coordinating events, gathering feedback and helping to co-develop solutions that minimise disruption. This hands-on role consistently improves understanding and yields insights that strengthen scheme delivery.

Additional change-management activity, such as planning, stakeholder mapping and producing communication materials, can be delivered in-house or by contractors depending on capacity and scale.

Best practice from similar programmes highlights five principles for effective engagement:

1. **Start early and engage iteratively** to build understanding and secure buy-in, especially where service levels or budgets may change.
2. **Communicate clear, benefit-led- messages** focused on biodiversity gains, carbon reduction and long-term cost savings.
3. **Use inclusive, multi--channel outreach** to reach diverse community groups, including those less likely to engage through traditional methods.
4. **Measure and adapt** using clear success metrics and continuous feedback from both qualitative and quantitative sources.
5. **Collaborate with partners** including neighbouring authorities and private sector organisations to share costs, expertise and ensure a consistent biomass supply.

The PLO role must be embedded within the project, not treated as an add-on, with engagement and communications plans fully aligned to ensure coherent messaging and consistent approvals.

As part of the Greenprint engagement programme, browser-based maps were shared with all participating parishes, created using the Council's GIS system. These simple tools allowed parishes to view local cut-and-collect plots via a single link, enabling more informed discussions and quicker resolution of concerns. For example, in areas used for recreation, the map helped explain why a maintenance strip was retained along popular walking routes.

Finally, results from the National Highways and Transport (NHT) Survey for WSCC and SGC provided valuable insight into public attitudes toward highways services and climate-related actions. These findings demonstrate strong public support for environmental improvements and further justify investment in communication and engagement.

4. Contractual Implications and Legal Planning

Transitioning to cut-and-collect has direct implications for existing contracts and employment legislation. Whether verge maintenance is delivered in-house or by contractors, changes must be reviewed for compliance with current agreements and TUPE regulations. In some cases, adopting cut-and-collect may not be feasible within existing contractual frameworks. Early engagement with procurement, HR and contractors is essential.

Process 2: Green Estate Maintenance Operation

Process 2 covers verge-management operations, including cut-and-collect, identifying process improvements, and supplying biomass to Process 3. Across the UK, local authorities manage verge maintenance in a variety of ways. Some outsource delivery to external contractors, while others operate in-house teams through direct service organisations (DSOs). Because these operational models differ significantly, affecting budgets, processes, cultures, accountability and flexibility, it was essential that the Greenprint project worked with two authorities using contrasting approaches. This ensured the project could fully understand the range of practical challenges and opportunities that local authorities may face when adopting cut-and-collect or bioeconomy-focused maintenance methods.

1. Organising and Mobilisation of the Highway Teams

WSCC - Contractor Delivered Model

Verge maintenance in WSCC is delivered under contract by Grasstex Ltd, operating a conventional five cut-and-drop schedule. From the outset, Greenprint worked closely with Grasstex to secure their full involvement, recognising that their operational expertise and on-the-ground knowledge was critical to the project's success.

To avoid conflict with the commercial contract, the Greenprint trial was managed as a separate operation, with a clear mechanism in place to ensure participation did not have a detrimental financial impact on Grasstex. This approach has shown how cut-and-collect can be integrated into contract-based service delivery, highlighting the contractual, commercial and operational changes that may be needed elsewhere in the UK. To apply it, authorities must first define precise requirements - such as number of cuts per year, maximum intervals between cuts, handling and transport of arisings, and contract length. Current contracts may need pricing renegotiation based on insights from the Greenprint project, and where insufficient time remains for contractors to acquire new equipment, a new procurement may be required. Ultimately, feasibility depends on individual contract terms and the willingness of parties to agree necessary changes.

SGC – In-House (DSO) Model

In contrast, SGC Council delivers its verge work internally through the Grounds Services division of StreetCare, operating as a direct service organisation (DSO). Maintenance of amenity grass is delivered under an established Service Level Agreement (SLA), with areas mapped within the Council's GIS layers as "Amenity Grass" in the wider "Council Maintained Grounds" dataset. These areas are defined as accessible grass not designated as fine turf or conservation, suitable for rotary or flail mowing.

The SGC Grounds team nominated a dedicated group of trained operatives to lead the cut-and-collect operations. These staff were engaged from the beginning, shaping decisions on plot selection, management approaches and machinery use. Their practical insight and local knowledge was instrumental in refining techniques and ensuring each site was well understood throughout the trial.

Why This Dual Model Approach Was Important

Working with both a contractor-delivered model (WSCC) and a DSO model (SGC) allowed Greenprint to:

- Understand the operational realities of implementing cut-and-collect in very different organisational structures.
- Identify contractual and commercial barriers that authorities using outsourced delivery may face.
- Explore how in-house teams can adapt operational practices, build capacity and embed new approaches.

- Capture a broader, more representative range of challenges, enabling the project to produce guidance and recommendations relevant to all types of UK local authorities.

This dual authority approach ensures that Greenprint's insights, tools and recommendations are applicable across the sector - regardless of whether verge maintenance is outsourced, delivered internally or operates through a hybrid model.

2. Training of the Gangs

The gangs with existing grass-cutting experience received familiarisation training on the new cut-and-collect mowers, delivered by the supplier. In WSCC they were also trained on the software used to record daily operational data. This activity was carried out manually in SGC. Crucially, the teams were involved from the outset - helping to identify which plots to cut, understanding the specific requirements of each site, and contributing their practical knowledge to the design of the operational approach.

Supervisory staff from the contractors were on-site at the start of each cutting season to ensure the gangs operated efficiently, balancing cutting speed with the required quality of finish. In SGC, operational records were kept manually as staff were not equipped with tablets that linked with the Council's existing asset management software. It is possible that recording data manually reduced operational efficiency due to the time each team member spent on completing daily returns. There may have been greater potential for errors and omissions in the data too - although no specific examples of this have been identified.

3. Infrastructure Preparation

The efficiency of the cut-and-collect operation in both authorities depended on securing suitable local sites to store grass cuttings before bulk transport for processing, as well as preparing the necessary infrastructure for new equipment. During the Greenprint trial, WSCC used the Drayton depot and the contractor's depot at Rudgwick, both within 10 miles of the trial areas. For future business-as-usual operations, WSCC would endeavour to eliminate double-handling of arisings to further improve efficiency and reduce costs.

To support low-carbon operations in 2025, a 3500-litre bunded HVO fuel tank was installed at Rudgwick for use by vehicles and mowers, alongside upgrades to depot infrastructure to accommodate the new machinery and temporary storage needs.

In SGC, the main StreetCare depot in Yate acted as the operational hub, supported by satellite depots in Patchway and Kingswood. Ride-on mowers were based at these satellites when working in distant parishes, but all cut grass was transported back to Yate for tipping, typically once per day via tractor and hook-lift trailer. As with WSCC, infrastructure planning was essential - not only for equipment deployment but also for safely holding collected grass before processing.

4. Machinery Selection and Procurement

Once the new Highway Verge Maintenance Regime Plan was established and the area's geographical and topographical constraints were assessed, we carried out a market survey of both urban and rural cut-and-collect mowers. The resulting inventory, along with practical information on each machine (Inventory and Pre-selection of Machineries), is provided in Appendix B. This list was first compiled in 2022 and updated over three years but should not be considered exhaustive.

The challenge of procuring the most suitable machinery in innovation projects cannot be underestimated. Equipment cost, maintenance requirements and expected lifespan must all be factored into decisions.

WSCC purchased machinery directly and allowed Grasstex Ltd to operate it on their behalf. In SGC, selection and procurement of the cut-and-collect equipment was carried out by the Council's Fleet Operations Manager who devised equipment specifications and issued a tender via an existing framework to provide purchase options in a compliant manner.

The selected out-front flail mowers were chosen by WSCC based on operational experience and manufacturer guidance. This configuration proved most effective for dealing with long, wet grass and delivered a cleaner finish than rotary decks, which tend to discharge cuttings outward and struggle in wet conditions. Rear-wheel steering supported navigation around street furniture, while high-lift tipping boxes enabled easy emptying into trailers and van-mounted systems.

In SGC three Iseki SF5 ride-on mowers, a hook-lift trailer and three skip containers were purchased, and their performance was monitored throughout their operational life, including servicing requirements and associated equipment costs.

5. Learnings on Machinery Used in Greenprint /QA System

Mower reliability was a significant issue across both WSCC and SGC operations. In WSCC, the cut-and-collect machinery had been purchased with the expectation that it would manage urban verges without difficulty. However, problems emerged immediately: one unit showed an oil leak on delivery, and during the 2024 season the mowers began to fail with increasing frequency. Breakdowns were attributed to build-quality and technical faults rather than operator error. A meeting with the dealer (Gaskins) and Kubota UK was held, during which Kubota suggested the machines were being pushed beyond their intended capability. WSCC disagreed, noting that the equipment should be robust enough to handle the grass conditions. Kubota subsequently provided complimentary servicing and committed to on-going monitoring through Gaskins.

Despite this, the 2025 season followed a similar pattern. Machines failed in rotation, one would be repaired only for another to break down, at times leaving only a single mower or the back-up Amazone unit operational. The Kubota ride-on proved overly complex and insufficiently robust for long, wet grass, while the initial Grillo mowers also struggled and required replacement. Some staff turnover further affected continuity of operation.

SGC experienced an equally wide range of mechanical failures. Common issues included bent or broken blades, split air-intake pipes, damaged collection boxes, punctures, and failed jockey-wheel arms. Failures also occurred on the flail deck, including broken plates, arms and belt tensioners, as well as a snapped crankshaft. Additional problems included jammed mulching plates, broken shear pins, and the need to replace anti-scalp wheels, covers, brackets, hoses and chute components. These issues aligned with broader design weaknesses seen across the fleet, such as failing lift arms, undersized chutes, broken welds and generally poor durability, often resulting in machines being out of service for extended periods.

Battery-powered equipment also delivered mixed results. Electric blowers performed reliably, but electric strimmer's lacked the necessary power for routine operations.

By the end of 2024, it had become clear that the volume and severity of machinery failures were contributing more to operational costs than originally anticipated. As a result, Grasstex trialled an alternative approach for certain sites. Further details are provided in Appendix C: Flail & Tractor Proof of Concept.

6. Logistics

In WSCC, four transit tipper vans and four tipping trailers were purchased to enable the cut-and-collect machines to be moved around the county and carry the grass cuttings back to the depot or disposal point. The van-trailer combination was split - two in the Horsham area and the other two working from the Drayton depot covering the southern parishes.

The methodology of the van-trailer combination worked well with the format of deploying the equipment, collecting and transporting the cut grass back to the depots - but this could have been more efficient if the grass was being disposed at the treatment site rather than being moved to the depot to then be collected by a grab lorry and taken to windrow composting facility. Again, transport and disposal costs are impacting the true cost to deliver this service effectively.

The use of HVO diesel was implemented in WSCC during the 2025 season to help reduce the carbon emissions for the service - this fuel type was used on both the mowers and the vans. The project team was aware that HVO is a more expensive form of fuel with issues around provenance / certification (as some HVO is created from palm oil). Assurances were therefore sought and made that this fuel came from a sustainable source and likely to be derived from maize.

In SGC, the BigAb 12 tonne tandem axle hook-lift trailer and three containers were purchased to test a different logistics system. Mowers were driven to the cut site and typically three of them worked simultaneously to fill an empty container placed centrally by the tractor. Upon arrival at site, drivers divided the cut site into three equal or optimal sections for each mower, minimising overlap and ensuring no areas were missed. Any visible litter was collected and bagged beforehand, by the mower crew. Full containers were transported back by tractor to the main operational depot in Yate, (typically one full skip per day) - for onward, weekly transport to a commercial AD plant.

7. Challenges

Across the project, several operational, equipment-related and data-management challenges affected efficiency, timelines and overall outcomes. While cut-and-collect proved achievable in urban areas, the machinery required was costly and delivered lower productivity than cut-and-leave operations. This is evidenced later in this report.

Operational Challenges

In WSCC staffing shortages reduced available crews and delayed the final Horsham cut to late December. Operatives initially struggled to adapt to new equipment and methods, leading to mower blockages and inconsistent cutting. Weather significantly influenced grass length, cut quality and tonnages:

- 2022: drought meant minimal growth
- 2023: very wet spring/summer meant delays, poor ground conditions, frequent blockages
- 2024: improved spring
- 2025: dry spring

Wet conditions also accelerated decomposition of stockpiled grass in the storage sites.

In SGC, although no staff shortages were experienced, the weather resulted in much less vigorous grass growth in 2025, which generated less than 60% of the tonnage collected in 2024 - resulting in a much higher cost per tonne of feedstock for processing.

Equipment Performance

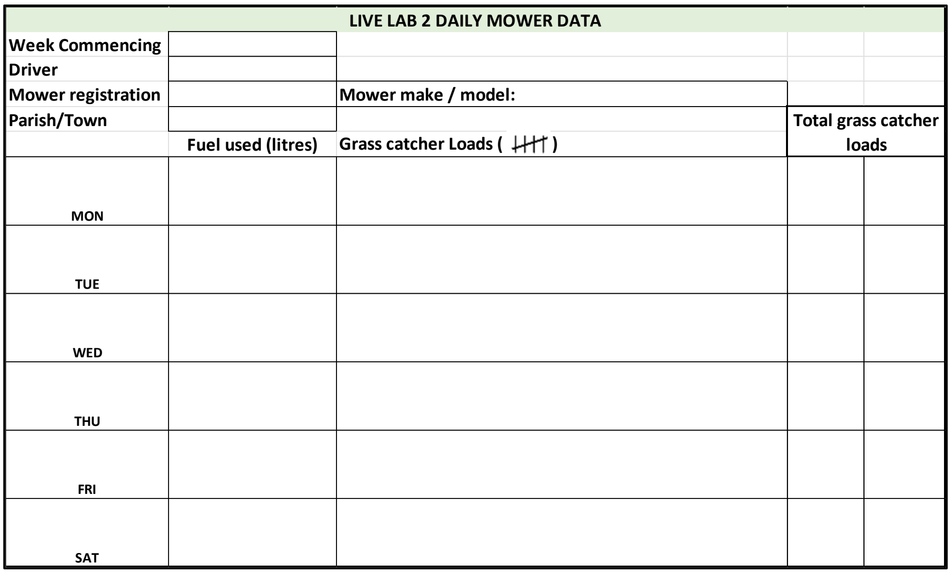
Mower reliability was a major issue. Frequent breakdowns stemmed from design weaknesses, failing lift arms, undersized chutes, broken welds, and poor durability, resulting in machines being out of service for weeks. In WSCC, Kubota ride-ons proved overly complex and not robust enough for long, wet grass. The initial Grillo mowers also struggled and required replacement. Some staff turnover also affected continuity.

Battery-powered tools performed inconsistently: electric blowers worked well, but electric strimmer’s lacked sufficient power.

Data-Management Challenges

Data recording in WSCC presented several early challenges, including inconsistencies caused by multiple staff entering information and occasional tablet failures that required retrospective updates.

In SGC paper proformas were designed and distributed to mower teams with an explanation from the supervisor on what data was needed and how to record it on the form. An example is shown below:



LIVE LAB 2 DAILY MOWER DATA				
Week Commencing				
Driver				
Mower registration		Mower make / model:		
Parish/Town			Total grass catcher loads	
	Fuel used (litres)	Grass catcher Loads (𝍸)		
MON				
TUE				
WED				
THU				
FRI				
SAT				

Figure 4: Blank daily sheet completed by mower drivers

Although weighbridges were available, weighing every load daily was impractical and would have caused major efficiency losses. Instead, both authorities focused on transporting full loads, with total seasonal tonnage in SGC derived from weighbridge tickets. Dividing this by the number of filled collection boxes provided an average box weight. Daily records of box count per location allowed estimated weights to be calculated by multiplying box numbers by this typical weight. This approach smoothed moisture-related fluctuations but reduced the granularity needed to compare growth rates between areas and months.

Limited Trials and Adaptation

Several planned trials were reduced or deferred, and variations in cutting frequency (from two to five cuts per year) produced markedly different operational outcomes. Less frequent cuts resulted in longer grass and slower progress, whereas more frequent cuts seemed to improve machinery efficiency through reduced mechanical strain. A short trial in both councils using a compact tractor with a flail cut-and-collect attachment demonstrated greater reliability but lacked the manoeuvrability required in urban environments with extensive street furniture and parked vehicles. Nonetheless, the equipment performed well in larger open spaces and is more suited to rural verges, parks, and sites maintained on an annual cutting cycle.

8. Lessons Learned

1. **Improving Recruitment and Workforce Planning:** Streamlined hiring processes and competitive wages are essential to minimise workforce gaps. Early and on-going training programmes should be implemented to enable operatives to adapt quickly to new equipment and operational methods.
2. **Reducing Equipment Downtime:** A preventive maintenance programme and adequate spare parts inventory are critical to minimising operational disruptions. Engagement with manufacturers is recommended to drive improvements in equipment design, durability, and reliability.

3. **Enhancing Data Collection and Accuracy:** Standardised data entry protocols and automated validation tools can improve data consistency. Assigning a dedicated data officer to oversee the collection process ensures greater reliability in reporting.
4. **Equipment Selection and Maintenance:** Early trials demonstrated the need for mowers capable of handling long grass; investment in more durable models, such as the Iseki SF5, has proven beneficial. Regular maintenance schedules and the availability of back-up units and spares will be necessary to prevent extended delays caused by equipment breakdowns.

Process 3: Biomass Technology

This section summarises the evaluation of biomass conversion technologies specifically hydrothermal carbonisation (HTC), pyrolysis, and anaerobic digestion (AD). The assessment examined technical feasibility, operational constraints, economic viability, and potential contributions to circular economy and carbon sequestration objectives.

1. Hydrothermal Carbonisation (HTC)

The project explored hydrothermal carbonisation (HTC) as a potential pathway for converting various biomass feedstocks into value-added products. HTC offers a promising approach for processing wet feedstocks, producing hydrochar and useful by-products such as heat and process liquids.

The initial strategy focused on processing the following feedstocks through HTC:

- Wet road verge biomass
- Kerbside-collected green waste
- Anaerobic digestion (AD) fibre

The goal was to produce hydrochar that could be:

- Further upgraded into biochar, or
- Used as a bitumen extender in road construction applications

In addition, the HTC liquid by-product was intended for further anaerobic digestion (AD) processing, while residual heat generated from the process would be sold to the grid.

While HTC remains technically feasible across all three targeted feedstocks, several practical and economic challenges emerged during assessment and testing:

- Economic viability: The high capital investment required for HTC infrastructure renders the process economically unattractive under current market conditions.
- Revenue limitations: The lack of significant gate fees for road verge biomass and kerbside green waste further reduces financial viability, limiting the potential for cost recovery and return on investment.
- Unstable biochar in the case of pure grass

Collectively, these factors demonstrated that, despite its technical potential, HTC does not currently offer a sustainable or commercially viable route for biomass conversion within this project's context.

Based on these findings, the project team decided to exclude HTC as a primary pathway for biomass conversion. Nevertheless, a single large-scale batch of road verge biomass was processed via HTC to demonstrate technical feasibility and generate operational data to inform future research.

2. Pyrolysis

Pyrolysis was assessed as an alternative and complementary pathway to hydrothermal carbonisation (HTC), with the aim of evaluating its technical feasibility, economic potential, and carbon-reduction benefits. The initial plan focused on converting dried feedstocks, road-verge biomass, forestry waste and AD fibre, into biochar, liquid fuels, gas, and usable heat.

Compared with HTC, pyrolysis proved more economically viable and technically robust, offering lower capital costs, higher biochar yields with greater carbon stability, and greater flexibility in accepting mixed feedstocks, including material containing plastics.

However, several constraints required refinement of the original approach.

- AD fibre is currently unsuitable due to low-cost land-spreading
- Road-verge biomass from WSCC alone cannot supply sufficient volume for a stand-alone facility, and wider sourcing would incur prohibitive transport costs.
- Forestry waste is available only in limited quantities locally.

Seasonal variation in grass cuttings also challenges year-round utilisation; a 10,000-tonne-per-year plant would require supplementary winter feedstocks.

Further analysis showed that gaseous and liquid by-products are generated in small volumes and require costly purification for external use. Consequently, all gases and liquids are combusted on-site, and excess heat is recycled for drying feedstock, leaving no surplus energy for export.

Based on updated technical and economic findings, pyrolysis of combined grass and green waste has been identified as the most viable long-term conversion route. WSCC data confirms adequate local green-waste supply to complement seasonal grass cuttings, enabling continuous operation and supporting circular-economy and carbon-sequestration objectives.

In addition to using biochar in road-building materials, the project will also undertake a large-scale biochar burial trial to test higher-volume carbon storage potential in soils, providing evidence for future carbon-removal initiatives. Refer to Appendix D for LCA and TEA commercial scale up of biochar production.

Further technical details, testing results and Business Case are available in **Appendix E** and the **WP3 End of Year 2 Report.**

Greenprint

Year 2 Final Report

South Gloucestershire Council
West Sussex County Council

31/03/2025

[Greenprint Year 2 Final Report]

3. Anaerobic Digestion

In 2023, household food waste in SGC was collected weekly under the long-standing PFI contract with Suez, which also operated the district's recycling centres and waste transfer stations. Food waste was taken to the Sort It recycling centres and then processed via AD at Geneco's Avonmouth plant. Early discussions indicated that the Yate Sort It centre could also accept grass cuttings from the Greenprint pilot for co-mingling with food waste. However, regulatory delays linked to Ofgem's RHI and RO schemes, particularly fuel-classification and sampling requirements, made approval slow and uncertain. By late 2023, the financial and operational risks were deemed too high, and co-mingling was halted. At the same time, the Avonmouth AD plant went offline for extended maintenance, adding further uncertainty.

Grass was initially diverted to the Council's composting contractor, with 45.7 tonnes collected from the Yate pilot area in 2023. In 2024, after further testing, grass collected from within 7 parishes was delivered to Cannington Bio Energy near Bridgwater, an approved AD facility able to accept grass as a single feedstock. A short co-mingling trial at Cannington failed due to blockages caused by long, fibrous grass, and all subsequent loads were supplied as grass-only. Storage bunkers were installed at the Yate depot to support this process.

Further discussions with Geneco in early 2025 explored renewed co-mingling options, but their partner plant, Evercreech AD, declined due to contamination risks. Grass continued to be sent to Cannington until April 2025, when a contaminated load caused another blockage. Deliveries were then redirected to Charlton Park Biogas in Wiltshire, transported by a biomethane-powered vehicle, where processing continued until October 2025.

4. Contractual & Regulatory Considerations

Pyrolysis Considerations

UK regulations currently restrict both allowable feedstocks for biochar production and land-application rates (capped at 1 t/ha/year under EA LRWP 61). Research from the Biochar Demonstrator indicates that total application amount, not annual rate, is the more important factor, for arable land with no negative soil impacts observed up to 20 t/ha. Another key factor is feedstock costs making tree trimmings and green waste potentially attractive. These findings informed the Independent Greenhouse Gas Review, supported by contributions from the project team and recent policy work.

Anaerobic Digestion Operations

Verge cuttings are classified as waste under the Environmental Permitting (England and Wales) Regulations 2016. They are typically coded as EWC 20 02 01 (biodegradable waste from parks and gardens), though EWC 20 03 01 may apply where litter or contamination is present. Once removed from site, verge cuttings must be transported, stored and treated as waste.

Because verge material is highly variable, acceptance criteria must be established before it can be used as feedstock at permitted treatment facilities such as AD or composting sites. Concerns include heavy metals, tyre-derived microplastics and other contaminants, which may compromise the quality of compost or digestate applied to land.

The Environment Agency (EA) governs waste classification and permitting and requires the correct EWC code to be used with an adequate description:

- EWC 20 02 01 for verge cuttings (i.e. plant matter only) from the A road, free of litter or other material
- EWC 20 03 01 for separately collected litter from the verge; and
- EWC 20 03 01 if all the waste on the verge is collected up together (i.e. a mixture of the verge cuttings and litter).

For AD use, verges may require a thorough litter pick- before cutting.

In 2025, WSCC explored diverting grass cuttings from Pagham, Aldwick and Bersted to a local AD plant. Although the operator was willing, the facility did not hold the necessary EA permit to process roadside-collected grass. Obtaining a permit variation would take up to two years and involve significant cost, so the option- was not pursued for the 2025 season. The project therefore focused solely on biochar production.

AD Co-mingled with Food Waste

SGC proposed co--mingling grass with its existing food waste stream, as this offers significant efficiencies compared with treating grass as a separate feedstock (lower costs, higher biogas yields, better use of existing infrastructure, simpler logistics).

However, UK AD plants must secure approval before accepting co--mingled grass. Operators must:

1. Apply to the Environment Agency (EA) to vary their permit, demonstrating that the mixed feedstock poses no additional environmental risk.
2. Notify Ofgem by updating sustainability documentation (FMSQ, FCCQ) and, if required, recalculating emissions and biogas outputs.

No co-mingled material can be accepted until both EA and Ofgem approvals are granted. This process can take several months and may temporarily affect eligibility for renewable energy payments. For this reason, trials involving co-mingling of grass with food were not possible and grass was disposed of as a single feedstock.

5. Challenges

Key Challenges:

- Ofgem approval (FCCQ/FMSQ) created significant delays and financial risk for AD operators.
- Key AD facilities (e.g., Geneco in Avonmouth) were unavailable due to long-term- maintenance.
- Mixed or contaminated loads caused plant blockages and rejection of co--mingling trials.
- Most food waste- AD plants cannot accept unprocessed grass due to engineering and contamination constraints.
- Transport capacity and load weight- limits affected scheduling and operational reliability.
- Inconsistent feedstock quality, especially grass length, directly impacted AD processing performance.
- Lack of established markets for the biochar currently makes it difficult to provide a reliable source of income.
- Plastics present in food waste anaerobic digestion (AD) fibre reduced the effectiveness of HTC. This contamination prevented adequate moisture removal after the filter press stage. This negated the energy advantage of HTC for water removal and reduced process performance.
- Hydrochar produced at ~200°C had low stability. As a result, it could only be used as a solid biofuel, not for long-term carbon storage. Additional post-pyrolysis would be required to convert hydrochar into stable biochar.
- HTC systems require high capital investment. The process is only economically viable where high gate fees exist (e.g., sewage sludge), which is not the case for verge biomass.
- The amount of grass cuttings available locally is not sufficient to operate a commercial pyrolysis facility. A plant processing 10,000 tonnes per year cannot rely solely on grass.
- Grass could be sourced from wider areas to increase supply. However, transport costs would be very high, making the process economically unfeasible.
- Grass cuttings are seasonally available. Additional biomass sources would be required to operate the facility during winter.
- Pilot trials reported challenges with feeding grass cuttings into the processing plant. This limited the ability to continue processing during trials.
- Grass feedstock contains ~80% moisture, requiring significant drying before pyrolysis. Drying adds additional energy demand and operational complexity.

6. Lessons Learned

- Regulatory approval for changes to AD feedstock mixes is slow, complex, and often misaligned with operational needs - early operator interest does not guarantee approval.
- Co-mingling grass with food waste poses high technical, financial, and contamination risks unless the AD plant is specifically designed and permitted- for variable feedstocks.
- Long, fibrous grass is incompatible with most food waste pre--treatment systems and can damage equipment. Every AD plant is different and designed to operate in a way that best matches the feedstock characteristics and in compliance with its operational

permit requirements. Back-up disposal routes and local storage capacity are essential to avoid operational disruption.

- Pilot scale testing, resilient transport arrangements, and continuous communication with operators and regulators are critical to avoiding delays and initiating changes in regulations.
- **HTC process limitations:** HTC trials showed reduced performance when digestate contained plastic contamination, which hindered effective moisture removal. In addition, hydrochar produced at ~200 °C was not sufficiently stable for long-term carbon sequestration, requiring further pyrolysis and increasing costs.
- **Economic viability of processing technologies:** HTC was found to have significantly higher capital and operational costs compared with pyrolysis. With high gate fees, HTC is not economically viable for processing verge biomass.
- **Feedstock availability constraints:** Local grass cuttings alone are insufficient to support a commercial-scale biochar facility requiring around 10,000 dry tonnes of feedstock annually. Grass supply is also highly seasonal, creating additional challenges for maintaining year-round operations.
- **Moisture and operational challenges:** Grass cuttings contain high moisture levels (around 80%), requiring substantial drying before pyrolysis. Pilot trials also identified operational difficulties in feeding loose grass into processing systems.
- **Transport and supply chain impacts:** Transporting grass from outside the local area significantly increases both greenhouse gas emissions and production costs. Minimising feedstock transport distances is therefore critical for maintaining environmental and economic viability.
- **Preferred feedstock strategy:** Blending grass with green waste or woody biomass provides a more reliable and scalable feedstock supply. A co-mingled feedstock mix ensures sufficient material availability while improving processing efficiency.
- **Preferred conversion technology:** Pyrolysis was identified as the most suitable conversion technology for biochar production. It offers higher biochar yields, lower greenhouse gas emissions, and significantly lower production costs than HTC.
- **Biochar utilisation pathways:** Several applications for biochar were assessed, including agricultural use and road infrastructure. Using biochar as a layer beneath new roads showed the lowest lifecycle emissions and carbon removal cost among the options evaluated.
- **The lack of established markets for biochar** currently makes it difficult to provide a reliable source of income. A government-led initiative to structure the biochar market would help establish a “true” price for biochar and connect providers to users more clearly.

Process 4: By-products and Energy Use

1. Biochar in Road Trials

Our focus was on solutions that support long-term carbon reduction. We examined options for durably sequestering residual carbon, selecting biochar as a stable medium for long-term CO_2

storage. Two practical trial approaches were developed. For more information, please see appendix F.

Test 1: Biochar Incorporation in Asphalt

Biochar was assessed as an additive in bituminous materials to support carbon sequestration within highway construction. It is suitable only for the base course, as material placed in the wearing course would be lost through abrasion, and its brittle nature requires careful mixing to avoid weakening the pavement. Biochar made solely from grass cuttings was too fine and combustible, whereas mixed-biomass biochar performed acceptably. However, practical incorporation rates were limited to around 1% of the base course.

A road trial was carried in 2025 out on Old Edinburgh Road (B7001), Bellshill, North Lanarkshire, covering a resurfacing area of approximately 1,420-2,000 m^2. The site was selected through a collaboration between LL2 Projects group that includes North Lanarkshire, which was undertaking innovative materials research and trials, making it the most appropriate location to monitor our new product. Two 150 m^2 trial strips were planned using hot-mixed asphalt incorporating biochar at 1% and 2%. The works required two 20-tonne lorry loads, with a total biochar requirement of 700kg. The biochar was produced via pyrolysis of a feedstock comprising 10% grass cuttings and 90% green waste, followed by pelletising. Initial testing showed pellets did not disintegrate sufficiently during hot-mixing, leading to the development of a granular biochar derived from green waste. This material was successfully incorporated at 1% but attempts to achieve 2% were unsuccessful. Grass-only biochar was rejected due to combustion risk.

Test 2: Using biochar in road foundations and other excavations

To increase sequestration capacity beyond what is achievable through asphalt incorporation, biochar is also being trialled within road foundations. Earlier work tested three configurations:

- Placement below the foundation layer
- Mixing biochar with Type 1 aggregate foundation
- Compacting a biochar layer above the Type 1 foundation

These trials, delivered with Sussex Road Laboratory and contractors, will require several years of trafficking to fully evaluate durability, with monitoring continuing for five years post-project.

Building on this approach, a dedicated biochar burial trial is planned at Drayton Depot, Chichester. Three patching locations along the main access road, subject to identical traffic loading, have been selected.

- Patch 1 -100% type1 - Control
- Patch 2 - 20% Biochar/type 1 mix (by volume)
- Patch 3 - 30% Biochar/type 1 mix (by volume)

The excavation depth is 620mm and the design of the patch is geo separator layer with 420mm Type 1/ Biochar blend, 100mm AC 32 HDM 40/60 (Clause 929), 60mm AC20 HDM 40/60 (Clause 929) and 40mm Tarmac Ultipave 10mm.

2. Other Trials:

Cage Technologies Ltd - feasibility of grass-based biomethane as a sustainable fuel for SGC's mowing fleet

SGC commissioned Cage Technologies Ltd to assess whether grass clippings from municipal cut-and-collect operations could be converted into biomethane to fuel the Council's mowing fleet. Using operational data from the Greenprint initiative, including diesel use, grass collection volumes and costs, the study evaluated the technical, environmental and financial feasibility of switching from diesel to biomethane-powered mowers.

The study confirmed that a closed-loop system is technically viable, environmentally beneficial and capable of generating enough biomethane to power the entire fleet with surplus for export. The analysis assumed biomethane-fuelled operations across 30% of the 473-hectare mowing area, cut four times annually (equivalent to roughly 568 hectares per year).

However, the economic assessment identified a barrier: labour accounts for around 90% of operating costs, creating a structural deficit that fuel savings, RTFC income or surplus sales cannot offset. Labour expenditure exceeds the total financial benefits, resulting in an annual operating loss.

A labour cost reduction of 38 - 46% would be required to approach break-even; without this, the project cannot achieve financial sustainability, even with capital grants. Grants would strengthen the investment case but would not eliminate the recurring deficit.

The Council must therefore decide whether to:

I. explore operational changes to deliver the required labour efficiencies.
II. proceed as a strategic Net Zero investment accepting an ongoing subsidy: or
III. pause deployment until economic conditions improve.

Full calculations and capital requirements are provided in the final study document in Appendix G.

Eunomia Ltd - IcaN Greenprint Modelling Final Report

This report presented the outcomes of research conducted for SGC on the development of a bespoke carbon credit, available for purchase by organisations seeking to demonstrate positive local climate action. The data provided by SGC was based on pilot experiments at selected Greenprint sites, as well as experimental data for anaerobic digestate production, biogas and methane production at two different AD plants.

The report demonstrated that moving to a cut-and-collect approach is successful in reducing carbon emissions; however, the net societal impact is expected to be negative due to the high operational costs for SGC.

Based on the data available, the modelling recommended a sale price per tonne of carbon of between £658-£845 depending on the end-use pathway to cover SGC's costs (and £301-£488 to deliver a net benefit to the council i.e. including the social cost of carbon). This equates to 11,640m^2-14,947m^2 (1.2 - 1.5ha) of cut-and-collect area.

The table below presents the combined GHG emission savings from SGC operations, and the avoided emissions associated with each pathway's constituent end-use products. The final column also presents the associated societal monetary value of these emission savings, taking the mid-point of 2016-2040 carbon price series. This analysis shows that the optimal pathway from a carbon perspective is through the production of organic fertiliser and electricity production (as opposed to biomethane). It is important to note however that this does not take into account the potential for the biomethane fuel to be used on SGC's own vehicle fleet, which could potentially provide operational cost savings, were SGC to take ownership of transport to Charlton Park biogas plant.

Avoided emissions and value for end-use pathways

End-use pathway	Avoided emissions ($kgCO_2e/1,000m^2/year$)	Carbon Value ($£/1,000m^2$)
Organic fertiliser + electricity production	86.0	£30.69
Organic fertiliser + biomethane	66.9	£23.90

Full details can be seen in the final study document in the reference documents.

Whole Lifecycle Cost Model

1. Process 0: Initiation

As detailed elsewhere in this document, due to the significant capital investment and operational changes involved, we developed a Business Case to validate the Greenprint project. This Business Case was prepared externally by a leading engineering consultancy specialising in infrastructure support services. However, you may also wish to consider engaging smaller consultancies with specific expertise in pyrolysis / biochar uses or anaerobic digestion, or if the necessary competencies exist within your team, to develop the Business Case in-house.

2. Process 1: Highways Maintenance Strategy

Effective public engagement is essential when implementing cut-and-collect and reduced cut regimes. To ensure a smooth transition, WSCC appointed a Public Liaison Officer (PLO) for at least six months each year during the change-over period, supported by a communications team as needed. The estimated cost for these dedicated public engagement roles is £20,000. Additional expenses related to change-management activities - such as internal planning, stakeholder research, and the production of outreach materials - can be managed either in-house or through contractors, depending on available resources and the scale of engagement required. Investing in these resources is critical for building public trust, minimising disruptions, and fostering positive community relationships, ultimately contributing to the successful delivery of the project. This approach aligns with best practices that emphasise diverse and inclusive outreach, early and frequent communication, clear success metrics, and on-going evaluation of engagement strategies. Collaboration with local authorities or private partners is also recommended to optimise costs and ensure resource availability. These measures help to embed responsive communication into the maintenance strategy and facilitate broader public support for operational changes.

Indicative Greenprint Costs:

- PLO for 6 months a year = £20,000
- Communication back-up = £10,000
- Comms materials and events = £20,000

3. Process 2: Green Estate Maintenance Operation Optimisation Performance

This section of the report provides an overview of the trial costs for both WSCC and SGC, along with cost projections derived from the whole life cycle cost model. The analysis breaks down the trial's total costs for four cuts into their individual components to highlight the contribution of each element.

A comparison between cut-and-collect and cut-and-drop operations, based on trial data, is presented in the cut-and-collect and cut-and-drop trial cost comparison section. This section will not compare the costs of WSCC with SGC, as both councils use different processes and operations to carry out verge management work and cannot be compared realistically.

Additionally, the whole life cycle cost estimates for both methods are presented, with scenarios involving a single cut, two cuts per year, and five cuts per year, with results shown for both councils.

Cut-and-collect Cost Breakdown

The cost information presented below was obtained from data recorded in WSCC and SGC during the cut-and-collect trial between March and November 2025.

WSCC

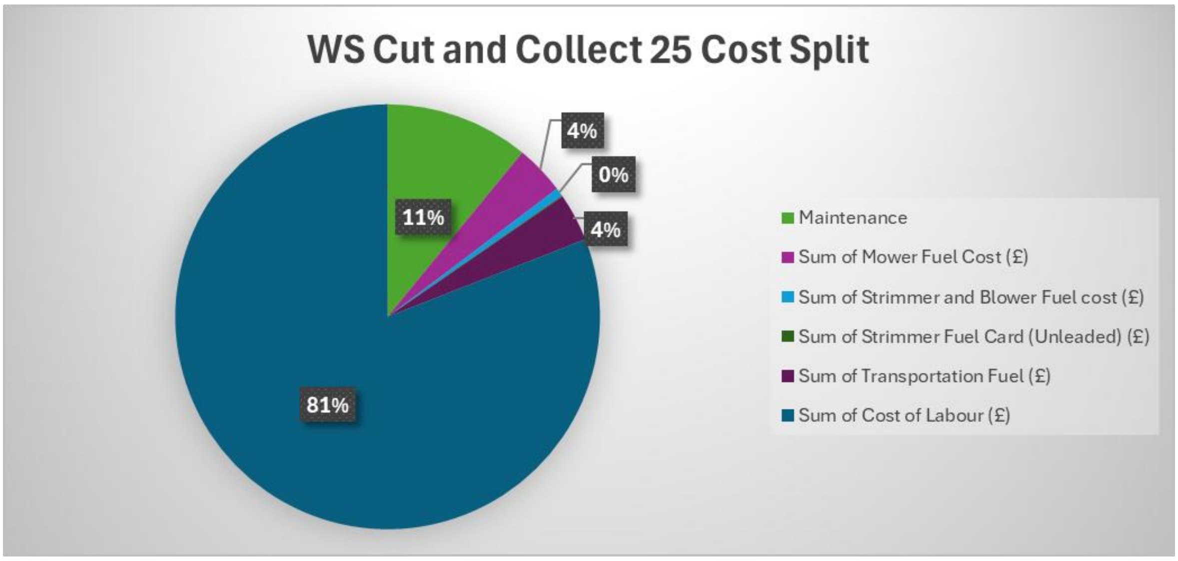
WSCC used a team comprising three operatives, one mower and two vans to transport equipment and grass cuttings.

OPEX

OPEX costs for cut-and-collect were derived from asset management software 'CONFIRM' data collected daily by operatives performing the work. These costs included labour, fuel and maintenance. Grass disposal did incur a cost of £8,328.07, but future biomass processing methods, such as pyrolysis, could remove this disposal cost so it has been subtracted from the OPEX total, reducing the total cost in 2025 to £101,908. Transport costs between the cut site and disposal site were included; these may change if the disposal location changes. The cut grass was taken to the Grasstex depot, but alternative storage/processing locations could impact transportation costs.

OPEX Costs Detail

Category	Description	Total Cost 2025
Sum of Mower Fuel Cost (£)	Operative recorded amount of fuel used each day	**£ 3,865.11**
Sum of Strimmer and Blower Fuel cost (£)	Operative recorded amount of fuel used each day	**£ 645.07**
Sum of Strimmer Fuel Card (Unleaded) (£)	Operative recorded amount of fuel used each day	**£ 70.95**
Sum of Transportation Fuel (£)	Fuel usage was monitored via fuel card statement	**£ 3,752,97**
Sum of Cost of Labour (£)	Day rate for contractor operatives with national insurance, pension and admin costs included in the rates	**£ 83,032.67**
Maintenance	Total maintenance expenditure for 2025	**£ 11,221.04**



Labour (81%) and maintenance (11%) constitute the primary cost drivers within the operation. Labour services were supplied by WSCC's contractor Grasstex and billed on a day rate basis. Maintenance costs were predominantly made up of mower repair and maintenance, which accounted for 71.5% of the total maintenance spend. The transportation of grass from the site represents the third-largest expenditure category accounting for 5% of total OPEX costs. The remaining costs are attributable to fuel consumption for equipment, including mowers, strimmer's and blowers.

CAPEX

CAPEX costs for cut-and-collect were based on the purchase price of machinery, annualised over its expected lifespan. The below table provides a detailed breakdown of the equipment purchased with its annualised cost.

Cut and Collect Equipment

Council	Equipment	Purchase Cost / Unit	Quantity	Total Cost	Service Life	Cost / Year
WSCC	Transit Leader Single Chassis Cab 350	£ 39,588.00	4	£ 158,352.00	7	£ 22,621.71
WSCC	KUBOTA FC4-501	£ 51,450.00	2	£ 102,900.00	3	£ 34,300.00
WSCC	FS411 Stihl strimmer, BR800 Blower	£ 1,089.00	2	£ 2,178.00	2	£ 1,089.00
WSCC	TT3621 Electric Tipping Trailer	£ 7,500.00	4	£ 30,000.00	7	£ 4,285.71
WSCC - Total		**£ 99,627.00**		**£ 293,430.00**		**£ 62,296.43**

SGC

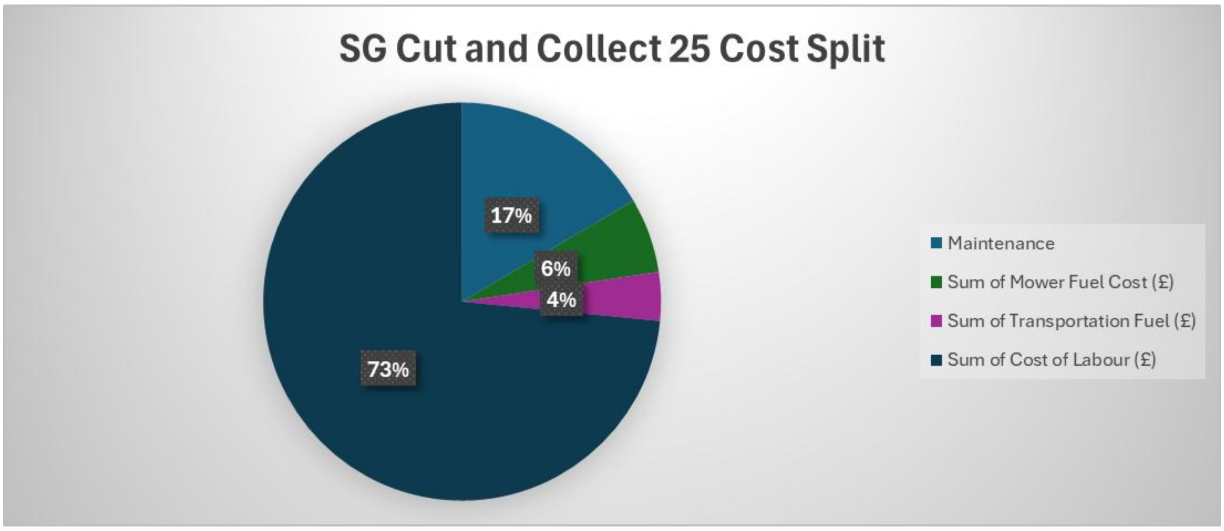
SGC used a team comprising four operatives, three mowers, one tractor and one hook-lift trailer with three containers to transport equipment and grass cuttings.

OPEX

OPEX costs for cut-and-collect were derived from data collected daily by operatives performing the work. These costs included labour, fuel and maintenance. Transport costs, between the cut site and storage site were included - these may change if the storage/disposal location changes. The cut grass was taken to the council’s main operational depot in Yate - alternative storage/processing locations would impact transportation costs.

OPEX Costs Detail

Category	Description	Total Cost 2025
Sum of Mower Fuel Cost (£)	Operative recorded amount of fuel used each day	**£ 5,321.92**
Sum of Transportation Fuel (£)	Fuel usage was monitored via fuel card statement	**£ 3,460.80**
Sum of Cost of Labour (£)	Day rate for operatives	**£ 64,333.27**
Maintenance	Total maintenance expenditure for 2025	**£ 14,482.36**



Labour (73%) and maintenance (17%) represented the largest cost components, with labour sourced from an in-house team and calculated using the internal hourly rate for operatives. Maintenance costs were primarily comprised of mower repair and servicing, which accounted for over 50% of the total maintenance spend. Mower fuel costs were the third-highest expense, while the remaining costs were attributed to the transportation fuel for removing grass.

CAPEX

CAPEX costs for cut-and-collect were calculated by annualising machinery purchase costs over expected operational years. The below table provides a detailed breakdown of the equipment purchased with its annualised cost.

Typical Team - Cut and Collect						
Council	Equipment	Purchase Cost / Unit	Quantity	Total Cost	Useful Life	Cost / Year
SGC	Trailer Tandem Axle Hooklift Trailer with 3 Containers	£ 46,800.00	1	£ 46,800.00	6	£ 7,800.00
SGC	Iseki SF5 x 2	£ 50,820.00	2	£ 101,640.00	3	£ 33,880.00
SGC	Grillo FD2200TS with Rotary Deck	£ 55,246.00	1	£ 55,246.00	3	£ 18,415.33
SGC	Muthing Flail kit for Iseki SF551 mower	£ 11,040.00	1	£ 11,040.00	3	£ 3,680.00
SGC	Case Maxxum 125 Tractor (WU71 TKA - asset number 43652	£ 74,800.00	1	£ 74,800.00	6	£ 12,466.67
SGC	Husqvarna 520iRX Brushcutter strimmer	£ 339.00	2	£ 678.00	2	£ 339.00
SGC - Total		**£ 239,045.00**		**£ 290,204.00**		**£ 76,581.00**

Cut-and-Collect and Cut-and-Drop Trial Cost Comparison

This section explains how data from the 2025 trial was used to calculate the cost per square metre for both the cut-and-collect and cut-and-drop (BAU) programmes, with the total tonnes of grass collected and the estimated square meterage required to collect a single tonne of grass in both councils. The analysis highlights the cost difference between the two approaches for each council, providing an indication of the cost per square metre difference between the two programmes. To determine the cost per square metre, the total expenditure (TOTEX) was divided by the total area covered during the trial. For a detailed breakdown of the tables, cost descriptions, and calculation methods used in this section, please refer to table 6.1 in the Appendix G.

WSCC

Over the course of the cut-and-collect trial for WSCC, a total of £102,588 was spent on OPEX costs. OPEX and CAPEX were then added together to show WSCC incurred a total cost of £178,300 over the course of the trial in 2025.

After dividing the TOTEX costs by the total square metres cut in the trial by WSCC, it is estimated that the cost of a cut-and-collect programme would be £0.08 per square metre. When applying the same process to the trial data for cut-and-drop where the TOTEX is divided by the total square metre area cut, the cost is estimated to be £0.03 per square metre. When comparing the cost per square metre of cut-and-collect against cut-and-drop it is estimated that a cut-and-collect programme is 2.6 times more expensive than a cut-and-drop programme in WSCC.

Total tonnes of grass were calculated by multiplying the total number of full collection boxes against the estimated weight a single box can hold (114.3kg) before needing to be emptied (for detail on weight calculations see table in the appendix G). For WSCC a total of 371 tonnes of grass was collected during the trial of which after being processed (where 80% of total weight is lost due to drying) 74.27 tonnes would be the total weight used for biochar. To calculate the total area that would need to be cut to collect a single tonne of grass, the total area cut was divided by the tonnes collected during the trial. This showed that for WSCC approximately 5,927.93 square metres would need to be cut to collect 1 tonne of grass.

Cut and Collect
4 Cuts

Category	£/year	Comments
C&C (OPEX)	£110,916	value taken from data record for total cut and collect costs for 25
C&C (OPEX) without disposal	£102,588	£8,328.07 = disposal cost. This is subtracted from the total cost
C&C (CAPEX)	£75,712	This was calculated from the annualised cost of all the machinery used in the experiment.
C&C (TOTEX)	£178,300	

Category	tonnes	Comments
Total Grass Collected (wet)	371.36	This is the total recorded weight of grass collected.
Total Grass Collected (dry)	74.27	It is assumed that 80% of grass is moisture, and only 20% is useable for biochar production. This is 20% of the weight.

Category	£/tonne	Comments
Cost of C&C / dry tonne	£2,400.63	This is the cost to collect a useable tonne of biochar with current methods.
AD Wet Ton Cost	£480.13	This is the cost to collect a useable tonne of grass for AD with current methods.

Category	sqm
Total Area Cut in 25	2,201,400.00

Category	£/sqm	Comments
C&C cost / sqm	£0.08	The recorded cost to cut 1 sqm under experimental conditions

Category	sqm/tonne	Comments
Wet tonne	5,927.93	The recorded sqm that is required to collect 1 tonne of grass.
Dry tonne	29,639.65	The recorded sqm that is required to collect 1 useable tonne of grass.

Cut and Drop

Category	£/year	Comments
BAU (OPEX)	£29,394.44	Value taken from cut and drop record file
BAU (CAPEX)	£27,900	This was calculated from the BAU machinery that would be used in a similar area.
BAU (TOTEX)	£57,294.44	

Category	sqm
Total Area Cut	1844696

Category	£/sqm	Comments
BAU cost / sqm	£0.03	The recorded cost to cut 1 sqm under BAU conditions

Difference Between Cut and Collect vs Cut and Drop

Difference in cost per sqm
£0.05

SGC

Over the course of the cut-and-collect trial for SGC a total of £87,598 was recorded on OPEX costs. OPEX and CAPEX were then added together to show SGC incurred a total cost (TOTEX) of £164,179.

After dividing the TOTEX costs by the total square metres cut in the trial by SGC, it is estimated that the cost of a cut-and-collect programme would be £0.11 per square metre. When applying the same process to the trial data for cut-and-leave where the TOTEX is divided by the total square metres cut, the cost is estimated to be £0.04 per square metre. When comparing the cost per square metre of cut-and-collect against cut-and-leave, it is estimated that a cut-and-collect programme is 2.6 times more expensive than a cut-and-leave programme in SGC.

In SGC a total of 192 tonnes of grass was collected during the trial. To calculate the total area that would need to be cut to collect a single tonne of grass, the total area cut was divided by the tonnes of grass collected during the trial. This showed that for SGC an estimated 7,663.19 square metres would be needed to be cut to collect 1 tonne of grass.

Cut and Collect

Category	£/year	Comments
C&C (OPEX)	£87,598	value taken from data record for total cut and collect costs for 25
C&C (OPEX) without disposal	£87,598	£0 = disposal cost. This is subtracted from the total cost
C&C (CAPEX)	£76,581	This was calculated from the annualised cost of all the machinery used in the experiment.
C&C (TOTEX)	£164,179	

Category	tonnes	Comments
Total Grass Collected (wet)	192.024	This is the total recorded weight of grass collected.
Total Grass Collected (dry)	38.4048	It is assumed that 80% of grass is moisture, and only 20% is useable for biochar production. This is 20% of the weight.

Category	£/tonne	Comments
Cost of C&C / dry tonne	£4,274.97	This is the cost to collect a useable tonne of biochar with current methods.
Ad Wet Ton Cost	£854.99	This is the cost to collect a useable tonne of grass for AD with current methods.

Category	sqm
Total Area Cut	1,471,517.18

Category	£/sqm	Comments
C&C cost / sqm	£0.11	The recorded cost to cut 1 sqm under experimental conditions

Category	sqm/tonne	Comments
Wet tonne	7663.194101	The recorded sqm that is required to collect 1 tonne of grass.
Dry tonne	38315.9705	The recorded sqm that is required to collect 1 useable tonne of grass.

Cut and Drop

Category	£/year	Comments
BAU (OPEX)	£69,272	ıd drop record file
BAU (CAPEX)	£64,383	This was calculated from the BAU machinery that would be used in a similar area.
BAU (TOTEX)	£133,655.29	

Difference Between Cut and Collect vs Cut and Drop

Difference in cost per sqm
£0.07

4. Whole Life Cycle Cost Model Outputs

To project costs within the model, the cost per square metre derived from the cut-and-collect trial analysis was applied to calculate the total cost of a single cut across the full area for both WSCC and SGC. From this total, the known CAPEX was subtracted to determine OPEX, which was then allocated according to the cost split identified in the trials and inputted into the cost model template. The template was further updated with CAPEX figures, anticipated income, and transportation costs sourced from the University of Nottingham's transportation model. For a detailed explanation of the methodology and assumptions used in these projections, please refer to the Cost Model Assessment Report.

WSCC

Cost Model Summary

To calculate the estimated costs of a cut-and-collect programme for the whole of WSCC, the cut-and-collect trial cost per square metre of £0.08 was used as a basis for the model, with the assumption that 100% of the total area will be cut and collected utilising 6 teams to carry out the work. The cost per square metre was then multiplied by the total area of 4,658,763.64 square metres that the council currently has a responsibility to cut. This provided a total cost of £488,508.83 for a single cut in WSCC.

Currently the council runs a 5 cut per year programme costing £677,045.00pa which, if it was changed to cut-and-collect, would mean a cost of £1,675,790.81 per year. As a cut-and-collect programme has been proven to help reduce the total number of required cuts per year, a two cut per year requirement was calculated using the model to show a total cost of £ £785,329.33 per year.

The model also highlights how applying a cut-and-collect programme across the whole council area can help provide economies of scale benefit by reducing the cost per square metre of the programme. This benefit is primarily driven by the more cost-efficient spread of CAPEX across a larger area meaning investment in equipment is better utilised.

Cut and collect cost and ton collection estimates for 6 teams

Cut Number	Area	Cost	Cost per sqm	Total tons collected	Dry tons collected	Difference to curent Cut and Drop Costs
1	4,658,763.64	£ 488,508.83	£ 0.10	688.1	137.6	-£ 188,536.17
2	9,317,527.28	£ 785,329.33	£ 0.08	1376.3	275.3	£ 108,284.33
5	23,293,818.20	£1,675,790.81	£ 0.07	3440.6	688.1	£ 998,745.81

After calculating the total costs for OPEX and CAPEX the cost of transporting the grass to a biochar processing facility was also built in using a transportation model developed by the University of Nottingham. This model assumes that grass will account for 2.7% of biomass used for biochar with the remaining 97.3% coming from green waste in the council. The primary cost drivers in this model are the fuel for the trucks used to transport the biomass and salary for the drivers. With estimated tonnes of grass collected in WSCC for two cuts being 1376.3 tonnes, the total transportation cost would be £22,463.46 per year.

When adding the OPEX, CAPEX and transportation cost together for two cuts per year, WSCC would have a total cost of £807,792.78 per year. As the grass will be sold to make biochar there is revenue recovery on the cost for the council. Biochar currently has a value of £450 per tonne which, when multiplied by the estimated tonnes of grass being collected for two cuts in WSCC, shows an income of £123,863.34 per year. After taking into account the income from biochar sales, the total cost for WSCC for two cuts per year comes to £683,929.44.

SGC

Cost Model Summary

To calculate the estimated costs of a cut-and-collect programme for the whole of SGC, the cut-and-collect trial cost per square metre of £0.11 was used as a basis for the model with the assumption that 100% of the total area will be cut and collected utilising 4 teams to carry out the work. The cost per square metre was then multiplied by the total area of 4,733,299.29 square metres that the council currently has a responsibility to cut. This provided a total cost of £726,277.83 for a single cut in SGC.

Currently the council runs numerous different cuts for different areas they are responsible for which costs approximately £1,425,699 per year, so the model was set to calculate what a 5 cut per year programme would look like. If the council changed to cut-and-collect programme with 5 cuts per year it would mean a cost of £2,563,925.03 per year. As a cut-and-collect programme has been proven to help reduce the total number of required cuts per year, a two cut per year requirement was calculated using the model to show a total cost of £1,209,364.41 per year.

The model also highlights how applying a cut-and-collect programme across the whole council area can help provide economies of scale benefit by reducing the cost per square metre of the programme. This benefit is primarily driven by the more cost-efficient spread of CAPEX across a larger area meaning investment in equipment is better utilised.

Cut and collect cost estimates 4 teams						
Cut Number	Area	Cost	Cost per sqm	Total tons collected	Dry tons collected	Difference to curent Cut and Drop Costs
1	4,733,299.29	£ 757,844.21	£ 0.16	617.7	123.5	-£ 667,855.11
2	9,466,598.58	£ 1,209,364.41	£ 0.13	1235.3	247.1	-£ 216,334.90
4	18,933,197.16	£ 2,112,404.82	£ 0.11	2470.7	494.1	£ 686,705.51
5	23,666,496.46	£ 2,563,925.03	£ 0.11	3088.3	617.7	£ 1,138,225.72

After calculating the total costs for OPEX and CAPEX, the cost of transporting the grass to a processing facility was also included. The primary cost drivers in this model are the fuel for the trucks used to transport the biomass and salary for the drivers. With estimated tonnes of grass collected in SGC for two cuts being 1235.3 tonnes the total transportation cost would be £52,772.02 per year.

When adding the OPEX, CAPEX and transportation cost together for two cuts per year, SGC would have a total cost of £1,262,136.43 per year. As the grass may be sold for anaerobic digestion, revenue recover on the cost for the council has been built into the model. The estimated sale price to anaerobic digestion is £10 per tonne which when multiplied by the estimated tonnes of grass being collected for two cuts in SGC shows an income of £12,353 per year. After taking into account the income from biomass sales, the total cost for SGC for two cuts per year comes to £1,249,783.43.

Carbon

Project partners procured to lead on the carbon element of Greenprint were:

- the Future Highways Research Group (FHRG)
- the University of the West of England (UWE).

Greenprint commissioned the FHRG Carbon Analyser Tool to determine the carbon emissions of the traditional cut-and-leave versus the experimental cut-and-collect verge management methods - along with detailed analysis of the biomass outputs. Further academic analysis and more detailed modelling was provided by the UWE.

FHRG

Proving Services Ltd, founded in 2003, established the Future Highways Research Group (FHRG) in 2016, now comprising 35+ highway authorities. The April 2023 Greenprint Outline Business Case highlighted FHRG as central to project delivery, using its tools for assessing interventions and managing carbon data via its standards.

FHRG was procured by SGC in February 2024. Following recent updates, including enhanced carbon tools and an expanded four-inventory analysis model (released August 2023), FHRG improved its ability to model, assess, and prioritise interventions - supporting effective targeting of LL2 funding.

UWE

In April 2021 SGC had signed a collaboration agreement with UWE, following a pre-contractual MOU drafted in July 2020, opening the door to working together in research, consultancy and regular review meetings to progress opportunities to deliver the South Gloucestershire Climate Emergency Action Plan. In connection with the agreement, a new Project Schedule was then drafted and signed in January 2024 to specifically provide academic rigour, oversight and assessment, to the modelling work initiated via the FHRG for the Greenprint project.

1. The carbon analysis steps

During the early stages of the project, the FHRG Carbon Analyser Tool was used to establish a baseline of emissions for WSCC and SGC Highways, Transport and Planning services using

2022/23 data. This baseline provided context for understanding the relative impact of emissions reductions from grass cutting within overall service emissions.

A defined carbon boundary set the scope of included activities, with separate assessments for each council. SGC primarily delivers services through an in-house (direct labour) model, whereas WSCC uses a contracted delivery model split across multiple service areas.

Service functions and activities were mapped through workshops with FHRG, resulting in 15 functions (58 activities) for SGC and 12 functions (115 activities) for WSCC. Data collection covered four key areas: sites and premises, staff and contractors, vehicles and plant, and purchased goods and services (supply chain).

The resulting service-level carbon assessments were submitted to ADEPT in July 2024, with summary statements provided separately by FHRG.

A November 2024 report by UWE outlined the Biogenic Carbon Baseline, highlighting progress in the first year of Live Labs 2, including development of the carbon strategy, calculation tools, and key lessons learned. It emphasised the significance of biogenic emissions and soil carbon sequestration.

Biogenic emissions arise when verge biomass is left in situ (“cut-and-leave”) and decomposes through aerobic and anaerobic processes, releasing CO_2, N_2O, and CH_4. In contrast, a cut-and-collect approach reduces these emissions and enhances the soil’s capacity to sequester greenhouse gases, enabling natural insetting.

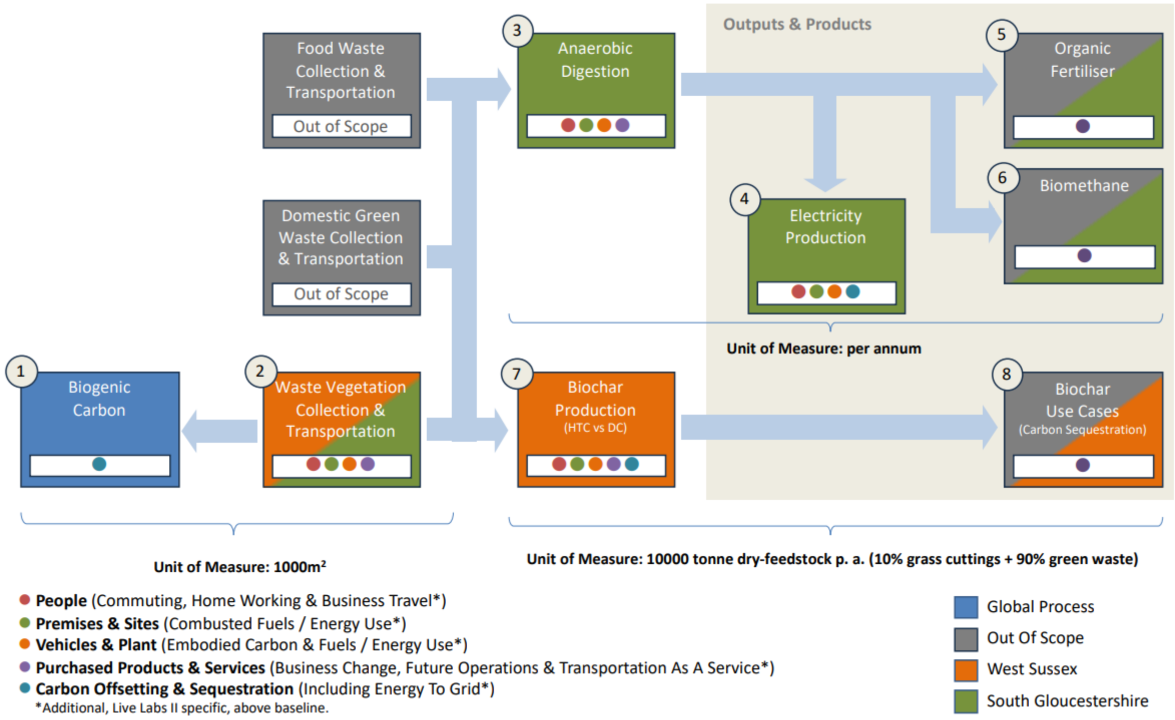
In February 2025, the Greenprint carbon baseline report was published on the ADEPT Live Labs 2 website, outlining how cut-and-leave and cut-and-collect grass maintenance methods would be compared. Baseline sites were chosen for their similarity and proximity to experimental sites to ensure accurate comparisons. The report compared carbon data from both approaches and scaled findings to the total grass area managed by each council. While cut-and-collect showed higher operational carbon in 2024, this reflected only one stage of the project, with potential carbon savings expected in later stages through processes such as biogenic carbon reduction, AD or pyrolysis, and reduced mowing frequency.

Moving forward beyond baselining, the Greenprint focus then turned to creating experimental carbon profiles to compare cut-and-collect with existing grass cutting operations. This enabled emissions to be tracked and highlighted the impact of new processes on carbon emissions - encompassing data collection on Stage 2 of the assessment route map (see below).

It should be noted that: for the co-mingled options involving Anaerobic Digestion (AD) and pyrolysis, only emissions associated with the grass fraction of the feedstock (for AD approximately 20% of the total, with the remaining 80% comprising food waste) have been taken into consideration. This approach was adopted because under REDII accounting rules, wastes such as food waste are treated as zero-burden feedstocks, meaning emissions associated with their original production are not included in lifecycle calculations.

With respect to co-mingled pyrolysis feedstock (approximately 2.7% grass and 97.3% other green waste materials), the carbon calculations are derived from the University of Nottingham Business Case report. This report is based on a biochar production facility with a capacity of 10,000 tonnes per annum, adapted to reflect the total green estate available to WSCC.

Live Labs II: Carbon Assessment Route Map (West Sussex & South Gloucestershire) v11.6



Stage 2 verge management data from SGC and WSCC recorded key operational metrics, including equipment used, time, labour and plant costs, fuel consumption, grass volume and weight, transport distances, and disposal costs. Data was collected daily, manually by SGC and via the 'Confirm' system by WSCC, and summarised by cut number and area, with costs reported separately.

Two verge management approaches were assessed: **cut-and-leave (C+L)**, the baseline method where cut material remains on site, and **cut-and-collect (C+C)**, where vegetation is removed. C+L is standard practice across both authorities, while C+C was trialled in selected areas. All data was normalised per 1000 m^2 of grass cut.

Greenprint carbon data was submitted to FHRG in October 2025, alongside a Scope and Limitations document outlining data sources, assumptions, and constraints. FHRG developed a bespoke carbon model, which informed further analysis by UWE. A lifecycle emissions spreadsheet was produced, building on the 'actual value' method for biomethane co-digestion as set out in greenhouse gas calculation guidance.

The full report and analysis is available in the reference documents: Adkins Greenprint Carbon Model.

A summary of the carbon emissions associated with the verge management and biomass processing trials modelled in Greenprint is shown below:

This table shows a summary of the carbon model results from UWE.

Option		Harvesting			Transport			Land use change	soil carbon	Processing			Distribution	Use	CCS	CCR	Total
		$e_{ec,n}$			$e_{td,feedstock,n}$			e_{ln}	$e_{sca,n}$	e_p			$e_{td,product}$	e_u	e_{ccs}	e_{ccr}	$kgCO_2e/1000m^2$
		fossil	biogenic	total	fossil	biogenic	total	biogenic	biogenic	fossil	biogenic	total					
Cut and leave	WSCC (C&L)	4.82	34.75	**39.57**													**39.57**
	SGC (C&L)	2.28	26.88	**29.16**													**29.16**
Cut & Collect (100% G AD)	WSCC$_{\text{(diesel transport)}}$	11.61	0.00	**11.61**	3.51	0	**3.51**	**0.00**	**-61.92**	0.00	50.30	**50.30**	0	0	0	0	**3.49**
	SGC$_{\text{(diesel transport)}}$	17.62	0.00	**17.62**	2.71	0	**2.71**	**0.00**	**-61.92**	0.00	38.91	**38.91**	0	0	0	0	**-2.68**
Cut & Collect (100% G AD)	WSCC$_{\text{(biomethane transport)}}$	11.61	0.00	**11.61**	0	0.025	**0.03**	**0.00**	**-61.92**	0.00	50.30	**50.30**	0	0	0	0	**0.01**
	SGC$_{\text{(biomethane transport)}}$	17.62	0.00	**17.62**	0	0.003	**0.00**	**0.00**	**-61.92**	0.00	38.91	**38.91**	0	0	0	0	**-5.39**
C&C (20% G, 80% F, AD)[1]	WSCC$_{\text{(diesel transport)}}$	2.32	0.00	**2.32**	5.26	0	**5.26**	**0.00**	**-12.38**	0.00	69.77	**69.77**	0	0	0	0	**64.96**
	SGC$_{\text{(diesel transport)}}$	3.52	0.00	**3.52**	4.07	0	**4.07**	**0.00**	**-12.38**	0.00	53.97	**53.97**	0	0	0	0	**49.17**
C&C (20% G, 80% F, AD)[1]	WSCC$_{\text{(biomethane transport)}}$	2.32	0.00	**2.32**	0.00	0.038	**0.04**	**0.00**	**-12.38**	0.00	0.00	**69.77**	0	0	0	0	**59.74**
	SGC$_{\text{(biomethane transport)}}$	3.52	0.00	**3.52**	0.00	0.004	**0.00**	**0.00**	**-12.38**	0.00	0.00	**53.97**	0	0	0	0	**45.11**
C&C (10% G, 90% W, PYR)[2]	WSCC$_{\text{(diesel transport)}}$	1.16	0.00	**1.16**	0.73	0	**0.73**	**0.00**	**-6.19**	0.74	15.55	**16.29**	0	0	-1.92	0	**10.07**
C&C (2.7% G, 97.3% W, PYR)[2]	WSCC$_{\text{(diesel transport)}}$	0.31	0.00	**0.31**	0.14	0	**0.14**	**0.00**	**-1.67**	0.74	15.55	**16.29**	0	0	-0.52	0	**14.55**

Table 1: Summary worksheet: Showing pathway emissions for biomethane and biochar generated from feedstocks classified as products. Units $kgCO_2e$ per 1000 m^2

[1] Food waste is treated as zero-burden feedstocks, meaning emissions associated with their original production are not included in lifecycle accounting

[2] Due to the emerging nature of biochar technology, additional research with academic partner UoN has been undertaken to quantify emissions for these emergent areas. Does not include emissions associated with woody biomass harvesting.

Note that:

1) Food waste is treated as zero-burden feedstocks, meaning emissions associated with their original production are not included in lifecycle accounting
2) Does not include emissions associated with woody biomass harvesting.

The model accounts for emissions across the key stages of the biomass supply chain, including:

- Feedstock cultivation and harvesting (e_{ec})
- Transport of feedstock to processing facilities (e_{td})
- Soil carbon changes associated with altered land management (e_{sca})
- Processing emissions from anaerobic digestion (AD) or pyrolysis (e_p)

Option	Harvesting			Transport			Land use change	soil carbon	Processing			Distribution	Use	CCS	CCR	Total	Whole estate[3]
	$e_{ec,n}$			$e_{td,feedstock,n}$			e_{ln}	$e_{sca,n}$	e_p			$e_{td,product}$	e_u	e_{ccs}	e_{ccr}	kgCO$_2$e/1000m^2	tonnes CO$_2$e
	fossil	biogenic	total	fossil	biogenic	total	biogenic	biogenic	fossil	biogenic	total						
Grass	2,888.43		2,888.43	1,304.45		1,304.45		-15,560.27	257.85	4,899.15	5,157.00			- 540,000.00		- 546,210.38	- 546.21
Green Waste	106,979.02		106,979.02	88,000.00		88,000.00			9,292.15	176,550.85	185,843.00			- 19,460,000.00		- 19,079,177.98	- 19,079.18
Total	109,867.45	-	109,867.45	89,304.45	-	89,304.45		-15,560.27	9,550.00	181,450.00	191,000.00			- 20,000,000.00		- 19,625,388.37	- 19,625.39

This table show the carbon results for Pyrolysis co-mingled derived from the UoN Business Case. Please note it does not take into consideration the Co2 related to gathering the woody biomass, but the transport of it.

The Greenprint carbon model evaluates lifecycle greenhouse gas (GHG) emissions associated with verge-side grass management and utilisation pathways. The methodology follows the Renewable Energy Directive (REDII) "actual value" lifecycle accounting approach, aligned with the UK Green Gas Support Scheme (GGSS) methodology for biomethane systems.

These emissions are aggregated and normalised to a functional unit of kg CO$_2$e per 1000m^2 of verge area managed. Emissions associated with capital equipment manufacture, biomass combustion, and indirect land-use change are excluded from the analysis in accordance with GGSS accounting conventions.

Importantly, the model applies a whole-system perspective for the grass only, capturing additional carbon flows associated with soil carbon changes and potential carbon sequestration from biochar.

2. Baseline Scenario: Cut-and-Leave Verge Management

The baseline scenario represents the current management practice in which verge grass is cut but left on site to decompose. The model applies an emission factor of 0.206 tCO$_2$e per tonne of fresh grass biomass decomposing on site. This value is consistent with laboratory measurements and comparable aerobic composting studies, indicating that unmanaged decomposition can represent a significant source of greenhouse gas emissions.

From a lifecycle perspective, the cut-and-leave baseline represents the highest-emission management pathway, as all of the carbon contained in the biomass ultimately returns to the atmosphere without delivering any energy recovery or long-term carbon storage.

3. Cut-and-Collect Management and Soil Carbon Effects

Transitioning from cut-and-leave to cut-and-collect management alters the carbon balance in two important ways.

1. Removing biomass from the verge prevents the decomposition of organic residues *in situ*. This directly eliminates the methane and nitrous oxide emissions associated with unmanaged decomposition.

2. The model accounts for potential soil carbon improvements associated with improved grassland management practices. Empirical soil measurements taken during the project indicate that changing verge management practices may result in gradual increases in soil organic carbon.

The analysis estimates a soil carbon sequestration benefit equivalent to approximately −61.9 kg CO_2e per 1000 m^2 annually, based on expected carbon accumulation rates over a 20-year period.

These sequestration rates are broadly consistent with findings from international studies of improved grassland management, which typically report soil carbon increases in the range of 0.1-0.3 tonnes of carbon per hectare per year following improved vegetation management practices.

Consequently, the shift from cut-and-leave to cut-and-collect produces an immediate improvement in carbon performance even before considering the utilisation pathway of the collected biomass.

4. Anaerobic Digestion Pathway

In the anaerobic digestion pathway, collected grass is processed to produce biogas, which is subsequently upgraded to biomethane for injection into the gas grid.

The lifecycle emissions associated with this process arise primarily from:

- Energy consumption during digestion and upgrading
- Methane leakage from digestion and upgrading equipment
- Digestate storage and handling

Feedstock composition

One of the AD scenarios shows grass representing 20% of the digester feedstock, with the remaining 80% consisting of food waste - a co-mingled feedstock.

This approach reflects the operational reality of most commercial AD plants, which commonly rely on mixed feedstocks to optimise digestion performance and energy yields.

While anaerobic digestion of 100% grass performs better than cut-and-leave management due to controlled methane capture, co-digestion with food waste typically delivers superior performance in terms of biogas yield, process stability, and emissions per unit of energy generated.

5. Pyrolysis and Biochar Pathways

Pyrolysis converts biomass into three main products:

- Biochar
- Bio-oil
- Syngas

Biochar carbon can remain stable in soils for centuries to millennia - as a result, pyrolysis systems are often capable of delivering net-negative greenhouse gas emissions, depending on the feedstock source and energy balance of the system.

Feedstock composition

The only Pyrolysis scenario viable is a co-mingled feedstock presenting 2.7% of the digester feedstock, with the remaining 97.3% consisting of green waste.

This approach reflects the operational reality of Invica industry commercial pyrolysis plants.

Comparative Interpretation of the options

- The baseline cut-and-leave approach results in the highest lifecycle emissions because biomass carbon is released to the atmosphere without any beneficial use.
- Cut-and-collect management improves the carbon balance by preventing these emissions and allowing biomass to be utilised within energy or carbon-storage systems.
- The anaerobic digestion pathway provides substantial climate benefits through renewable gas production and fossil fuel displacement, particularly when integrated with waste co-digestion systems.
- The pyrolysis pathway has the potential to deliver the greatest climate benefit due to the long-term stabilisation of carbon in biochar, effectively converting biomass carbon into a durable carbon sink.

Other specific highlights from the data

- In SGC, cut-and-collect saved up to 34.55 kgCO2e per 1000m2 compared with cut-and-leave (100% grass to AD, with biomethane transport option). With the feedstock co-mingling processing option of 20% grass / 80% food to AD, the carbon emissions are 168% higher than cut-and-leave.
- In WSCC, cut-and-collect saved up to 39.56 kgCO2e per 1000m2 compared with cut-and-leave (100% grass to AD, with biomethane transport option). With the feedstock co-mingling processing option of 20% grass / 80% food to AD, the carbon emissions are 164% higher than cut-and-leave.

- In SGC, fossil fuel carbon emissions for cut-and-collect harvesting over 1000m2 were 7.7 times that of cut-and-leave - for 100% grass to AD processing options. In WSCC, fossil fuel carbon emissions for cut-and-collect harvesting over 1000m2 were 2.4 times that of cut-and-leave - for 100% grass to AD processing options. These higher operational emissions incurred in the process of cut-and-collect also come with higher financial costs - the most significant proportion of which has been shown to be labour costs.

- For cut-and-leave, biogenic emissions made up between 87.8% (WSCC) and 92.2% (SGC) of all emissions associated with harvesting - highlighting the value of removing the biomass from the verge (despite the additional fossil fuel required to achieve that).

- The 100% grass to AD processing option results in the lowest emissions of all options modelled.

- Co-digestion with food waste delivers superior performance in terms of biogas yield, process stability, and emissions per unit of energy generated

Key Implications

The results indicate that utilising verge biomass as a resource rather than leaving it to decompose can significantly improve the carbon balance of verge management.

From a climate mitigation perspective:

- Cut-and-leave represents the least favourable option, as it allows biomass carbon to return directly to the atmosphere.

- Anaerobic digestion provides meaningful emissions reductions, particularly when integrated with waste feedstocks.

- Pyrolysis and biochar systems offer the potential for net-negative emissions, making them a particularly promising pathway for long-term carbon management.

Taken together, the results highlight the potential for verge biomass management to transition from a routine maintenance activity into a meaningful component of regional climate mitigation strategies.

6. Whole-Estate Carbon Implications

To provide a clearer indication of the potential climate impact of each management pathway, the model results can be extrapolated from the functional unit of $kgCO_2e$ per 1000 m^2 to the scale of the full managed verge estate within the project authorities. For the purposes of this assessment, the total verge area considered is **4,658,734 m^2** for WSCC and **4,733,000 m^2** for SGC. Scaling the lifecycle emissions results to these estate areas allows the comparative carbon implications of each option to be interpreted in terms of total annual emissions or savings associated with verge management across each authority.

The values presented below therefore represent the estimated annual greenhouse gas impact for the full verge estate under each option.

Option		Total kgCO₂e/1000m²	Whole estate tonnes CO₂e
Cut and leave	WSCC (C&L)	39.57	**184.37**
	SGC (C&L)	29.16	**137.94**
Cut & Collect (100% G AD)	WSCC(diesel transport)	3.49	**16.28**
	SGC(diesel transport)	-2.68	**-12.69**
Cut & Collect (100% G AD)	WSCC(biomethane transport)	0.01	**0.06**
	SGC(biomethane transport)	-5.39	**-25.50**
C&C (20% G, 80% F, AD)[1]	WSCC(diesel transport)	64.96	**302.67**
	SGC(diesel transport)	49.17	**232.59**
C&C (20% G, 80% F, AD)[1]	WSCC(biomethane transport)	59.74	**278.35**
	SGC(biomethane transport)	45.11	**213.37**
C&C (10% G, 90% W, PYR)[2]	WSCC(diesel transport)	10.07	**46.92**
C&C (2.7% G, 97.3% W, PYR)[2]	WSCC(diesel transport)	14.55	**67.81**

Summary showing estimated total pathway emissions across the whole estate for biomethane and biochar generated from feedstocks classified as products. Units kgCO$_2$ e per 1000m2 and tonnes CO2e per estate. The total estate area considered is 4,658,735m2 for WSCC and 4,730,000m2 for SGC.

The data from the Adkins carbon modelling shows that the 100% grass to AD option results in the lowest emissions in both authorities, with the highest emissions associated with the 20% grass / 80% food to AD option.

Option	Harvesting			Transport			Land use change	soil carbon	Processing			Distribution	Use	CCS	CCR	Total	Whole estate[3]
	$e_{ec,n}$			$e_{td,feedstock,n}$			e_{ln}	$e_{sca,n}$	e_p			$e_{td,product}$	e_u	e_{ccs}	e_{ccr}	**kgCO$_2$e/1000m^2**	**tonnes CO$_2$e**
	fossil	biogenic	**total**	fossil	biogenic	**total**	biogenic	biogenic	fossil	biogenic	**total**						
Grass	2,888.43		2,888.43	1,304.45		1,304.45		-15,560.27	257.85	4,899.15	5,157.00			- 540,000.00		- 546,210.38	- 546.21
Green Waste	106,979.02		106,979.02	88,000.00		88,000.00			9,292.15	176,550.85	185,843.00			- 19,460,000.00		- 19,079,177.98	- 19,079.18
Total	109,867.45	-	109,867.45	89,304.45	-	89,304.45		-15,560.27	9,550.00	181,450.00	191,000.00			- 20,000,000.00		- 19,625,388.37	- 19,625.39

The combined findings from the Adkins carbon model and the University of Nottingham's research enable an estimated calculation of carbon emissions and savings for producing biochar across West Sussex. The assessment assumes a feedstock composition of 2.7% grass and 97.3% green waste, with two grass cuts per year and an annual production capacity of 10,000 tonnes of biochar. As transportation emissions for green waste were not part of the original trial, these were estimated by scaling grass collection emissions in proportion to the higher volume of green waste. Processing emissions for a facility of this scale were estimated by the University of Nottingham at approximately 191 tonnes of CO$_2$ per year, apportioned according to feedstock ratios. Overall, based on the Nottingham research, the production process is associated with a carbon saving of roughly two tonnes of CO_2 for every tonne of biochar generated.

7. Carbon moves up the agenda during the lifetime of the Greenprint project:

The ADEPT Decarbonisation Pledge and the DfT Carbon Leadership Programme

During April 2025 a new pledge was launched by the ADEPT Live Labs 2 programme inviting stakeholders to drive meaningful decarbonisation across all aspects of the UK's road network and rethink how the highways infrastructure reduces carbon. The pledge was launched by ADEPT on 23rd April 2025 at the Live Labs 2 Westminster stakeholder event, sponsored by Claire Young MP and featuring DfT Minister Lilian Greenwood MP: Sign the pledge - industry decarbonisation pledge | ADEPT.

Following on from this, in June 2025 the DfT established the Carbon Leadership Programme (CLP), as part of a broader agenda to reduce carbon emissions from the highways sector, requiring local authorities to provide accurate, consistent, and timely carbon-related data. The programme is operated by the FHRG and includes the following tools:

1) Carbon Footprint Assessment (CFA)
    - a whole-service carbon footprint assessment.
2) Best Practice Carbon Assessment (BPCA)
    - an assessment of the progress of each LHA's journey towards net zero.

For Live Labs II, the Carbon Profiler Toolkit (CPT) replicated the functions of Carbon Analyser within an automated Excel workbook, connected to cloud servers. The CFA and CPT combined, covered the functions of Carbon Analyser in a much simpler, accessible form.

Both SGC and WSCC have since submitted CFA and BPCA data and received assessment reports back from FHRG.

Benefits Realisation

This section provides a detailed overview of the key benefits identified during the initial phase of the project. It evaluates the extent to which these anticipated advantages were realised by the project's completion, highlighting notable innovations that have emerged as a result. KPI's were also established at the beginning of the project. Please refer to Appendix H.

1. Benefits

This section focuses on determining the benefits of the project. The following table is a summary of the benefits that have been considered initially as an outcome of this project and the actual achievements at the end of the project.

Benefit Category	Benefit	Timeframe for Realisation	Trend end 3 years
Economic	Cost reduction associated with verge management processes (£) allowing councils and other parties involved to dedicate resources in other areas	Long term (7 years or more)	The Greenprint trials demonstrated that while cut-and-collect verge management currently costs around 2.6 times more than cut-and-drop, the trials provided clear, evidence-based- insight into why these cost differentials exist. Crucially, they identified labour intensity and mower reliability as the primary cost drivers. Revealing a practical pathway to reduce costs through more appropriate, resilient machinery (such as tractor mounted- flail systems) and improved operational design.
	Revenue increase (£) allowing councils and other parties involved to dedicate resources in other areas	Short term (in the next year)	We haven't been able to realise any revenue from the project.
Reduction of CO2e	Reduce emissions (CO2e) required for processes reducing impact on climate change	Short term (in the next year)	163 tonnes CO_2e saved across SGC when cut-and-collect grass was sent to anaerobic digestion using biomethane transport. 189 tonnes CO_2e saved across WSCC under the same operational approach. Removing grass arisings eliminated emissions

			associated with unmanaged decomposition, which the model estimates at 0.206 tCO_2e per tonne of fresh grass left in situ
	Increase carbon sequestration (CO2e) reducing impact on climate change	Long term (7 years or more)	Improved verge management saves an estimated −61.9 $kgCO_2e$ per 1,000 m^2 per year through increased soil carbon stocks.
Biodiversity	Increase in biodiversity, from reducing nitrogen and ammonia in the soil, particularly with vegetation that thrives in low nitrogen soils	Long term (7 years or more)	With regard to biodiversity outcomes, the project timeframe has been too short to determine whether the Greenprint programme has resulted in measurable increases in biodiversity. Although the interventions were designed to enhance wildflower diversity, improve habitat quality, and support ecological connectivity, ecological monitoring has only been conducted over a two-year period. This duration is insufficient to robustly assess changes in species richness, habitat structure, or pollinator populations, which typically emerge over longer, multi-year timescales. As a result, no definitive conclusions can currently be drawn on the scale or effectiveness of biodiversity benefits, and continued monitoring will be required to assess longer term ecological impacts. More comparable conclusions are to become apparent towards the five-year mark.
	Decreased eutrophication (excessive enrichment of the soil), from reducing nitrogen and ammonia in the soil, resulting in increased biodiversity and avoiding other negative ecological impacts that are unknown.	Long term (7 years or more)	Positive despite variations in weather over three years.

	Decreased acidification in soils, resulting in increased biodiversity and avoiding other negative ecological impacts that are unknown.	Long term (7 years or more)	Same conclusion as first biodiversity summary.
Job Creation and EDI	Increased number of jobs involved in the project	Short term (in the next year)	WSCC employed a Junior Management Consultant Apprentice
	Promotion of STEM encouraging more people into a needed area of society	Medium term (1-7 years)	Sustainability & CSR Apprenticeships: WSCC upskilled a young female staff member through Level 4 Sustainability and Level 7 CSR apprenticeships to build internal expertise. These qualifications strengthen future capability in sustainability and improve gender representation in a male-dominated sector.
	Encouraging diversity of workforce allowing a greater variety of perspectives through different backgrounds which are necessary to solve complex problems.	Medium term (1-7 years)	WSCC held an EDI engagement day at Aldingbourne Trust. Insights helped shape the Equality Impact Assessment and identified actions to improve inclusivity in project delivery and recruitment.
Behaviour	Workforce and customer levels of satisfaction and wellbeing increased as their awareness that the council is working towards a target that is good for the planet.	Short term (in the next year)	Staff and contractor have been supportive. No complaints from members of the public. WSCC Public Liaison Officer Steve Hill feedback was public positive to the environmentally focused initiative.
	Increase in satisfaction of councils from aesthetics associated with biodiverse verges.	Long term (7 years or more)	Ongoing conversations with local communities - creating an effective feedback loop and communications approach.

Better communication within councils	Removal of siloes, enabling bigger solutions to bigger problems	Medium term (1-7 years)	Due to the nature of the project being R&D, fully integrated communications across different operations such as green estates and waste management have been challenging. However the project has shown interconnecting between the two departments, when referring to current operations, to understand how this could be adopted to introduce Greenprint at full scale.
Systems thinking	Being able to think at scale over several years encourages long-term systems thinking	Short term (in the next year)	The Greenprint project has showcased both councils' ability to think at scale. With short- to long-term goals in mind for each area of implementation, of a full-scale adoption of Greenprint county-wide.
Manage relative abundances of grassland indicator species	Increase relative abundance and diversity of positive indicators and reduce relative abundance of negative indicators	Long term (7 years or more)	Monitoring and trend analysis required over next five years.
Ecological value	Increased diversity of food plants for invertebrates	Long term (7 years or more)	Monitoring and trend analysis required over next five years.
Compliance with Environmental Regulations	Enhanced compliance with biodiversity duties under Environment Act 2021 S102	Short term (in the next year)	The project operated in line with current environmental regulations and national policy expectations, supported by expert oversight from Professor Colin Snape (University of Nottingham), lead of the UK Biochar Demonstrator. Working with the CO$_2$RE Greenhouse Gas Removal Hub, Professor Snape engaged directly with UK Government departments to ensure the project's approach to biochar aligned with existing regulatory frameworks and evidence-based best practice. While the project demonstrated that biochar can be safely regulated and integrated into decarbonisation pathways, it remained fully compliant with current rules, despite broader regulatory gaps at national level.

Diversification of energy supplies	Production of energy from different sources means that there is more resilience for energy production as well as options which can provide greater gains in different circumstances	Medium term (1-7 years)	For biochar production, green waste and grass cuttings are wet feedstocks. As a result, most of the available energy is required to dry these materials, leaving only a small amount of excess energy available for export or conversion to power. The Greenprint project has successfully generated electricity via the processing of biomass by anaerobic digestion.
Increased knowledge within the industry	Greater likelihood that others will be able to solve problems that need solving at a national or international scale. Allow others to replicate processes at lower cost, resulting in all benefits at a larger scale.	Medium term (1-7 years)	The Greenprint project has strengthened knowledge and capability across the highways and verge management sector by actively sharing learning at a national level. Both councils have presented the project at major industry forums, including Highways UK and LCRIG Strictly Highways, and delivered webinars and presentations in collaboration with sector bodies such as LGTAG, LCRIG and CIHT. This engagement has helped elevate industry understanding of the project's approach to carbon reduction and biodiversity-led- verge management. In parallel, the project has produced practical toolkits, guidance and "How To" materials, alongside a published Thought Leadership report, providing a clear and replicable pathway for other councils to adopt the Greenprint model at lower cost and reduced risk.
Industry and legislative innovation (aka OFGEM)	Highlighting the regulatory challenges in order to inform other local authorities	Short term (in the next year)	Mixing grass with food waste in an anaerobic digestion (AD) plant may require the operator to get a new permit from Ofgem. The approval process takes a long time, and energy payments to the plant are paused once the application is submitted.
Innovation management	Working and recording innovative	Short term (in the next year)	Achieved through GP reports. Our work has significantly enhanced understanding of carbon across the

	processes can allow for greater knowledge in the industry		highways department and its contractors. Sharing these insights with the wider highways teams has highlighted low-carbon opportunities beyond our project and provided clarity on which areas of the network contribute most to carbon emissions, helping to guide future focus and adding value to the department's broader environmental efforts.
Traffic efficiency	Reduction in traffic movements means that there is less traffic on the roads	Long term (7 years or more)	A reduction in traffic movements could not be directly quantified during the trial period. However, a reduced cutting approach is expected to improve traffic efficiency by lowering the frequency of verge works, particularly in locations requiring traffic management where maintenance activities can contribute to congestion. Fewer cutting visits are also anticipated to deliver health and safety benefits by reducing the time operatives spend working in live roadside environments. While these impacts were not measured directly, the approach is expected to support improved traffic flow, enhanced workforce safety, and indirect carbon savings through fewer vehicle movements and reduced traffic disruption.
Increased road durability	Increasing production of biochar into asphalt will result in better material for ensuring road durability	Medium term (1-7 years)	Through the Greenprint programme, WSCC, working with the University of Nottingham, assessed the feasibility of converting grass cuttings and green waste into biochar for use in road construction. The assessment confirmed road surfacing, particularly asphalt and aggregates, as a technically viable and scalable deployment route for locally produced biochar. Research demonstrated that biochar can be incorporated into asphalt at low inclusion rates (around 1% by weight) without compromising performance, while improving resistance to rutting, ageing and high

			temperature deformation. These benefits support longer asset life, reduced maintenance and improved whole-life value. Road construction was identified as a strong deployment pathway due to its high material demand, tolerance for non-agricultural-grade biochar, and ability to lock biogenic carbon into long lived infrastructure assets. As a result, highways applications provide a practical, scalable route to support carbon management and net zero objectives using locally sourced green waste.
Verge litter	Reduction of verge litter and plastics as they are being removed in the process	Short term (in the next year)	Through the Greenprint trials, SGC and WSCC demonstrated that litter contamination of verge biomass is predictable, manageable, and best addressed through proactive intervention. Building on litter surveys by Keep Britain Tidy and specialist waste consultants, the councils integrated targeted pre-cut litter removal directly into verge maintenance, rather than treating litter picking as a separate, reactive activity. Trials showed that removing litter before mowing is the single most effective action to prevent plastic fragmentation and downstream environmental harm. On rural routes including the A4174 and B4058, pre-cut litter sweeps reduced contamination in collected grass cuttings to around 0.1% by weight, compared to levels exceeding 5% without intervention, rendering material unsuitable for anaerobic digestion and increasing operational and compliance risks. By combining litter removal and verge cutting into a single, planned activity, the approach reduced repeat highway visits, lowered labour and traffic management costs, and significantly improved operative safety by minimising time spent working near live traffic. As verge cleanliness

			improves over time, these benefits are expected to compound, delivering sustained environmental, safety and financial gains.
Verge management	Improved logistics and efficiencies within verge management	Short term (in the next year)	The Greenprint project has improved logistics and operational efficiency within verge management by demonstrating a viable low intervention maintenance approach. By reducing the frequency of seasonal verge cuts, Greenprint streamlined maintenance operations and simplified annual planning. This reduction in cutting frequency can allow staff time, machinery, and contractor capacity to be redeployed to other priority activities throughout the year, improving overall resource utilisation without compromising verge condition. Fewer verge cuts also reduce the need for traffic management, resulting in less disruption to the highway network and improved journey reliability for road users. A reduced frequency of roadside working lowers exposure to live traffic, delivering clear health and safety benefits. Additional efficiency gains arise from reduced use of mowing equipment, leading to lower fuel consumption, reduced wear and tear, and decreased maintenance requirements. Collectively, these outcomes demonstrate how Greenprint delivered a more efficient, safer, and cost effective approach to verge management while supporting wider environmental objectives.
Agriculture	Reduction in use of fertilisers for improved agricultural yields	Medium term (1-7 years)	The project found that biochar can reduce fertiliser demand by limiting nutrient runoff, but this agricultural benefit was only achievable where the biochar met the required

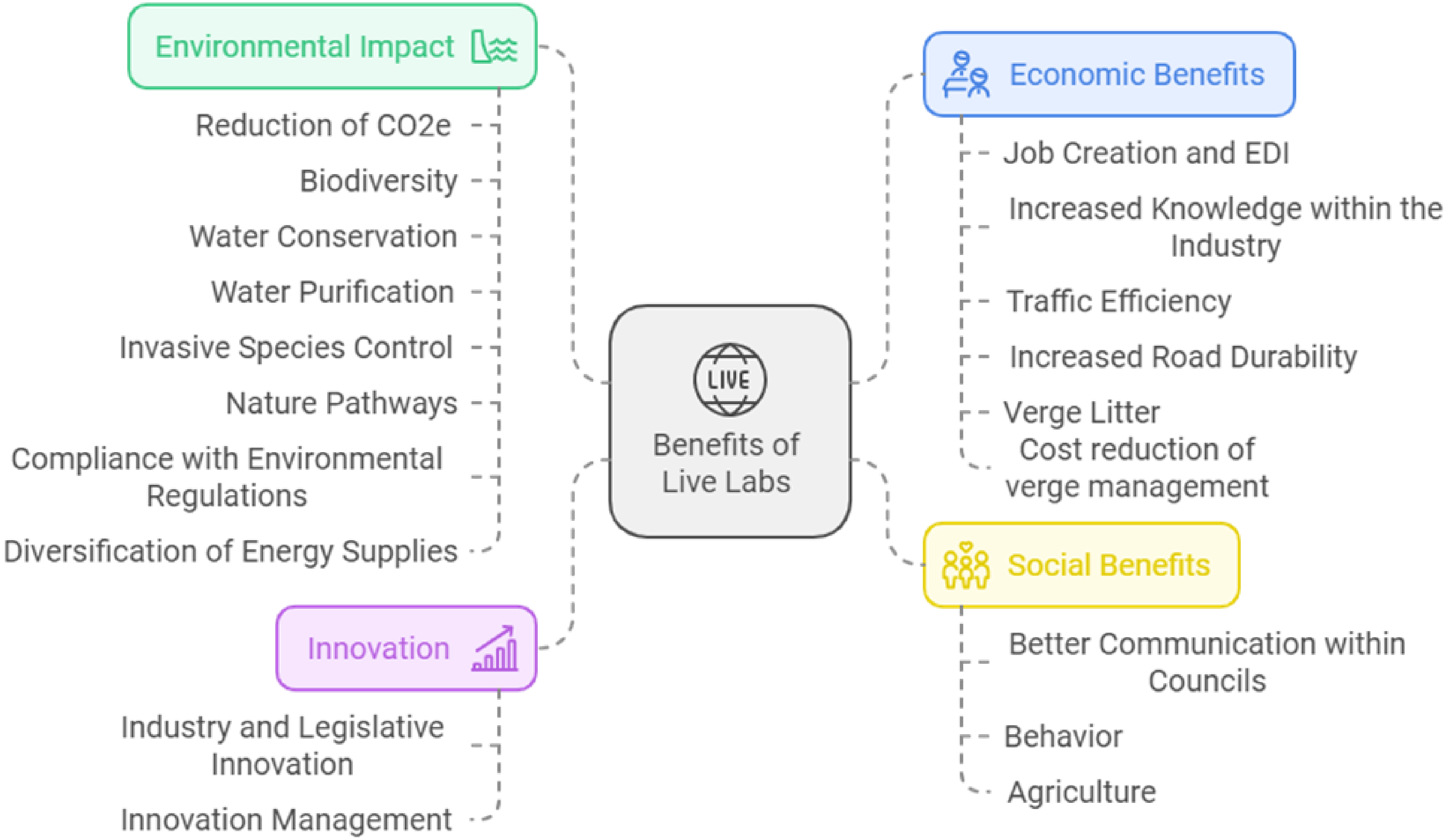
			specifications for use on land. Where material fell outside these standards, the anticipated nutrient retention benefits could not be reliably realised. The digestate from AD is also returned to agriculture and used a fertiliser.

As this innovation project concludes, it is important to acknowledge that while many of the anticipated benefits have been realised some, mostly arising at a later stage, remain conditional and will require practical, individual follow-up actions. Given the nature of the project, it is recognised that not all benefits could be fully achieved or even quantified. Nevertheless, significant resources have been dedicated ensuring that the progress made is both realised and well understood.

The primary focus throughout the project has been on delivering key benefits related to cost reduction, decreasing carbon emissions, and enhancing biodiversity - reflecting the main priorities of the project. ADEPT has prioritised carbon reduction, councils have emphasised cost-effectiveness, and residents have valued increased biodiversity within their local verges.

The additional benefits outlined are largely secondary, arising as positive outcomes from efforts to achieve these primary goals. Many of these benefits extend beyond the project's immediate timeframe, making it essential to establish on-going evaluation measures to monitor and assess the lasting impact and success of the work completed.

In summary, while the project has achieved most of the benefits envisaged, continued practical engagement and long-term evaluation will be critical to fully realise and sustain its benefits.



Benefits of Live Labs

Environmental Impact

- Reduction of CO2e
- Biodiversity
- Water Conservation
- Water Purification
- Invasive Species Control
- Nature Pathways
- Compliance with Environmental Regulations
- Diversification of Energy Supplies

Innovation

- Industry and Legislative Innovation
- Innovation Management

Economic Benefits

- Job Creation and EDI
- Increased Knowledge within the Industry
- Traffic Efficiency
- Increased Road Durability
- Verge Litter Cost reduction of verge management

Social Benefits

- Better Communication within Councils
- Behavior
- Agriculture

2. Innovations

At the heart of the LL2 initiative, the project has embraced forward-thinking approaches, as evidenced by the streams of work below. These initiatives demonstrate a focus on exploring new technologies and solutions, enhancing project efficiency, and opening possibilities for additional funding and collaboration with industry partners. The table below highlights various areas relating to innovations. For a full reference to Biomass innovations activities. Please refer to Appendix I.

Innovations	Description	Status
Reduce maintenance regime in line with Plantlife guidelines	Strategy to reduce annual maintenance through community engagement and change management. Expected to reduce cuts and carbon emissions. Trials are being conducted in phased parishes.	To be achieved in the long term.
Operation of cut-and-collect of arisings (biomass)	Evaluating cut-and-collect equipment, logistics of storage/transport, and overall process optimisation to reduce carbon emissions.	Achieved
Purchase & use of specialist cut-and-collect equipment	Working with manufacturers to improve efficiency and bioenergy compatibility of mowers. Monitoring machine performance and costs.	Achieved
Biomass processing (arisings)	Exploring centralised and decentralised biomass processing via pyrolysis and AD for energy production and material reuse. Assessing emissions, energy return and feasibility.	Achieved HTC was evaluated and determined to be unsuitable for the project. Pyrolysis was selected as the most feasible method for biomass processing. Over 300 tonnes of biomass disposed of via AD in SGC.
Development of new road binder and aggregates	Investigating use of biochar in asphalt. Includes lab tests, binder and aggregate assessments, and road trial.	Achieved (note that the biochar is not appropriate for binder).
Carbon measurement	Using FHRG and UWE tools and standards to baseline and monitor carbon emissions from interventions. Includes 2022/23 carbon baselines for both counties and a review paper on sequestration.	Carbon has been consistently measured across all stages of the project to assess the impact of the trials, inform decision-making, and support the development of a data-driven emissions-modelling

		capability for Local Highways Authorities (LHAs). The programme applied the FHRG Carbon Calculation & Accounting Standards, which provide a structured, step-by-step methodology for implementing greenhouse-gas (GHG) protocols within LHA operations. This ensured that all calculations were transparent, replicable, and grounded in an accepted carbon-accounting framework. This alignment ensured that assessments were grounded in international best practice and capable of supporting robust carbon management across the full lifecycle of highways-estate interventions. Some carbon-related aspects required for the Greenprint fell outside the existing scope of the FHRG toolset. These included: • Carbon sequestration • Biogenic carbon • Anaerobic digestion (AD) • Biochar application
Bio Energy	Collaborating with Cage Technologies to investigate the feasibility of converting AD-derived biogas into biofuels for use in maintenance equipment.	Achieved - feasibility study completed.
Greenprint "How To" document	Creating a comprehensive guidance document for other local authorities to adopt similar practices in green estate management.	Achieved

3. Biodiversity

With 97% of species-rich grassland lost in England and Wales since the 1930s, road verges now represent one of the largest remaining grassland resources - around 70% of Britain's 260,000 ha of roadside verge is grassland. Verge management therefore offers a rare, scalable opportunity for local authorities to deliver biodiversity uplift while decarbonising maintenance. Plantlife's two-year baseline study provides the first ecological benchmark for assessing how cut-and-collect regimes could shift verge grassland condition over time.

Key Findings

- Species richness is relatively stable, with only a 2% difference across both counties between 2024 and 2025.
    - SGC showed a 16% drop in species in 2025, strongly linked to extreme rainfall variation (2024: very wet; 2025: one of the driest springs on record).
- Rural verges support more species overall, though urban verges showed a 44% increase in positive indicator species in 2025 - likely reflecting drought-tolerant flora and more frequent mowing.
- Positive grassland indicators increased by 19% overall in 2025, but absolute numbers remain low, confirming that most verges are currently low-quality grassland and highlighting the need to protect remnant high-value patches.
- Negative indicators are more abundant in rural back verges, suggesting infrequent mowing is driving competitive species dominance and vegetation succession.
- Mowing intensity patterns are clear:
    - Urban verges show more frequent and lower-height mowing, reflected in the dominance of mowing tolerant species (e.g., ryegrass, dandelion).
    - Rural verges host taller, mowing-intolerant species such as False Oatgrass and Cow Parsley.
- Vegetation height was up to 22% shorter in 2025, again linked to low rainfall.
- Forbs increase from road edge to back verge - more strongly in rural sites - while grasses dominate more in wetter SGC.
- Flower abundance varied with rainfall and timing:
    - SGC had consistently more flowering than WSCC.
    - Rural-urban differences fluctuated between years, again emphasising weather-driven variability.
- No meaningful correlation between soil characteristics and vegetation was found - strongly suggesting that management, not soil chemistry, is the primary driver of verge biodiversity outcomes.

Limitations

The study highlights the practical challenges of roadside monitoring: lost quadrat markers, ground disturbance, departures from mowing controls, and highly variable weather all reduced data consistency. As a result, the two years should be treated as a broad baseline, not as trend evidence.

Conclusion

The 2024 - 2025 surveys provide a foundational baseline, not evidence of ecological trends. Continued monitoring over the next five years, combined with consistent site marking and standardised management, will be essential for assessing how verge management influences biodiversity over time.

The findings reinforce that:

- Cut-and-collect regimes remain one of the strongest available levers for improving verge biodiversity.
- Urban verges are an under-recognised biodiversity opportunity, capable of hosting positive indicator species when mowing is optimised.
- Management change matters more than soil conditions, supporting the case for investment in systemic operational shifts.
- Weather extremes will increasingly influence vegetation, underscoring the need for climate-resilient management strategies.

4. Equality, Diversity and Inclusion

Inclusive Leadership Programme - Diversity Trust

WSCC embedded Equality, Diversity and Inclusion (EDI) as a strategic priority within Greenprint, recognising that inclusive leadership must be modelled from the top. Two leadership sessions delivered by the Diversity Trust supported senior leaders to reflect on how EDI shapes culture, decision-making and frontline practice. The sessions strengthened understanding of how highways and environmental service decisions affect diverse communities, ensuring social equity is considered alongside technical and financial outcomes. This work aimed to create a wider “halo effect” by embedding inclusive behaviours into BAU and future programmes.

Achieving Cultural Competency - Diversity Trust

To strengthen frontline delivery, WSCC ran two cultural competency sessions for 40 operational managers. Training focused on confident public engagement, understanding protected characteristics and developing respectful, inclusive teams. This investment ensures operational staff deliver services in an empathetic and equitable way aligned to Council values.

EDI Day - Aldingbourne Trust

A dedicated EDI Day with the Aldingbourne Trust marked WSCC’s first co-designed service changes with residents representing protected characteristics. Lived-experience insights informed the Greenprint Equality Impact Assessment and highlighted potential unintended impacts. The event also explored recruitment pathways for under-represented groups. WSCC has committed to continuing co-design with seldom-heard communities, embedding the learning into future practice.

Greenprint Apprentice

To create long-term social value, WSCC introduced a bespoke Greenprint apprenticeship for a local young person, covering communications, project management, budgeting and operational delivery. Although initially aimed at supporting a care leaver, practical constraints prevented this. Nevertheless, the programme successfully created a meaningful career pathway into the highways and sustainability sector.

Women in Leadership - A Greenprint-enabled Partnership

Relationships built through Greenprint enabled a joint WSCC-SGC Women in Leadership programme. Two cohorts (30 women) completed the course, with around seven achieving promotions. The initiative strengthened gender representation, supported succession planning and built an inclusive leadership pipeline across both authorities.

Apprenticeships and Workforce Development

WSCC invested in specialist skills to sustain Greenprint outcomes. A team member progressed from a Level 4 Sustainability apprenticeship to a Level 7 CSR qualification, supporting both professional development and the ambition to improve female representation in highways. These skills strengthen WSCC’s long-term capacity to deliver climate- and nature-aligned work.

SGC Equalities Workshops and Training

Under Greenprint’s EDI work package, SGC ran half-day workshops with Equalities Voice partners to identify priorities and inform EQIAs. Managers from highways-related services engaged directly with EDEI groups, supported by the Live Labs team. Recommendations from 2024-25 workshops were integrated into SGC’s BAU StreetCare EQuIAA, including updates to grass and verge management assessments, annual partner workshops, strengthened alignment with the Tackling Inequalities Plan 2024-2028, and continued EDI workforce development. Diversity Trust reports were published in March 2024 and August 2025. SGC and WSCC also curated an EDI panel at Highways UK 2025.

Summary

Greenprint demonstrates that environmental innovation is strengthened by inclusive leadership and social value investment. Through leadership development, cultural competency training, community co-design and workforce growth, WSCC and SGC have shown how environmental transformation can support organisational change, improve public trust and open equitable pathways into the sector.

Limitations of Greenprint

1. Importance of Limitations

As with any ambitious innovation project, it is essential to recognise the limitations encountered during the project not as shortcomings, but as natural and necessary elements of early-stage system transformation. Demonstrator projects are designed to test boundaries, expose constraints, and reveal where existing processes, markets or technologies are not yet mature. These limitations provide critical learning that helps shape future iterations, de-risk large-scale adoption, and identify where enabling policy, investment, or cross-sector partnerships are required.

Importantly, they also highlight significant opportunities: the potential to adapt the system for wider contexts, to unlock new circular-economy value chains, to strengthen data and monitoring frameworks, and to accelerate technological readiness. By acknowledging these constraints openly, the programme provides a stronger foundation for the next phase of innovation - one that can build on real-world insights, move toward operational scale, and deliver long-term biodiversity, carbon and cost benefits.

2. Greenprint Limitations:

The limitations identified in Greenprint were:

- **Context-specific design**

Greenprint was tailored to WSCC and SGC’s operational realities, meaning replication elsewhere would require adaptation to local governance, maintenance practices, ecological baselines and market conditions.

- **Short project timeframe**

The three-year trial was insufficient to evidence full biodiversity and carbon-sequestration gains, which typically emerge over 5-7+ years. These will instead be captured through the five-year monitoring and evaluation period.

- **Partial system closure**

Although circular-economy progress was made, a fully closed system was not achieved. The absence of a consistent, permitted end-use route for all biomass limited the ability to demonstrate a fully circular model.

- **Economic uncertainty**

Whole-life cost savings were not realised during the trial, with all operational scenarios costing more than BAU. This reflects the early-stage nature of the system and the lack of mature markets or stable demand for recovered materials.

- **Technology constraints**

HTC was unsuitable for verge arisings, and pyrolysis, while promising, requires scale, stable feedstock and integrated infrastructure beyond project scope. Importantly, pyrolysis using 100% grass does not work and requires co-mingling with other materials.

- **Data limitations**

Early gaps in baseline data, particularly for carbon, required modelling and extrapolation, reducing confidence in some quantified outcomes and highlighting the need for longer-term, repeatable monitoring.

- **Dependence on external actors**

System performance relied on third-party facilities and suppliers, reducing local authority control and introducing scalability risks. External processors also retain revenue from by-products, limiting opportunities for cost recovery on cut-and-collect operations.

- **Requirement to involve wider services and time limitations**

Despite early engagement with Waste teams, it became clear later that a 100% grass-only model was unsustainable due to regulatory, mechanical, carbon and cost constraints. The project evolved accordingly, but time was insufficient for a full Waste-led business assessment. A late-stage business case did identify the key barriers to co-mingling for AD or pyrolysis.

Challenges

1. The Value of Challenges and Intelligent Failure in Innovation

Innovation projects inevitably encounter challenges, and this should be seen not as a weakness, but as a sign that the work is pushing boundaries, testing assumptions, and uncovering the real-world constraints that need to be addressed for long-term success. Within Greenprint, every difficulty, deviation or unexpected outcome represents an intelligent failure: a moment where the project learns quickly, adapts, and avoids repeating the same mistakes. By openly acknowledging these challenges, the programme provides a clear roadmap for others who may wish to adopt or scale similar systems, ensuring they benefit from the lessons already earned. This transparency is intentional; it reflects a commitment to honesty, sector improvement, and collective progress. Sharing what didn’t work is just as important as sharing what did - because it strengthens the evidence base, accelerates innovation across the industry, and ultimately leads to more resilient, more effective solutions.

2. Summary of the Main Challenges

- **Operational complexity:** Cut-and-collect operations were significantly more complex than conventional cut-and-drop regimes, resulting in lower productivity. This underscored the need for streamlined workflows, improved equipment suitability and operational planning tailored to circular-economy management.

- **Machinery reliability**: Frequent equipment breakdowns, maintenance issues and supply-chain delays increased costs and disrupted delivery. These challenges highlighted the importance of high-reliability machinery, strong supplier partnerships and pre-emptive maintenance regimes.

- **Logistics and transport**: Biomass transport was one of the largest drivers of cost and carbon - particularly when depots or processing facilities were distant. This points to future opportunities for decentralised processing hubs, strategic depot locations and more efficient routing (e.g. using the existing waste depots and transport arrangements)

- **Workforce adaptation**: The transition to new operational methods required significant training. Staff shortages, skills gaps and workforce churn impacted operational consistency, signalling the importance of investment in workforce development and retention.

- **Public perception:** Reduced cutting frequencies offer substantial ecological value, yet they must be matched with sustained communication to address public concerns about appearance, untidiness or safety. Engagement will remain central to building long-term social and political support.

- **Contractual constraints**: Existing maintenance contracts and employment regulations limited operational flexibility and slowed implementation. Early contractual review and closer supplier collaboration are essential for future scaling.

- **Regulatory barriers**: Waste classification of verge arisings constrained processing options and created delays for anaerobic digestion (AD) and biochar pathways. Clearer regulatory frameworks and consistent national guidance will be critical enablers of circular verges systems.

- **Biochar market:** Lack of established market for the biochar and high variability in costs for the purpose of Greenprint.

- **Weather dependency**: Year-to-year swings in rainfall and growing conditions significantly influenced grass yield, cutting efficiency and biomass quality, reinforcing the need for adaptable operational models resilient to climate variability.

Risks

In our initial assessment prior and during the project, we identified and addressed a range of potential direct and indirect risks to ensure the smooth progression of our project. We do manage a live risk register however we have summarised below:

1. Weather & Operational Constraints

- Strong dependency on weather and seasonality may delay cut-and-collect operations, trials and ecological outcomes.
- Machinery performance issues, breakdowns, and long equipment lead times may restrict planned activity levels and delivery.

2. Stakeholder, Political & Community Resistance

- Limited community engagement and late communication may generate opposition to reduced-cut regimes.
- Insufficient internal buy-in (e.g., Waste, Highways) and potential political resistance may impede implementation or scale-up.

3. Regulatory, Compliance & Material Quality Risks

- Environment Agency / Ofgem permitting delays or refusals could block biomass processing routes.
- Contamination in verge arisings (litter, metals, microplastics) may restrict acceptance by treatment facilities.

4. Financial & Economic Viability

- Higher costs of cut-and-collect and budget constraints may limit scope and long-term feasibility.
- Uncertain biochar revenue and economic returns could weaken the business case for BAU adoption (e.g. lack of structured biochar market).

5. Technical, Innovation & Ecological Uncertainty

- New materials (e.g., biochar-based binders) may not deliver required performance.
- Long-term ecological impacts on biodiversity, soil, and vegetation remain uncertain and may affect perceived success.

6. Resource, Dependency & Scalability Risks

- Limited staff capacity, potential loss of key personnel, and reliance on external contractors/specialist suppliers create delivery vulnerabilities.
- Pilot results may not translate directly to county-wide or multi-authority roll-out; toolkit adoption and knowledge-sharing depend on sustained engagement.

Conclusion

West Sussex County Council				
Operation	Total Cost (£)	kgCO2e / 1000m2 operation	Total kgCO2e (whole estate)	Tonnes CO2e (whole estate)
C&L	£ 677,045.00	39.57	368,692.26	368.69
C&C 100% Grass - to AD (biomethane transport)	£ 785,329.33	0.01	93.17	0.09
C&C 20% Grass 80% Food - to AD (biomethane transport)	£ 785,329.33	59.74	556,625.61	556.63
C&C 10% Grass 90% Green waste - to Pyrolysis	£ 807,792.78	10.07	93,826.92	93.83
C&C 2.7% Grass 97.3% Green waste - to Pyrolysis	£ 855,717.78	14.55	135,569.18	135.57

South Gloucestershire Council				
Operation	Cost	kgCO2e / 1000m2 operation	Total kgCO2e (whole estate)	Tonnes CO2e (whole estate)
C&L	£ 1,425,699.31	29.16	276,046.01	276.05
C&C 100% Grass - to AD (biomethane transport)	£ 1,209,364.41	- 5.39	- 51,024.97	- 51.02
C&C 20% Grass 80% Food - to AD (biomethane transport)	£ 1,209,364.41	45.11	427,038.26	427.04

*Table is based on 100% of area for both councils conducting a two cut per year operation, (* kgCO2e data taken from Adkins carbon model).*

Summary of Options Assessed

The evaluation examined five principal verge management and biomass processing pathways:

1. Traditional cut-and-leave
2. Cut-and-collect with 100% grass processed via AD
3. Co-mingled AD integrating 20% grass with 80% food waste
4. Co-mingled pyrolysis blending 10% verge grass with 90% green waste.
5. Co-mingled pyrolysis blending 2.7% verge grass with 97.3% green waste.

Although traditional cut-and-leave remains the lowest cost operational model, it also represents one of the highest emission pathways. Most cut-and-collect pathways demonstrated materially lower carbon footprints, with AD emerging as the most immediately practicable option and pyrolysis offering substantial long-term sequestration potential when grass is co-processed with other feedstocks. Both AD and pyrolysis currently incur higher operational costs than business-as-usual verge management.

Trial Findings

The trial programme generated substantial empirical evidence demonstrating that cut-and-collect practices deliver significantly enhanced environmental performance relative to cut-and-leave. Carbon savings achieved through both AD and pyrolysis outweigh the additional emissions associated with collection logistics. AD produced considerable emissions reductions through renewable energy generation, avoidance of fugitive methane emissions, and improvements in soil carbon. Pyrolysis demonstrated strong performance when grass was co-processed with woody biomass, enabling durable carbon sequestration via biochar. Independent assessments by UWE, Eunomia, and academic partners validated the robustness of these findings.

Cut-and-collect with 100% grass processed via AD

Overall, this approach draws strength from its reliance on existing, proven technology that is already widely used and understood. As a processing method, it offers some of the greatest potential for reducing carbon emissions, making it a highly impactful option within green estate management practices. While the primary costs are associated with cut-and-collect operations, these expenses are balanced by the significant environmental benefits and the long-term value created through effective carbon reduction.

Co-mingled integrating 20% grass with 80% food waste via AD

Integrating 20% grass with 80% food waste in a co-mingled biomass stream represents a holistic solution for processing grass within existing waste management systems. This approach leverages established green waste logistics infrastructure, though it would require updates to accommodate the collection and transportation of grass. While the primary expenses still stem from cut-and-collect operations, additional costs may arise depending on the terms for moving grass to processing facilities. The most significant challenge is regulatory: no co-mingled material can be accepted until Environment Agency / Ofgem approvals are secured, potentially introducing delays and further cost before grass can be incorporated into wider green waste streams. Despite these constraints, co-mingling offers a long-term viable, scalable and holistic option- to treat green and biomass wastes -compared with processing grass alone.

Co-mingled pyrolysis blending 10% verge grass with 90% green waste.

Initial investigation in pyrolysis demonstrated that producing high-quality biochar from 100% grass was not feasible, reinforcing the need to blend grass with other green waste materials. Initial trials using a mixture of 10% grass and 90% green waste produced biochar of good quality, confirming that co-mingling supports performance and viability. However, further analysis showed that the total amount of grass collected across two cuts would fall short of the volume required to consistently contribute 10% of the biochar feedstock, meaning additional green waste would be necessary to maintain the desired composition. Additional green waste in the biochar composition was also sown to produce a higher quality biochar.

Co-mingled pyrolysis blending 2.7% verge grass with 97.3% green waste.

The trial highlighted that co-mingled pyrolysis--blending approximately 2.7% verge grass with 97.3% woody green waste was the most feasible approach for transforming collected grass into a higher quality biochar (as opposed to 100% or 10% grass). As verge grass loses around 80% of its weight during pyrolysis, a majority of the feedstock required for biochar production would need to come from readily available green waste rather than grass alone. While this method is technically viable, the absence of an established market for biochar limits the potential for revenue generation. As a result, the dominant costs of this approach remain tied to cut-and-collect operations, alongside additional transportation requirements for moving both grass and green waste to the processing facility and the large CAPEX investment required initially.

Public feedback during the trials was notably positive. Anticipated concerns, especially around reduced cutting frequencies, did not materialise due to the significant public engagement undertaken upfront at the start of the project. Improved verge appearance and consistent communication supported favourable public perception. Biodiversity assessments indicated improved ecological outcomes, particularly in urban settings where reduced nutrient loading supports more diverse plant communities.

The trials also highlighted the operational prerequisites for effective large-scale deployment. Local authorities must possess a detailed baseline understanding of their current operational model - including total grass area, cutting regimes, contracting arrangements, equipment suitability, biomass yield variability, site accessibility, and available processing capacity. Year to year fluctuations in biomass yields, driven by meteorological variation, underline the importance of adaptive operational planning.

Overall Conclusion

Collectively, the Greenprint trials demonstrate that cut-and-collect verge management can make a substantive contribution to local authority decarbonisation, biodiversity enhancement, and circular economy objectives. Although the approach currently incurs higher operational expenditure and capital investment, the project establishes clear pathways for cost reduction, particularly through improvements in labour efficiency, machinery utilisation, routing optimisation, and logistical planning. The environmental benefits, encompassing both renewable energy potential and carbon sequestration capability, are considerable. Public acceptance further strengthens the strategic case for transition.

The evidence indicates a necessary reframing of verge grass from a maintenance liability to a resource with meaningful carbon, energy and material value. Reconceptualising verge biomass as part of a wider, integrated biomass management system is essential to achieving long-term sustainability, operational resilience, and fiscal credibility.

Recommended Pathway

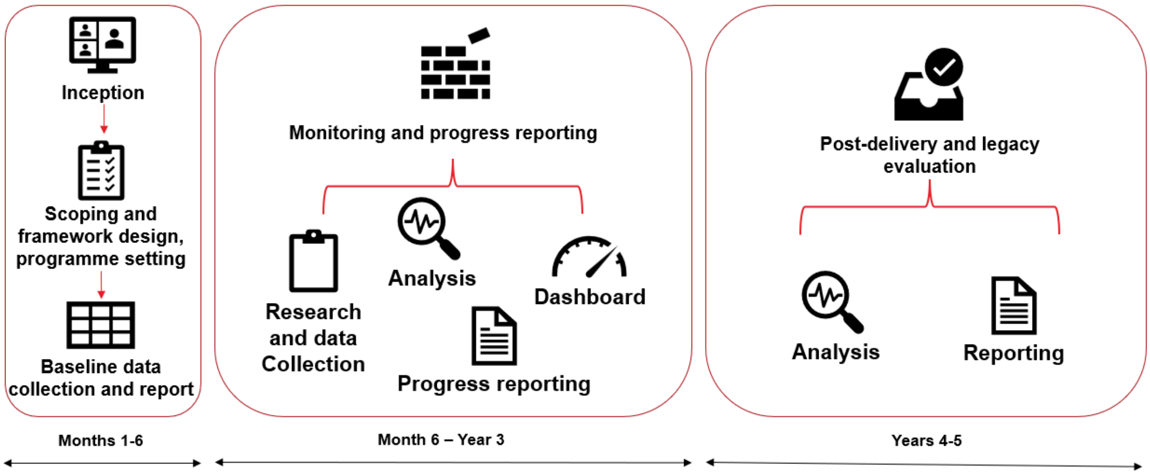
A phased implementation approach offers local authorities the most coherent and achievable route to transition. In the near term, processing 100% verge grass through AD represents the most immediately deliverable option due to existing infrastructure capacity, established operational familiarity, and significant carbon reduction benefits. Concurrently, reducing cutting frequencies can deliver additional emissions savings and ecological gains. Although this pathway does not achieve immediate cost savings, it creates a solid platform upon which efficiencies can be gradually realised.

In the medium to long term, greater system-wide value emerges from models integrating verge grass with other biomass streams. Co-mingled AD with food waste can reduce overall service costs and create operational synergies across waste management functions. Co-mingled pyrolysis, when underpinned by stable woody biomass blends and appropriate infrastructure, provides substantial carbon sequestration potential through biochar production. Realising these benefits will require targeted/capital investment, regulatory alignment, major waste contract review, and the development of reliable feedstock pathways.

Monitoring and Evaluation

A central pillar of the ADEPT Live Labs 2: Decarbonising Local Roads programme is the commitment to rigorous, independent monitoring and evaluation. To ensure the programme generated credible, evidence-based insights for the sector, ADEPT appointed Arup to lead the monitoring and evaluation function.

In November 2023 Arup first engaged with Greenprint and shared the outline of the proposed evaluation programme, running from 2023 to 2028 - as shown below:



Arup published the Live Labs 2 Evaluation Framework Report in March 2024 setting out how evaluation questions would be answered, outlining the analytical and data collection techniques that would be used, and explaining how their approach was to be operationalised

During the project monitoring activities were reported on a quarterly basis, aligning with LL2 Commissioning Board meetings and including regular monitoring alongside process, impact and value for money evaluation activities.

Monitoring questions were presented on a quarterly monitoring form, including subject headings typically covering the following areas:

- Funds received and forecast / current spending
- Innovations developed
- Planned actions on innovations
- Project delays and risks
- Change control
- Collaboration and developing new links - internally and externally
- Communications activities planned and completed
- Lessons learned
- Feedback for ADEPT as the programme managers

Year 3 process evaluation research culminated in interviews with the project team discussing several areas, including:

- Delivery and progress to date
- Readiness for BAU and potential scalability
- Communication activities
- Knowledge sharing
- Wider programme context
- Lessons learned
- Innovation processes
- Carbon measurement

From April 2026, the Live Labs 2 programme enters its Legacy phase, moving from active delivery to a targeted focus on post-delivery impacts, learning and the persistence of change. ADEPT has confirmed funding for a fourth year of the Live Labs programme, focused on the externalisation of findings to support wider industry adoption. In parallel, funding is in place for Arup to continue delivery of the Monitoring and Evaluation (M&E) legacy work, ensuring that programme learning, impacts and value for money are robustly evidenced and synthesised.

Workstreams requiring engagement will be as follows:

- **Process Evaluation** - (interviews in Q4 2026/27)

Purpose: To assess how Live Labs 2 has supported innovation during the Establishing New BAU phase, focusing on what worked, what didn't, and why. This includes governance, delivery processes, collaboration, market engagement, and how BAU practices have evolved post-implementation.

- **Carbon & Value for Money (VfM) Analysis** - (engagement in Q4 2026/27 and Q4 2027/28)

Purpose: To collect updated carbon data and technical inputs to support monetisation of benefits and scaling-up scenario modelling, enabling robust VfM appraisal of delivered interventions and potential national-level impact.

- **Behavioural Change Analysis** - (engagement in Q1 2026/27 and Q4 2027/28)

Purpose: To test and refine contribution claims and behavioural change through two rounds of qualitative interviews.

From Delivery to Legacy

Making Greenprint Business as Usual

Through this programme, WSCC and SGC have piloted and deployed a range of new technologies to support the transition away from conventional verge management. These trials have demonstrated measurable benefits, including reduced mowing frequency, lower operational emissions, improved cost efficiency, and enhanced biodiversity and soil carbon sequestration. Multiple biomass processing pathways, such as AD, HTC and pyrolysis, have also been evaluated to understand their feasibility and potential application within a future operating model.

As the current phase of Greenprint progresses, both councils have identified the need for a detailed implementation plan to support long-term adoption. The Greenprint team are now developing these plans, drawing on our technical involvement, existing contractual, political and operational constraints and deep understanding of the programme's outcomes. The implementation plans will set out how each authority can embed Greenprint's findings within their operational practices and strategic ambitions, ensuring that all successes and lessons learned from the project are captured, transferred, and taken forward into future delivery.

In SGC, the parishes involved have shown a high level of engagement and enthusiasm throughout the project. Local stakeholders have developed a strong understanding of the programme and its wider benefits, particularly in relation to carbon reduction and biodiversity enhancement. Following project end, the council remains committed to the pursuit of carbon emissions savings from green estate management and will be following up this commitment in several ways:

- Cut-and-collect will continue within Yate parish funded by the SGC Climate and Nature Emergency Team. All biomass will be initially delivered to Charlton Park Biogas AD plant in Wiltshire, as was done in 2025. Discussions are also being held with a proposed AD plant operator in the Severnside area of South Gloucestershire regarding terms for the disposal of council-maintained grass from beyond 2027.
- Data will continue to be recorded to further inform the understanding of where efficiencies can be achieved.
- All sample site verges identified by Plantlife and previously monitored for soil carbon and biodiversity changes will continue to be subject to cut-and-collect, making further monitoring possible.
- The Council's ICaN programme will include the Greenprint cut-and-collect option as a scheme that is available for sponsorship.
- Regional adoption of cut-and-collect solutions for the management of green spaces has been put forward by SGC for inclusion in the WECA Growth Strategy, to encourage scaling up of regional facilities for the biogenic processing of cuttings to displace fossil fuel consumption.
- SGC will participate in the FHRG Future Research programme; to explore how local authorities can leverage green waste for local green energy generation and carbon sequestration.

In WSCC, the context has been more challenging, with significant contractual and financial pressures alongside the authority progressing through devolution. As a result, the council has decided, in the short term, to revert to the previous cut-and-leave maintenance model while longer-term options are refined. Positively, the project has successfully engaged teams beyond highways, with waste and sustainability services now actively considering how elements of the programme, including pyrolysis and the use of biochar, could be taken forward through a feasibility study that will be carried out during financial year 26/27. This broader organisational engagement represents a meaningful legacy of the project and highlights its ability to catalyse cross-council collaboration despite wider constraints that can be built upon in our next contract renewal for Highways and the Waste department. WSCC will carry on with the cut-and-collect on biodiversity sample sites.

Project consultants Amey have been commissioned to produce a report on options for both councils on transitioning from the traditional cut-and-leave approach (BAU) to a cut-and-collect model – a Business Case and Delivery Plan will be produced in May 2026. This will present options for permanently lowering carbon emissions and generating green energy over a wider area, placed in the context of the operational, regulatory, technical and financial challenges of doing so.

Officers from both councils will participate in the ADEPT Live Labs 2 Year 4 externalisation programme where project learnings will be shared at selected events across the country and via the five-year post-project monitoring and evaluation programme led by Arup.

Progressing the Learnings from Greenprint in the wider sector

The Future Highways Research Group in partnership with one of Greenprint strategic partners, Amey, will advance the work initiated through the Greenprint Live Labs 2 programme by taking forward a new research stream focused on local green energy generation and carbon sequestration. This next phase will explore how local authorities can convert green waste and recycle into valuable energy, fuels, biochar and other marketable by-products. The overarching aim is to help councils offset energy costs, develop new revenue streams, and significantly reduce their carbon footprints, strengthening financial resilience in the process.

Building on Greenprint

This research theme will deepen the analysis started within Greenprint, concentrating particularly on two high-potential value streams:

- Local electricity production using biogas from AD
- Biochar production and utilisation through pyrolysis of grass cuttings and green waste

Greenprint demonstrated that the revenue potential of these pathways can be substantial when set against costs and risks. FHRG will build abstract modelling tools to enable authorities to quantify the potential benefits within their own operating contexts.

Scope and Focus of the New Research

FHRG will assess opportunities for local authorities to reduce or offset costs and generate income through the intelligent use and trading of waste-derived resources. The programme will consider:

- Electricity generation from AD biogas
- Green fuel production, including biomethane
- Biochar manufacturing as a licensable, saleable material
- Generation of carbon credits through long-term sequestration
- Saleable by-products such as CO_2, heat, digestates, and agronomic nutrients (N, P, K)

This includes a detailed review of the operating models required, the enabling conditions for market development, and the policy changes needed for value realisation, particularly around permitting, mandated biochar inclusion in infrastructure, and sequestration through burial or incorporation into new developments.

Strategic Priorities/Key Enablers

The development of a financially sustainable model hinges on simultaneously reducing the cost of cut-and-collect operations and maximising the value extracted from biomass processing. This requires enhancements in operational efficiency, expansion of scale across larger geographies, logistics optimisation, and the continued development of markets for grass-derived biomethane and biochar. Monetising carbon savings and maintaining a structured programme of biodiversity monitoring will further strengthen the evidence base and support future investment decisions. Scaling Greenprint beyond pilot activity requires a set of strategic priorities and enabling conditions to be strengthened or developed. While the technical feasibility of cut-and-collect, anaerobic digestion, and pyrolysis has been demonstrated, effective large-scale implementation depends on improvements across governance, operations, markets, and policy. Key enablers include stronger internal collaboration within local authorities, supportive legislative and regulatory frameworks, access to mature carbon and biochar markets, appropriate equipment and skills, and clearer alignment with corporate climate and nature priorities.

Collaboration Between Local Authority Teams

Greenprint highlights the need for closer collaboration between local authority teams, particularly grounds maintenance, waste management, highways, and climate functions. Under existing operating models, verge grass is typically managed as a maintenance by-product, with decisions optimised for service delivery rather than environmental or resource outcomes. Greenprint reframes verge arisings as a recoverable biomass resource, requiring coordinated planning and delivery across multiple teams.

Improved integration between groundskeeping and waste teams is essential to enable efficient cut-and-collect operations, compliant handling of material, and onward processing through anaerobic digestion or pyrolysis. Grounds teams influence mowing regimes, timing, and feedstock quality, while waste teams bring expertise in material classification, logistics, and treatment routes. Without this alignment, operational inefficiencies increase and the environmental benefits demonstrated through Greenprint are harder to realise.

More broadly, engagement with climate and finance teams is required to ensure carbon savings are captured within corporate reporting, funding decisions reflect long-term value, and verge management is recognised as a strategic contributor to net zero and biodiversity objectives rather than a purely operational activity.

Legislative and Regulatory Change

Greenprint also demonstrates that current legislation and regulation present barriers to scaling biomass-based solutions, particularly in relation to pyrolysis and biochar. As highlighted in the policy submission to government, existing waste regulations mean that biochar produced from certain treated or processed feedstocks can continue to be classified as waste, even where it meets recognised environmental standards. This restricts land application, increases regulatory burden, and introduces uncertainty for both local authorities and processors.

In addition, biochar and other greenhouse gas removal approaches are not yet fully embedded within UK carbon valuation and support mechanisms, limiting their ability to generate stable revenues compared with other decarbonisation technologies. The absence of clear policy ownership across government departments further complicates engagement and long-term planning for delivery bodies seeking to invest at scale.

Addressing these issues through targeted legislative reform and clearer policy frameworks would materially improve the viability of scaling Greenprint. There is a clear role for local authorities and partners to collectively lobby government to reduce regulatory barriers, recognise biochar within carbon policy, and provide greater certainty for emerging markets.

Other Areas for Consideration

In addition to the priorities above, several other areas require development to support large-scale implementation:

- **Equipment and technology choices** - improving cutting, collection, storage, and processing efficiency.
- **Workforce capability and performance** - ensuring teams have the skills and capacity to deliver new operational models.
- **Carbon and biochar market development** - creating clearer, more reliable revenue streams.
- **Engagement with Ofgem and energy regulation** - particularly where AD and biomethane production are involved.

- **Clarification of waste status following thermal treatment** - reducing regulatory risk once biomass is processed.
- **Local authority funding models for climate and nature** - aligning budgets with long-term environmental outcomes.
- **Elevating Greenprint within corporate priorities** - embedding verge management within strategic climate agendas.
- **Engagement with national carbon leadership programmes** - strengthening alignment with wider net zero governance.