ICaN Greenprint Modelling

Final Report

3rd June 2026

1.0 Introduction

This report presents the outcomes of research conducted for South Gloucestershire Council (SGC) on the development of a bespoke carbon credit, available for purchase by organisations seeking to demonstrate positive local climate action. The emission savings are delivered via Greenprint - a carbon-negative systems model for green infrastructure management which is trialling nature-based, bio-circular solutions for climate mitigation by re-defining road verge vegetation management.

Greenprint is part of ADEPT Live Labs 2: Decarbonising Local Roads in the UK[1], which is a three-year, UK-wide £30 million programme funded by the Department for Transport, (DfT), that aims to decarbonise the local highway network. In particular, Greenprint is an innovation project which is investigating potential new ways grass cuttings could be used, including producing biogas, biomethane fuel for vehicles and an additive for asphalt road surfacing material called biochar.

Under Greenprint, SGC is trialling a cut-and-collect approach to grass verges and selected green spaces, reducing mowing frequency and removing grass cuttings that would otherwise be left on site. The collected material is then diverted to an anaerobic digestion facility to generate biogas for electricity generation, biomethane-fuel, or anaerobic digestate for fertiliser application. This approach simultaneously supports enhanced biodiversity (through less frequent mowing and allowing wildflowers to flourish), increased soil carbon storage and reduced fugitive carbon emissions from traditional mowing regimes.

Whilst not currently feasible for South Gloucestershire due to an absence of a local pyrolysis plant, the potential use of biochar as an end product for the grass cutting are also considered, as this could potentially be a feasible pathway in future.

This document sets out:

1. The **methodology** used to determine a suitable carbon credit price for SGC's scheme;
2. The **recommended sale price** for the bespoke carbon credit; and
3. A discussion of the **optimal end-product pathway** (e.g., biomethane for fuel, biogas for electricity generation, anaerobic digestate for fertiliser) for the grass-cuttings biomass, taking into account cost, carbon reduction potential, market demand and scalability. There is also a qualitative discussion of the potential wider benefits (biodiversity and societal) that have not been built into the cost model due to a lack of available data, but are nonetheless mentioned to lend further support as to the benefits of GreenPrint.

By clearly articulating the approach, assumptions and calculation steps, the report aims to provide SGC with a robust foundation for establishing and marketing an additional product through the Investing in Climate and Nature (ICaN) platform.

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[1] https://www.adeptnet.org.uk/livelabs2.

1.1 End use pathways

Once the grass cuttings have been collected and sent to the storage depot – located in Yate – there are different options for the end product that can be produced using them, each with an associated carbon profile, and in some cases biodiversity benefit opportunities. Broadly, the grass cuttings can be processed in two main ways:

- One option is to send the cutting to an **anaerobic digestion (AD) biogas plant**, where they can be converted into anaerobic digestate for use as an on-farm fertiliser additive, as well as into biogas for electricity generation or upgrading to biomethane. Because biogas (or biomethane if further refined) are byproducts of the production of anaerobic digestate, the costs and benefits of anaerobic digestate in terms of its end use should be considered in addition to either biogas or biomethane's end uses.

- Alternatively, the feedstock could be sent to a **pyrolysis plant** and converted into biochar for use as an asphalt additive. However, this pathway is not currently viable for SGC due to the lack of a local pyrolysis facility capable of receiving the feedstock, and therefore the associated high transport costs. As a result, for biochar, only the external carbon profile associated with its production and end use has been assessed, to support understanding of potential future integration into SGC's Greenprint model. For the purposes of this study, which focuses solely on options that are presently feasible, SGC's direct involvement in this pathway is not considered.

The different end use pathways considered in this study are therefore:

1) AD fertiliser + biogas

2) AD fertiliser + biomethane

3) Biochar (asphalt additive) [external only: production and end use]

The different profiles for each of the different products, as well as the costs and benefits that should be considered under each are summarised in Table 1. The biochar pathway has been greyed out to show that this is not a feasible pathway currently for SGC, and that SGC's operational emissions and costs are not considered for this pathway.

Table 1: Impact pathways for material producing different products

Plant type	**Product produced**	**End use of product**	**Costs/benefits to be considered**
AD biogas plant	AD fertiliser	Application on farm	Soil carbon benefits
			Avoided emissions
AD biogas plant	Biogas	Electricity production	Avoided emissions
AD biogas plant	Biomethane	Vehicle fuel	Avoided emissions
Pyrolysis plant	Biochar	Asphalt additive	Carbon emissions from production
			Soil carbon benefits
			Avoided emissions

1.2 The SGC context

The data provided by SGC has been based on pilot experiments at selected sites, as well as experimental data for anaerobic digestate production, biogas and methane production at two different AD plants. In April of 2025, SGC terminated use of the Cannington Biogas AD facility for the processing of the grass cuttings, and transferred to Charlton Park Biogas AD plant. For Charlton Park, cuttings are collected by Geneco, operating a fleet of biomethane trucks (as opposed to diesel fuelled trucks transporting the material to Cannington). The move to Charlton Park therefore brings with it distinct advantages in terms of carbon savings for transporting the material to the AD plant. As the optimal pathway in this respect, this model uses and presents the experimental data from Charlton Park, and not Cannington.

The area used to conduct the experimental field studies of carrying out **cut and collect** in SGC covered several test pilot sites in 2025 including Yate, Bradley Stoke, Kingswood, Patchway, Stapp Hill & Mangotsfield, Stoke Gifford, and Thornbury with a total cut area of 367,875m^2, approximately 37ha. The area used to conduct the field studies of carrying out **cut and leave** in SGC in 2025 was an area in Doddington, with a total cut area of 254,010m^2, approximately 25ha.

The analysis below was also scaled to the total SGC roadside verge grass (473ha), which is presented in Section 3.3).

2.0 Methodology

2.1 Model flow

As shown in Figure 1, the first task was to lay out the impact pathways for the cut and collect method in terms of a costs and benefits diagram, detailing different pathways according to the end product. The model flow is divided into costs and benefits accruing as a result of SGC's involvement in the process (i.e. the carrying out of the cut and collect) and 'external' costs and benefits that accrue once the feedstock (the grass cuttings) have been passed to the AD biogas plant or pyrolysis plant, and is applied as an end use product. These 'external' costs and benefits are already shown in Table 1 but are reproduced in Figure 1 for completeness.

2.2 Sources of data and unit of analysis

To determine the different assumptions in the model, a combination of data provided by SGC, primarily the LiveLabs II Proforma, and independent desk-based research undertaken by Eunomia was used. These are shown below in Table 2.

Table 2: Summary of data sources, uses and source

Data source(s)	Application	Source
-LiveLabs II Proforma -Adkins Greenprint carbon assessment framework	• Operational emissions (diesel for transport to depot; resource days; diesel for mowers) • Operational costs (diesel for transport to depot; resource days; diesel for mowers) • Emissions from transport to AD plant • Avoided emissions (Electricity production; organic fertiliser; biomethane production) • Biogenic emissions of cut and leave	SGC

SGC Cut Schedules	• Cut frequences for both methods	SGC
Disposal tonnages summary 2025	• Cost for transport to AD plant	SGC
-Carbon baseline report -Adkins Greenprint carbon assessment framework	• Biogenic emissions of cut and leave; carbon sequestration potential of cut and collect	SGC
ITP Energised - UK Grid emission factors	• Displaced-grid factor emissions (electricity production via biogas)	Eunomia
Department for Transport (2025) 'RTFO and SAF Mandate Technical Guidance'	• Well to wheel carbon intensity (diesel)	Eunomia
Kramar, V. (2025) 'Carbon intensity 'Carbon intensity of biomethane for different raw materials and production technologies' *UA BIO*	• Well to wheel carbon intensity (biomethane)	Eunomia
OCW (n.d.) 'Energy Supply Systems for Buildings: Summary table with heating values and CO2 emissions'	• Carbon per m^3 of biomethane	Eunomia
Environment Agency (2025) 'Biochar – evidence on potential environmental impacts and social implications.'	• Qualitative information on biochar and its effects on soils	Eunomia
Walling, E. and Vaneeckhaute, C. (2020) 'Greenhouse gas emissions from inorganic and organic fertilisers used in agriculture and their mitigation options'	• Organic and synthetic fertiliser transport distances respectively (from production plant to farm) • Synthetic fertiliser production emission factor (Ammonium nitrate average factor for United Kingdom reported in table 1) • Emission factor for synthetic and digestate N - post-application in fields respectively (from table 11)	Eunomia
Rodríguez, F., Tietge, U., Lanfranco, S. and Muncrief, R. (2021) CO_2 emissions from trucks in the European Union: An analysis of the heavy-duty CO_2 standards baseline data.	• Average CO_2 emission factor for road transport operations per tonne-km	Eunomia
Bakkaloglu et al. (2021) 'Quantification of methane emissions from UK biogas plants'	• Quantifying methane emissions from UK AD biogas plants from leakage	Eunomia
Brown *et al.* (2020) 'An assessment of road-verge grass as a feedstock for farm-fed anaerobic digestion plants'	• Estimation of methane yield per tonne of Volatile Solid of road side grass cuttings	Eunomia
Canadian National Railway (CN) (n.d.) CN's Carbon Calculator emission factors.	• Average CO_2 emission factor for sea transport (bulk carrier)	Eunomia
Farmers Weekly (n.d.) 'Q&A: Tips on using anaerobic digestate as a fertiliser'	• Nutrient content of grass-cutting digestate (N)	Eunomia
New Mexico State University (n.d.) *Agricultural circulars: ID 56854*	• Nutrient content of synthetic fertiliser (N)	Eunomia

Institute of Materials, Minerals and Mining (2025) 'Asphalt mix to capture carbon'	- Biochar content in biochar-enriched asphalt	Eunomia
Tisserant & Cherubini, 2019. 'Potentials, Limitations, Co-Benefits, and Trade-Offs of Biochar Applications to Soils for Climate Change Mitigation'	- Biochar life cycle carbon impacts including supply chain and pyrolysis, avoided fossil carbon emissions by using bio-oil and pyrolysis gas for energy production, and carbon sequestration in biochar	Eunomia
Möller, K. and Müller, T. (2016) 'Effects of anaerobic digestate on soil fertility and plant growth – A review'	- Mass conversion ratio of grass feedstock to biochar	Eunomia
Chen et al. (2021). 'Life-cycle assessment of climate change impact on time-dependent emissions from asphalt pavement'	- Life cycle CO_2 emissions for one mile of two-lane asphalt pavement on principal arterial highway (excluding use phase and end of life)	Eunomia
We Love Paving (n.d.) 'What is the minimum thickness of asphalt pavement?'	- Asphalt depth (thickness)	Eunomia
Quora (n.d.) What is the density of asphalt paving?	- Asphalt density (agreement with Ma et al. (2016) above)	Eunomia
Quora (n.d.) 'Who decides how wide to make city and highway roads/lanes? How are these widths decided?'	- 2-lane asphalt payment width given pavement type in Ma et al. (2016)	Eunomia
Ma, F. et al. (2016) 'Greenhouse gas emissions from asphalt pavement construction: A case study in China'	- Supporting values for carbon footprint and dimensions of asphalt pavement (supports Chen et al. (2021) width, depth, and density assumptions used.)	Eunomia
Agg-Net (n.d.) 'The road to net-zero asphalt'	- Emission factor of asphalt – supporting derived values from Chen et al. (2021) and density assumptions	Eunomia

Figure 1: Model flow Diagram

2.3 Data gaps

This section sets out the key data gaps involved in the study.

Wildfire risk

The removal of grass cuttings from roadside verges may also bring additional benefits that are similarly difficult to quantify. For instance, removing grass cuttings from roadside verges may reduce wildfire risk as cut material, if left in situ, dries quickly and can create a continuous layer of fine, highly flammable fuel. Collecting and removing cuttings lowers fuel load and breaks fuel continuity along roads, which are common ignition sources. As a result, fires are less likely to start and, if they do, are less likely to spread rapidly. However, it is unclear how this compares to a baseline of uncut grass, where living grass retains more moisture which may attenuate fire risk. A lack of either in field testing or literature applicable to the roadside verge context makes estimating this reduction in fire risk difficult.

Local amenity

Removing grass from roadside verges can also enhance local amenities and placemaking, by improving visual quality and reinforcing local character by providing more purposeful, neat looking and attractive landscapes. Moreover, as discussed above, allowing grass to grow longer due to less frequent cutting allows for flower-rich (and hence colourful) verges. This can also increase human engagement with nature and aesthetic appeal. In addition, reducing or eliminating the need for regular mowing decreases noise, traffic disruption, and general inconvenience for nearby residents, resulting in a quieter, more pleasant environment and lower levels of ongoing disturbance. Conversely however, it could be argued that the longer gap between cuts results in progressively less neat looking verges. Ultimately, it should be noted that these potential benefits are heavily dependent on societal preference and are expected to only be modest in aggregate.

2.4 Analysis process

2.4.1 Operational costs

The operational costs to SGC for cut and collect versus baseline cut and leave were extracted from Livelabs data provided by SGC and are presented in Table 3. The frequency with which operational management must be carried out (more often for cut and leave for example) is also considered.

Table 3: Operational costs

Carbon Source	Cut and leave	Cut and collect
Fuel for verge cutting	✓	✓
Resource days for verge cutting	✓	✓
Transport of cuttings to depot	-	✓
Transport of cuttings from depot to AD plant	-	✓

In addition, some value can also be directly generated by SGC through cut and collect via the sale of the grass feedstock to the AD plant. This was advised by SGC to be at least £10 per tonne of feedstock but may be higher subject to market changes in future.

2.4.2 Carbon

The carbon profiles of Greenprint's key components and stages, under the different potential pathways, are summarised below and detailed further in Appendix A.1.0:

- **Biogenic emissions** from the cut and leave process. This arises because grass that is cut but left on site releases greenhouse gases as the plant material decomposes. These emissions come from both the damaged grass tissues and the microorganisms that break down the clippings over time.[2] Values were extracted directly from the Carbon Baseline report by UWE. UWE calculated biogenic emissions directly by measuring the amount of grass cut and left on site and applying greenhouse gas emission factors released during aerobic decomposition, validated using lab and field studies.

- **Increased carbon sequestration** from the transition from cut and leave to cut and collect as a result of less frequent cuttings. In particular, less frequent cutting allows plants to allocate more carbon below ground into the roots, which are much more efficiently stabilised as soil organic carbon than above-ground material, leading to gradual increases in long-term soil carbon storage. In contrast to biogenic emissions, carbon sequestration could not be directly quantified from short-term monitoring, so UWE relied on soil sampling combined with published literature to infer likely rates of soil carbon accumulation under different management regimes. The sequestration rate from cut and collect was determined to be 61.92 $kgCO_2/1000m^2$ (derived from the Adkins report).

- **Carbon difference for operational management and transport.** This quantifies the difference in carbon emissions for cut and leave versus cut and collect, taking into account the following metrics.
  - Fuel for verge cutting [both C&L and C&C]
  - Transport to undertake verge cutting [both C&L and C&C]
  - Transport of cuttings to depot [C&C only]
  - Transport of cuttings from depot to AD plant [C&C only]

- **Emissions due to leakage of methane from the AD plant.** Inevitably some methane leaks from the AD biogas plant during the anaerobic digestion process, which must be considered as part of the GHG profile of the cut and collect process. It was estimated that approximately 5.39kg CO_2e per 1,000m^2 of cut area are emitted due to methane leakage at the AD plant.

- **Avoided emissions of using anaerobic digestate** made using SGC grass cuttings, versus synthetic fertiliser (for which an energy-intensive manufacturing process is required). In addition, when applied to the soil, digestate can increase soil organic carbon and reduce net greenhouse gas emissions by recycling nutrients and carbon that would otherwise be lost as methane or CO_2.

- **Avoided emissions of burning biogas for electricity** produced in the processing of SGC grass cuttings. Generating electricity from biogas at an anaerobic digestion (AD) plant delivers carbon savings compared with the grid average since the biogas displaces electricity which is in part fossil-fuel-based and captures methane that would otherwise be released to the atmosphere. It should be noted that as the UK grid moves away from fossil fuels, this impact is expected to reduce over time.

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[2] Notably, carbon benefits arising from leaving grass cuttings, via decomposition into the below ground level, have not been included in the current carbon model. Although leaving clippings adds additional above-ground organic material to the verge each year, only a very small fraction of this carbon is expected to form stable soil organic carbon, and the annual change is negligible compared with the existing soil carbon stocks in near-equilibrium grassland systems (Phukubye et al., 2022).

- **Avoided emissions of using biomethane fuel** produced in the processing of SGC grass cuttings, as opposed to the use of diesel or petrol. Using biomethane as a fuel instead of diesel or petrol avoids emissions by replacing fossil carbon with biogenic carbon and by capturing methane that would otherwise escape to the atmosphere. As a result, biomethane typically delivers substantial lifecycle greenhouse-gas savings compared with conventional road fuels, particularly in heavy transport. As with the point above, if the proportion of electric car usage continues to increase, this impact is expected to reduce over time.

- **Avoided emissions of using biochar** made using grass cuttings, as an asphalt additive. Using biochar as an additive in asphalt can deliver carbon savings by locking stable biogenic carbon into long-lived road materials, effectively sequestering carbon for decades. In addition, biochar can partially replace more carbon-intensive bitumen or fillers, reducing embodied emissions associated with conventional asphalt production.

To monetise these carbon impacts, 2020 UK carbon values produced by the Department for Energy Security and Net Zero (DESNZ) were applied over the 20-year appraisal period (2026–2045).

2.4.3 Biodiversity uplift

The transition to cut and collect may bring about biodiversity benefits on SGC grass verges. In particular, moving to cut and collect with less frequent cutting allows plants to flower and set seed, which increases plant species diversity and provides food and habitat for pollinators and other invertebrates. Removing cuttings also reduces nutrient enrichment of soils, favouring wildflowers over competitive grasses and creating more structurally diverse habitats that support a wider range of species. A systematic review by Jakbsen *et al.*(2018) suggested that to maximise plant species richness on roadside verges, vegetation should be mown once or preferably twice per year, and the cuttings (hay) should be removed after mowing (i.e. cut-and-collect).

Moreover, in March 2025, Plantlife published their baseline report for Greenprint areas, providing a starting point against which future vegetation survey results can be compared to assess change over time. However, since it provides a baseline only, it is not sufficient to estimate the actual biodiversity benefits that may accrue over time in SGC grass verges as a result of the change to cut and collect. Further testing over multiple years will be required to determine actual and estimated future biodiversity benefits.

Nonetheless, to provide a high-level estimate of the likely biodiversity benefits of moving from a cut and leave to a cut and collect management regime, the Biodiversity Metric (Defra, 2025) has been used as a proxy, applying the following assumptions:

- The verge area is classified as Modified Grassland, with the condition improving from poor to moderate over the 20-year appraisal period. This period is consistent with the time to target period in the Biodiversity Metric for this condition change (10 years).

- As per the Biodiversity Metric, a Temporal Multiplier and Difficulty Multiplier of 0.71 (10 years) and 1.00 (low difficulty) respectively have been applied.

- A strategic significance of 1.15 multiplier has been applied, reflecting the ecological desirability of the pilot locations within local nature recovery contexts.

- Based on Defra's BNG Market Analysis (Defra, 2021), a biodiversity unit value of £20,000 was used. This value has been inflated to 2025 prices and annualised over the standard 30-year BNG agreement period.

3.0 Findings

This section examines the carbon, SGC operational cost, and overall cost–benefit implications of transitioning SGC's grass verge management from a cut-and-leave to a cut-and-collect system.

3.1 GHG emissions

SGC operations

As shown in Table 4, from an SGC operational perspective alone, cut and collect delivers an annual GHG emission saving of 73kgCO_2e/1,000m^2 compared to cut and leave. This saving is largely driven by the improved sequestration potential associated with cut and collect, and also the elimination of biogenic emissions as grass cuttings are no longer left on roadside verges.

Table 4: Carbon profiles for SGC operation – cut and collect vs cut and leave (baseline)

Carbon Source	Cut and leave	Cut and collect	Difference
	kgCO_2e/1,000m^2/year		
Fuel for verge cutting	2.2	9.8	-7.6
Transport (verge cutting and collection)	0.0	7.4	-7.4
Resource Days	0.1	0.4	-0.4
Energy for strimmers	0.0	0.0	0.0
Biogenic emissions	26.9	0.0	26.9
Sequestration	0.0	-61.9	61.9
Total	**29.2**	**-44.3**	**73.4**

Avoided emissions for uses of product

Table 5 presents the avoided emissions for each of the end use products made from the grass cuttings under the cut and collect scenario. As described above, biochar as an asphalt additive is not a current option as an end use product for SGC, but is shown here to better demonstrate potential future options should other a pyrolysis plant become locally operational. It is important to note that the digestate for use as a fertiliser will always be produced as an end product at the AD plant, whilst there are two options for the gas that is emitted as a bi-product of the anaerobic digestion process; the burning of biogas for electricity production, or the generation of biomethane for use as a vehicle fuel.

Inevitably some methane leaks from the AD biogas plant during the anaerobic digestion process, which as a greenhouse gas contributes towards GHG emissions which must be considered as part of the carbon profile of the cut and collect process. Estimates on the proportion of methane leaked to the atmosphere vary, for example Bakkaloglu *et al.* (2021) details a range of leakage calculations based on findings across 10 different AD biogas plants in the UK. As derived from the Adkins report, the figure of 5.39 kgCO2e/1000m^2 has been used for methane leakage at the AD plant.

Table 5: Methane leakage and avoided emissions by end of use product

End use product	Plant type	Emissions (kgCO$_2$e/1,000m^2/year)	Avoided emission (kgCO$_2$e/1,000m^2/year)
Methane leakage	AD plant	5.4	0.0
Organic fertiliser digestate	AD plant	0.0	5.8
Electricity production	AD plant	0.0	58.3
Biomethane	AD plant	0.0	39.3
Biochar as asphalt additive	Pyrolosis plant	0.0	5.8

Combined GHG emissions by end use pathway

Table 6 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.

Table 6: Avoided emissions and value for end use pathways

End use pathway	Avoided emissions (kgCO$_2$e/1,000m^2/year)	Carbon Value (£/1,000m^2)
Organic fertiliser + electricity production	132.2	£49.0
Organic fertiliser + biomethane	110.8	£41.1

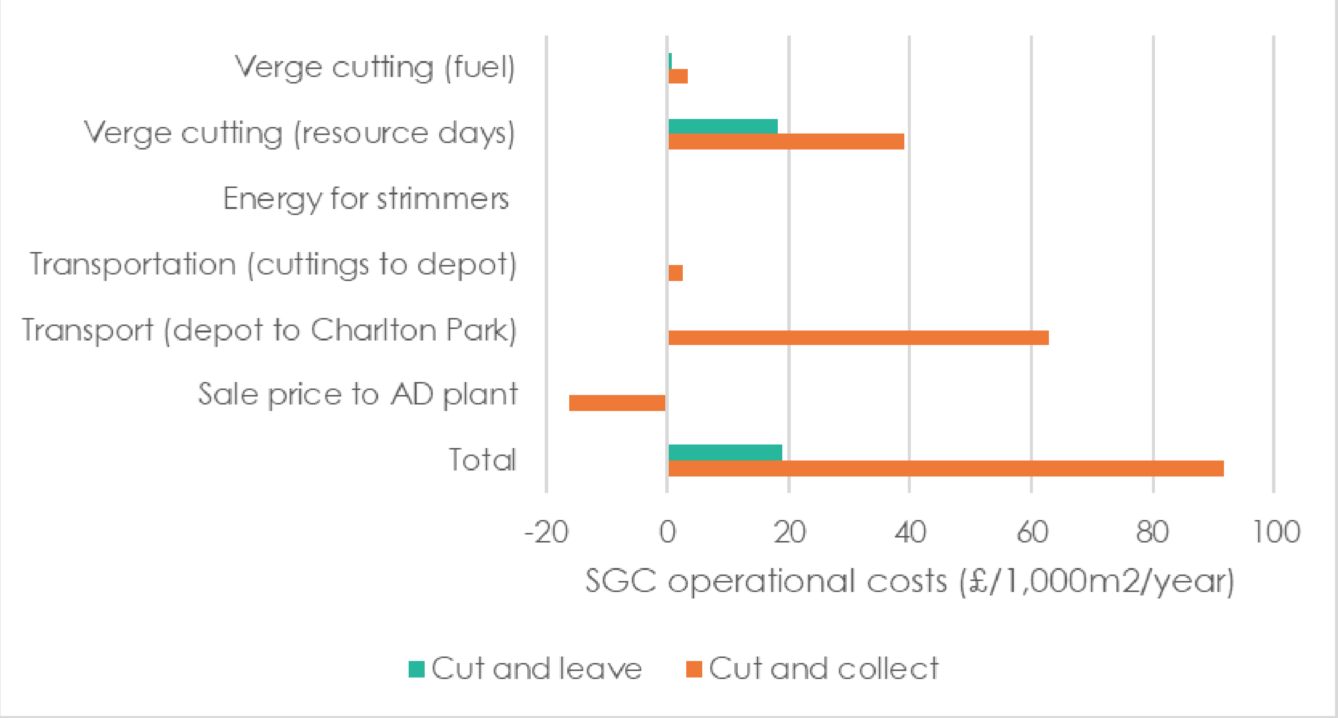
3.2 Operational costs to SGC

Table 7 and Figure 2 below present the operational cost difference for SGC between cut and collect versus cut and leave for the different elements of the processes relevant to each. As can be seen, cut and collect is more expensive than cut and leave, being £73 more expensive per 1,000m^2 of cut area per year. The main driver of this higher cost is the considerable cost to transport the cuttings to the AD plant. Despite a reduced cut frequency, cost in resource days for cut and collect is higher, owing to more time required associated with collection and moving of the cuttings in addition to cutting them. There is however a modest amount of revenue generated for cut and collect via the sale of grass cuttings to the AD plant, at £10 per tonne, or £16.22 per 1,000m^2 of cut area.

Table 7: Cost difference for cut and collect vs cut and leave

Cost category	Cut and leave	Cut and collect	Difference
	£/1,000m²/year		
Verge cutting (fuel)	£0.73	£3.38	-£2.65
Verge cutting (resource days)	£18.14	£38.99	-£20.85
Energy for strimmers	£0.07	£0.04	£0.03
Transportation (cuttings to depot)	£0.00	£2.68	-£2.68
Transport (depot to AD plant)	£0.00	£62.85	-£62.85
Sale price to AD plant	£0.00	-£16.22	£16.22
Total	**£18.94**	**£91.72**	**-£72.78**

Figure 2: SGC operational costs (cut and leave vs cut and collect)



3.3 Biodiversity Uplift

Applying the assumptions set out in Section **Error! Reference source not found.**, the move from cut and leave to cut and collect results in an expected biodiversity uplift of £77 per 1,000m² (2025 prices) as presented in Table 8 below.

Table 8: Biodiversity uplift

Biodiversity parameter	Unit	Cut and leave	Cut and collect	Difference
Biodiversity units	Units / 1,000m²	0.23	0.33	0.10
Biodiversity value	£ / 1,000m² / year	£185	£262	£77

3.4 Cost comparison

To generate a final cost-benefit analysis (CBA) for cut and collect versus cut and leave, the above outputs in Sections 3.1, 0 and 3.3 were combined. Specifically, these include:

- The cost difference for SGC in carrying out cut and collect vs cut and leave.
- The monetised carbon value associated with avoided emissions for SGC in the transition to cut and collect as well as the two end pathways.
- The expected biodiversity uplift in the transition to cut and collect.

Table 9 presents these combined values for each of the two end use pathways. This value is positive for both pathways, indicating an expected positive return on investment for cut and collect relative to cut and leave (with a benefit of £46 - £54 / 1,000m^2 / year). Critically, this relies on the inclusion of expected biodiversity benefits (using BNG unit values as a proxy), since the carbon benefits of a transition to cut and collect alone are not sufficient to counteract the increased operative costs associated with cut and collect.

It should be noted that this cost benefit analysis does not include the additional benefits discussed in 2.3 which cannot be robustly quantified, including amenity enhancements, and reduced wildfire risk and so should be taken as a conservative estimate. Notably, some values across pilot sites varied substantially between 2024 and 2025, with 2024 figures in cases being more than double those of 2025. This highlights the importance of accurately estimating key model inputs, while also recognising that divergence in critical assumptions can materially influence overall assessments of program feasibility. Finally, the value also does not consider the potential sale of carbon units through the ICaN platform (discussed further in Section 3.5 below) which would further increase overall value for money to SGC.

Table 9: Net social benefit for cut and collect vs cut and leave

End pathway	Net social benefit (£/1,000m^2/year)
Organic fertiliser + Electricity production	£53.56
Organic fertiliser + Biomethane	£45.64

As presented in Table 10, extrapolating this cost benefit analysis to the area in the experimental pilot area for cut and collect (36.9ha), results in an expected overall net benefit of £19,762 per year. If this were applied to the entire SGC roadside verge grass area, of 473ha, under the same conditions as the pilot, this would amount to £253,325 of expected net gain per year on average. It should be noted the overall figure is likely to vary per year and across areas in SGC depending on a number of factors, not limited to the growth rate of the grass, fuel costs and the rate of decarbonisation of the electricity grid in England.

Table 10: Costs and benefits

Monetised costs/benefits	Experimental pilot area (36.9ha)	Total SGC roadside verge grass area (473ha)
SGC operational costs	-£26,857	-£344,259
GHG emissions	£18,078	£231,727
Expected biodiversity uplift	£28,541	£365,857
Total	**£19,763**	**£253,325**

3.5 Sale price of carbon units

On a per tonne basis, the carbon savings are calculated to cost between £551-£657/tCO_2e depending on the end use pathway, or £728/ha. This cost also equates to a potential sale price of the carbon units, fully subsidising the move to cut and collect from cut and leave from a carbon perspective (i.e. reducing SGC's operating costs to those associated with the cut and leave scenario).

This is in line with the range of £492-£1,234/tCO_2e for the carbon reductions from installing heat pumps in schools and community facilities previously estimated by Eunomia, though above the Government's carbon price series recommended for carbon appraisals (£260-£326/tCO_2e for the 2025-2040 period)[3]. Similarly, this range is also considerably higher than carbon credits sold by, for example the UK Woodland Carbon Code, which in 2024 sold credits on average at £26.85/tCO_2e, the UK Peatland Code selling in 2024 at £25.04/tCO_2e[4].

This could make the projects less attractive to funders focused solely on avoided emissions. That said, these projects may still represent worthwhile investments when considering their wider benefits to biodiversity (as quantified in Section 3.3), fire risk, visual amenity and promoting circular economy principles. These broader impacts could enhance the business case for investment, particularly if well-communicated to potential funders. These considerations are explored further in Section 4.0.

4.0 Conclusions and Recommendations

Based on the data available, our modelling recommends a sale price per tonne of carbon of between £551-£657, depending on the end use pathway, to cover SGC's operational costs. This equates to 7,600m^2 - 9,000m^2 (0.76 – 0.90ha) of cut and collect area.

Alternatively, if a potential funder preferred to:

- Provide a fixed financial contribution, say £1,000, this would equate to carbon savings of 1.5-1.8 tCO_2e or management of 13,700m^2 for a year.
- Sponsor a given area of intervention, say 10,000m^2 for a year, this would equate to carbon savings of 1.2-1.4tCO_2e or £728 per year.

Ultimately, this report has demonstrated that moving to a cut-and-collect approach is successful in reducing carbon emissions and could deliver meaningful biodiversity benefits. While the carbon benefits alone do not fully offset the high operational costs to SGC, the inclusion of expected biodiversity benefits (with the caveats noted in Section 2.4.3) makes the overall social benefit of the transition positive. Moreover, it is important to note that these results are based on a pilot exercise, and costs are expected to decrease if the practice is adopted over a larger area. Our study has also identified several ways to improve the scheme's net benefits further:

1. **Prioritisation of cut and collect sites**: Costs associated with cut-and-collect are unlikely to be uniform across all sites. In particular, some areas may incur higher costs due to greater transport distances or more challenging terrain, while others may be significantly cheaper to service. Similarly, environmental factors such as soil type and sun exposure will drive higher grass growth rates in specific locations. This suggests that a targeted or phased approach – prioritising sites with lower collection and transport costs, could improve overall cost-effectiveness, rather than

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[3] https://www.gov.uk/government/publications/valuing-greenhouse-gas-emissions-in-policy-appraisal/valuation-of-greenhouse-gas-emissions-for-policy-appraisal-and-evaluation.

[4] https://www.woodlandcarboncode.org.uk/uk-carbon-prices.

assuming full participation of all potential land parcels. It is recommended to explore those areas where costs are lowest to bring down the average cost of the scheme and increase the overall net benefits.

2. **Optimisation at cutting regimes**: As the project matures, there may be opportunities to reduce costs through adaptive management, such as optimising cutting regimes (for example, assessing whether less frequent cutting could still deliver acceptable ecological, aesthetic and carbon outcomes). For instance, whilst 4 cuts per year was undertaken in the pilot exercise, this could potentially be reduced to 3 under a revised scheme. Scaling based on existing data, it is estimated that this reduction in cut frequency would reduce the cost of cut and collect by approximately £11 per 1,000m^2 of cut area per year, bringing the overall operating costs more in line with the cut and leave scenario.

3. **Explore potential for economies of scale**: If a greater area of land area is made part of the project and subject to cut and collect, the operational costs may reduce per m^2 from potential economies of scale. Whilst this report cannot suggest what order of magnitude reduction this might be without further available data, our analysis highlights where the greatest costs to SGC lie and therefore where there is greatest scope for cost reductions. For instance, should SGC be able to make efficiencies in resource use days (staff time) for cut and collect, the overall cost could be brought down substantially. Another high cost is transport of material to the AD plant, using an external contractor. Should SGC be able to deploy their own transport infrastructure, as a result of increased scale, this would similarly help reduce overall costs. Moreover, for the pilot, small bagging mowers that collect the grass as it is being cut have been used. These are less efficient than much larger agricultural style discharge mowers. If their use were adopted, we might expect to see further cost saving.

4. **Additional research into wider benefits**: Due to a lack of robust quantitative data, the study does not account for wider societal benefits including reduced fire risk and potential amenity benefits (see Section 2.3).

Finally, it is important to emphasise that a key strength of the scheme is its innovativeness. It delivers carbon and wider benefits in an under-explored sector that does not require land use changes (unlike tree planting for example), and that works within the boundaries of already ongoing management schemes. Elements such as this innovation as well as the wider benefits could be highlighted on the ICaN platform to lend further support to the value of the scheme and help attract potential funders to the project.

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A.1.0 Appendix: Method for calculating avoided use emissions savings

This appendix summarises the methodologies applied for each of the end use pathways.

A.1.1 Avoided emissions of using digestate fertiliser

To estimate the emissions savings from using digestate fertiliser relative to synthetic fertiliser across the full life cycle, life cycle emissions were calculated separately for each fertiliser type using a common reference unit (e.g. per kilogram of nitrogen applied). The emissions savings were then calculated as the difference between the two values. The life cycle stages included for both were production, transport, and post-application GHG effects in fields. For production emissions, it was assumed that organic fertiliser emissions are zero because it is a byproduct of AD. For synthetic fertiliser, an emissions factor expressed as kg CO_2e/kg of nitrogen was used, derived from Walling & Vaneeckhaute (2020). Post-application emissions for both fertilisers were also derived from this source in the same unit. Transport emissions were estimated by determining the distance travelled from the production facility to the site of application for both organic and synthetic fertilisers, and combining these distances with appropriate transport emission factors for the modes used (e.g. kg CO_2e per tonne-kilometre for long-haul road transport). A reference value cited for transport distance for organic fertiliser is 80km, while for synthetic nitrogen fertilisers it is between 500-1000km (Walling & Vaneeckhaute, 2020). Therefore, 80km was the assumed transport distance for organic fertiliser, while an average of 750km was used for synthetic. Assumptions were made about the relative contribution to the total transport distance of road vs sea transport for the two types of fertiliser:

- Organic fertiliser was assumed to be transported completely by road, while for synthetic, 80% was assumed to be bulk carrier sea transport, and the remaining 20% road.
- For both fertilisers, the road transport component was assumed to be comprised of 20% urban transport and 80% long-haul truck transport, which both imply different emissions factors.

Emissions factors for these transport modes in tonne-kilometre units were obtained for both types of truck and a bulk carrier ocean vessel from Rodríguez et al. (2021) and the Canadian National Railway Carbon Calculator respectively. These tonne-km units were converted to kilograms of nitrogen content (to make them comparable with the production emissions value and post application value) by first dividing by 1,000, then dividing the value by the proportion of nitrogen content in the two types of fertilisers. These factors were then multiplied by the calculated distances of each respective transport mode to arrive at the total emissions for transport of both fertilisers.

Emissions for production, transport, and post-application effects were summed to obtain a total life cycle carbon value for the two fertilisers. The two values were converted to be expressed on a per kg of fertiliser metric, with the difference taken between them to obtain the relative life cycle carbon emissions savings from substituting synthetic with organic fertiliser. Finally, this value was then converted to units of $kgCO_2e/1,000m^2$/year (by first expressing emissions on a per-tonne-of-feedstock basis) for use in the model.

A.1.2 Avoided emissions of using biogas for electricity production

The approach taken to calculate avoided emissions from using biogas for electricity generation, relative to grid-supplied electricity, involved quantifying the emissions associated with biogas combustion and comparing these with the typical emissions intensity of grid electricity.

Livelabs Proforma data was used to determine the amount of electricity, in kilowatt hours, that could be produced per tonne of grass feedstock. It was determined that the emissions profile for the burning of biogas produced by the AD plant, for electricity, was a carbon neutral activity because it largely recycles carbon that is already part of the short-term natural carbon cycle, rather than adding new carbon to the atmosphere.

Average emissions factors for electricity generation for the UK grid were applied from latest available (2024) grid emission factors data published by ITPenergised[5] (0.21kgCO_2e/kwh). This considers the combined sources used to generate electricity in the UK. Finally, this value was multiplied by the amount of electricity produced per tonne of grass feedstock to determine emissions savings per tonne of grass feedstock, to which the conversion factor for amount of feedstock produced per area of cut area was subsequently applied to determine emissions reduction in kgCO_2e/1,000m^2/year.

A.1.3 Avoided emissions of using biomethane

To estimate the relative avoided emissions benefit of using biomethane as a vehicle fuel relative to diesel fuel (the typical fuel used in HGV transportation), the “well to wheel” carbon intensities of biomethane versus diesel were compared.

The first step was to determine the amount of biomethane produced per kilogram of feedstock. Well to wheel carbon intensities of biomethane and diesel respectively, measured in gCO_2e/MJ, were the applied from Department for Transport reports[6] and academic technical report summaries.[7] The difference between these values was then divided by the energy content of biomethane, measured in MJ/m^3 to determine the reduced emissions per m^3 of biomethane. This was divided by the biomethane production per kg of feedstock to determine carbon emissions per kg of feedstock, which was subsequently converted into emissions reduction in kgCO_2e/1,000m^2/year.

A.1.4 Avoided emissions of using biochar

To estimate the relative emissions benefit of biochar as an asphalt additive, the life cycle emissions of a reference amount of conventional asphalt was compared with those of the same amount of biochar-enriched asphalt.

For conventional asphalt, the life cycle assessment used was Chen et al. (2021) which estimates total GHG emissions for a one mile of two-lane asphalt pavement on principal arterial highway. The value used excluded use phase and end of life emissions, focusing only on production, transport and construction phases.

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[5] New 2024 UK Grid Emissions Factors - ITPEnergised

[6] Department for Transport (2025) ‘RTFO and SAF Mandate Technical Guidance’ [Available at: rtfo-and-saf-mandate-technical-guidance-2025.pdf]

[7] Kramar, V. (2025) ‘Carbon intensity of biomethane for different raw materials and production technologies’

For biochar, the life cycle emissions were derived from a literature review by Tisserant & Cherubini (2019) that presented the distribution of emission values from across the literature on biochar for:

1. Supply chain and pyrolysis emissions
2. Avoided emissions from the use of bio-oil and pyrolysis gas for energy production, and
3. The carbon sequestered in biochar, which were all summed.

In order to derive a reference emissions value of biochar-enriched asphalt, the calculated life cycle biochar emissions were multiplied by 3%, which is an industry value for the typical enrichment percentage of asphalt with biochar. This value was then added to 97% of the total life cycle emissions calculated for one tonne of conventional asphalt, representing one tonne of biochar-enriched asphalt. The life cycle emissions value for one tonne of asphalt was then subtracted from the same value for one tonne of biochar-enriched asphalt to obtain the relative emissions savings per tonne of asphalt. Finally, this value was converted to units of kgCO_2e/1,000m^2/year.