

APPENDIX D FUGITIVE EMISSIONS FROM THE TRANSPORT OF STRAW

A.1 Overview

- A.1.1 It is understood that no formal studies have quantified the actual amounts that are shed from straw in transit. The following analysis has therefore been prepared to provide an initial feel for the volumes of material involved and demonstrate why the issue is not considered to represent a key operational or environmental issue along the main haulage routes. Indeed straw loss associated with the commercial supply of Biomass facilities at other sites in Europe & the UK has been considered to be of such limited concern that reviews have identified that the risks associated with netting / covering of vehicles offset any issues relating to straw loss.
- A.1.2 Underlying calculations to support the analysis are attached as a separate spreadsheet in Annex A to this note.
- A.1.3 The analysis is considered in two parts:
- How much straw might be lost in transit; and then
 - Where is the straw deposited.

A.2 Quantifying losses in transit

Losses per trip

- A.2.1 Straw losses from vehicle load are only incurred at the exposed surfaces on each load. Any starting point for the calculations of straw loss is therefore to calculate the extent of exposed surfaces on a standard commercial straw load. Such loads are typically 36 Hesston bales arranged in 3 layers, 6 bales long by 2 bales wide. The ends are ignored as they will not be subjected to the drag forces that will blow straw loose from a load. Allowing two exposed sides and the load top, the total exposed area on each commercial load is estimated to be 80m².
- A.2.2 Typically straw losses would only be incurred to a particular depth in the exposed bale. The analysis in this note is based on a 50mm exposure depth. Total volume of the boundary layer on each vehicle exposed to potential straw losses is therefore calculated to be of the order of 7.3m³.
- A.2.3 An estimate of 1% of actual volume loss has been utilised to calculate the likely level of boundary volume straw loss. The number is necessarily low because as any higher level of losses would represent a severe impact on the ability of the bale twine to hold the bale together. In all but a very few cases, bales are recorded as being firmly bound upon arrival at site and so it is known that the fundamental structure of the bale is generally sound (bales which do have a loose structure are usually spotted during loading and rejected at the field origin).
- A.2.4 On the basis of the above assumptions the volume of straw lost per load is 0.07m³. Given the density of straw, the estimated loss from each load is therefore 10.7kg, which is 0.05% of the payload by mass.

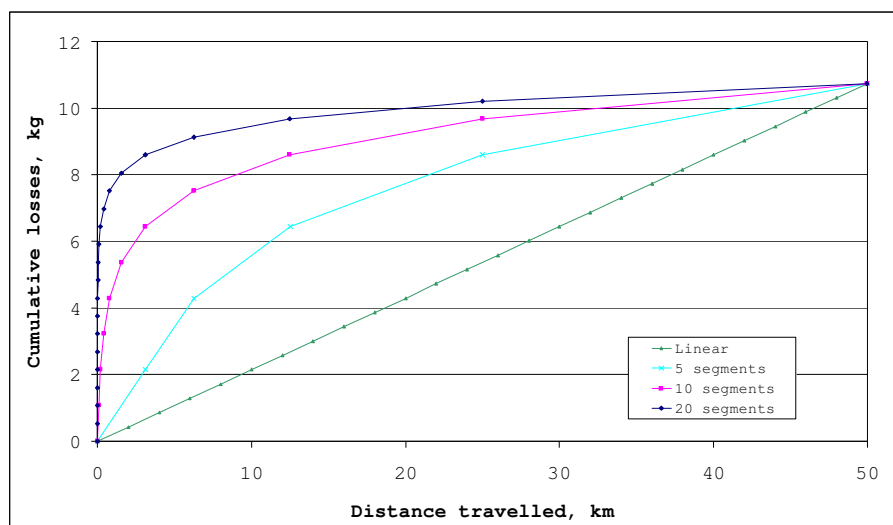
Total losses

- A.2.5 The plant will require of the order of 12,020 straw deliveries per year to operate at capacity. The total losses over all deliveries would therefore be of the order of 129 tonnes out of a total annual requirement of 238,000 tonnes.

A.3 Quantifying where straw will be deposited.

Losses per trip

- A.3.1 To assist the analysis in this report, it is assumed that every straw load travels of the order of 50km to site. This represents the average distance from supply to plant for the fuel contracted to date. Two factors are likely to change this number:
- (a) 50km is as the crow flies, actually distances travelled will be higher; and
 - (b) Straw contracting policy generally would be to source more remote straw first, such that the balance of straw will be obtained from farms close to the site with the potential to reduce average transport distances.
- A.3.2 The two factors above will tend to cancel each other out and it was felt that, on balance, the 50km assumption was therefore reasonable.
- A.3.3 If straw was lost at a constant rate over the average 50km trip then the losses per km travelled per vehicle would therefore be 0.214 kg/km.
- A.3.4 Typically such an average rate of straw loss would not take place along the length of the delivery vehicle journey due to the following issues.
- (a) Losses caused by vibration (i.e. shaking straw free from bales) are likely to occur in the first few hundred metres travelled. There will be further losses, but the rate of loss is likely to be far less later in the journey when loose straw has already fallen away.
 - (b) Losses caused by drag (i.e. plucking straw free from bales as a result of air flow over the surface) are likely to occur soon after the load is first moved at higher speeds. Again, it stands to reason that the initial losses will be highest.
- A.3.5 The implication of the above two issues is that losses should not be expected to be constant over the journey. Instead, the rate of loss can be expected to drop as the journey progresses from the point of straw origin.
- A.3.6 The figure below illustrates this point. The straight line shows the how the losses would accumulate over the standard 50km journey if the rate of loss is constant over the journey. The curves illustrate how cumulative losses would vary over distance travelled if losses are more pronounced in the early stages in the journey. The curves have been created by dividing the journey into segments and assuming that the losses during each segment are constant; the distance travelled in each segment is twice the distance travelled in the preceding segment.



A.3.7 It is considered that a reasonable straw loss relationship is modelled when the journey is split into 10 segments. However, the key relationship to note is that, for any of the predicted loss curves, the losses in the first 25km of the journey are far higher than those suffered in the latter half of the journey. The following table summarises these results.

Curve	First half losses (kg)	First half losses (%)	Second half losses (g/km)
Linear	5.4	50%	215
5 segment	8.6	80%	86
10 segment	9.7	90%	43
20 segment	10.2	95%	21

A.3.8 Based on the trends presented in the figure, the losses at the end of the journey are estimated to be in the order of just 50g/km travelled.

Total losses

A.3.9 The analysis of a single journey described above is considered to tell only part of the story. Given that the REP site is considered likely to generate over 12,000 operational HGV deliver journeys per year, it is important that total losses are considered.

A.3.10 Straw stocks are dispersed over a wide area at hundreds of individual stockpile origins. Thus, in each year, individual country lanes will only suffer deposition from a handful of straw lorries at the start of their journeys; the numbers on each road will increase with capacity of the road and proximity to the plant.

A.3.11 The above curves and the reasoning behind them have demonstrated that losses are concentrated in the early part of the journey. As discussed above, fortunately, this coincides with roads that are less frequently exposed to straw journeys. Moreover, the early stages in each journey will be on predominantly rural roads which are more exposed to agricultural traffic and their associated fugitive emissions. For these reasons (fewer journeys and inherent agricultural exposure), the cumulative losses on roads remote from the plant are not likely to cause a nuisance.

A.3.12 The frequency of journeys over roads close to the plant will increase, peaking on the A18 / B1206 corridor - which is anticipated accommodate virtually all straw delivery vehicles due to local routeing agreements. The table below summarises the deposition on Boston Road assuming 12,020 deliveries a year over 50 weeks, each comprising 5.5 delivery days.

Curve	Annual deposition (kg/km)	First half losses (kg/week)	Second half losses (kg/delivery day)
Linear	2582	51.6	9.4
5 segment	1033	20.7	3.8
10 segment	517	10.3	1.9
20 segment	258	5.2	0.9

Summary

A.3.13 The results of this analysis are considered to reflect the operation of other Biomass facilities within Europe and the UK. Visits to these sites demonstrate strictly limited evidence of straw loss both within the plant area and on the immediate highway links serving the facilities. Such evidence is considered to reflect the efficient baling systems utilised for the straw and the fact that any straw loss from the vehicle would likely have taken place at the point of origin and / or the early parts of the vehicle journey.

Annex A: Spreadsheet Calculations

BRIGG RENEWABLE ENERGY PLANT

DIMENSIONS

HESSTON BALES

Height	mm	1270
Width	mm	1200
Length	mm	2450
Mass	kg	550
Volume	m ³	3.7
Density	kg/m ³	147

PAYLOAD

Bales long		6
Bales across		2
Bales high		3
Bales		36
Length	m	14.7
Height	m	3.8
Width	m	2.4
Total volume	m ³	134
Surface area, top	m ²	35
Depth of boundary layer	mm	50
Volume of boundary layer	m ³	1.8
Surface area, side	m ²	55
Volume of one side	m ³	2.8
Volume of boundary layer	m ³	7.3
Proportion of total	%	5%

LOADS

Total mass delivered	t/y	238,000
Mass per payload	t	19.8
Payloads		12020

LOSSES

Losses	%	1%
Loss per load	m ³	0.07
	kg	10.7
Total, boundary layers	m ³	87642
Losses	m ³	876
	kg	129099
	t	129
Losses	%mass	0.05%