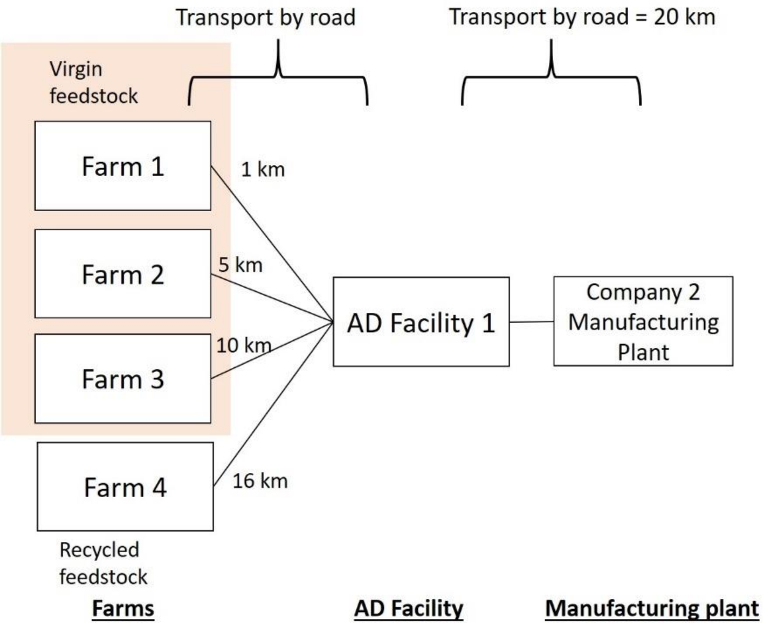
Material 5: Anaerobic digestate produced by Company 2

Company 2 is supplied with solid anaerobic digestate from a single AD facility. The feedstock used by the AD facility is 70% energy crops (a virgin material) and 30% poultry manure (a recycled material).

As per Table 1, anaerobic digestate should be treated as a virgin material or a recycled material depending on the source material. Where the digestate is a blend of sources the scores for the material should be the weighted average for the proportion of each source in the blend on an annual basis. The weighting should be applied after the individual score is generated for each source even though they are in a blend for parts of the production process. Therefore, individual scores are generated for each category of feedstock (based on anaerobic digestate being produced 100% from each feedstock) before a product score is derived.

Supply chain map for Company 2 digestate



Company 2 is supplied with anaerobic digestate from a single AD facility 20 km away. This facility is a farming operation (Farm 1) with an on-farm digestor (AD Facility 1). 75% of the energy crop feedstock (maize silage) is produced on-farm (Farm 1). The remaining 25% of the energy crop feedstock comes from two neighbouring farms (Farm 2 and Farm 3). Farm 2 is rented land that is 5 km away. The land is managed by Farm 1 and supplies 15% of the feedstock. Farm 3 is 10 km away and supplies 10% of the feedstock. All farm operations at Farm 3 are carried out by Farm 3, except for the maize harvest and transport of the silage to Farm 1, which is carried out by Farm 1.

The poultry manure comes from a poultry farm (Farm 4) that is 16 km away and is supplied by specialist contractors.

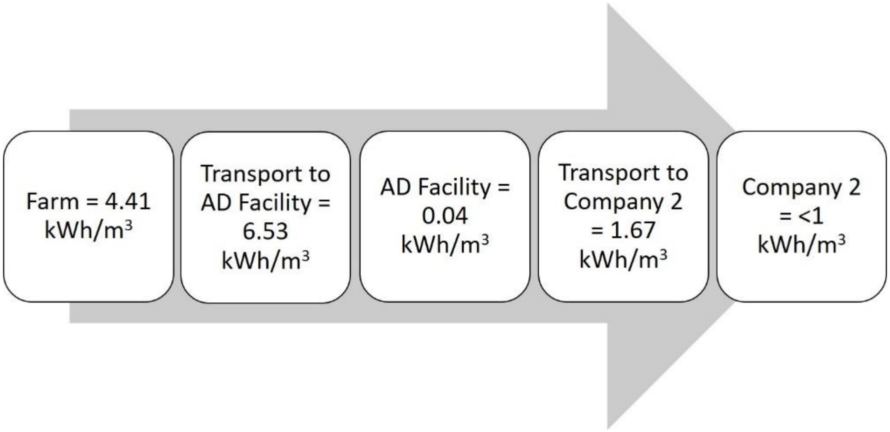
Energy crop feedstock

This is a virgin material (by-product) (Table 1); therefore the starting point for this material is the field. However, as per Table 3, for some criteria (energy use and water use) generic data should be used at the farm and for transport to the AD facility (unless site specific data is available) and for other criteria (social compliance, pollution and resource use efficiency) the starting point for assessment is the farm (social compliance only) or the AD facility. The end point is the end of the mixing system (Table 1).

The product is a solid digestate; therefore, per Table 2 it is responsible for 6% of the impact at the farm, 6% of the impact at the digestor, 67% of the impact at the separator and 100% of the impact after the separator up to the mixing system.

As per Table 7, it is assumed that there is 10% recoverable fibre by weight of input material and that 1 tonne of fibre has a volume of 2.7 m^3.

Energy use (in extraction, transport and production)



As per Table 3, generic data should be used for the operations at the farm and for transport to the anaerobic digestion facility (unless real data is available).

As per Table 7, typical energy use for farm practices associated with energy crops are available from a range of sources. One example is the AD tool produced by the Bioenergy and Organic Resources Research Group at the University of Southampton. This is used to generate generic data in this worked example.

Using the tool the average UK yield of maize silage is 45 t/ha and the total energy use in crop production (excluding fertiliser applications) is 82 l/ha (including average 1 km transport on-farm). 1 litre of diesel is equivalent to 10.9 kWh (Table 4). Anaerobic digestate (from energy crops) is responsible for 6% of the impact at the farm (Table 2). As per Table 7, it is assumed that there is 10% recoverable fibre by weight of input material and that 1 tonne of fibre has a volume of 2.7 m^3. Therefore, the energy use at the farm that the anaerobic digestate (from energy crops) is responsible for ((82*10.9)/(45*0.1*2.7))*0.06 = 4.41 kWh/m^3

There is no additional energy used in transport of maize silage from Farm 1 to the AD Facility 1 as this is covered by the average 1 km on-farm transport.

Maize silage is transported 5 km by road from Farm 2 to the AD Facility 1 (10 km for the round trip as the return journey for empty vehicles is in scope). An average load is 16 tonnes. The tractor and trailer uses 25 litres of diesel per hour. 1 litre of diesel is equivalent to 10.9 kWh (Table 4). It is assumed that 6 km of the return journey is made at the maximum speed limit for agricultural tractors and trailer of 40 kph and the rest of the journey is made at an average speed of 20 kph, therefore the 10 km round trip has a drive time of 21 minutes. As per Table 7, it is assumed that there is 10% recoverable fibre by weight of input material and that 1 tonne of fibre has a volume of 2.7 m^3. Anaerobic digestate (from energy crops) is responsible for 6% of the impact of transport from the farm to the AD facility (Table 2). Therefore, the fossil fuel energy use for transport of the maize silage to AD Facility 1 is ((10*((21/60)*25)*10.9)/(16*0.1*2.7))*0.06 = 13.25 kWh/m^3 (Farm 2)

Maize silage is transported 10 km by road from Farm 3 to the AD Facility 1 (20 km for the round trip as the return journey for empty vehicles is in scope). It is assumed that 16 km of the return journey is made at the maximum speed limit for agricultural tractors and trailer of 40 kph and the rest of the journey is made at an average speed of 20 kph, therefore the 20 km round trip has a drive time of 36 minutes.

Farm	Energy use in transport to AD Facility (kWh/m^3)	% of Company 2 volume (virgin material only)	Weighted energy by volume (kWh/m^3)
1	0 (fully covered in crop production)	75	0
2	((10*((21/60)*25)*10.9)/(16*0.1*2.7))*0.06 = 13.25	15	13.25*0.15 = 1.99
3	((20*((36/60)*25)*10.9)/(16*0.1*2.7))*0.06 = 45.42	10	45.42*0.10 = 4.54
		Average annual energy use	6.53

As per Figure 4 only energy use from fossil fuels is in scope. AD Facility 1 is powered by the renewable energy produced by the facility itself, as is the separator and drying operations. However, AD Facility 1 uses diesel fuelled manitou, teleporter type machine to load the digestor. This consumes 3 litres of diesel per hour and is run for one hour per day. The volume of maize silage loaded per day is 200 tonnes. 1 litre of diesel is equivalent to 10.9 kWh (Table 4). As per Table 7, it is assumed that there is 10% recoverable fibre by weight of input material and that 1 tonne of fibre has a volume of 2.7 m^3. Anaerobic digestate (from energy crops) is responsible for 6% of the impact at the AD facility (Table 2). Therefore, the fossil fuel use by AD Facility 1 is ((3*1*10.9)/(200*0.1*2.7))*0.06 = 0.04 kWh/m^3.

Solid anaerobic digestate is transported 20 km by road from AD Facility 1 to Company 2. (the return journey for empty vehicles is out of scope – third party haulage). An average load is 20 tonnes. The articulated lorry uses 0.414 litres of diesel per kilometre (Table 5, 75% weight laden). 1 litre of diesel is equivalent to 10.9 kWh (Table 4). As per Table 7, it is assumed that 1 tonne of fibre has a volume of 2.7 m^3. Anaerobic digestate (from energy crops) is responsible for 100% of the impact of transport from the AD facility to the manufacturing plant (Table 2). Therefore, the fossil fuel energy use for transport of the fibre to manufacturing plant is (20*0.414*10.9)/(20*2.7) = 1.67 kWh/m^3

Company 2 uses Q litres of diesel per m^3 of final product. 1 litre of diesel is equivalent to 10.9 kWh (Table 4). = Q*10.9 = BB kWh/m^3. It is assumed BB is <1 kWh/m^3.

Therefore, the total non-renewable energy used from farm to the mixing system is 4.41+6.53+0.04+1.67+<1 kWh/m^3 = 13.15±0.50 kWh/m^3. Therefore, the material scores 14 (Figure 4).

Water use (in extraction and production)

As per Table 3, generic data should be used for crop production.

As per Table 8 energy crops (including maize silage) used to supply AD facilities are typically un-irrigated in the UK so no potable or abstracted water is used.

The AD Facility uses stored rainwater harvested from the site, so no potable or abstracted water is used.

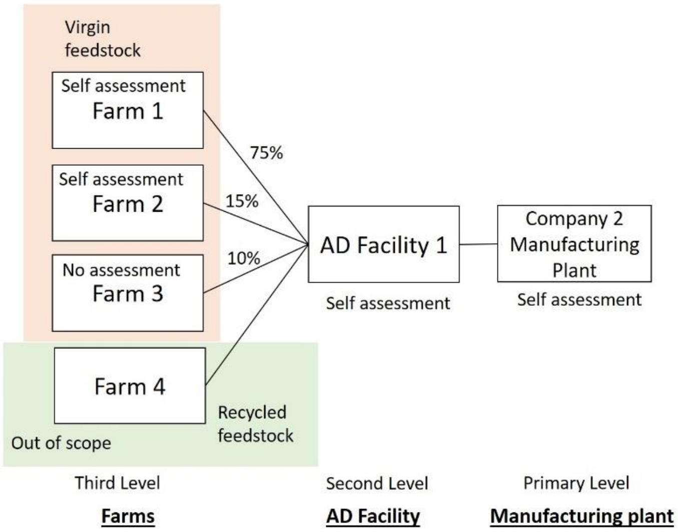
No water is used by Company 2 to manufacture the final product.

Therefore, no (zero) potable or abstracted water is used from farm to mixing system and the material scores 20 (Figure 6).

Social compliance

Company 2, the AD Facility and its own Farm (Farm 1, including the rented land at Farm 2 managed by Farm 1) have completed self-assessment questionnaires to demonstrate social compliance. As per Table 10, this is valued at 0.5 of an audited third party assessment.

Farm 3 has not undertaken any form of assessment. They have no proof of their social compliance.



Ingredient Rater for Growing Media Material

Growing media material type	Number of tiers / steps in supply chain	Primary level	Second level	Third level	Fourth level	Fifth level
Another	3	1	1	3		
Percent of material obtained by level	1	100%	100%	75%		
	2			15%		
	3			10%		
	4					
	5					
		100%	100%	100%	0%	0%
SAQ or Audit	1	SAQ	SAQ	SAQ		
	2			SAQ		
	3			None		
	4					
	5					
OVERALL MATERIAL SCORE	49.00%					

The level of proof of social compliance, as calculated using the social compliance calculator is 49% and the material scores 9 (Figure 8).

Habitat and biodiversity

All the land in Farms 1, 2 and 3 used to grow maize was not semi-natural habitat immediately before planting of these energy crops and have been in agricultural use for decades. Farms 2 and 3 are not in a higher level environmental scheme or being managed to a similar standard. Farm 1 is signed up to a Countryside Stewardship agreement.

Therefore, Farms 2 and 3 score 6 and Farm 1 scores 18. As per Figure 14 a weighted average score needs to be generated for batches from multiple farms.

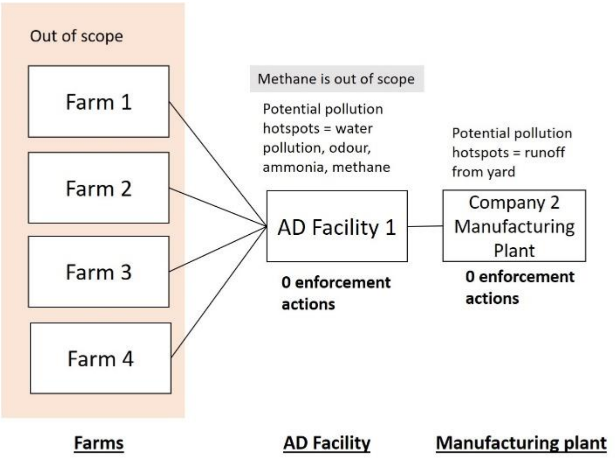
Farm	Habitat and biodiversity score	% of Company 2 volume (virgin material only)	Weighted habitat score by volume
1	18	75	18*0.75 = 13.5
2	6	15	6*0.15 = 0.9
3	6	10	6*0.10 = 0.6
Average habitat and biodiversity score			15

Pollution

As per Table 3, the starting point for anaerobic digestate (from energy crops) for pollution is the AD Facility.

The potential pollution hotspots at the AD Facility are water pollution from storage of feedstock or digestate, runoff from yard, odour, dust, ammonia and loss of biogas. As the biogas is methane it is out of scope because it is a greenhouse gas.

The potential pollution hotspots at the Growing Media Manufacturer (Company 2) is runoff from the yards.



The Environment Agency monitors emissions to air and water from the AD Facility and Company 2. They have brought no enforcement actions against any of the companies. Therefore, the pollution score for this material is 12 (Figure 15).

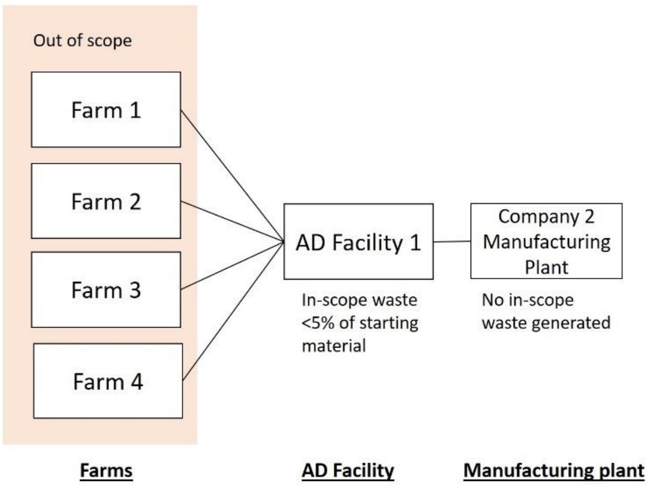
Renewability

Maize is renewable within 5 years at a single site (Table 12), therefore, the material score is 20 (Figure 17).

Resource use efficiency

As per Table 3 the starting point for resource use efficiency for anaerobic digestate (from energy crops) is the AD Facility.

As per Table 1 anaerobic digestate (from energy crops) is a virgin by-product. A small volume of in-scope waste is generated in its production (non-biodegradable plastic sheeting used over silage stores) which is disposed of to landfill. The volume of unrecycled waste is less than 5% of the volume of the starting material. Therefore, the material score is 8 (Figure 18).

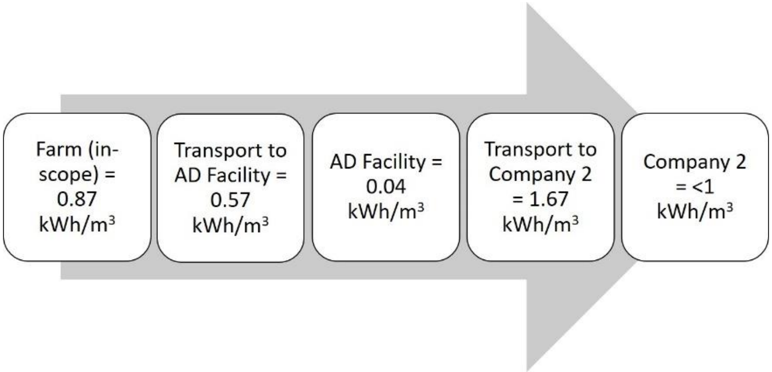


Waste material feedstock

The poultry manure is a recycled material (per Table 1), therefore the starting point for this material is the point at which transport is commercially viable (Table 1), which is the poultry farm. Removal of manure from the poultry houses is carried out by contractors who remove the material, load it on to lorries and have contracts to deliver the material to the AD Facility. The end point is the end of the mixing system (Table 1).

As per Table 7, it is assumed that there is 10% recoverable fibre by weight of input material and that 1 tonne of fibre has a volume of 2.7 m^3.

Energy use (in extraction, transport and production)



In scope fuel use at Farm 4 is from loading lorries for transport. The telehandler uses 10 litres of diesel per hour and it takes 1 hour to load each lorry, so 10 L/load. An average load is 28 tonnes. 1 litre of diesel is equivalent to 10.9 kWh (Table 4). As per Table 7, it is assumed that there is 10% recoverable fibre by weight of input material and that 1 tonne of fibre has a volume of 2.7 m^3. It is assumed that anaerobic digestate (from waste materials) has the same distribution of impacts as anaerobic digestate (from energy crops) and, therefore, is responsible for 6% of the impact before the AD facility from the point that transport is commercially viable (Table 2). Therefore, the in-scope fossil fuel energy use at Farm 4 that the anaerobic digestate is responsible for is = ((10*10.9)/(28*0.1*2.7))*0.06 = 0.87 kWh/m^3

Poultry manure is transported 16 km by road from Farm 4 to the AD Facility 1 (the return journey for the empty vehicle is out of scope as it will not return to Farm 4 but go on to a different poultry farm). An average load is 28 tonnes. The articulated lorry uses 0.414 litres of diesel per kilometre (Table 5, 75% weight laden). 1 litre of diesel is equivalent to 10.9 kWh (Table 4). As per Table 7, it is assumed that there is 10% recoverable fibre by weight of input material and that 1 tonne of fibre has a volume of 2.7 m^3. Anaerobic digestate (from waste materials) is responsible for 6% of the impact of transport from Farm 4 to the AD facility (Table 2). Therefore, the fossil fuel energy use for transport of the poultry manure to AD Facility 1 is ((16*0.414*10.9)/(28*0.1*2.7))*0.06 = 0.57 kWh/m^3

As per Figure 4 only energy use from fossil fuels is in scope. AD Facility 1 is powered by the renewable energy produced by the facility itself, as is the separator and drying operations However, AD Facility 1 uses diesel fuelled manitou, teleporter type machine to load the digestor. This consumes 3 litres of diesel per hour and is run for one hour per day. The volume of maize silage loaded per day is 200 tonnes. 1 litre of diesel is equivalent to 10.9 kWh (Table 4). As per Table 7, it is assumed that there is 10% recoverable fibre by weight of input material and that 1 tonne of fibre has a volume of 2.7 m^3. Anaerobic digestate (from energy crops) is responsible for 6% of the impact at the AD facility (Table

2). Therefore, the fossil fuel use by AD Facility 1 is ((3*1*10.9)/(200*0.1*2.7))*0.06 = 0.04 kWh/m^3.

Solid anaerobic digestate is transported 20 km by road from AD Facility 1 to Company 2. (the return journey for empty vehicles is out of scope – third party haulage). An average load is 20 tonnes. The articulated lorry uses 0.414 litres of diesel per kilometre (Table 5, 75% weight laden). 1 litre of diesel is equivalent to 10.9 kWh (Table 4). As per Table 7, it is assumed that 1 tonne of fibre has a volume of 2.7 m^3. <u>Anaerobic digestate (from energy crops)</u> is responsible for 100% of the impact of transport from the AD facility to the manufacturing plant (Table 2). Therefore, the fossil fuel energy use for transport of the fibre to manufacturing plant is (20*0.414*10.9)/(20*2.7) = 1.67 kWh/m^3

Company 2 uses Q litres of diesel per m^3 of final product. 1 litre of diesel is equivalent to 10.9 kWh (Table 4). = Q*10.9 = BB kWh/m^3. It is assumed BB is <1 kWh/m^3.

Therefore, the total non-renewable energy used from the start of commercially viable transport to the mixing system is 0.87+0.57+0.04+1.67+<1 kWh/m^3 = 3.65±0.50 kWh/m^3. Therefore, the material scores 18 (unless BB > 0.95) (Figure 4).

Water use (in extraction and production)

There is no water use attributable to anaerobic digestate (from waste materials) at Farm 4.

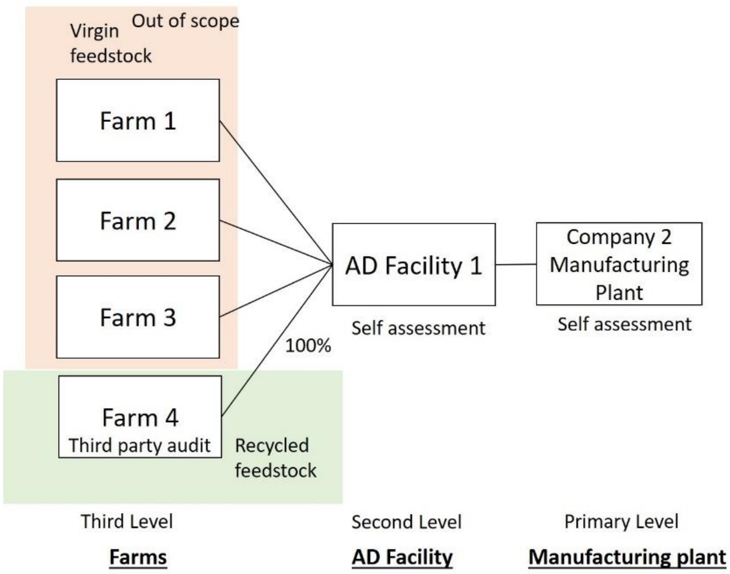
The AD Facility uses stored rainwater harvested from the site, so no potable or abstracted water is used.

No water is used by Company 2 to manufacture the final product.

Therefore, no (zero) potable or abstracted water is used from farm to mixing system and the material scores 20 (Figure 6).

Social compliance

Company 2 and AD Facility 1 have completed self-assessment questionnaires to demonstrate social compliance. As per Table 10, this is valued at 0.5 of an audited third party assessment. The Poultry Farm (Farm 4) has had a third party audit.



Growing media material type	Number of tiers / steps in supply chain	Primary level	Second level	Third level	Fourth level	Fifth level
Another	3	1	1	1		
Percent of material obtained by level	1	100%	100%	100%		
	2					
	3					
	4					
	5					
		100%	100%	100%	0%	0%
SAQ or Audit	1	SAQ	SAQ	Audit		
	2					
	3					
	4					
	5					
OVERALL MATERIAL SCORE	60.00%					

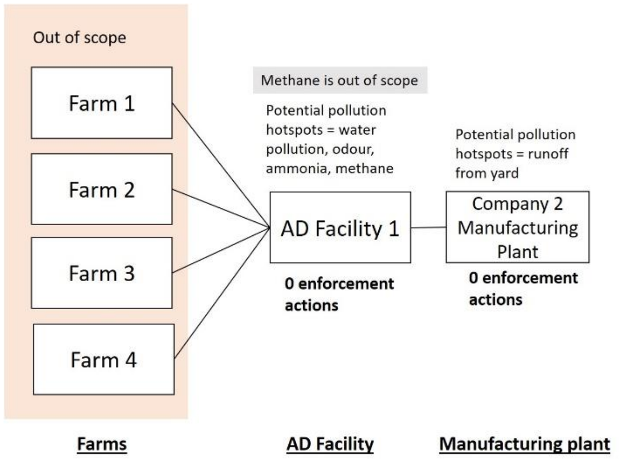
The level of proof of social compliance, as calculated using the social compliance calculator is 60% and the material scores 11 (Figure 8).

Habitat and biodiversity

The material is a recycled material, therefore, the habitat and biodiversity score for this material is 20.

Pollution

The potential pollution hotspots at the AD Facility are water pollution from storage of feedstock or digestate, runoff from yard, odour, dust, ammonia and loss of biogas. As the biogas is methane it is out of scope because it is a greenhouse gas.



The potential pollution hotspots at the Growing Media Manufacturer (Company 2) is runoff from the yards.

The Environment Agency monitors emissions to air and water from the AD Facility and Company 2. They have brought no enforcement actions against any of the companies. Therefore, the pollution score for this material is 12 (Figure 15).

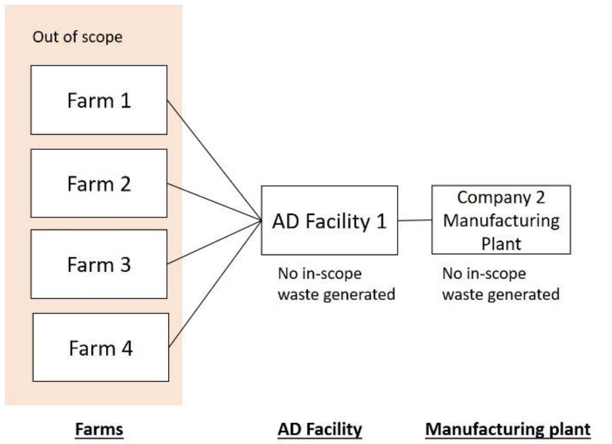
Renewability

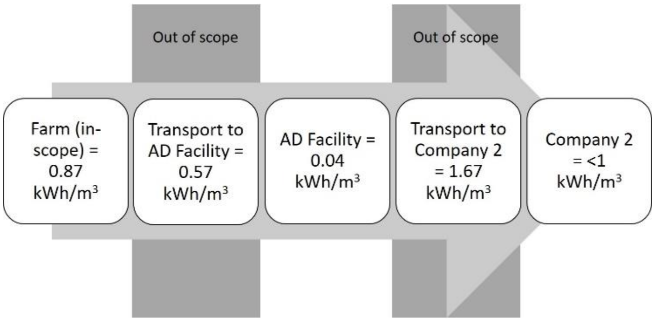
For recycled materials only the formation/growth of the original virgin material that is being recycled is in scope. The material is manufactured from poultry manure which results from the consumption of mainly plant material by poultry. This is renewable at a single site within 5 years (Table 12). Therefore, the material score is 20 (Figure 17).

Resource use efficiency

As per Table 1 anaerobic digestate (from waste) is a recycled material (with a starting point when transport is commercially viable) and no in-scope waste is generated in its production.

Therefore, as per Figure 18 it is necessary to determine the processing energy used for the recovery of this material before a score can be assigned.





The calculations used for the energy criterion should be used here. Transport energy use is out of scope so should be excluded from the total. Therefore, processing energy use here is 1.41±0.50 kWh/m^3. The score is dependent on whether this value is < or > 8.1 kWh/m^3. As this value is < 8.1 kWh/m^3 the material score is 20 (Figure 18).

Anaerobic digestate weighted average product score

Company 2 is supplied with solid anaerobic digestate from a single AD facility. The feedstock used by the AD facility is 70% energy crops and 30% poultry manure. Therefore, the product score will be 70% of the score for the energy crop plus 30% of the score for the poultry manure.

Where criteria scores are decided based on quantified units (i.e. kWh/m^3, l/m^3, %) it makes more sense to create weighted averages of these quantified units to determine a new score rather than creating weighted averages of the scores themselves. This approach is taken for the energy use, water use and social compliance criteria.

Energy use

Material	kWh/m3	% material	Weighted average
AD from energy crops	13.15±0.50	70	13.15±0.50*0.7 = 9.21±0.35
AD from waste	3.65±0.50	30	3.65±0.50*0.3 = 1.10±0.15
		Average annual energy use	10.31±0.50

Therefore, the material score is 14 (Figure 4). If the weighted average had been applied to the original scores rather the kWh/m^3 the material would have scored 15.2.

Water use

Material	L/m^3	% material	Weighted average
AD from energy crops	0	70	0

AD from waste	0	30	0
Average annual water use			0

Therefore, the material score is 20 (Figure 6).

Social compliance

Material	% compliance	% material	Weighted average
AD from energy crops	49	70	49*0.7 = 34.3
AD from waste	60	30	60*0.3 = 18
Average social compliance			52.3

Therefore, the material score is 11 (Figure 8). If the weighted average had been applied to the original scores rather the % compliance the material would have scored 9.6.

Habitat and biodiversity

Material	Score	% material	Weighted average
AD from energy crops	15	70	15*0.7 = 10.5
AD from waste	20	30	20*0.3 = 6
Average score			16.5

Pollution

Material	Score	% material	Weighted average
AD from energy crops	12	70	12*0.7 = 8.4
AD from waste	12	30	12*0.3 = 3.6
Average score			12

Renewability

Material	Score	% material	Weighted average
AD from energy crops	20	70	20*0.7 = 14
AD from waste	20	30	20*0.3 = 6
Average score			20

Resource use efficiency

Material	Score	% material	Weighted average
AD from energy crops	8	70	8*0.7 = 5.6
AD from waste	20	30	20*0.3 = 6
Average score			11.6

Summary: material score

The material score is:

Criteria	Score
Energy	14
Water	20
Social compliance	11
Habitat and biodiversity	16.5
Pollution	12
Renewability	20
Resource use efficiency	11.6

References