PROJECT REPORT:
PR-24070-EN

(MD-24179-EN)

MANUFACTURER:
Hostrup Sand A/S

DATE:
December 2024

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1 General

This LCA study has been conducted according to the requirements in EN 15804:2012+A2:2019.

1.1 MANUFACTURER AND COMMISSIONER

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1.4 DATE

This report is conducted in the period August 2024 to November 2024. The results are based on production data collected at Hostrup Sand A/S, covering the first and second halves of 2023, as well as the first half of 2024, totaling 1.5 years of data.

1.5 DECLARED PRODUCT AND PRODUCT USE

Hostrup Sand A/S is a company that specializes in sourcing and providing high-quality sand, which is processed using modern and efficient machinery. The production site of Hostrup Sand is located in Esbjerg, Denmark.

In this study, two products are declared: quartz sand and sand/compost mix. The sand is of grain size 0/1 mm, 0/2 mm and 0/4 mm and can be used for various applications, including as sand for the concrete industry, golf courses, sports facilities, and playgrounds. The sand/compost mix can be used as a growth layer, topdressing, and for repair of sports fields and golf courses. See Figure 1 for product pictures.

Sand product *Sand/compost mix*

Figure 1 - Picture of the declared products produced by Hostrup Sand A/S

For more detailed information about Hostrup Sand and their product range, you can visit their website directly.

2 Goal

The LCA study documented in this report has been carried out to support the development of a Type III declaration according to the requirements in EN 15804:2012+A2:2019, and thereby communicate scientifically based environmental information for the declared product. The results of the LCA study, presented as an EPD, is intended to be used for business-to-business (B2B) communication. At present, there is not an EN product-specific PCR covering the declared products; therefore, EN15804:2012+A2:2019 is used as the core PCR in the current study.

3 Scope and modelling principles

3.1 DECLARED/FUNCTIONAL UNIT

3.1.1 Definition

In this study, various sand products, including quartz sand and a sand/compost mix from Hostrup Sand A/S, are declared.

Hostrup Sand produces sand in the fractions 0/1 mm, 0/2 mm, and 0/4 mm. The manufacturing processes for these sand products are identical, regardless of grain size. Consequently, the difference between these products in terms of their environmental impacts is assumed to be negligible. Therefore, sand with grain sizes of 0/1 mm, 0/2 mm, and 0/4 mm is declared with the same set of results in this study.

In addition to sand, a mixed product comprised of sand and compost is produced at the facility of Hostrup Sand. The sand/compost mix is declared with a separate set of results.

The declared products from Hostrup Sand is presented in Table 1.

Table 1 – Declared products from Hostrup Sand

Product	Product variation	Product composition
Quartz sand	0/1 mm	100% sand
	0/2 mm	100% sand
	0/4 mm	100% sand
Sand/compost mix	0/1 mm & compost	85% sand, 15% compost (weight-%)
	0/4 mm & compost	85% sand, 15% compost (weight-%)

LCI- and LCIA-results in this EPD are related to a declared unit of 1000 kg of sand and sand/compost mix respectively at the production site, as indicated in Table 2.

Table 2 - Declared unit

Name	Value	Unit
Declared unit	1000	kg
Conversion factor to 1 kg	0,001	-

3.1.2 Technical specifications

Hostrup Sand are committed to delivering products and services that meet the standards of quality and safety. The different sand products adhere to certain product standards, as indicated in Table 3. Product declarations and documentation on sieve curves can be found on the website of Hostrup Sand (hostrupsand.dk/deklarationer og sigtekurve).

Table 3 – Technical specifications

EN standard	Sand 0/1 mm	Sand 0/2 mm	Sand 0/4 mm	Sand/compost mix
EN 12620:2002+A1 Aggregates for concrete	☒	☒	☐	☐
Dancerts supplerende bestemmelser for certificering af faldunderlag, 3. udgave, 01-08-2020	☒	☐	☒	☐
Dancerts supplerende bestemmelser for certificering af sand til brug i sandkasser, udgave 3, 01-08-2020	☒	☒	☒	☐

3.1.3 Dangerous substances

The declared products from Hostrup Sand A/S does not contain substances listed in the "Candidate List of Substances of Very High Concern for authorisation" (http://echa.europa.eu/candidate-list-table). A signed declaration by Hostrup Sand is included in Appendix 1 – REACH statement.

3.1.4 Calculation rules for averaging data

The declared products are manufactured by Hostrup Sand at the extraction and processing site in Esbjerg, Denmark, which is why no average data for different suppliers or production sites have been used.

Specific data derived from production processes at Hostrup Sand, for the reporting period from Q1 2023 to Q2 2024, is used as basis for calculations in this study. Upstream and downstream processes from the production at Hostrup Sand are primarily modelled with the use of generic data.

3.2 SYSTEM BOUNDARY

A cradle-to-gate study with options, modules C1-C4, and module D is reported in this study. The additional module included is A4. The declared modules are shown in Figure 2, which follows the modular approach in EN 15804:2012+A2:2019.

System boundary (X = included in LCA; MND = module not declared)																
Product			Construction process		Use							End of life				Beyond system boundary
Raw material supply	Transport	Manufacturing	Transport	Construction installation process	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	De-construction demolition	Transport	Waste processing	Disposal	Reuse- recovery- recycling potential
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
X	**X**	**X**	**X**	MND	MND	MND	MND	MND	MND	MND	MND	**X**	**X**	**X**	**X**	**X**

Figure 2- System boundary according to EN 15804:2012+A2:2019.

The extraction and processing of sand takes place at the production site of Hostrup Sand in Esbjerg, Denmark. It is therefore chosen to declare the impacts of raw material extraction and manufacturing of the sand product as part of module A3. See below description and section 4 for further details.

A1 includes the supply of compost for the sand/compost mix product.
A2 includes transport of compost for the sand/compost mix product from the supplier to the production site.
A3 includes sand extraction from the seabed, water draining in a sand wheel, sorting of the sand by grain size, and internal transport. For the sand/compost mix product, an additional process step of loading and mixing sand and compost is included.

A4 includes the transport of the product to the construction site.

C1-C4 includes the removal of the product from the construction site, transport and final disposal at the end-of-life stage.

D includes any benefits or loads resulting from reuse of materials leaving the product system.

The specific production system of the declared products in this EPD is described in detail in section 4.

3.2.1 Omissions of life cycle stages, processes or data needs

As shown in Figure 2, the LCA study covers the product stage (A1-A3), the transport to the construction process stage (A4), the end-of-life stage (C1-C4), and benefits and loads beyond the product system (D). The construction installation process (A5) and the use stage (B1-B7) are thus omitted from this study.

The sand produced by Hostrup Sand can be used for both bound and unbound applications. As aggregate products that are integrated with further products cannot be separated at end-of-life, C and D modules are not reported for products where the sand is physically integrated with other products, for example concrete, brick, or mortar. These uses for aggregate are determined to fulfil the three criteria stated in EN 15804 in section 5.2 and are, therefore, exempt from reporting modules C1-C4 and module D. A cradle to gate study with options (A4) is, therefore, reported for any bound sand products. For other unbound uses of sand, the scope of the EPD corresponds to a cradle to gate study with options, modules C1-C4, and module D, where a likely end-of-life scenario is described in section 4.6.

Production, maintenance and disposal of capital equipment, i.e., the production facilities, machinery and transport equipment, is emitted from this study. This is due to a lack of availability of data. Moreover, as these capital goods handle large amounts of material throughout their operational lifespan, the environmental impact associated with this equipment per declared unit is assumed to be below the cut-off criteria of 1% (see section 3.3).

3.3 CUT-OFF CRITERIA

3.3.1 Application and assumptions

The general rules applied for exclusion of inputs and outputs in the LCA, is in compliance with the rules in EN 15804:2012+A2:2019, 6.3.5, where the omission for input-flows pr. module must be maximum 5 % of energy usage and mass and at most 1 % for unit processes.

3.3.2 Excluded processes

No material or energy flows known to cause significant emissions into air and water, or soil related to the environmental indicators of EN 15804:2012+A2:2019 have been excluded to the best of knowledge. Omitted processes, such as vehicles, buildings and infrastructure, described in section 3.2.1, are considered to be below the cut-off criteria and have an insignificant influence on the environmental impacts of the considered product system.

3.4 ALLOCATION PRINCIPLES AND PROCEDURES

3.4.1 Documentation and justification of allocation procedures

In accordance with EN 15804:2012+A2:2019, allocation of energy and material inputs has been conducted based on mass because the difference in revenue from the co-products is low.

3.4.2 Uniform application of allocation procedures

Allocation of energy and material inputs are done uniformly for all declared products.

4 Life cycle inventory analysis (LCI)

The following chapter presents the life cycle inventory (LCI) as well as a description of all modules and unit processes included in the LCA modeling of the respective product systems. The data quality of all used unit processes is assessed in terms of geographical, temporal, and technological representativeness. Data validation, as well as links to the individual datasets used in this LCA, can be found in section 4.12.

The life cycle inventory covers the declared modules (A1-A3, A4, C1-C4, D). Key processes included within the system boundary for the studied product systems are presented in Figure 3. Note that the flow diagram covers all products declared in this study, and therefore not all processes are necessarily relevant for each individual product.

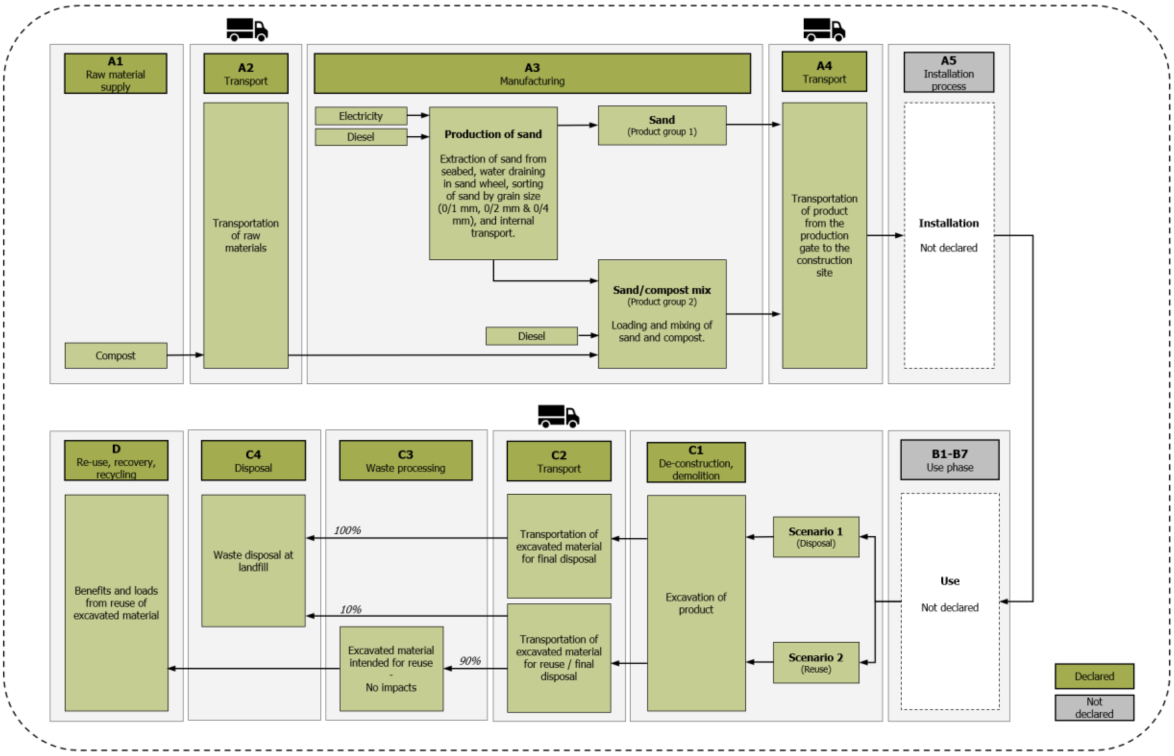

Figure 3 - Flow diagram of key processes within the product system declared

4.1 GENERAL UNIT PROCESSES

4.1.1 Transport scenarios

Transport distances and means of transportation are determined based on information about suppliers and customers of Hostrup Sand.

The transport module used in the modeling can be seen in Figure 4. The transport module is parameter-based, and the transport distance is initially set to 0 km, which means that no fuel is consumed (as shown in the figure). When the distance (the parameter) is subsequently adjusted according to the specific input and output materials to be transported, the fuel consumption and emissions are likewise adjusted accordingly.

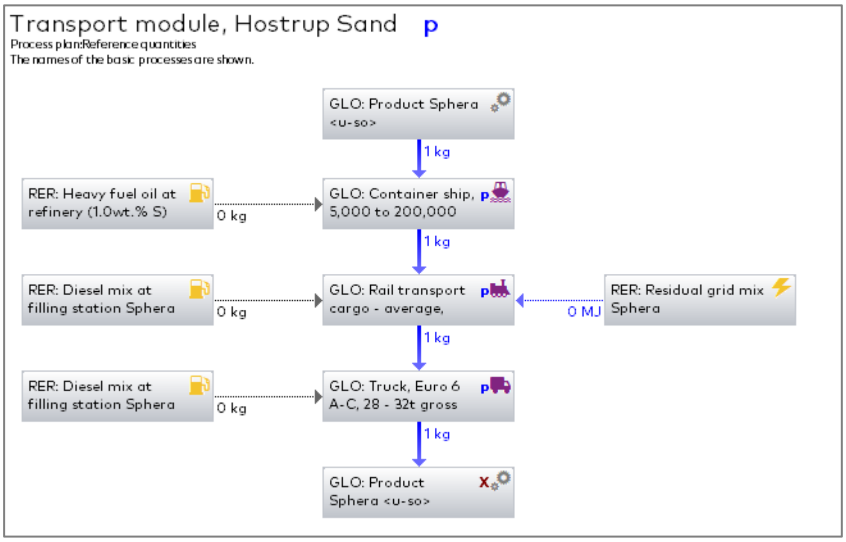

Figure 4 - Transport module used in the model

The transportation processes and fuel used are described in section 4.1.1.1 - 4.1.1.2. All transportation in the product system is modeled as road transport, thus only processes used for road transportation and diesel fuel are described in the sections below.

4.1.1.1 Road transportation

Transportation by truck is based on the unit process GLO: Truck, Euro 6 A-C, 28 - 32t gross weight / 22t payload capacity, Sphera. The reference year of the process data set is 2022.

The transport is generally handled by professional logistics operators who operate under standard market conditions. Therefore, the default values of transport process parameters (pay load, utilization rates, etc.) are kept, except for the percentage of biogenic carbon in the combustion of diesel, which in the dataset for road transport is adjusted to 8.28 wt.% corresponding to the content in the diesel mix used (see section 4.1.1.2).

4.1.1.2 Fuel for transportation

For truck transport, the input of diesel is based on the unit process RER: Diesel mix at filling station, Sphera. The reference year of the process data set is 2019.

4.2 UNIT PROCESSES A1 - RAW MATERIALS AND SEMI-FINISHED PRODUCTS

The following section presents the LCI data related to the initial stage of the production phase - A1. This includes a description and quantification of the raw materials required to produce the declared products. Furthermore, the LCA datasets used for the modeling are presented.

4.2.1 Supply of compost

For the production of the mixed product, an input of compost is required. Hostrup Sand have used two different suppliers of compost, one waste handler located in Germany and one in Fredericia. At present, the waste handler in Fredericia (Fredericia Kommune) is used, and it is assumed that Hostrup Sand will continue to receive compost from this supplier in the future. The compost is made from bio-waste (branches, leaves, etc. from gardens and parks) collected in the municipality.

In accordance with the guidelines of EN 15804 in section 6.3.5.2, processes part of the waste processing in the previous product system are not included in this study. Waste processing of bio-waste up to end-of-waste state is considered part of the previous product system, and therefore, the material input of compost is burden free. No packaging is included in the delivery of compost, as it is transported in bulk, loaded directly onto trucks. The transportation of compost from the waste handler to the production facility of Hostrup Sand is declared in module A2.

4.3 UNIT PROCESSES A2 - TRANSPORTATION BETWEEN A1 AND A3

The following section presents the transport between A1 and A3, including the means of transport and the unit processes used for the modeling. Transport distances and types are determined based on information from Hostrup Sand.

4.3.1 Transport of compost

As described in section 4.2, the compost is transported from a waste handler in Fredericia to the production facility of Hostrup Sand in Esbjerg. The type of transport and distance is shown in Table 4. The transport processes used are described in section 4.1.

Table 4 - Transport of raw materials

Raw material	Route		Type	Distance	Unit
	From	To			
Compost	Fredericia Kommune Vejlbyvej 40 7000 Fredericia, Denmark	Hostrup Sand A/S Hostrupvej 42B 6710 Esbjerg, Denmark	Truck	100	km

4.4 UNIT PROCESSES A3 – MANUFACTURING

The following section presents the LCI associated with the manufacturing stage of the production phase – A3. This includes a description and quantification of the manufacturing of the declared products at the production facility of Hostrup Sand in Esbjerg, including a quantification of energy and material inputs and outputs.

4.4.1 Production of the declared products

The sand sold by Hostrup Sand is sourced from the bottom of a lake at the production site. The sand is extracted from the seabed using a dredger, which is a specialized equipment with a powerful pump and suction pipe. During suction, any larger particles and debris can be separated using a grille/sieve on the dredger. See Figure 5.

Extraction of sand from the seabed by a dredger. *Transportation of sand to land via a pipeline.*

Figure 5 - Extraction of sand from the seabed at Hostrup Sand

The extracted material is transported via a pipeline to a sand wheel on land. The sand wheel is used to drain water from the wet sand. The water is returned to the lake, whereas the sand is transported on a conveyer belt and stocked in a pile for further drying. See Figure 6.

Sand wheel to drain water from wet sand. *Transportation of sand by conveyer belt.*

Figure 6 - Draining of water from the extracted sand

After drying, a loader moves the sand from the drying pile to the sorting facility. At the sorting facility, the sand is transported on a conveyer belt to a sieving tower with sand sifters of different mesh sizes that separate the sand into three fractions based on grain size: 0/1 mm, 0/2 mm, and 0/4 mm. See Figure 7.

Loading of sand for sorting. *Sieving tower and sorting of sand in three fractions.*

Figure 7 - Sorting of sand in fractions 0/1 mm, 0/2 mm and 0/4 mm.

After sorting, the production of sand is complete. The sand is sold directly for use in bound applications (e.g. concrete, mortar or bricks) or unbound applications (e.g. impact-absorbing surfaces or sports facilities).

A fraction of the sand is mixed with compost to produce a "green mix" primarily used as topsoil and topdressing on grass areas and sports fields. The sand (mainly of grain size 0/1 mm) and compost are mixed and sifted in a trommel (rotary screen) to separate coarse compost materials from the finished product. The sieve can be adjusted to either 3 mm or 6 mm, depending on the use of the final product. See Figure 8 for product pictures.

Compost for production of sand/compost mix *Mixed product ready for use.*

Figure 8 - Production of sand/compost mix

The density of compost and sand is 0.8 ton/m^3 and 1.5 ton/m^3 respectively. With a mixing ratio of 25% compost and 75% sand, the weight distribution using the given volume ratio is 0,15 kg compost/ton product (15%) and 0,85 kg sand/ton product (85%) – see below calculation.

The volume of the mixed product per ton is calculated:

$$(0{,}25 \cdot V) \cdot 0{,}8 + (0{,}75 \cdot V) \cdot 1{,}5 = 1$$

$$1.325 \cdot V = 1$$

$$V = \frac{1}{1{,}325} = 0{,}7547\ m^3$$

The weight of the sand and compost per ton product is calculated:

$$Weight_{compost} = 0{,}25 \cdot 0{,}7547 m^3 \cdot 0{,}8 \frac{ton}{m^3} = 0{,}1509\ ton$$

$$Weight_{sand} = 0{,}75 \cdot 0{,}7547 m^3 \cdot 1{,}5 \frac{ton}{m^3} = 0{,}8491\ ton$$

The total production of sand and mixed product at Hostrup Sand in the reference period is given in Table 5.

Table 5 - Total production at Hostrup Sand in the reference period from Q1 2023 to Q2 2024.

Total production, Hostrup Sand	Amount	Unit
Production of sand (0/1 mm, 0/2 mm, and 0/4 mm)	124.279	ton
Production of sand/compost mix	14.536	ton

No packaging is required for the storage and transport of sand and sand/compost mix, as it is transported in bulk, loaded directly onto trucks from stockpiles at the production site in Esbjerg.

4.4.2 Energy and material inputs for the production

In Table 6, the total consumption of energy and material inputs for the production of the declared products are given, covering the reference period from Q1 2023 to Q2 2024.

Table 6 - Total consumption of energy and material inputs at the production facility of Hostrup Sand

Total consumption of energy and material inputs	Amount	Unit
Electricity consumption		
Electricity: dredger, wheel, sorting (sand)	219.376	kWh

Diesel consumption		
Diesel: loader of sand	67.953	liters
Diesel: loader and mixer of sand/compost mix	17.709	liters
Auxiliary materials		
Lubricants: dredger, wheel, sorting (sand)	341	liters
AdBlue: loader and mixer of sand/compost mix	335	liters

A description and quantification of energy and material inputs per declared unit of product, as well as unit processes used for the modeling, is provided in section 4.4.2.1 - 4.4.2.4.

4.4.2.1 Electricity

Electricity is used to operate the dredger, sand wheel and the sorting facility at Hostrup Sand. Electricity consumption is considered equal for all outputs from these processes, i.e. sand with grain size of 0/1 mm, 0/2 mm, and 0/4 mm, considering the similarities in the manufacturing of these products. To calculate the consumption of electricity per ton of sand extracted, transported and sorted, mass allocation is used. See below calculation.

Total electricity consumption: 219.376 kWh
Total production of sand: 124.279 ton

Electricity consumption per ton of manufactured sand: 219.376 kWh / 124.279 ton = 1,756 kWh/ton
The following conversion factor from kWh to MJ is used: 3,6 MJ/kWh.

Hostrup Sand purchases electricity from OK. Certified green electricity is not used at the production site in Esbjerg, and therefore, the process for electricity used at the site in the modeling is based on the residual mix in Denmark, where electricity production is adjusted for the exchange of electricity and electricity sales (individually declared electricity) – in accordance with the guidelines from EPD Denmark[1].

LCA data for the supply of electricity is based on the process DK: Residual grid mix, Sphera. The reference year for the unit process is 2021.

4.4.2.2 Diesel

Diesel is used to operate the sand loader at the sorting facility, as well as the loader and mixer used for the production of the sand/compost mix. The fuel consumption for this machinery in the reporting period has been provided by Hostrup Sand. As the total amount of sand extracted is managed by the loader prior to sorting, the consumption of diesel per ton of sand is calculated by mass allocation of the diesel consumed, according to the calculation below:

Total diesel consumption of sand loader: 67.953 liters
Total mass of extracted sand: 124.279 ton

Diesel consumption per ton of extracted sand: 67.953 liters / 124.279 ton = 0,547 liters/ton

Based on the total amount of sand/compost mix produced, the consumption of diesel of the loader and mixer per ton of sand/compost mix is allocated, according to the calculation below:

Total diesel consumption of loader and mixer: 17.709 liters
Total production of sand/compost mix: 14.536 ton

Diesel consumption per ton of manufactured sand/compost mix: 17.709 liters / 14.536 ton = 1,218 liters/ton

[1] Guide from EPD Danmark: https://www.epddanmark.dk/epd-community/guide-om-el-og-epd-er/

Following conversion factor from liters to kg is used: 0,84 kg/liter diesel[2].
The lower heating value (LHV) of diesel is: 35,87 MJ/liter[3].

LCA data for the supply of diesel is based on the process RER: Diesel mix at filling station, Sphera. The reference year for the unit process is 2019.

Since product-specific data for fuel combustion in machinery operation has not been obtained, generic data from the LCA for Experts database is used. There is no dataset in the available background database in LCA for Experts specifically for modeling emissions from diesel combustion in machinery. Therefore, diesel combustion in transport machinery is modeled using a proxy process for corresponding diesel combustion in an excavator, which is described in more detail in Appendix 3 - Modelling of diesel combustion in machinery.

4.4.2.3 Lubricants

Lubricants are used in machinery for sand extraction, processing and sorting. The use of lubricating oil is done under a maintenance contract, and Hostrup Sand has provided data from the maintenance company on the total consumption of lubricants in the reporting period. To calculate the consumption of lubricants per ton of sand produced, mass allocation is used – see below calculation.

Total consumption of lubricants:	341 liters
Total production of sand:	124.279 ton

Consumption of lubricants per ton of manufactured sand: 341 liters / 124.279 ton = 0,00274 liters/ton
The following conversion factor from liters to kg is used: 0,825 kg/liter lubricant.

Production-specific LCA data for the lubricant has not been obtained, which is why generic data from the LCA for Experts database has been used. The production of lubricant is based on the unit process RER: Lubricants at refinery, Sphera. The reference year of the process data set is 2020.

4.4.2.4 AdBlue

AdBlue is a solution used in diesel engines to reduce nitrogen oxide emissions. Hostrup Sand has reported that AdBlue is used by the loader and mixer of sand/compost mix. The consumption of AdBlue per ton of mixed product produced is calculated by mass allocation, according to the calculation below:

Total AdBlue consumption of loader and mixer:	355 liters
Total production of sand/compost mix:	14.536 ton

AdBlue consumption per ton of manufactured sand/compost mix: 355 liters / 14.536 ton = 0,023 liters/ton
The following conversion factor from liters to kg is used: 1,088 kg/liter AdBlue.

The standard composition of AdBlue is 32.5% high-purity urea and 67.5% deionized water[4], and is modelled accordingly. Production-specific LCA data for the AdBlue has not been obtained, which is why generic data from the LCA for Experts database has been used. The production of AdBlue is based on the following unit processes:

- Urea: RER: Urea (46% N), Fertilizers Europe. The reference year of the process data set is 2023.
- Deionized water: RER: Water (deionised), Sphera. The reference year of the process data set is 2023.

4.4.3 Mass balance

A mass balance has been calculated on the total amount of inputs and outputs in the production at Hostrup Sand to ensure consistency and balance in the LCA model.

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[2] Link to source on the density of diesel: https://www2.mst.dk/udgiv/publikationer/2003/87-7972-403-5/html/kap02.htm
[3] Link to the Danish Energy Agency with standard factors used: https://ens.dk/sites/ens.dk/files/CO2/energistyrelsens_standardfaktorer_for_2021-25-01-2022.pdf
[4] Link to TotalEnergies, "What is AdBlue?": https://totalenergies.co.uk/adbluer-what-it-whats-it-made-how-does-it-work-and-more

The inputs include the quantity of raw materials and intermediate products consumed in the manufacturing of the declared product, as well as any packaging for incoming materials. The outputs include the finished product and any production waste. Details of the inputs and outputs in the mass balance can be found in Table 7. No packaging (ingoing or outgoing) is required in the production of sand and mixed product by Hostrup Sand, and the production processes does not generate any waste for processing or disposal.

Table 7 - Inputs to the mass balance

Material/component	Product 1	Product 2	Unit
Inputs to the mass balance			
Sand (mixed)	1000	850	kg
Compost	0	150	kg
Total	**1000**	**1000**	**kg**
Outputs from the mass balance			
Sand (0/1 mm, 0/2 mm, and 0/4 mm)	1000	0	kg
Green mix	0	1000	kg
Total	**1000**	**1000**	**kg**

A summary of the overall mass balance of the production at Hostrup Sand is provided in Table 8, showing a deviation of 0% for the declared products.

Table 8 - Summary of the overall mass balance

	Product 1	Product 2
Total input	1000	1000
Total output	1000	1000
Deviation in ton	0	0
Deviation in %	0	0

4.5 UNIT PROCESSES A4 - TRANSPORT FROM A3 TO THE CONSTRUCTION SITE

Hostrup Sand supplies sand and mixed product to the Danish market, but they also have customers based in Northern European countries such as Norway and Germany. An average distance of 200 km from the factory gate to the consumer is assumed, based on data provided by Hostrup Sand. Details on the transport scenario used is given in Table 9. The transport processes used are described in section 4.1.

Table 9 - Information related to module A4

Scenario information	Value	Unit
Fuel type	Diesel	-
Vehicle type	Truck, Euro 6, 28 - 32t gross weight / 22t payload capacity	-
Transport distance	200	km
Capacity utilisation (including empty runs)	55	%
Gross density of products transported	1500	kg sand/m^3
	1325	kg sand/compost mix/m^3

4.6 UNIT PROCESSES C1 – C4, END OF LIFE

The following section presents the LCI associated with the end-of-life of the declared products. As stated in section 3.2.1, any sand product integrated into another product that cannot be separated at end of life does not have C1-C4 or D modules reported, in accordance with EN 15804:2012+A2:2019. Examples of sand used in bound products include, but is not limited to, sand for concrete, bricks and mortar. For information on end-of-life for these types of products, please refer to a relevant EPD for the specific application.

According to Hostrup Sand, unbound applications of sand include, but is not limited to, sand for impact-absorbing surfaces and sports facilities. As it is not bound to other materials, it can be extracted from the construction and, depending on the application, potentially reused or recycled at the end-of-life stage. Based on information from Hostrup Sand and input from their customers, sand used in unbound applications such as impact-absorbing surfaces at e.g. playgrounds and fitness areas or on sports facilities such as beach volleyball courts, is exposed to contamination throughout the use phase. As a result of this contamination, the sand is typically disposed of at the end-of-life stage. While there are technologies available for cleaning sand, Hostrup Sand indicates that sand is more often deposited, among others due to economic considerations. Therefore, this practice is included as a conservative scenario in the modeling.

Natural resources such as sand can potentially be reused when constructions are removed or modified. According to a publication by InnoBYG[5], excavated resources are often reused or recycled in new construction projects, typically at a different construction site. The primary reasons for not using excavated material on-site include regulatory requirements, storage options (construction site logistics), and economic considerations. Direct reuse, where the excavated resources are reused on-site, occurs only on a few occasions.

For applications involving sand and sand/compost mix on grass areas and sports fields, it is assumed that these materials remain in the construction and do not generate waste for processing or disposal. Natural grass and sports fields can theoretically last indefinitely with continuous maintenance, although they may require periodic renovations. If renovation occurs, the top layer containing the sand and sand/compost mix may be removed and, provided it is uncontaminated, reused in other landscaping or construction projects. If the material is unsuitable for reuse due to contamination or degradation, it may be disposed of in a landfill.

Based on the above information, the following two scenarios for the EoL stage are assumed in this LCA study.

- **Scenario 1**: The product is disposed of in a landfill at EoL. Applicable for sand only.
- **Scenario 2**: The product remains in its original use at a new location at EoL. Applicable for sand and sand/compost mix.

Please refer to Table 10 for information on modules C1 – C4, and section 4.6.1 and section 4.6.2 for a detailed description.

Table 10 - Information related to modules C1-C4

Scenario information	Scenario 1	Scenario 2	Unit
Collected separately	1000	1000	kg
Collected with mixed waste	0	0	kg
For reuse	0	900	kg
For recycling	0	0	kg
For energy recovery	0	0	kg
For final disposal	1000	100	kg
Assumptions for scenario development	Europe	Europe	-

[5] Publication by InnoBYG, "Fra byggeaffald til ressource":https://webuilddenmark.dk/wp-content/uploads/2024/07/Fra-byggeaffald-til-ressource.pdf

4.6.1 EoL Scenario 1

In this scenario, the end-of-life is modeled as the extraction of product from construction (C1), transport to a landfill (C2), and disposal of product in a landfill (C4).

4.6.1.1 C1 De-construction/demolition

It is assumed that the sand will be extracted from the site by an excavator, before being loaded onto a truck. It is likely for extraction and loading to be carried out by a diesel driven machine. Specific foreground data on the extraction and loading of sand by an excavator has not been obtained. Instead, an average value for energy consumption during demolition of buildings in Denmark is used. The energy consumption for demolition is mainly associated with the operation of the machinery used and is therefore expressed as diesel consumption per ton of demolished material. The energy consumption is based on a report published by the Danish Environmental Protection Agency in 2022, which gathered data from four different demolition projects at Tscherning[6].

Diesel consumption, demolition: 1,4 liter diesel/ton demolished material
Following conversion factor from liters to kg is used: 0,84 kg/liter diesel[2].

Process-specific data for diesel combustion in an excavator has not been obtained, and therefore generic data from the LCA for Experts database is used. Please refer to Appendix 3 - Modelling of diesel combustion in machinery for further details.

4.6.1.2 C2 transport from C1 to C4

The waste sand is assumed to be transported from the construction site to a landfill in the nearby region. As the transport distance will depend on the location of the construction site, an estimate on the average transport distance to a landfill in a European context is used. Based on a conservative approach, the transport for waste processing is modeled as 50 km of road transport. The type of transport and distance is shown in Table 11. The transport processes used are described in section 4.1.

Table 11 - Transport of waste at EoL

Material	Route		Type	Distance	Unit
	From	To			
Sand	C1 - Construction site	C4 - Landfill	Truck	50	km

4.6.1.3 C3 Waste processing for reuse, recovery and/or recycling

No impacts occur for module C3.

4.6.1.4 C4 Disposal

As stated, 100% of the sand is assumed to be deposited in a landfill. The following unit process is used for modelling disposal of sand: RER: Inert matter (Unspecific construction waste) on landfill, Sphera. The reference year of the process data set is 2023.

4.6.2 EoL Scenario 2

In this scenario, the end-of-life is modeled as the extraction of product from construction (C1) and transport to another location (C2) for use in a new application. Based on a conservative approach, losses of 10% are assumed for the product over its use and during removal at EoL. The losses are modelled as being disposed of in a landfill (C4). Reuse of product is declared in module D.

4.6.2.1 C1 Deconstruction and demolition

Please refer to section 4.6.1.1 for a description of the extraction of product from the construction.

[6] Report from the Environmental Protection Agency: https://www2.mst.dk/Udgiv/publikationer/2022/02/978-87-7038-353-0.pdf

4.6.2.2 C2 transport from C1

The extracted product for reuse is assumed to be transported from the construction site to a new site in the nearby region. It is assumed transported directly for reuse without any intermediate storage, and therefore the transport is considered outside the system boundary.

The losses of 10% of the product over its use and during removal at EoL is transported to a landfill in the nearby region. The distance and means of transport are assumed equal to the described scenario in section 4.6.1.2. Type of transport and distance is shown in Table 11. The transport processes used are described in section 4.1.

Table 12 - Transport of waste sand

Material	Route		Type	Distance	Unit
	From	To			
Losses of sand or sand/compost mix	C1 - Construction site	C4 - Landfill	Truck	50	km

4.6.2.3 C3 Waste processing for reuse, recovery and/or recycling

No impacts occur for module C3.

4.6.2.4 C4 Disposal

As stated in the scenario description, 10% of the product is assumed to be lost during use and removal at EoL and deposited in a landfill. Disposal of product in a landfill is modelled equal to the landfilling scenario described in section 4.6.1.4.

4.7 UNIT PROCESSES D REUSE, RECOVERY AND/OR RECYCLING POTENTIALS

For the EoL scenario 2, the sand and sand/compost mix are assumed to be reused at a new location. Any benefits or loads resulting from reuse of materials leaving the product system is presented in section 4.7.1 and section 4.7.2 below.

4.7.1 Reuse of sand

Only virgin materials are used in the production of sand, and thus the fraction of sand recovered from waste processing is credited in module D, in accordance with the guidelines in EN15804, Appendix D 3.4.

Table 13 - Information related to module D, EoL scenario 2 (sand)

Scenario information/materiel	Value	Unit
Reused material, sand	900	kg

To model the credit from reuse of sand, the following unit process from the LCA for Experts database is used: RER: Sand 0/2, Sphera. The reference year of the process data set is 2023.

4.7.2 Reuse of sand/compost mix

In accordance with the guidelines in EN15804, Appendix D 3.4., only virgin materials are credited in module D. The compost used in the sand/compost mix is recycled material and is therefore not credited. Thus, only the fraction of sand in the sand/compost mix is credited in module D.

Table 14 - Information related to module D, EoL scenario 2 (sand/compost mix)

Scenario information/materiel	Value	Unit
Reused material, sand/compost mix	765*	kg
**Only the sand (virgin material) of the sand/compost mix is credited in module D.*		

4.8 FLOWS OF BIOGENIC CARBON

The content of biogenic carbon in the product and sales/transport packaging is stated in Table 15. As presented in the table, no sales/transport packaging is required, which is why there is no information on the content of biogenic carbon for product packaging. Furthermore, the sand does not contain any biogenic carbon.

The compost used to produce the sand/compost mix does contain biogenic carbon as it is an organic material. During the composting process, the organic materials are broken down by microorganisms through aerobic respiration. This process releases some of the contained carbon as carbon dioxide (CO_2). However, a significant portion of the carbon remains in the compost as stable organic matter. The carbon content in compost can vary depending on the type of organic materials used and the composting process itself. The content of carbon in the compost used by Hostrup Sand is based on the product data sheet from the supplier in Germany, as this was not available from the Danish supplier. Based on the information provided (see Appendix 2 – Product data sheet), the carbon content of the compost is 6.73% of fresh mass (wet weight), which corresponds to 67.3 kg carbon per ton compost.

The content of biogenic carbon in the product is calculated with use of below equation:

$$Amount\ of\ material\ [kg] \cdot Content\ of\ biogenic\ carbon\ in\ material\ [kg/kg\ ]$$

Table 15 - Biogenic carbon at factory gate

BIOGENIC CARBON CONTENT PER 1 TON PRODUCT			
Parameter	**Unit**	**Sand**	**Sand/compost mix**
Biogenic carbon content in product	[kg C]	0,00E+00	1,01E+01
Biogenic carbon content in accompanying packaging	[kg C]	0,00E+00	0,00E+00
Note: 1 kg biogenic carbon is equivalent to 44/12 kg of CO_2			

Flows of biogenic carbon are converted to CO_2 emissions to account for the uptake of biogenic CO_2 in A1 and the subsequent release when the product leaves the system for reuse in C3. According to EN15804+A2 section 5.4.3, the effect of permanent biogenic carbon storage shall not be included in the calculation of the GWP and thus, a release of biogenic CO_2 in C4 is also modelled.

4.9 PERM & PENRM

An overview of calorific values for all relevant materials is presented in Table 16.

Table 16 - Calorific values

	Net calorific value	**Unit**	**Source**
Materials in sand			
Sand	0	MJ/kg	-
Materials in sand/compost mix			
Sand	0	MJ/kg	-
Compost	18	MJ/kg (dry weight)	Value from the Danish Environment Agency. The dry weight of the compost is 61,5% of total mass. Link: https://www2.mst.dk/udgiv/publikationer/2005/87-7614-610-3/html/bil04.htm

PERM (renewable primary energy resources used as raw materials) and PENRM (non-renewable primary energy resources used as raw materials) are calculated for the individual materials using the formulas below, which are directly implemented in the LCA for Experts model. See Table 17.

PERM (MJ) = calorific value (renewable material) (MJ/kg) x material quantity (kg)

PENRM (MJ) = calorific value (non-renewable material) (MJ/kg) x material quantity (kg)

Table 17 - PERM & PENRM values

PERM & PENRM for all relevant materials			
Parameter	**Unit**	**Sand**	**Sand/compost mix**
PERM	[MJ]	0,00E+00	1,66E+03
PENRM	[MJ]	0,00E+00	0,00E+00

The datasets used from the LCA for Experts background database contain values for PERT and PENRT. For the calculation of PERE and PENRE, the following formulas are directly implemented in the LCA for Experts model:

PERE = PERT – PERM
PENRE = PENRT – PENRM

In the scenario where the sand/compost mix is reused at the EoL stage, it will exit the system in C3 and appear with a negative value in PERM (MJ) and a positive value in CRU (kg).

The sand/compost mix landfilled will not appear in the energy-resource indicators in the C-modules as the energy resource is considered "consumed as raw material" and is not transformed into something else that exits the system.

4.10 ENERGY

Green electricity and biogas certificates are not used in this study. As stated in section 4.4.2.1, the production of Hostrup Sand is located in Esbjerg, Denmark, and therefore the process used for modelling electricity consumption is the residual grid mix in Denmark. The emission factor for electricity used in the foreground system is stated in Table 18.

Table 18 - Information about the energy mix in the foreground system

Dataset	EF	Unit
Residual grid mix, DK, ref. year 2021	0,578	kg CO_2e/kWh

4.11 SOURCES OF GENERIC DATA OR LITERATURE

Generic data and background data are based on the LCA for Experts database 2024.1 as well as sources mentioned in each chapter of this report.

4.12 VALIDATION OF DATA

4.12.1 Data quality assessment

The data quality of all unit processes used in this study is evaluated according to the scale: Very good (VG), Good (G), Fair (F), Poor (P) or Very Poor (VP), as per EN15804+A2, Annex E, Table E1. The evaluation is performed based on time (Ti), geographical (Geo), and technical (Te) representativeness of the data. The results can be found in Table 19.

Most datasets are assessed as very good or good. These datasets are considered valid and representative, and therefore do not introduce significant uncertainty to the overall results. The unit process for diesel combustion is assessed as being of fair quality in terms of geographical representativeness, as it is modeled as a proxy with German background conditions.

Table 19 - Data quality assessment

Material	Geo	Process	Ref. year	Link	Geo	Ti	Te
Energy and ancillary materials							
Electricity	DK	Residual grid mix	2021	DK: Residual grid mix, Sphera	VG	G	VG
Diesel	RER	Diesel mix at filling station	2019	RER: Diesel mix at filling station, Sphera	G	G	VG
Excavator	DE	Fuel combustion	2022	See Appendix 3 - Modelling of diesel combustion in machinery	F	VG	G
Lubricants	RER	Lubricants at refinery	2020	RER: Lubricants at refinery, Sphera	G	G	G
AdBlue	RER	Urea (46% N)	2023	RER: Urea (46% N), Fertilizers Europe	G	VG	G
	RER	Water (deionised)	2023	RER: Water (deionised), Sphera	G	VG	G
Transport							
Truck	GLO	Truck, Euro 6, 28-32 t gross weight	2022	GLO: Truck, Euro 6 A-C, 28 - 32t gross weight / 22t payload capacity, Sphera	G	VG	VG
Disposal							
Landfill	RER	Inert matter (unspecific construction waste) on landfill	2023	RER: Inert matter (Unspecific construction waste) on landfill, Sphera	G	VG	VG
Credit							
Sand	RER	Sand 0/2	2023	RER: Sand 0/2, Sphera	G	VG	VG

4.12.2 Treatment of missing data

Diesel combustion is modeled using a proxy, in the absence of process-specific data. The representativeness of the data is assessed accordingly.

5 Life cycle impact assessment (LCIA)

5.1 LCIA PROCEDURES AND CALCULATIONS

The LCIA results are calculated using the Environmental Footprint (EF 3.1) and impact methodology for classification and characterization of input and output flows. This is in accordance with EN15804+A2:2019. The following environmental impact categories are calculated:

- Global warming (GWP)
- Global warming fossil (GWPf)
- Global warming biogenic (GWPb)
- Global warming land use and land use change (GWPluluc)
- Ozone depletion (ODP)
- Acidification for soil and water (AP)
- Eutrophication fresh water (EP F)
- Eutrophication marine (EP M)
- Eutrophication terrestrial (EP T)
- Photochemical ozone creation (POCP)
- Depletion of abiotic resources-elements (ADPe)
- Depletion of abiotic resources-fossil fuels (ADPf)
- Water use (WDP)
- Particulate matter (PM)
- Ionizing radiation (IRP)
- Eco toxicity freshwater (ETP-fw)
- Human toxicity cancer effect (HTP-c)
- Human toxicity non cancer effect (HTP-nc)
- Soil quality (SQP)

5.2 LCIA AND LCI RESULTS

In this section, all LCIA results are presented in the following order:

- Sand (section 5.2.1)
- Sand/compost mix (section 5.2.2)

The estimated impact results of the LCIA are relative expressions and do not indicate the impacts endpoints, the exceeding of thresholds, safety margins or risks.

5.2.1 Results for sand

In Table 20 - Table 24 the LCIA and LCI results are shown for the sand product. The results are given per 1000 kg of sand, and divided into the modules A1-A3, A4, C1-C4 and D.

Table 20 - Core environmental impact indicators

ENVIRONMENTAL IMPACTS PER 1 TON SAND															
						Scenario 1 (Disposal)					Scenario 2 (Reuse)				
Indicator	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-total	kg CO_2 eq.	0,00E+00	0,00E+00	2,77E+00	1,82E+01	4,46E+00	4,55E+00	0,00E+00	1,50E+01	0,00E+00	4,46E+00	4,55E-01	0,00E+00	1,50E+00	-1,77E+00
GWP-fossil	kg CO_2 eq.	0,00E+00	0,00E+00	2,73E+00	1,78E+01	4,37E+00	4,46E+00	0,00E+00	1,50E+01	0,00E+00	4,37E+00	4,46E-01	0,00E+00	1,50E+00	-1,77E+00
GWP-biogenic	kg CO_2 eq.	0,00E+00	0,00E+00	9,25E-03	4,27E-02	2,36E-02	1,07E-02	0,00E+00	-1,03E-01	0,00E+00	2,36E-02	1,07E-03	0,00E+00	-1,03E-02	1,62E-02
GWP-luluc	kg CO_2 eq.	0,00E+00	0,00E+00	2,83E-02	3,00E-01	7,18E-02	7,51E-02	0,00E+00	8,98E-02	0,00E+00	7,18E-02	7,51E-03	0,00E+00	8,98E-03	-1,48E-02
ODP	kg CFC 11 eq.	0,00E+00	0,00E+00	9,78E-12	2,63E-12	6,30E-13	6,58E-13	0,00E+00	4,04E-11	0,00E+00	6,30E-13	6,58E-14	0,00E+00	4,04E-12	-1,30E-11
AP	mol H^+ eq.	0,00E+00	0,00E+00	2,32E-02	2,80E-02	5,77E-02	7,01E-03	0,00E+00	1,06E-01	0,00E+00	5,77E-02	7,01E-04	0,00E+00	1,06E-02	-8,78E-03
EP-freshwater	kg P eq.	0,00E+00	0,00E+00	7,30E-06	7,63E-05	1,82E-05	1,91E-05	0,00E+00	3,40E-05	0,00E+00	1,82E-05	1,91E-06	0,00E+00	3,40E-06	-6,31E-06
EP-marine	kg N eq.	0,00E+00	0,00E+00	1,04E-02	1,07E-02	2,61E-02	2,69E-03	0,00E+00	2,74E-02	0,00E+00	2,61E-02	2,69E-04	0,00E+00	2,74E-03	-3,13E-03
EP-terrestrial	mol N eq.	0,00E+00	0,00E+00	1,15E-01	1,26E-01	2,88E-01	3,15E-02	0,00E+00	3,01E-01	0,00E+00	2,88E-01	3,15E-03	0,00E+00	3,01E-02	-3,45E-02
POCP	kg NMVOC eq.	0,00E+00	0,00E+00	3,38E-02	2,79E-02	8,49E-02	6,96E-03	0,00E+00	8,37E-02	0,00E+00	8,49E-02	6,96E-04	0,00E+00	8,37E-03	-8,82E-03
ADPm[1]	kg Sb eq.	0,00E+00	0,00E+00	2,01E-07	1,56E-06	3,72E-07	3,89E-07	0,00E+00	9,70E-07	0,00E+00	3,72E-07	3,89E-08	0,00E+00	9,70E-08	-1,89E-07
ADPf[1]	MJ	0,00E+00	0,00E+00	3,55E+01	2,35E+02	5,63E+01	5,88E+01	0,00E+00	1,97E+02	0,00E+00	5,63E+01	5,88E+00	0,00E+00	1,97E+01	-2,72E+01
WDP[1]	m^3 world eq. deprived	0,00E+00	0,00E+00	3,55E-02	2,77E-01	6,62E-02	6,92E-02	0,00E+00	1,71E+00	0,00E+00	6,62E-02	6,92E-03	0,00E+00	1,71E-01	-2,14E-01
Caption	GWP-total = Global Warming Potential - total; GWP-fossil = Global Warming Potential - fossil fuels; GWP-biogenic = Global Warming Potential - biogenic; GWP-luluc = Global Warming Potential - land use and land use change; ODP = Ozone Depletion; AP = Acidifcation; EP-freshwater = Eutrophication – aquatic freshwater; EP-marine = Eutrophication – aquatic marine; EP-terrestrial = Eutrophication – terrestrial; POCP = Photochemical zone formation; ADPm = Abiotic Depletion Potential – minerals and metals; ADPf = Abiotic Depletion Potential – fossil fuels; WDP = water use														
Disclaimer	[1] The results of this environmental indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.														

Table 21 – Additional environmental impact indicators

ADDITIONAL ENVIRONMENTAL IMPACTS PER 1 TON SAND															
						Scenario 1 (Disposal)					Scenario 2 (Reuse)				
Parameter	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**	**C1**	**C2**	**C3**	**C4**	**D**
PM	[Disease incidence]	0,00E+00	0,00E+00	9,09E-07	2,96E-07	2,31E-06	7,39E-08	0,00E+00	1,33E-06	0,00E+00	2,31E-06	7,39E-09	0,00E+00	1,33E-07	-5,38E-07
IRP[2]	[kBq U235 eq.]	0,00E+00	0,00E+00	8,08E-02	6,22E-02	1,49E-02	1,55E-02	0,00E+00	2,40E-01	0,00E+00	1,49E-02	1,55E-03	0,00E+00	2,40E-02	-2,89E-01
ETP-fw[1]	[CTUe]	0,00E+00	0,00E+00	1,78E+01	1,75E+02	4,19E+01	4,37E+01	0,00E+00	1,14E+02	0,00E+00	4,19E+01	4,37E+00	0,00E+00	1,14E+01	-1,41E+01
HTP-c[1]	[CTUh]	0,00E+00	0,00E+00	4,37E-10	3,53E-09	8,43E-10	8,82E-10	0,00E+00	2,69E-09	0,00E+00	8,43E-10	8,82E-11	0,00E+00	2,69E-10	-4,09E-10
HTP-nc[1]	[CTUh]	0,00E+00	0,00E+00	1,81E-08	1,58E-07	3,88E-08	3,96E-08	0,00E+00	1,04E-07	0,00E+00	3,88E-08	3,96E-09	0,00E+00	1,04E-08	-1,26E-08
SQP[1]	-	0,00E+00	0,00E+00	1,14E+01	1,16E+02	2,77E+01	2,89E+01	0,00E+00	5,44E+01	0,00E+00	2,77E+01	2,89E+00	0,00E+00	5,44E+00	-7,66E+00
Caption	PM = Particulate Matter emissions; IRP = Ionizing radiation – human health; ETP-fw = Eco toxicity – freshwater; HTP-c = Human toxicity – cancer effects; HTP-nc = Human toxicity – non cancer effects; SQP = Soil Quality														
Disclaimers	[1] The results of this environmental indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator. [2] This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.														

Table 22 - Parameters describing resource use

RESOURCE USE PER 1 TON SAND															
						Scenario 1 (Disposal)					Scenario 2 (Reuse)				
Parameter	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	[MJ]	0,00E+00	0,00E+00	5,17E+00	2,03E+01	4,85E+00	5,07E+00	0,00E+00	3,44E+01	0,00E+00	4,85E+00	5,07E-01	0,00E+00	3,44E+00	-9,69E+00
PERM	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PERT	[MJ]	0,00E+00	0,00E+00	5,17E+00	2,03E+01	4,85E+00	5,07E+00	0,00E+00	3,44E+01	0,00E+00	4,85E+00	5,07E-01	0,00E+00	3,44E+00	-9,69E+00
PENRE	[MJ]	0,00E+00	0,00E+00	3,55E+01	2,35E+02	5,63E+01	5,88E+01	0,00E+00	1,97E+02	0,00E+00	5,63E+01	5,88E+00	0,00E+00	1,97E+01	-2,72E+01
PENRM	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	[MJ]	0,00E+00	0,00E+00	3,55E+01	2,35E+02	5,63E+01	5,88E+01	0,00E+00	1,97E+02	0,00E+00	5,63E+01	5,88E+00	0,00E+00	1,97E+01	-2,72E+01
SM	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	[m^3]	0,00E+00	0,00E+00	3,85E-03	2,26E-02	5,40E-03	5,65E-03	0,00E+00	5,23E-02	0,00E+00	5,40E-03	5,65E-04	0,00E+00	5,23E-03	-8,67E-03
Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials; PENRM = Use of non renewable primary energy resources used as raw materials; PENRT = Total use of non renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non renewable secondary fuels; FW = Net use of fresh water														

Table 23 – End-of-life (waste categories and output flows)

WASTE CATEGORIES AND OUTPUT FLOWS PER 1 TON SAND															
						Scenario 1 (Disposal)					Scenario 2 (Reuse)				
Parameter	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**	**C1**	**C2**	**C3**	**C4**	**D**
HWD	[kg]	0,00E+00	0,00E+00	9,36E-09	9,01E-09	2,16E-09	2,25E-09	0,00E+00	4,92E-08	0,00E+00	2,16E-09	2,25E-10	0,00E+00	4,92E-09	-1,74E-08
NHWD	[kg]	0,00E+00	0,00E+00	9,23E-03	3,84E-02	9,19E-03	9,61E-03	0,00E+00	1,00E+03	0,00E+00	9,19E-03	9,61E-04	0,00E+00	1,00E+02	-3,75E+01
RWD	[kg]	0,00E+00	0,00E+00	7,19E-04	4,29E-04	1,03E-04	1,07E-04	0,00E+00	2,07E-03	0,00E+00	1,03E-04	1,07E-05	0,00E+00	2,07E-04	-1,78E-03
CRU	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	9,00E+02	0,00E+00	0,00E+00
MFR	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MER	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EET	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption	HWD = Hazardous waste disposed; NHWD = Non hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy														

Table 24 – Biogenic carbon content at factory gate

BIOGENIC CARBON CONTENT PER 1 TON SAND		
Parameter	**Unit**	**At the factory gate**
Biogenic carbon content in product	kg C	0,00E+00
Biogenic carbon content in accompanying packaging	kg C	0,00E+00

5.2.2 Results for sand/compost mix

In Table 25 - Table 29 the LCIA and LCI results are shown for the sand/compost mix. The results are given per 1000 kg of product, and divided into the modules A1-A3, A4, C1-C4 and D.

Table 25 - Core environmental impact indicators

ENVIRONMENTAL IMPACTS PER 1 TON SAND/COMPOST MIX										
						Scenario 2 (Reuse)				
Indicator	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
GWP-total	kg CO_2 eq.	0,00E+00	1,36E+00	6,24E+00	1,82E+01	4,46E+00	4,55E-01	0,00E+00	1,50E+00	-1,50E+00
GWP-fossil	kg CO_2 eq.	0,00E+00	1,34E+00	6,12E+00	1,78E+01	4,37E+00	4,46E-01	0,00E+00	1,50E+00	-1,50E+00
GWP-biogenic	kg CO_2 eq.	-2,75E+00	3,20E-03	2,84E-02	4,27E-02	2,36E-02	1,07E-03	2,48E+00	2,65E-01	1,38E-02
GWP-luluc	kg CO_2 eq.	0,00E+00	2,25E-02	8,65E-02	3,00E-01	7,18E-02	7,51E-03	0,00E+00	8,98E-03	-1,26E-02
ODP	kg CFC 11 eq.	0,00E+00	1,97E-13	8,87E-12	2,63E-12	6,30E-13	6,58E-14	0,00E+00	4,04E-12	-1,11E-11
AP	mol H^+ eq.	0,00E+00	2,10E-03	6,99E-02	2,80E-02	5,77E-02	7,01E-04	0,00E+00	1,06E-02	-7,46E-03
EP-freshwater	kg P eq.	0,00E+00	5,72E-06	2,21E-05	7,63E-05	1,82E-05	1,91E-06	0,00E+00	3,40E-06	-5,36E-06
EP-marine	kg N eq.	0,00E+00	8,06E-04	3,16E-02	1,07E-02	2,61E-02	2,69E-04	0,00E+00	2,74E-03	-2,66E-03
EP-terrestrial	mol N eq.	0,00E+00	9,46E-03	3,48E-01	1,26E-01	2,88E-01	3,15E-03	0,00E+00	3,01E-02	-2,93E-02
POCP	kg NMVOC eq.	0,00E+00	2,09E-03	1,03E-01	2,79E-02	8,49E-02	6,96E-04	0,00E+00	8,37E-03	-7,49E-03
ADPm[1]	kg Sb eq.	0,00E+00	1,17E-07	4,95E-07	1,56E-06	3,72E-07	3,89E-08	0,00E+00	9,70E-08	-1,61E-07
ADPf[1]	MJ	0,00E+00	1,77E+01	7,94E+01	2,35E+02	5,63E+01	5,88E+00	0,00E+00	1,97E+01	-2,31E+01
WDP[1]	m^3 world eq. deprived	0,00E+00	2,08E-02	8,88E-02	2,77E-01	6,62E-02	6,92E-03	0,00E+00	1,71E-01	-1,82E-01
Caption	GWP-total = Global Warming Potential - total; GWP-fossil = Global Warming Potential - fossil fuels; GWP-biogenic = Global Warming Potential - biogenic; GWP-luluc = Global Warming Potential - land use and land use change; ODP = Ozone Depletion; AP = Acidifcation; EP-freshwater = Eutrophication – aquatic freshwater; EP-marine = Eutrophication – aquatic marine; EP-terrestrial = Eutrophication – terrestrial; POCP = Photochemical zone formation; ADPm = Abiotic Depletion Potential – minerals and metals; ADPf = Abiotic Depletion Potential – fossil fuels; WDP = water use									
Disclaimer	[1] The results of this environmental indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator.									

Table 26 – Additional environmental impact indicators

ADDITIONAL ENVIRONMENTAL IMPACTS PER 1 TON SAND/COMPOST MIX										
						Scenario 2 (Reuse)				
Parameter	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
PM	[Disease incidence]	0,00E+00	2,22E-08	2,78E-06	2,96E-07	2,31E-06	7,39E-09	0,00E+00	1,33E-07	-4,57E-07
IRP[2]	[kBq U235 eq.]	0,00E+00	4,66E-03	8,19E-02	6,22E-02	1,49E-02	1,55E-03	0,00E+00	2,40E-02	-2,46E-01
ETP-fw[1]	[CTUe]	0,00E+00	1,31E+01	5,16E+01	1,75E+02	4,19E+01	4,37E+00	0,00E+00	1,14E+01	-1,20E+01
HTP-c[1]	[CTUh]	0,00E+00	2,65E-10	1,11E-09	3,53E-09	8,43E-10	8,82E-11	0,00E+00	2,69E-10	-3,48E-10
HTP-nc[1]	[CTUh]	0,00E+00	1,19E-08	4,92E-08	1,58E-07	3,88E-08	3,96E-09	0,00E+00	1,04E-08	-1,07E-08
SQP[1]	-	0,00E+00	8,68E+00	3,37E+01	1,16E+02	2,77E+01	2,89E+00	0,00E+00	5,44E+00	-6,51E+00
Caption	PM = Particulate Matter emissions; IRP = Ionizing radiation – human health; ETP-fw = Eco toxicity – freshwater; HTP-c = Human toxicity – cancer effects; HTP-nc = Human toxicity – non cancer effects; SQP = Soil Quality									
Disclaimers	[1] The results of this environmental indicator shall be used with care as the uncertainties on these results are high or as there is limited experienced with the indicator. [2] This impact category deals mainly with the eventual impact of low dose ionizing radiation on human health of the nuclear fuel cycle. It does not consider effects due to possible nuclear accidents, occupational exposure nor due to radioactive waste disposal in underground facilities. Potential ionizing radiation from the soil, from radon and from some construction materials is also not measured by this indicator.									

Table 27 - Parameters describing resource use

RESOURCE USE PER 1 TON SAND/COMPOST MIX										
					Scenario 2 (Reuse)					
Parameter	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
PERE	[MJ]	0,00E+00	1,52E+00	8,62E+00	2,03E+01	4,85E+00	5,07E-01	0,00E+00	3,44E+00	-8,24E+00
PERM	[MJ]	1,66E+03	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	-1,49E+03	0,00E+00	0,00E+00
PERT	[MJ]	1,66E+03	1,52E+00	8,62E+00	2,03E+01	4,85E+00	5,07E-01	-1,49E+03	3,44E+00	-8,24E+00
PENRE	[MJ]	0,00E+00	1,77E+01	7,94E+01	2,35E+02	5,63E+01	5,88E+00	0,00E+00	1,97E+01	-2,31E+01
PENRM	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
PENRT	[MJ]	0,00E+00	1,77E+01	7,94E+01	2,35E+02	5,63E+01	5,88E+00	0,00E+00	1,97E+01	-2,31E+01
SM	[kg]	1,50E+02	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
RSF	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
NRSF	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
FW	[m^3]	0,00E+00	1,69E-03	8,00E-03	2,26E-02	5,40E-03	5,65E-04	0,00E+00	5,23E-03	-7,37E-03
Caption	PERE = Use of renewable primary energy excluding renewable primary energy resources used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non renewable primary energy excluding non renewable primary energy resources used as raw materials; PENRM = Use of non renewable primary energy resources used as raw materials; PENRT = Total use of non renewable primary energy resources; SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non renewable secondary fuels; FW = Net use of fresh water									

Table 28 – End-of-life (waste categories and output flows)

WASTE CATEGORIES AND OUTPUT FLOWS PER 1 TON SAND/COMPOST MIX										
					Scenario 2 (Reuse)					
Parameter	**Unit**	**A1**	**A2**	**A3**	**A4**	**C1**	**C2**	**C3**	**C4**	**D**
HWD	[kg]	0,00E+00	6,76E-10	9,85E-09	9,01E-09	2,16E-09	2,25E-10	0,00E+00	4,92E-09	-1,48E-08
NHWD	[kg]	0,00E+00	2,88E-03	1,59E-02	3,84E-02	9,19E-03	9,61E-04	0,00E+00	1,00E+02	-3,19E+01
RWD	[kg]	0,00E+00	3,22E-05	7,02E-04	4,29E-04	1,03E-04	1,07E-05	0,00E+00	2,07E-04	-1,51E-03
CRU	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	9,00E+02	0,00E+00	0,00E+00
MFR	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
MER	[kg]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EEE	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
EET	[MJ]	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00	0,00E+00
Caption	HWD = Hazardous waste disposed; NHWD = Non hazardous waste disposed; RWD = Radioactive waste disposed; CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EEE = Exported electrical energy; EET = Exported thermal energy									

Table 29 – Biogenic carbon content at factory gate

BIOGENIC CARBON CONTENT PER 1 TON SAND/COMPOST MIX		
Parameter	**Unit**	**At the factory gate**
Biogenic carbon content in product	kg C	1,01E+01
Biogenic carbon content in accompanying packaging	kg C	0,00E+00

5.3 RELATIONSHIP OF THE LCIA RESULTS TO THE LCI RESULTS

A contribution analysis has been conducted to indicate which processes and materials contribute the most to the core environmental indicators for the declared products.

The results of the contribution analysis are presented in the following order:

- Sand (section 5.3.1)
- Sand/compost mix (section 5.3.2)

LCIA are relative expressions and do not predict impacts category endpoints, the exceeding of thresholds, safety margins or risks.

5.3.1 Contribution analysis, sand

Table 30 and Table 31 shows the processes contributing the most to the specific impact categories of the core environmental indicators, and how much they contribute to the given impact category. Please note that results in module D are not included in the contribution analysis.

Overall, the results of the contribution analysis covering module A1 – A3 (product stage) show that the manufacturing and combustion of diesel has the largest contributions to the total results in most impact categories.

Considering all modules declared, transport to the construction site (A4) is a primary contributor. When considering EoL scenario 1, landfilling of the product waste (C4) is also a primary contributor to several impact categories. When considering EoL scenario 2, combustion of diesel for the extraction of the material from the construction (C1) is also a primary contributor to several impact categories.

Table 30 - Maximum contribution to impact categories, module A1 – A3

Contribution analysis, Sand				
		Maximum contribution: A1 – A3		
Impact Category	Unit	Contribution	% of category	Process
GWP-total	kg CO_2 eq.	1,49E+00	54%	A3: Diesel combustion
GWP-fossil	kg CO_2 eq.	1,37E+00	50%	A3: Diesel combustion
GWP-biogenic	kg CO_2 eq.	1,23E-01	52%	A3: Diesel combustion
GWP-luluc	kg CO_2 eq.	2,80E-02	99%	A3: Diesel manufacturing
ODP	kg CFC 11 eq.	9,53E-12	97%	A3: Electricity
AP	mol H^+ eq.	2,11E-02	91%	A3: Diesel combustion
EP-freshwater	kg P eq.	7,12E-06	98%	A3: Diesel manufacturing
EP-marine	kg N eq.	9,78E-03	94%	A3: Diesel combustion
EP-terrestrial	mol N eq.	1,07E-01	93%	A3: Diesel combustion
POCP	kg NMVOC eq.	3,17E-02	94%	A3: Diesel combustion
ADPm	kg Sb eq.	1,45E-07	72%	A3: Diesel manufacturing
ADPf	MJ	2,20E+01	62%	A3: Diesel manufacturing
WDP	m^3 world eq. deprived	2,58E-02	73%	A3: Diesel manufacturing

Table 31 – Maximum contribution to impact categories, module A - C

Contribution analysis, Sand							
		Maximum contribution: A1-A3, A4, C1-C4 (Scenario 1)			Maximum contribution: A1-A3, A4, C1-C4 (Scenario 2)		
Impact Category	**Unit**	**Contribution**	**% of category**	**Process**	**Contribution**	**% of category**	**Process**
GWP-total	kg CO_2 eq.	1,82E+01	41%	A4: Transport	1,82E+01	66%	A4: Transport
GWP-fossil	kg CO_2 eq.	1,78E+01	40%	A4: Transport	1,78E+01	66%	A4: Transport
GWP-biogenic	kg CO_2 eq.	3,16E-01	32%	C1: Diesel combustion	3,16E-01	35%	C1: Diesel combustion
GWP-luluc	kg CO_2 eq.	3,00E-01	53%	A4: Transport	3,00E-01	72%	A4: Transport
ODP	kg CFC 11 eq.	4,04E-11	75%	C4: Landfill	9,53E-12	56%	A3: Electricity
AP	mol H^+ eq.	1,06E-01	48%	C4: Landfill	5,40E-02	45%	C1: Diesel combustion
EP-freshwater	kg P eq.	7,63E-05	49%	A4: Transport	7,63E-05	71%	A4: Transport
EP-marine	kg N eq.	2,74E-02	35%	C4: Landfill	2,51E-02	50%	C1: Diesel combustion
EP-terrestrial	mol N eq.	3,01E-01	35%	C4: Landfill	2,75E-01	49%	C1: Diesel combustion
POCP	kg NMVOC eq.	8,37E-02	35%	C4: Landfill	8,11E-02	52%	C1: Diesel combustion
ADPm	kg Sb eq.	1,56E-06	45%	A4: Transport	1,56E-06	69%	A4: Transport
ADPf	MJ	2,35E+02	40%	A4: Transport	2,35E+02	67%	A4: Transport
WDP	m^3 world eq. deprived	1,71E+00	79%	C4: Landfill	2,77E-01	50%	A4: Transport

5.3.2 Contribution analysis, sand/compost mix

Table 32 show the processes contributing the most to the specific impact categories of the core environmental indicators, and how much they contribute to the given impact category. Please note that results in module D are not included in the contribution analysis.

Overall, the results of the contribution analysis covering module A1 – A3 (product stage) show that the manufacturing and combustion of diesel has the largest contributions to the overall results in most impact categories. Considering all modules declared, the transport to the construction site (A4) and combustion of diesel for the extraction of the material from the construction (C1) are the primary contributors to the impact categories.

Negative numbers are observed for "Global warming, biogenic" which indicates a sequestration of CO_2 from biogenic sources and is primarily due to the biogenic carbon content in the compost.

Table 32 - Maximum contribution to impact categories

Contribution analysis, sand/compost mix							
		Maximum contribution: A1-A3			Maximum contribution: A1-A3, A4, C1-C4		
Impact Category	Unit	Contribution	% of category	Process	Contribution	% of category	Process
GWP-total	kg CO_2 eq.	3,32E+00	44%	A3: Diesel combustion	1,82E+01	56%	A4: Transport
GWP-fossil	kg CO_2 eq.	3,05E+00	41%	A3: Diesel combustion	1,78E+01	56%	A4: Transport
GWP-biogenic	kg CO_2 eq.	-2,75E+00	79%	A1: Compost	-2,75E+00	40%	A1: Compost
GWP-luluc	kg CO_2 eq.	6,25E-02	57%	A3: Diesel manufacturing	3,00E-01	60%	A4: Transport
ODP	kg CFC 11 eq.	8,10E-12	89%	A3: Electricity	8,10E-12	49%	A3: Electricity
AP	mol H^+ eq.	4,70E-02	65%	A3: Diesel combustion	5,40E-02	32%	C1: Diesel combustion
EP-freshwater	kg P eq.	1,59E-05	57%	A3: Diesel manufacturing	7,63E-05	60%	A4: Transport
EP-marine	kg N eq.	2,18E-02	67%	A3: Diesel combustion	2,51E-02	35%	C1: Diesel combustion
EP-terrestrial	mol N eq.	2,39E-01	67%	A3: Diesel combustion	2,75E-01	34%	C1: Diesel combustion
POCP	kg NMVOC eq.	7,06E-02	67%	A3: Diesel combustion	8,11E-02	36%	C1: Diesel combustion
ADPm	kg Sb eq.	3,24E-07	53%	A3: Diesel manufacturing	1,56E-06	58%	A4: Transport
ADPf	MJ	4,90E+01	50%	A3: Diesel manufacturing	2,35E+02	57%	A4: Transport
WDP	m^3 world eq. deprived	5,76E-02	53%	A3: Diesel manufacturing	2,77E-01	44%	A4: Transport

5.4 CHARACTERISATION MODELS AND FACTORS

See section 5.1.

6 Life cycle interpretation

6.1 THE RESULTS

6.1.1 Results for sand

The results for the relative contributions to the core environmental indicators, distributed among the life cycle modules declared, are illustrated in Figure 9 (A1-A3), Figure 10 (A1-A3, A4, C1-C4, and D (Scenario 1)), and Figure 11 (A1-A3, A4, C1-C4, and D (Scenario 2)).

For the production of sand, consumption of diesel and electricity are the main contributors to the environmental impacts. Overall, the impact from the product stage is minor compared to all life cycle modules declared, where the greatest impacts in most impact categories are related to downstream processes such as transport to the construction site and end-of-life activities.

Negative emissions are observed for "Global warming, biogenic". This is primarily related to the biogenic carbon content in the diesel mix used. There may be some minor deviations despite efforts to balance biogenic carbon flows in the system. The dataset used to model landfilling of product waste (see section 4.6.1.4) result in a small uptake of emissions in the GWP-biogenic category. The reason for this uptake is not transparent is the description of the dataset, however this deviation is not considered to be of significant importance for the overall results.

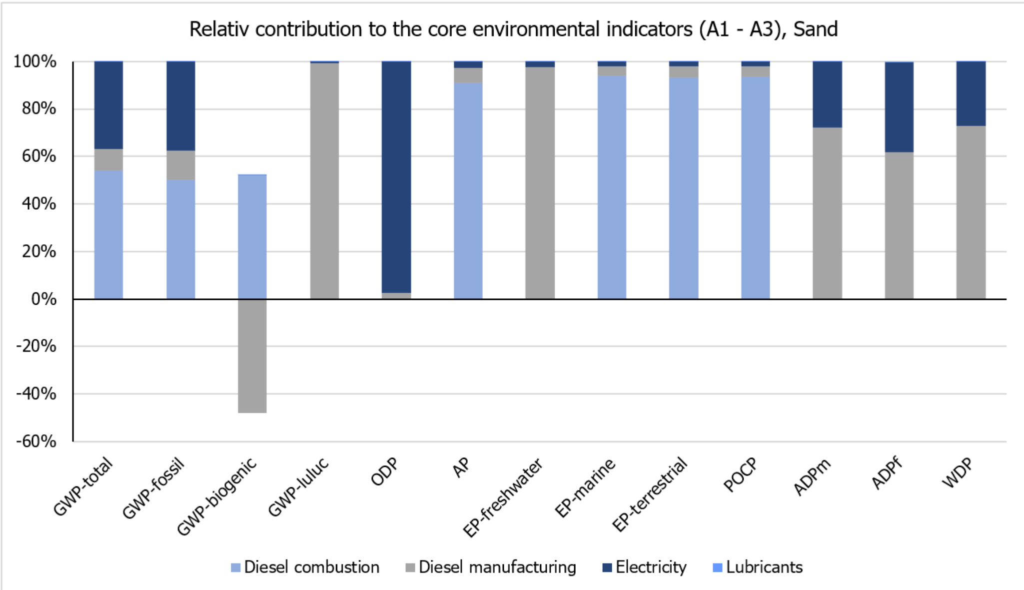

Figure 9 – Relative contributions to impact categories for the LCA modules A1-A3 for sand

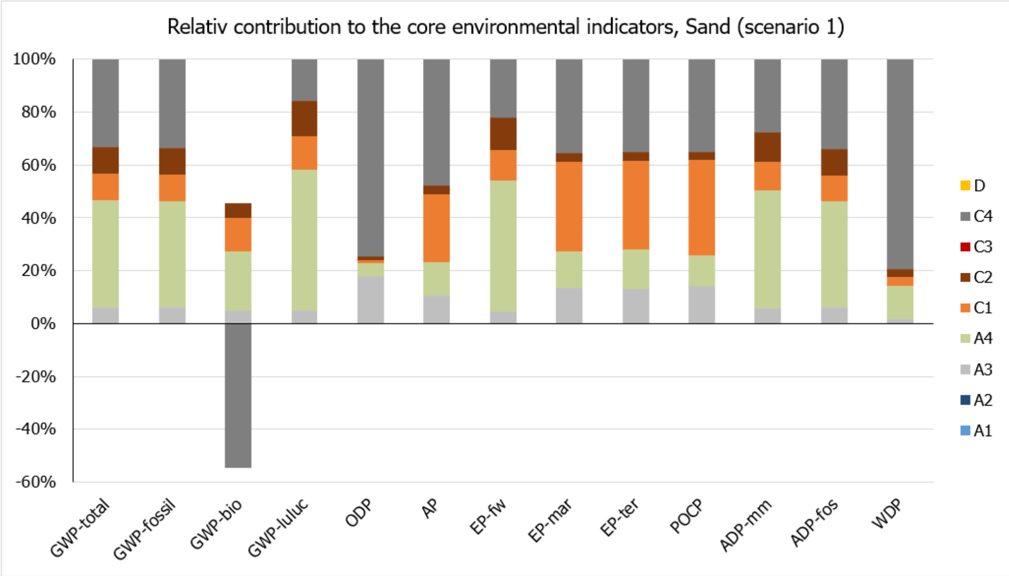

Figure 10 – Relative contributions to impact categories for the LCA modules A1-A3, A4, C1-C4, D (scenario 1) for sand

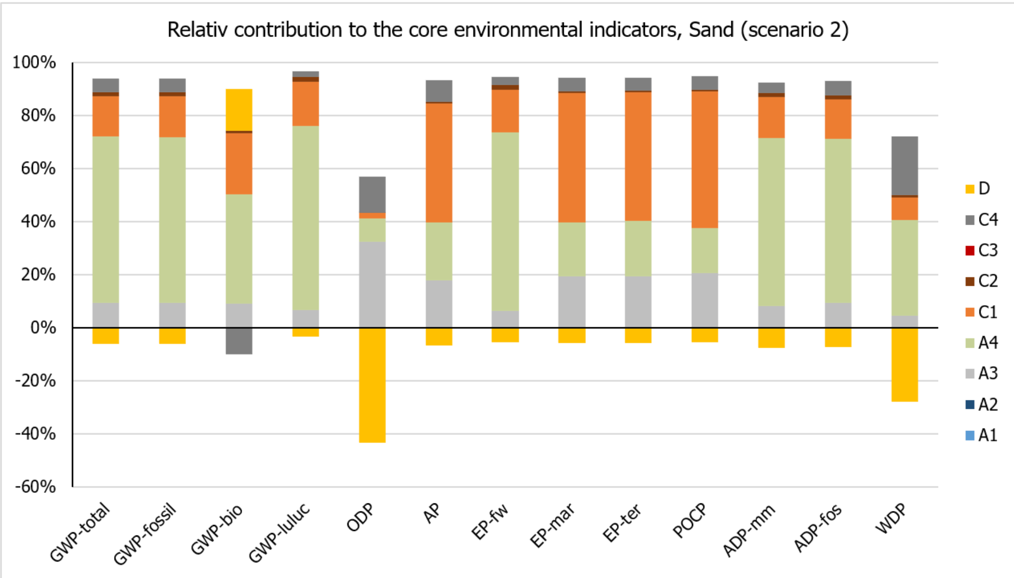

Figure 11 – Relative contributions to impact categories for the LCA modules A1-A3, A4, C1-C4, D (scenario 2) for sand

6.1.2 Results for sand/compost mix

The results for the relative contributions to the core environmental indicators, distributed among the life cycle modules declared, are illustrated in Figure 12 (A1-A3, A4, C1-C4, and D).

In addition to impacts from energy consumption for the production of sand, as mentioned in section 6.1.1, the production of sand/compost mix includes impacts from transportation of compost. A negative contribution to "GWP-bio" in the product stage is related to the biogenic carbon content of compost. A "release" of the biogenic carbon of compost is accounted for at the end-of-life stage.

Overall, the impact from the product stage is minor compared to all life cycle modules declared, where the greatest impacts in most impact categories are related to downstream processes such as transport to the construction site and end-of-life activities.

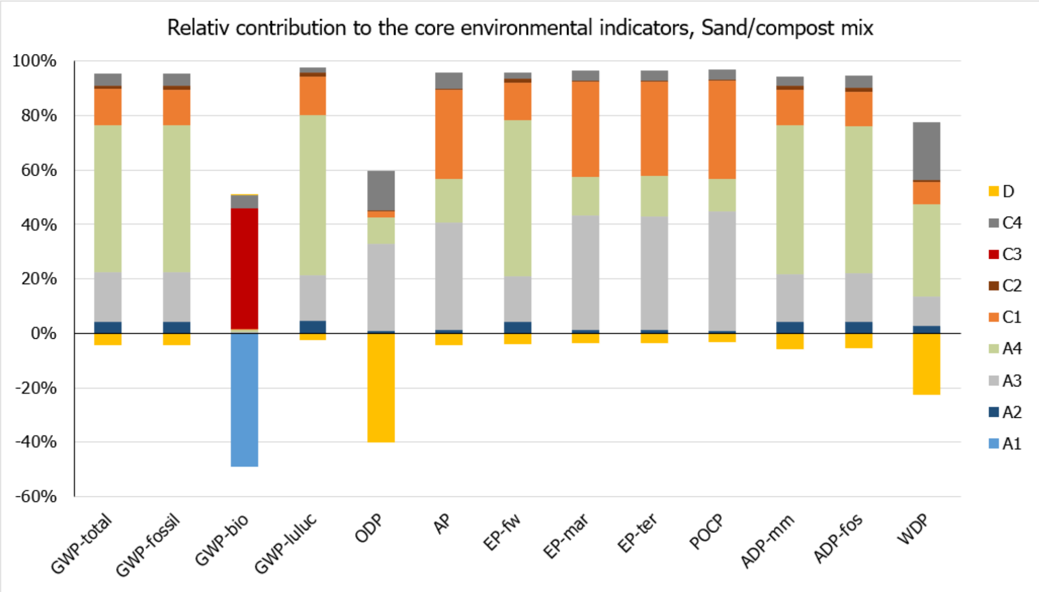

Figure 12 – Relative contributions to impact categories for the LCA modules A1-A3, A4, C1-C4, D for sand/compost mix

6.2 ASSUMPTIONS AND LIMITATIONS

Assumptions used in this study and the quality of the data used in the modelling are described in chapter 4.

Two scenarios for the end-of-life stage, considered to be the most likely for the sand products declared, are considered in this study. If it is known that the unbound sand product has a different end-of-life scenario, this should be taken into consideration in the interpretation of results given in this LCA study.

6.3 VARIANCE FROM THE MEANS

As stated in section 3.1.1, sand of different grain sizes is produced at the facility. All sand products are declared with the same set of results as they undergo the same manufacturing steps at the production facility, and thus the difference between products is assumed to be 0 %.

6.4 DATA QUALITY ASSESSMENT

The foreground data is of good quality and is based on annual data from the production site. The product-specific data has been collected for the period from Q1 2023 to Q2 2024.

The quality of the background data is generally assessed as good or very good. Please refer to section 4.12 for the data validation.

6.5 VALUE-CHOICES, RATIONALES AND EXPERT JUDGEMENTS

Not relevant.

7 Documentation on additional information

- Figure 13, Figure 14, and Figure 15 – Figure of the respective product systems modelled
- Appendix 1 – REACH statement
- Appendix 2 – Product data sheet
- Appendix 3 - Modelling of diesel combustion in machinery

8 Data availability for verification

Figure 13, Figure 14, and Figure 15 shows the product systems as they are modelled in LCA for Experts with a description and color code of which LCA modules the individual unit processes are declared within.

LCIA results can be found in chapter 5 of this report.

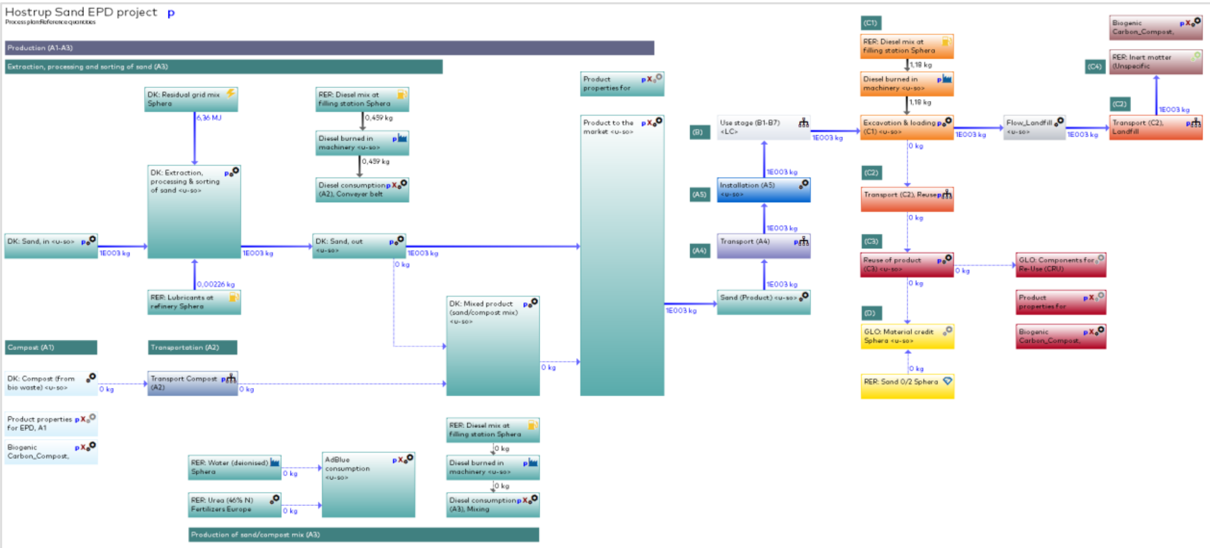

Figure 13 - The product system for **sand, EoL scenario 1**, as modelled in LCA for Experts with the assignment of processes to the life cycle sub modules (A1-A4, C1-C4 and D).

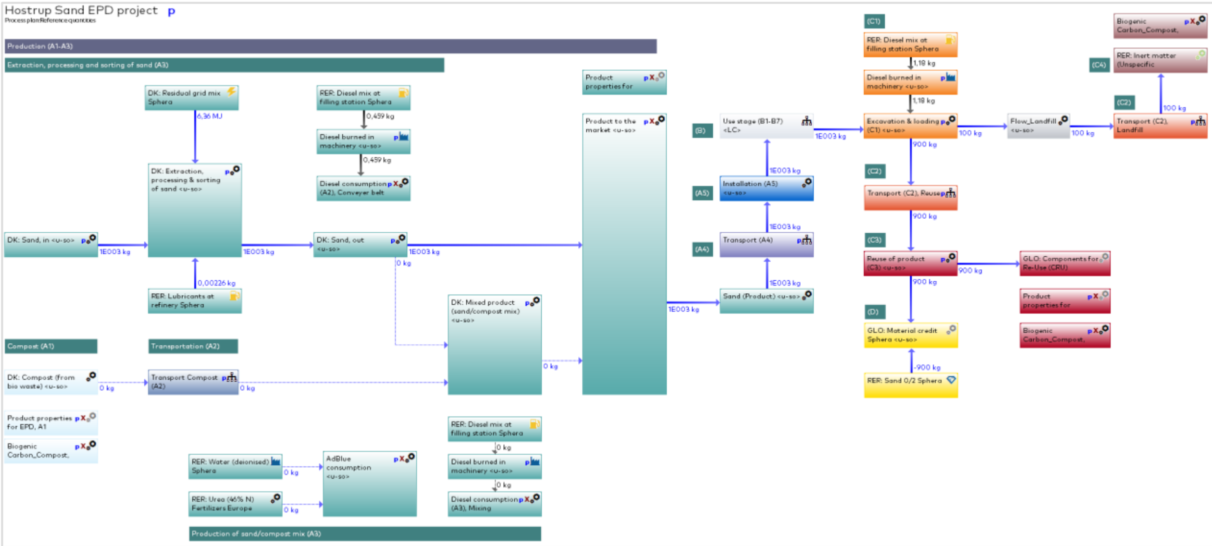

Figure 14 - The product system for **sand, EoL scenario 2**, as modelled in LCA for Experts with the assignment of processes to the life cycle sub modules (A1-A4, C1-C4 and D).

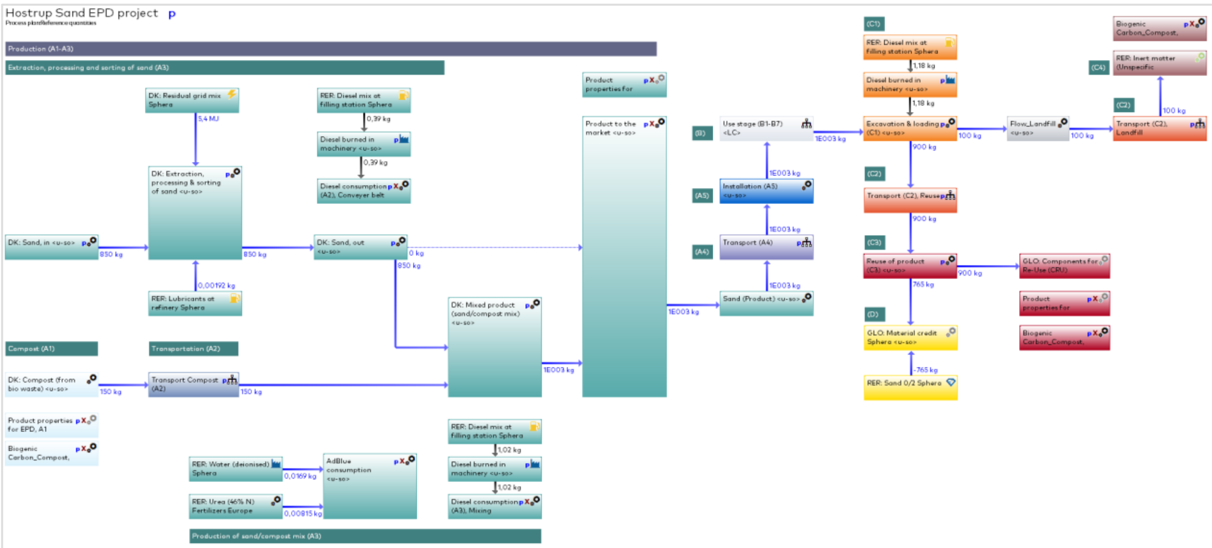

Figure 15 - The product system for **sand/compost mix**, as modelled in LCA for Experts with the assignment of processes to the life cycle sub modules (A1-A4, C1-C4 and D).

9 References

- GaBi 2024.1 Professional Database http://www.gabi-software.com/nw-eu-danish/databases/gabi-databases/professional/

- GaBi 2024.1 Extension DB II, Energy http://www.gabi-software.com/nw-eu-danish/databases/gabi-databases/energy/

- GaBi 2024.1 Extension DB XIV, Construction materials http://www.gabi-software.com/nw-eu-danish/databases/gabi-databases/construction-materials/

- EN 15804
  DS/EN 15804 + A2:2019 - "Bæredygtighed inden for byggeri og anlæg - Miljøvaredeklarationer - Grundlæggende regler for produktkategorien byggevarer"
  EN 15804 reference package [3.1]

- EN 15942
  DS/EN 15942:2011 – "Bæredygtighed inden for byggeri og anlæg - Miljøvaredeklarationer (EPD) - Kommunikationsformat: business-to-business (B2B)"

- ISO 14025
  DS/EN ISO 14025:2010 – "Miljømærker og -deklarationer - Type III-miljøvaredeklarationer - Principper og procedurer

- ISO 14040
  DS/EN ISO 14040:2008 – "Miljøledelse – Livscyklusvurdering – Principper og struktur"

- ISO 14044
  DS/EN ISO 14044:2008 – "Miljøledelse – Livscyklusvurdering – Krav og vejledning"

10 Appendices

10.1 APPENDIX 1 – REACH STATEMENT

HOSTRUP SAND

Hostrup Sand A/S
Hostrupvej 42B
6710 Esbjerg, Denmark
CVR: 3294 0625

Esbjerg, 22-11-2024

REACH statement

In connection with the registration and publication of the EPD covering sand products produced by Hostrup Sand A/S, I hereby declare that the included products do not contain any substances on the REACH list "Candidate List of Substances of Very High Concern for Authorisation" from the European Commission (https://echa.europa.eu/da/candidate-list-table).

Signature

Mariann Esh

10.2 APPENDIX 2 – PRODUCT DATA SHEET

Jahreszeugnis Biogutkompost 2024

Jahreszeugnis 2024

JZ-Nr.: 1065-2401-1

Anlage Borgstedtfelde
BGK-Nr.: 1065
AWR BioEnergie GmbH
Borgstedtfelde 15
D 24794 Borgstedt

BGK

Fertigkompost (feinkörnig)

Humus- und Nährstoffdünger

- Regional hergestellt aus nachhaltigen Rohstoffen
- Erhöht die Wasseraufnahme- und Wasserhaltefähigkeit des Bodens
- Fördert die Humusreproduktion und verringert die Bodenerosion
- Enthält alle essentiellen Haupt- und Spurennährstoffe
- Verwendung auf Ackerflächen; hygienisch unbedenklich

GÜTEZEICHEN KOMPOST RAL

RAL-GZ 251
www.gz-kompost.de

Prüfung Rechtsbestimmungen und Regelwerke

- ☑ RAL-Gütesicherung (RAL-GZ 251, Überwachungsverfahren)
- ☑ Bioabfallverordnung - BioAbfV
- ☑ Düngemittelverordnung - DüMV
- ☑ Organisches Düngemittel
- ☑ EU-Ökoverordnung VO (EU) 2021/1165, Anhang II

Eigenschaften	Wert	Einheit
Trockenmasse	61,5	% FM
Rohdichte	603	kg/m³
Organische Substanz	228	kg/t FM
Humus-C	67	kg/t FM
pH-Wert (H_2O)	8,7	
C/N-Verhältnis	15	
Frei von keimfähigen Samen und austriebsfähigen Pflanzenteilen		
Hygienisierend und stabilisierend behandelt		

Nährstoffgehalte	kg/t FM	kg/m³
Stickstoff gesamt (N)	8,61	5,19
Stickstoff $CaCl_2$-löslich (N)	0,49	0,29
Stickstoff organisch (N)	8,12	4,90
Phosphat gesamt (P_2O_5)	4,92	2,97
Kaliumoxid gesamt (K_2O)	7,93	4,78
Magnesiumoxid gesamt (MgO)	2,77	1,67
Basisch wirks. Bestandteile (CaO)	23,37	14,09

Monetäre Bewertung	€/t FM	€/m³
Düngewert [1]	14,91	8,99
Humuswert [2]	11,44	6,90

FM: Frischmasse,
1) Düngewert gemäß aktuellem Marktwert, ermittelt über äquivalente Kosten mineralischer Düngung nach Landhandelspreisen (Okt. - Dez. 2023, netto) (1,26 €/kg N anrechenbar (N-lös zzgl. 5 % von N-org); 1,02 €/kg P_2O_5; 0,81 €/kg K_2O; 0,10 €/kg CaO).
2) Der Wert von Humus-C beträgt 0,17 €/kg Humus-C (Kalkuliert auf Basis eines Strohpreises von 72,50 €/t)

Anlagen zum Jahreszeugnis
- Anwendungsempfehlung Landwirtschaft
- Anwendungsempfehlung Landschaftsbau

Jahreszeugnis der BGK
Dieses Jahreszeugnis ist ein Warenbegleitdokument der RAL-Gütesicherung Kompost. Grundlage sind die Medianwerte mehrerer Untersuchungsergebnisse (siehe Seite 'Untersuchung'). Die Anwendungsempfehlungen und Prüfungen berücksichtigen die relevanten Vorgaben der einschlägigen Rechtsbestimmungen/Regelwerke

Weitere Informationen zum BGK-Zeugnis sind im Merkblatt Prüfzeugnis (Dok. 251-010-2) und den Qualitätsanforderungen Fertigkompost (Dok. 251-006-2) enthalten.

BGK - Bundesgütegemeinschaft Kompost e.V. ist die von RAL (www.ral.de) anerkannte Organisation zur Durchführung der Gütesicherung für die Warengruppe Kompost.

Das Zeugnis wurde elektronisch erstellt und gilt ohne Unterschrift.

BGK - Bundesgütegemeinschaft Kompost e. V.
Köln, den 03.01.2024

BGK

www.kompost.de

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10.3 APPENDIX 3 - MODELLING OF DIESEL COMBUSTION IN MACHINERY

For the modeling of diesel combustion in production machinery, a proxy process is used that is based on the emission profile from the combustion of diesel in an excavator. The proxy process is based on the following dataset from the LCA for Experts database: DE: Excavator, Sphera. The reference year of the process data set is 2022. The content of biodiesel of the fuel combusted is set to 8,28 wt., corresponding to the content in the diesel mix used (RER: Diesel mix at filling station, Sphera).

In Table 33, inputs and outputs in the original dataset is shown, used for modeling diesel combustion in production machinery.

Table 33 – Inputs and outputs in the original dataset.

Original LCA for Expert dataset			
Outputs			
Excavated material [Materials]	Mass	1,00E+00	kg
Carbon dioxide [Inorganic emissions to air]	Mass	5,04E-04	kg
Carbon dioxide (biotic) [Inorganic emissions to air]	Mass	4,55E-05	kg
Carbon monoxide [Inorganic emissions to air]	Mass	4,71E-06	kg
Dust (PM2.5) [Particles to air]	Mass	1,28E-06	kg
Nitrogen oxides [Inorganic emissions to air]	Mass	9,28E-06	kg
NMVOC (unspecified) [Group NMVOC to air]	Mass	2,14E-06	kg
Sulphur dioxide [Inorganic emissions to air]	Mass	6,94E-07	kg
Inputs			
Diesel [Refinery products]	Mass	1,69E-04	kg
Excavated material [Materials]	Mass	1,00E+00	kg

The emission profile for the proxy process is calculated by scaling all outputs to an input of 1 kg of diesel, and then removing the excavated material from the process, see Table 34. All outputs were calculated using Eq. 1:

$$\text{Output pr. input of 1 kg diesel (kg)} = \frac{\text{Original output (kg)}}{0{,}0001694\ \text{kg}} \qquad \textbf{Eq. 1}$$

Table 34 - Inputs and outputs of the proxy-process

Adjusted dataset			
Outputs			
Diesel [Refinery products]	Mass	2,98E+00	kg
Carbon dioxide [Inorganic emissions to air]	Mass	2,69E-01	kg
Carbon dioxide (biotic) [Inorganic emissions to air]	Mass	2,78E-02	kg
Carbon monoxide [Inorganic emissions to air]	Mass	7,57E-03	kg
Dust (PM2.5) [Particles to air]	Mass	5,48E-02	kg
Nitrogen oxides [Inorganic emissions to air]	Mass	1,26E-02	kg
NMVOC (unspecified) [Group NMVOC to air]	Mass	4,10E-03	kg
Sulphur dioxide [Inorganic emissions to air]	Mass	2,98E+00	kg
Inputs			
Diesel [Refinery products]	Mass	1,00E+00	kg