Secugrid®

Environmental Product Declaration

NAUE

Environmental Product Declaration (EPD)
Secugrid®

Secugrid® R6 uniaxial PET
Product family

Secugrid® Q1 biaxial PP
Product family

Secugrid® Q6 biaxial PET
Product family

Declaration holder

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Declared product:

NAUE Secugrid®, geosynthetic for slope retention

Data calculation by

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Independent verification of the declaration and data, according to EN ISO 14025:2010 ☒ internal ☐ external	

1. General aspects

This Environmental Product Declaration (EPD) is commissioned by NAUE GmbH & Co. KG and accomplished by treeze Ltd. in 2020. The study has been conducted according to the requirements of the standard EN 15804:2012+A2:2019 (EN 15804, 2019) and IES product category rules (IES 2018). The investigated products are the NAUE geosynthetics Secugrid® PET and Secugrid® PP intended for the use in many fields of civil engineering including landfill engineering and hydraulic engineering.

This EPD is a revision and extension of a work done in 2017 for the same kind of geosynthetics (NAUE 2017). In comparison to 2017, the data are evaluated based on new background inventory where available. Furthermore, in this revision also the "end-of-life stage" (C1 – C4) is evaluated.

2 Product

2.1 Description and application

The investigated products are the NAUE geogrids Secugrid® PET (Polyester) and Secugrid® PP (Polypropylene) intended for the use in many fields of civil engineering including road construction, landfill engineering and hydraulic engineering.

The classification number according to the UN CPC classification system is 36950.

The Secugrid® PET product line is mainly used for applications like reinforced slopes and retaining walls, load transfer platforms over piles, bridging of mining voids and sinkholes as well as veneer reinforcement in landfill engineering. The product line provides superior longterm design strength characteristics due to its high resistance against creep effects. Furthermore, high strength at low strain (high tensile modulus) is achieved a result of prestressed bars, which reduces deformation of the individual Secugrid® reinforced structures.

Figure 1 Secugrid® R6 PET uniaxial geogrid

The Secugrid® PP product line is mainly used for reinforcement of unbound aggregate layers in foundations, road pavements and trafficked areas. On top of weak subgrades, the geogrid reinforcement increases the shear strength of the base aggregate and thus its load distribution capacity, which allows the reduction of fill material in comparison to unreinforced layers. Furthermore, the product can reduce potential differential settlements and provides lateral restraint for the base course material. Thus, the base course generates a higher stiffness, longer lifetimes and higher serviceability compared to unreinforced constructions.

The main differences between the two product lines are the different raw materials. This EPD describes the weighted average Secugrid® products sold by NAUE. The results of this EPD are representative for all Secugrid® products of NAUE using the same raw material.
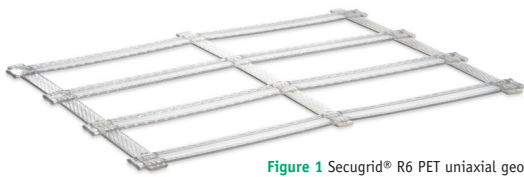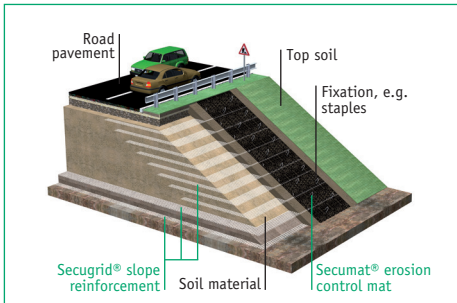

Figure 2 Secugrid® reinforced slope with 45° inclination
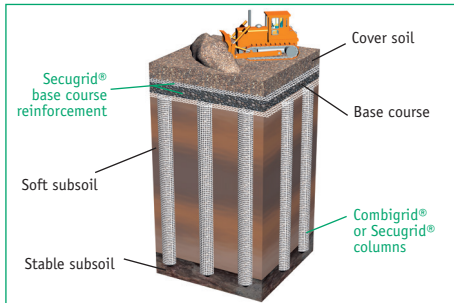

Figure 3 Base course reinforcement in areas with soft subsoils

Figure 4 Secugrid® reinforcement over areas prone to subsidence
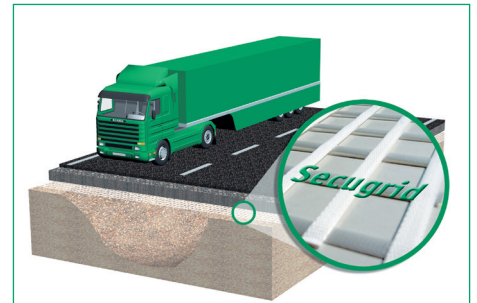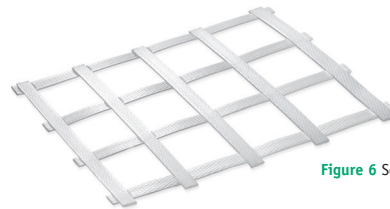

Figure 5 Secugrid® Q6 PET biaxial geogrid

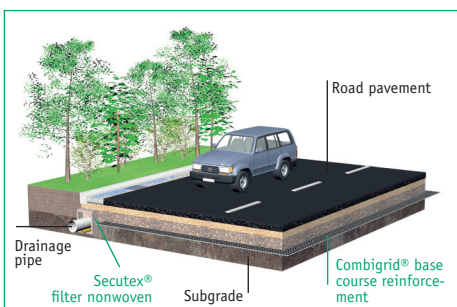**Figure 6** Secugrid® Q1 PP biaxial geogrid

Figure 7 Base course improvement with the composite product Combigrid® for separation and reinforcement

Figure 8 Secugrid® soil reinforcement in railroad applications

Figure 9 Base course reinforcement for a windfarm access road over soft subsoils

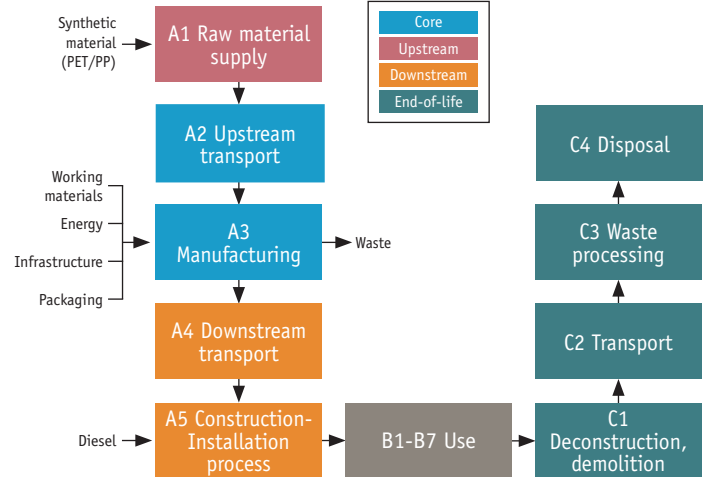| Product stage			Construction process stage		Use stage	End-of-life stage			
Raw material supply	Transport	Manufacturing	Downstream transport (to construction site)	Construction-Installation process	Use	Deconstruction, demolition	Transport	Waste processing	Disposal
A1	A2	A3	A4	A5	B1-B7	C1	C2	C3	C4
X	X	X	X	X	n.a.	X	X	X	X

Figure 10
Graphical overview of the life cycle stages covered by the EPD of geosynthetics

2.2 Raw material (A1)

Secugrid® PET and Secugrid® PP are manufactured using either polyester or polypropylene (PP) as the main raw material. To produce Secugrid® PP 93% PP, 2% Talcum, 1% polyethylene (HDPE) and 3% recycled materials are used. Secugrid® PET is produced using 98% PET and 2% recycled materials. More detailed information on the materials used is shown in Tab. 2.

Secugrid® PP is delivered in linear low-density polyethylene packaging foils (1.7g/m²).

2.3 Transport (A2)

The transport to manufacturer (A2) considers transports of raw materials to the NAUE manufacturing site. The raw materials are transported from the producer to the NAUE production site by lorries only. The average shipping distances for PET, PP and Talcum are 187km, 153km and 1600km, respectively.

2.4 Manufacturing (A3)

Secugrid® is made of stretched, monolithic plastic flat or profile bars with welded junctions. The manufacturing stage (A3) includes working materials, energy consumption, disposal of production wastes (scrap, lubricating oil, and municipal waste), the infrastructure (factory halls and office buildings and the corresponding land use), and the product's packaging. The manufacturing site is in Germany. Therefore, the German consumption mix at low voltage level is used to model the electricity use in manufacturing. The consumption mix displays the electricity domestic net production including imports. Small amounts of secondary plastic are used (1.7% and 3.1% for Secugrid® PET and Secugrid® PP, respectively). The production wastes amount to 2.7% and 4.1% relative to the material inputs of PET and PP, respectively.

Table 1
Specific raw material, working material and energy consumption, wastes produced and infrastructure requirements per square meter of average Secugrid® PET and Secugrid® PP.

* filed confidentially
** tkm/m² - ton-kilometer per m²

Specific material consumption	Specific material and energy use per m²	Unit	Secugrid® PET	Secugrid® PP
Production volume and reference year	Annual production volume	tons	*	*
	Annual production volume	m²	*	*
	Reference year		2019	2019
	Mass per unit area	g/m²	583	313
A1 Raw material	Recycling material	g/m²	10.2	10.1
	PET	g/m²	591.1	
	PP	g/m²		304.3
	Talcum	g/m²		8.0
	Polyethlyene (HDPE)	g/m'		4.7
A2 Upstream transport	Lorry, 25 tons	tkm/m²	1.11E-01	5.93E-02
A3 Manufacturing (working material and energy consumption)	**Working material**			
	Tap water	kg/m²	3.98E-02	4.23E-02
	Lubricating oil	kg/m²	3.56E-05	1.92E-05
	Packaging			
	Paper case / cardboard	kg/m²	7.35E-04	1.20E-02
	PVC	kg/m²	8.82E-03	
	LLDPE (Packaging)	kg/mv		1.68E-03
	Energy			
	Electricity	kWh/m²	8.15E-01	2.21E-01
	Diesel	MJ/m²	2.41E-02	1.30E-02
	Light fuel oil	MJ/m²	9.02E-02	4.84E-02
	Waste			
	Municipal waste	kg/m²	1.84E-03	6.73E-04
	Hazardous waste (machine oil)	kg/m²	5.51E-05	1.08E-05
	PET to recycling	kg/m²	1.65E-02	
	PP to recycling	kg/m²		1.35E-02
	Land use			
	Total area	m²/m²	1.33E-03	8.43E-04
	Factory halls	m²/m²	4.50E-04	2.84E-04
	Office buildings	m²/m²	1.82E-05	1.15E-05
	Other sealed area	m²/m²	6.87E-04	4.35E-04
	Share related to product	%	11%	38%
A4 Downstream transport	Ship	tkm/m²	2.91E+00	2.51E+00
	Lorry, 25 tons	tkm/m²	4.97E-01	2.33E-01
A5 Construction and installation	Diesel consumption installation	MJ/m²	1.04E+00	1.04E+00
C1 Deconstruction	Diesel consumption deconstruction	MJ/m²	1.68E+01	1.01E+01
C2 End-of-life transport	Lorry, 25 tons	tkm/m²	3.14E-02	1.68E-02
C4 Disposal	Municipal waste incineration, PET	kg/m²	5.25E-01	
	Municipal waste incineration, PP	kg/m²		2.70E-01
	Municipal waste incineration, Talcum/Bentonite	kg/m²		7.14E-03
	Municipal waste incineration, HDPE	kg/m²		4.15E-03
	Landfill, PET	kg/m²	5.83E-02	
	Landfill, PP	kg/m²		3.00E-02
	Landfill, Talcum/Bentonite	kg/m²		7.93E-04
	Landfill, HDPE	kg/m²		4.61E-04

2.5 Distribution transport (A4)
Transports from the manufacturer to the customer, merchant or distribution platform are considered based on the current sales of NAUE. Shipping within Europe is realised by truck and to the rest of the world mainly by means of freight ships. Shipped geosynthetics are transported to port by lorry.

2.6 Construction and installation (A5)
The construction and installation stage considers the mounting of Secugrid® PP and Secugrid® PET. Other processes such as excavation of foundation or ground compaction are outside the system boundary. The diesel consumption of mounting the geosynthetics amounts to 1.04MJ/m².

2.7 Deconstruction (C1)
The deconstruction as part of the end-of-life processes (C1) covers the on-site dismantling of Secugrid® PET and Secugrid® PP. The diesel consumption of dismantling the geosynthetics amounts to 16.8 and 10.1MJ/m², respectively.

2.8 Transport to product's waste processing (C2)
The end-of-life transports (C2) considers the transportation of the geosynthetics to a recycling site or disposal. On average, Secugrid® PET and Secugrid® PP are transported 54km to the nearest waste incineration plant or landfill.

2.9 Waste processing (C3)
Secugrid® PET and Secugrid® PP are directly disposed of. That is why no wasted processing is included in the assessment.

2.10 Disposal (C4)
The end-of-life disposal (C4) includes the emissions from waste disposal, physical pretreatment, and management of the disposal site. Secugrid® PET and Secugrid® PP are disposed of 90% in municipal waste incinerations and 10% in landfills.

Figure 11
Secugrid® production

Figure 12
Secugrid® loading

Figure 13
Secugrid® installation

3 LCA – Calculation rules
3.1 Declared unit
The declared unit is 1m² of Secugrid® PET and Secugrid® PP with densities of 583 and 313g/m², respectively.

3.2 System boundaries
This EPD is a cradle-to-grave declaration excluding the usage stage. The product system of geosynthetics comprises the product stage (manufacture and supply of raw materials including purchase and intercompany logistics, manufacture of the components and of the product), the construction stage (mounting of the product) and the end-of-life stage (deconstruction, end-of-life transport and disposal).
The comparison of products based on their EPD is defined by the contribution they make to the environmental performance of the building. Consequently, the comparison of the environmental performance of construction products using the EPD information shall be based on the product's use in and its impacts on the building and shall consider the complete life cycle (all information modules).

3.3 Allocation and recycling
Wastes that reach the end-of-waste state and that are recycled leave the product system without bearing a share of the environmental impacts of the first life cycle. No credits are given for potentially avoided production. Secondary raw materials bear environmental impacts caused by scrap collection and recycling activities. This is in line with the "polluter pays" principle (EN 15804 ; IES 2012). Energy and working material consumption as well as infrastructure requirements of Secugrid® PET and Secugrid® PP manufacture are allocated according to the m² of the geosynthetics outputs.

3.4 Temporal and geographic validity
The life cycle assessment of Secugrid® PET and Secugrid® PP describes the geosynthetics used worldwide. It is valid for the purchase, production, and distribution situation in the recent past (last two years). All product alternatives described in this report are currently available on the market.

3.5 Background dataEN 15804
Foreground inventory data is mainly based on average annual production data provided by NAUE GmbH & Co. for the year 2019. The primary sources of background inventory data are the UVEK LCI data DQRv2:2018 (KBOB et al. 2018). These data are based on the ecoinvent data v2.2 (ecoinvent Centre 2010) and include updates of several background inventory data: electricity supply (Itten et al. 2014; Messmer & Frischknecht 2016a), natural gas supply (Schori et al. 2012), photovoltaics (Jungbluth et al. 2012; Frischknecht et al. 2015a), hydroelectric power generation (Flury & Frischknecht 2012), nuclear power and supply chain (Bauer et al. 2012), oil supply chain (Stolz & Frischknecht 2016a), wood products (Werner 2017), aluminium (Stolz & Frischknecht 2016b) and transportation (Stolz et al. 2016; Messmer & Frischknecht 2016b, c, d). The plastics inventory data of PET and PP refer to the years 1999/2000 and 1999, respectively and are based on data provided by PlasticsEurope (Boustead 2005-07).

The modelling and all calculations are performed with the LCA software SimaPro v9.1 (PRé Consultants 2020).
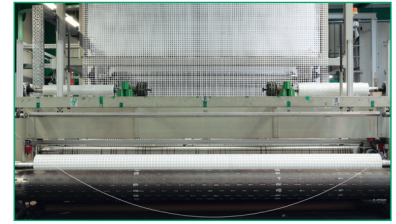
4 LCA – Results

LCIA results are relative expressions and do not predict impacts on category endpoints, the exceeding of thresholds, safety margins or risks. Impact category indicators required by the environmental product declaration standard were modelled as follows:

- Climate change – total: Global warming potential total (GWP-total), baseline model of 100 years of the IPCC based on IPCC (2013).
- Ozone depletion: Depletion potential of the stratospheric ozone layer (ODP), steady state ODPs (WMO 2015).
- Acidification: Acidification potential, Accumulated exceedance (Seppälä et al. 2006, Posch et al. 2008).
- Eutrophication aquatic freshwater: Eutrophication potential, fraction of nutrients reaching freshwater end compartment (EP-freshwater), EUTREND model (Struijs et al. 2009).
- Eutrophication aquatic marine: Eutrophication potential, fraction of nutrients reaching marine end compartment (EP-marine): EUTREND model (Struijs et al. 2009).
- Eutrophication terrestrial: Eutrophication potential (EP-terrestrial), Accumulated exceedance (Seppälä et al. 2006, Posch et al. 2008).
- Photochemical ozone formation: Formation potential of tropospheric ozone (POCP), LOTOS-EUROS (Van Zelm et al. 2008).
- Depletion of abiotic resources – minerals and metals [1]: Abiotic depletion potential for non-fossil resources (ADP-minerals & metals), CML 2002 (van Oers et al. 2002).
- Depletion of abiotic resources – fossil fuels1: Abiotic depletion potential for fossil resources (ADP-fossil), CML 2002 (van Oers et al. 2002).
- Water use1: Water (user) deprivation potential, deprivation weighted water consumption (WDP), Available WAter REmaining (AWARE, Boulay et al. 2017).
- Particulate matter (PM) emissions: Potential incidence of disease due to PM emissions, SETAC-UNEP (Fantke et al. 2016).
- Ionising radiation, human health [2]: Potential human exposure efficiency relative to U235 (IRP), Human health effect model as developed by Dreicer (1995) update by Frischknecht (2000).
- Ecotoxicity (freshwater)1: Potential comparative toxic unit for ecosystems (ETP-fw), USEtox model (DG-JRC 2015).
- Human toxicity, cancer effects1: Potential comparative toxic unit for humans (HTP-c), USEtox model (DG-JRC 2015).
- Human toxicity, non-cancer effects1: Potential comparative toxic unit for humans (HTP-nc), USEtox model (DG-JRC 2015).
- Land use related impacts / soil quality1: Potential soil quality index (SQP), soil quality index based on LANCA.
- Use of renewable and non-renewable energy (cumulative energy demand, CED): reported in net calorific value, as demanded in the product declaration guidelines. For each the total and the two sub-categories "primary energy resources used as raw material" (feedstock) and "primary energy resources excluding use as raw material" are reported.
- The "CED, raw materials used" was assessed on product basis, i.e. the net calorific value of the materials contained in the geosynthetics.
- The "CED total, renewable" and "CED total, non-renewable" are calculated with the method published in ecoinvent version 2.0 and expanded by PRé Consultants for resources available in SimaPro 9 database (Frischknecht et al. 2007; Frischknecht et al. 2015b; PRé Consultants 2015).
- Use of secondary materials: based on the feedstock used in the production of the geosynthetics.
- Use of renewable secondary fuels and use of non-renewable secondary fuels. Electricity is assumed to contain no secondary fuels.
- Use of net fresh water: Evaporated water is considered with 100%; elementary flows in the background system are accounted for as follows: 10% of water extracted from water bodies and 10% of process water used (e.g. Water, lake; Water, process, drinking) and 5% of cooling water used (e.g. water, cooling, surface).
- Waste, life cycle based: "Hazardous waste" covers hazardous waste deposited in underground storage facilities and is accounted for via the elementary flow of volume occupied in an underground deposit. The density of hazardous waste for the conversion to kg is taken from the ecoinvent report 13-III (Doka 2009). "Radioactive waste" covers low radioactive waste and high and medium radioactive waste. It is assessed likewise via the elementary flows "volume occupied, final repository for radioactive waste" and "volume occupied, final repository, low-active waste", respectively. The density of radioactive waste is taken from Dones (Dones 2007). Non-hazardous waste covers all waste going to landfills. The conversion of the land transformation elementary flows "transformation, to dumpsite" for slag compartment (22'500kg/m²), inert material landfill (22´500kg/m²), sanitary landfill (20'000kg/m²) and residual material landfill (16'000kg/m²) is conducted according to the average depth of the landfill sites and average waste densities given in Doka (2007).
- Materials for recycling: based on the materials wasted in production, i.e. PET and PP sold to the recycling company. The share of the waste for PP is 3.15% relative to the material input.
- Materials for energy recovery: weight of materials sent to municipal waste incineration plant, i.e. municipal waste.
- Long-term emissions are not included in the assessment because of implausible results of the indicator eutrophication.

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[1] The results of this environmental impact indicator shall be used with care as the uncertainties on these results are high or as there is limited experience 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 some construction materials is not either quantified by this indicator.

4.1 Secugrid® PET

Environmental Impact 1m² Secugrid® PET 583g/m²	Unit	A1 Raw material supply	A2 Up-stream transport	A3 Manufac-turing	A4 Down-stream transport	A5 Construc-tion and installa-tion	C1 Decon-struction	C2 End-of-life transport	C4 Disposal
Climate change - total	kg CO_2-eq.	1.64E+00	1.38E-02	5.88E-01	8.23E-02	1.06E-01	1.72E+00	3.91E-03	1.09E+00
Ozone depletion	kg CFC-11-eq	5.52E-08	7.27E-10	1.89E-08	3.89E-09	4.96E-09	8.01E-08	2.06E-10	1.71E-09
Acidification (AP)	kg H^+-eq	6.10E-03	6.01E-05	1.06E-03	9.53E-04	5.15E-04	8.30E-03	1.71E-05	2.13E-04
Eutrophication aquatic freshwater	kg PO_4^{3-}-eq	6.46E-05	2.11E-07	7.72E-05	1.27E-06	6.74E-07	1.09E-05	5.99E-08	1.81E-07
Eutrophication aquatic marine	kg N-eq	8.84E-04	1.42E-05	2.09E-04	2.33E-04	1.65E-04	2.67E-03	4.03E-06	1.18E-04
Eutrophication terrestrial	kg N-eq	9.84E-03	1.57E-04	2.43E-03	2.58E-03	1.82E-03	2.93E-02	4.45E-05	1.11E-03
Photochemical ozone formation	kg NMVOC-eq	4.10E-03	5.39E-05	7.17E-04	7.22E-04	5.38E-04	8.68E-03	1.53E-05	2.70E-04
Depletion of abiotic resources - minerals and metals	kg Sb-eq	5.04E-06	3.24E-08	8.00E-07	1.47E-07	2.71E-08	4.37E-07	9.18E-09	9.64E-09
Depletion of abiotic resources - fossil fuels	MJ oil-eq	4.15E+01	2.14E-01	8.87E+00	1.25E+00	1.45E+00	2.34E+01	6.08E-02	2.19E-01
Water use	m³ world eq. deprived	1.47E+02	7.03E-01	7.92E+01	4.40E+00	2.31E+00	3.73E+01	1.99E-01	7.53E-01
Particulate matter emissions	disease inci-dence	5.54E-08	1.01E-09	4.77E-09	5.16E-09	2.63E-09	4.25E-08	2.88E-10	1.12E-09
Ionising radiation, human health	kBq U235-eq	8.90E-02	3.51E-04	4.96E-02	2.40E-03	1.10E-03	1.77E-02	9.96E-05	3.34E-04
Ecotoxicity (freshwater)	CTUe	9.92E+00	1.57E-01	4.04E+00	8.79E-01	8.75E-01	1.41E+01	4.45E-02	3.00E-01
Human toxicity, cancer effects	CTUh	6.96E-10	4.27E-12	1.37E-10	2.51E-11	5.83E-11	9.40E-10	1.21E-12	4.08E-11
Human toxicity, non-cancer effects	CTUh	1.03E-08	2.39E-10	3.89E-09	1.20E-09	1.28E-09	2.06E-08	6.79E-11	3.18E-09
Land use related impacts / soil quality	-	1.32E+00	4.08E-02	8.63E-01	2.24E-01	1.59E-01	2.56E+00	1.16E-02	5.24E-02

Table 2
Environmental impact caused by the production of 1 square meter of average geogrid of the product family Secugrid® PET

Energy Demand 1m² Secugrid® PET 583g/m²	Unit	A1 Raw material supply	A2 Up-stream transport	A3 Manufac-turing	A4 Down-stream transport	A5 Construc-tion and installa-tion	C1 Decon-struction	C2 End-of-life transport	C4 Disposal
CED, non-renewable, total	MJ oil-eq	4.20E+01	2.14E-01	8.56E+00	1.25E+00	1.45E+00	2.34E+01	6.07E-02	2.25E-01
CED, non-ren., w/o raw mat. use	MJ oil-eq	2.84E+01	2.14E-01	8.56E+00	1.25E+00	1.45E+00	2.34E+01	6.07E-02	2.25E-01
CED, non-ren., raw mat. use	MJ oil-eq	1.36E+01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CED, renewable, total	MJ oil-eq	9.37E-01	3.53E-03	6.49E-01	2.27E-02	1.09E-02	1.76E-01	1.00E-03	3.59E-03
CED, renew., w/o raw material use	MJ oil-eq	9.37E-01	3.53E-03	6.49E-01	2.27E-02	1.09E-02	1.76E-01	1.00E-03	3.59E-03
CED, renew., raw material use	MJ oil-eq	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	MJ oil-eq	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary fuels	MJ oil-eq	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of electricity	MJ	0.00E+00	0.00E+00	2.93E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 3
Cumulative energy demand and energy use caused by the production of 1 square meter of average geogrid of the product family Secugrid® PET

Material Use 1m² Secugrid® PET 583g/m²	Unit	A1 Raw material supply	A2 Up-stream transport	A3 Manufac-turing	A4 Down-stream transport	A5 Construc-tion and installa-tion	C1 Decon-struction	C2 End-of-life transport	C4 Disposal
Use of net fresh water	m³	3.39E-03	9.40E-06	1.78E-03	5.62E-05	3.41E-05	5.51E-04	2.67E-06	2.88E-05
Hazardous waste	kg	1.78E-04	2.62E-07	2.40E-05	1.30E-06	6.49E-07	1.05E-05	7.44E-08	9.57E-07
Non-hazardous waste	kg	1.12E-01	1.65E-03	1.88E-02	7.63E-03	1.69E-03	2.72E-02	4.68E-04	7.47E-02
Radioactive waste	kg	6.67E-05	2.46E-07	6.02E-05	1.72E-06	8.17E-07	1.32E-05	6.97E-08	2.42E-07
Use of material	kg	5.91E-01	0.00E+00	9.59E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable material	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
Use of secondary material	kg	1.03E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary material	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
Components for re-use	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

Table 4
Material use and waste flows caused by the production of 1 square meter of the average Secugrid® PET

4.2 Secugrid® PP

Environmental Impact 1m² Secugrid® PP 313g/m²	Unit	A1 Raw material supply	A2 Up-stream transport	A3 Manufac-turing	A4 Down-stream transport	A5 Construc-tion and installa-tion	C1 Decon-struction	C2 End-of-life transport	C4 Disposal
Climate change - total	kg CO_2-eq.	6.59E-01	7.40E-03	1.59E-01	4.66E-02	1.06E-01	1.03E+00	2.10E-03	7.09E-01
Ozone depletion	kg CFC-11-eq	8.33E-11	3.90E-10	5.91E-09	2.07E-09	4.96E-09	4.80E-08	1.11E-10	8.05E-10
Acidification (AP)	kg H^+-eq	2.29E-03	3.23E-05	3.95E-04	7.15E-04	5.15E-04	4.98E-03	9.16E-06	9.41E-05
Eutrophication aquatic freshwater	kg PO_4^{3-} -eq	1.31E-05	1.13E-07	2.19E-05	7.20E-07	6.74E-07	6.52E-06	3.21E-08	1.01E-07
Eutrophication aquatic marine	kg N-eq	4.06E-04	7.62E-06	7.73E-05	1.75E-04	1.65E-04	1.60E-03	2.16E-06	4.45E-05
Eutrophication terrestrial	kg N-eq	4.34E-03	8.42E-05	8.84E-04	1.94E-03	1.82E-03	1.76E-02	2.39E-05	4.76E-04
Photochemical ozone formation	kg NMVOC-eq	2.35E-03	2.89E-05	2.57E-04	5.27E-04	5.38E-04	5.21E-03	8.21E-06	1.16E-04
Depletion of abiotic resources - minerals and metals	kg Sb-eq	1.45E-08	1.74E-08	2.40E-07	6.98E-08	2.71E-08	2.62E-07	4.93E-09	5.78E-09
Depletion of abiotic resources - fossil fuels	MJ oil-eq	2.16E+01	1.15E-01	2.64E+00	7.02E-01	1.45E+00	1.41E+01	3.27E-02	1.07E-01
Water use	m³ deprived	1.10E+00	3.77E-01	2.43E+01	2.55E+00	2.31E+00	2.24E+01	1.07E-01	4.34E-01
Particulate matter emissions	disease inci-dence	2.20E-08	5.44E-10	3.48E-09	2.66E-09	2.63E-09	2.55E-08	1.55E-10	4.67E-10
Ionizing radiation, human health	kBq U235-eq	1.22E-04	1.88E-04	1.48E-02	1.45E-03	1.10E-03	1.06E-02	5.35E-05	1.87E-04
Ecotoxicity (freshwater)	CTUe	2.39E-01	8.41E-02	1.25E+00	4.81E-01	8.75E-01	8.47E+00	2.39E-02	1.46E-01
Human toxicity, cancer effects	CTUh	3.94E-11	2.29E-12	4.54E-11	1.41E-11	5.83E-11	5.64E-10	6.50E-13	2.29E-11
Human toxicity, non-cancer effects	CTUh	2.52E-09	1.28E-10	1.24E-09	6.17E-10	1.28E-09	1.24E-08	3.64E-11	1.01E-09
Land use related impacts / soil quality	-	2.05E-02	2.19E-02	2.77E+00	1.21E-01	1.59E-01	1.54E+00	6.22E-03	3.31E-02

Table 5
Environmental impact caused by the production of 1 square meter of average geogrid of the product family Secugrid® PP

Energy Demand 1m² Secugrid® PP 313g/m²	Unit	A1 Raw material supply	A2 Up-stream transport	A3 Manufac-turing	A4 Down-stream transport	A5 Construc-tion and installa-tion	C1 Decon-struction	C2 End-of-life transport	C4 Disposal
CED, non-renewable, total	MJ oil-eq	2.18E+01	1.15E-01	2.55E+00	6.99E-01	1.45E+00	1.41E+01	3.26E-02	1.09E-01
CED, non-ren., w/o raw mat. use	MJ oil-eq	1.40E+01	1.15E-01	2.50E+00	6.99E-01	1.45E+00	1.41E+01	3.26E-02	1.09E-01
CED, non-ren., raw mat. use	MJ oil-eq	7.80E+00	0.00E+00	5.18E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
CED, renewable, total	MJ oil-eq	1.54E-01	1.89E-03	6.90E-01	1.34E-02	1.09E-02	1.06E-01	5.37E-04	2.03E-03
CED, renew., w/o raw material use	MJ oil-eq	1.54E-01	1.89E-03	6.90E-01	1.34E-02	1.09E-02	1.06E-01	5.37E-04	2.03E-03
CED, renew., raw material use	MJ oil-eq	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary fuels	MJ oil-eq	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of non-renewable secondary fuels	MJ oil-eq	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of electricity	MJ	0.00E+00	0.00E+00	7.95E-01	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 6
Cumulative energy demand and energy use caused by the production of 1 square meter of average geogrid of the product family Secugrid® PP

Material Use 1m² Secugrid® PP 313g/m²	Unit	A1 Raw material supply	A2 Up-stream transport	A3 Manufac-turing	A4 Down-stream transport	A5 Construc-tion and installa-tion	C1 Decon-struction	C2 End-of-life transport	C4 Disposal
Use of net fresh water	m³	7.29E-04	5.04E-06	5.77E-04	3.18E-05	3.41E-05	3.31E-04	1.43E-06	1.99E-05
Hazardous waste	kg	5.38E-08	1.41E-07	7.66E-06	6.62E-07	6.49E-07	6.28E-06	3.99E-08	6.90E-07
Non-hazardous waste	kg	5.99E-03	8.85E-04	8.28E-03	3.67E-03	1.69E-03	1.63E-02	2.51E-04	5.11E-02
Radioactive waste	kg	8.77E-08	1.32E-07	1.74E-05	1.05E-06	8.17E-07	7.91E-06	3.74E-08	1.35E-07
Use of material	kg	2.43E-01	0.00E+00	1.37E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable material	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
Use of secondary material	kg	7.75E-03	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Use of renewable secondary material	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
Components for re-use	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
Materials for recycling	kg	0.00E+00	0.00E+00	1.35E-02	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00
Materials for energy recovery	kg	0.00E+00	0.00E+00	6.73E-04	0.00E+00	0.00E+00	0.00E+00	0.00E+00	0.00E+00

Table 7
Material use and waste flows causes by the production of 1 square meter of average geogrid of the product family Secugrid® PP

4.2.1 Secugrid® PET

Fig. 14 and Fig. 15 show the relative contribution of the different life cycle stages (A1 – A5) to the total impact of the product and construction process stage A of Secugrid PET® and Secugrid PP®. The contribution is shown for the ten core indicators: climate change – total, ozone depletion, acidification (AP), eutrophication aquatic freshwater, eutrophication aquatic marine, eutrophication terrestrial, photochemical ozone formation, depletion of abiotic resources – minerals and metals, depletion of abiotic resources – fossil fuels. According to the EPD of 2017 (NAUE 2017) and for comparison purposes, the end-of-life stage C is not included in Fig. 14 and Fig. 15.
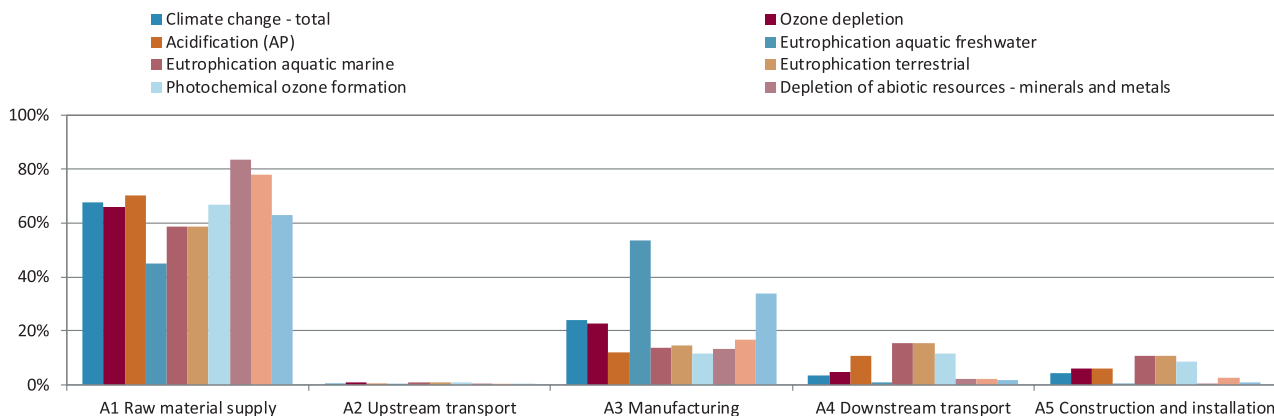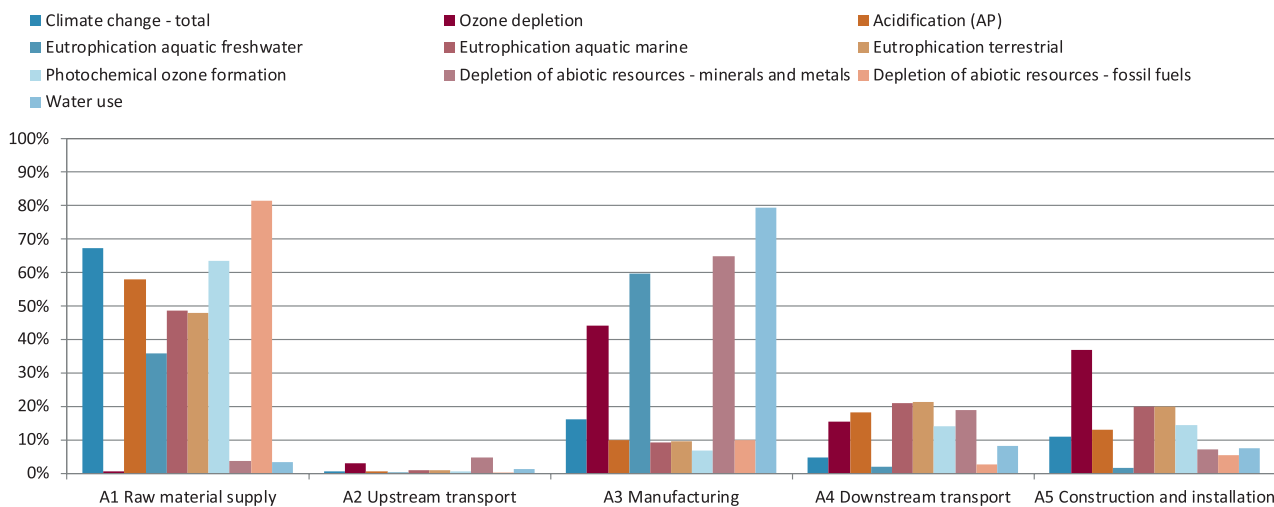

Figure 14
Relative contribution of the different life cycle stages (A1 – A5) to the total impact of the product and construction process stage A of Secugrid PET® (average mass per unit area)

4.2.2 Secugrid® PP

Figure 15
Relative contribution of the different life cycle stages (A1 – A5) to the total impact of the product and construction process stage A of Secugrid PP® (average mass per unit area)

4.3 Data quality

The quality of the data used to model geosynthetics produced by NAUE GmbH & Co. KG is high regarding the material composition, the transport logistics and the manufacture of components. Data are provided by NAUE GmbH & Co. KG and are reliable and detailed. The manufacturer's data are less than three years old and based on annual averages. The data representing the end-of-life stage are mainly based on assumptions and thus the data quality is considered to be low. The material supply of plastics is represented by best available data provided by the European Plastics association PlasticsEurope.

The UVEK LCI data DQRv2:2018 (KBOB et al. 2018) are used as background inventory data to complement the product system of geosynthetics. The UVEK LCI data DQRv2:2018 are based on the ecoinvent data v2.2 (ecoinvent Centre 2010) and contain inventory data of many basic materials and services. The database includes the most recent datasets of plastic feedstock. Most of the important background data are less than 10 years old.

Additional data quality considerations are documented within the KBOB LCI and ecoinvent database. A Monte Carlo analysis to assess uncertainties was not conducted. The overall background data quality is appropriate for the use in this LCA.

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