Programme for Environmental Product Declarations (EPD)

of the Swiss Supervisory Association for Stone Construction Materials

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ENVIRONMENTAL PRODUCT DECLARATION according to ISO 14025 and EN 15804

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OWNER OF THE DECLARATION	Association of the Swiss Aggregate and Concrete Industry (ASAC)
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Average EPD for Aggregates

Natural aggregate 0/4 mm, round
Natural aggregate 0/4 mm, crushed
Natural aggregate 4/x mm, round
Natural aggregate 4/x mm, crushed
Recycled aggregate 0/x mm

Contents

General information

Name of the manufacturer	**Name of the product**
Programme operator SÜGB – Swiss Supervisory Association for Stone Construction Materials Schwanengasse 12 CH-3011 Bern Switzerland	**Owner of the declaration / client** ASAC – Association of the Swiss Aggregate and Concrete Industry Schwanengasse 12 CH-3011 Bern Switzerland
Declaration number FSKB-2018-1-ECOINVENT	**Declared products/declared unit** Natural aggregate 0/4 mm, round Natural aggregate 0/4 mm, crushed Natural aggregate 4/x mm, round Natural aggregate 4/x mm, crushed Recycled aggregate 4/x mm
Type of declaration as per SN EN 15804 from cradle to gate	**Declared unit** 1 ton of the respective aggregate
This EPD is based on the Product Category Rules (PCR): PCR Instructions for Stone Construction Materials, PCR code 1.4.1-1, last updated 02.05.2018 [1] The PCR have been examined and approved by the PCR committee of the EPD programme of SÜGB and meet the requirements of SN EN ISO 14025 [2] and SN EN 15804 [3]	**Range of validity:** The average data published here is representative for average products of the respective aggregate produced by members of ASAC – Association of the Swiss Aggregate and Concrete Industry. Detailed information on the representativeness of average EPD is given in chapter 6. This EPD document is based on the information of the verified background report for the examined aggregates.
Issue date 01.10.2018 **Valid until** 01.10.2023	**Liability** The owner of the declaration is liable for the underlying information and evidence. SÜGB accepts no liability for the manufacturer's information, life cycle assessment data and evidence.
Author of the life cycle assessment Dr. Florian Gschösser – floGeco Hinteranger 61d A-6161 Natters Austria	**Verification** CEN standard EN 15804 serves as the core PCR Verification of the EPD by an independent third party according to ISO 14025 ☐ Internal ☒ External
Ernst Honegger Head of programme operator SÜGB	Daniel Kellenberger – Intep Integrale Planung GmbH, Independent examiner appointed by the PCR committee
S. Kytzia Prof. Susanne Kytzia Deputy chair of the PCR committee	Simone Stürwald Prof. Simone Stürwald, University of Applied Sciences, Rapperswil Independent examiner appointed by the PCR committee

1 Product

1.1 General product description

The following aggregates are being examined

- Natural aggregate 0/4 mm, round
- Natural aggregate 0/4 mm, crushed
- Natural aggregate 4/x* mm, round
- Natural aggregate 4/x* mm, crushed
- Recycled aggregate 4/x* mm.

* No maximum particle size (D_{max}) is determined for these aggregates. They comprise aggregates from 4 mm up to the largest aggregates produced in the plants (up to aggregates of D_{max} 63 mm – e.g. railway ballast), divided into round particles, crushed particles and recycled particles.

Natural aggregates consist of mineral deposits which have been mechanically processed. Natural aggregates are extracted from gravel pits (round particles & angular particles), quarries (angular particles – crushed) or from the seabed/lakebed (round particles & angular particles).

Recycled aggregates are produced by processing inorganic material that was previously used as construction material (secondary materials). This includes dismantled and mechanically processed concretes, asphalts and also processed masonry (bricks).

No dismantled asphalt construction materials are processed in ASAC member plants. Except for one, the analysed plants which produce recycled aggregates process solely dismantled concrete (limit values according to SN 640 743a "Use of demolished concrete [4]"). One plant indicated the raw materials for recycled aggregates as 75% concrete and 25% mixed rubble.

The recycled aggregates examined in this study could not be separated into 0/4 mm and 4/x mm fractions.

Aggregates are generally sold as a "wet product", i.e. 1 ton of aggregate always contains a certain percentage of moisture from the production process or storage.

1.2 Use

Aggregates are used as raw material for concrete (SN EN 12620 [5], SN 670 102b-NA [6]), mortar (SN EN 13139 [7], SN-670 101-NA [8]) and bituminous mixtures (SN EN 13043 [9], SN 670 103b-NA [10]).
They are also used as unbound and hydraulically bound materials (SN EN 13242 [11], SN 670119-NA [12], SN EN 13285 [13], SN EN 670 119-NA [14]) and as railway ballast (SN EN 13450 [15], SN 670 110-NA [16]).

For the various applications, the actually used aggregates are combined from different particle size classes according to the required material properties (grading curve). The analysed plants were asked which applications the aggregates analysed in this study are used for (**Fehler! Verweisquelle konnte nicht gefunden werden.**).

Table 1: Uses of aggregates

Use	Round particles 0/4	Angular particles 0/4	Round particles 4/x	Angular particles 4/x	Rec. aggregate 0/x
C	x	x	x	x	x
B	x	x	x	x	
M	x	x	x	x	
Hbm	x	x	x	x	
Um	x	x	x	x	x
Rb			x		
Explanation	C … Concrete, B … Bituminous mixtures, M … Mortar, Hbm … Hydraulically bound materials, Um … Unbound materials, Rb … Railway ballast				

1.3 Technical data

Fehler! Verweisquelle konnte nicht gefunden werden. to **Fehler! Verweisquelle konnte nicht gefunden werden.** contain the technical data for the examined aggregates (average values and range).

The average of the bulk densities determined for the individual aggregates is calculated weighted according to the production quantities of the individual plants. The bulk density is defined as the ratio of mass to volume (including pores) in loose state, i.e. in the loosest storage of the aggregate.

The storage density (also known as gross density or volumetric weight) describes the ratio of mass to volume (including pore space filled with water or air) as it occurs in nature (in situ) (natural ground). The conversion from bulk density to storage density is carried out using a literature value for the loosening factor associated with the aggregate (DIN 24095, Earth-moving machinery; Determination of performance; Terminology, units, symbols [17]). The loosening factor describes the relationship between the volumes of natural and loose soils.

Table 2: Technical data of natural aggregate 0/4 mm, round

Description	Value	Unit
Average bulk density (moisture content 4%)	1.52	t/m^3
Bulk density range	1.38 to 1.61	t/m^3
Loosening factor α_L	0.89	
Average storage density	1.71	t/m^3
Storage density range	1.55 to 1.81	t/m^3
Particle size		
Designation	(0/4)	mm

Table 3: Technical data of natural aggregate 0/4 mm, crushed

Description	Value	Unit
Average bulk density (moisture content 4%)	1.50	t/m^3
Bulk density range	1.37 to 1.53	t/m^3
Loosening factor α_L	0.89	
Average storage density	1.69	t/m^3
Storage density range	1.54 to 1.72	t/m^3
Particle size		
Designation	(0/4)	mm

Table 4: Technical data of natural aggregate 4/x mm, round

Description	Value	Unit
Average bulk density (moisture content 2%)	1.63	t/m^3
Bulk density range	1.49 to 1.66	t/m^3
Loosening factor α_L	0.89	
Average storage density	1.83	t/m^3
Storage density range	1.68 to 1.87	t/m^3
Particle size		
Designation	(4/x) [g]	mm

Table 5: Technical data of natural aggregate 4/x mm, crushed

Description	Value	Unit
Average bulk density (moisture content 2%)	1.39	t/m³
Bulk density range	1.30 to 1.44	t/m³
Loosening factor α_L	0.89	
Average storage density	1.56	t/m³
Storage density range	1.46 to 1.62	t/m³
Particle size		
Designation	(4/x)	mm

Table 6: Technical data of recycled aggregate 0/x mm

Description	Value	Unit
Average bulk density (moisture content 4%)	1.53	t/m³
Bulk density range	1.50 to 1.56	t/m³
Loosening factor α_L	0.89	
Average storage density	1.69	t/m³
Storage density range	1.69 to 1.75	t/m³
Particle size		
Designation	(0/x)	mm

1.4 Product-related standards, regulations and guidelines

The product standards applicable to aggregates in Switzerland are given in **Fehler! Verweisquelle konnte nicht gefunden werden.**.

Table 7: Standards for aggregates in Switzerland

Standard	Title
SN 670 050	Aggregates – basic standard [18]
SN EN 12620	Aggregates for concrete [5]
SN 670 102b-NA	Aggregates for concrete – National Annex [6]
SN EN 13139	Aggregates for mortar [7]
SN-670 101-NA	Aggregates for mortar – National Annex [8]
SN EN 13043	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas [9]
SN 670 103b-NA	Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas – National Annex [10]
SN EN 13242	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction [11]
SN 670 119a-NA	Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction – National Annex [12]
SN EN 13285	Unbound mixtures – specifications [13]
SN EN 670 119-NA	Unbound mixtures – specifications – National Annex [14]
SN EN 13450	Aggregates for railway ballast [15]
SN 670 110-NA	Aggregates for railway ballast – National Annex [16]
SN 670 071	Recycling – basic standard [19]

1.5 Delivery condition

Aggregates are stored in boxes, silos or without roofing (stockpiles) after the desired particle size has been reached in the plants, separated according to particle size classes (resulting from the upper and lower sieve with sieve classification). Depending on the desired grading curve, the various particle size classes are already combined into a particle mixture in the aggregate production plant or in the plant for the subsequent construction material (concrete, asphalt). Depending on the application, the aggregates are transported by truck or, in asphalt and concrete plants, also by conveyor belts or wheel loaders.

1.6 Base materials/auxiliary materials

The analysed average products do not contain any "substances of very high concern on the Candidate List for authorisation according to REACH, as of [15.01.2018]" [20].

Table 8: Base materials of natural aggregate 0/4 mm, round in mass %

Components:	**Mass %**
Natural sand 1)	96%
Water 2)	4%

1) Round particles from gravel pits and waters
2) Moisture content of the aggregate

Table 9: Base materials of natural aggregate 0/4 mm, crushed in mass %

Components:	**Mass %**
Natural, crushed aggregates 3)	96%
Water 4)	4%

3) Angular particles from gravel pits (crushed round particles) and quarries
4) Moisture content of the aggregate

Table 10: Base materials of natural aggregate 4/x mm, round in mass %

Components:	**Mass %**
Natural round gravel 5)	98%
Water 6)	2%

5) Round particles from gravel pits and waters
6) Moisture content of the aggregate

Table 11: Base materials of natural aggregate 4/x mm, crushed in mass %

Components:	**Mass %**
Natural, crushed aggregates 7)	98%
Water 8)	2%

7) Angular particles from gravel pits (crushed round particles) and quarries
8) Moisture content of the aggregate

Table 12: Base materials of recycled aggregate 0/x mm in mass %

Components:	Mass %
Concrete granulate [9)]	85.2%
Mixed granulate [10)]	7.6%
Asphalt granulate [11)]	max. 2.9%
Foreign matter [12)]	max. 0.3%
Water [13)]	4%

[9)] Angular particles from processed concrete
[10)] Angular particles from processed mixed rubble
[11)] Angular particles from processed asphalt
[12)] Materials of foreign origin (such as metals and plastics)
[13)] Moisture content of the aggregate

1.7 Manufacture

The examined natural aggregates are extracted from gravel pits (round particles & angular particles), quarries (angular particles – crushed) or from the seabed/lakebed (round particles & angular particles). Except for one plant, the extraction is carried out with excavation equipment (e.g. hydraulic excavators). In a quarry, the aggregate is extracted with explosives. It should be noted here that in Switzerland there are generally only very few plants in which aggregates are extracted with explosives.

The manufacturing processes are generally divided into:

- Stone extraction
- Crushing for particle size reduction (possibly multi-stage)
- Washing (washing out of clay and minute particles – elutriable material in a sludge tank or sludge press)
- Classification by particle size (possibly multi-stage)
- Storage on stockpiles or in containers
- Use of elutriable material

In those plants where no sludge tank is used to process elutriable material, a sludge press is used as an alternative.

A large part of the crushed aggregates is produced from crushed round particles.

Fehler! Verweisquelle konnte nicht gefunden werden. (chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**) **Fehler! Verweisquelle konnte nicht gefunden werden.**shows the schematic of the production processes including the relevant inputs and outputs and the system boundaries for the production process (red dotted line). The blue dotted line shows the system boundary for recycled aggregates. In the case of recycled aggregates, the system boundary is set at the point where the secondary raw material has reached the "end-of-waste state". The end-of-waste state is determined by 4 criteria (SN EN 15804 – Annex B [3]).

1.8 Product processing/installation

The product processing and installation of aggregates strongly depends on the possible or planned applications of the aggregate (raw material for construction materials or directly as construction material).

If the aggregate is used as a raw material for another construction material (e.g. concrete, mortar, asphalt, hydraulically bound materials), the processing in the course of the production of the construction material takes place either in a mixing plant or in situ at the building site.

If the aggregate is used as a separate construction material (e.g. as an unbound mixture or railway ballast), the installation is carried out with appropriate installation (excavators, wheel loaders, etc.) and compaction equipment (rollers, graders, rammers, etc.).

1.9 Packaging

As a rule, aggregates are delivered in loose form (without packaging material).

1.10 Use condition

In the case of aggregates as construction material (e.g. unbound foundation layer in road superstructure), there are no changes in the material composition over the period of use provided that the planning is carried out properly, the installation is carried out properly and professionally and the use is trouble-free.
If the aggregate is used as a raw material for other building products (e.g. concrete), it is no longer possible to consider the use stage or the use condition of the aggregate itself and this must be done in the EPD of the subsequent building product.

1.11 Environment & health during use

There are no known effects on the environment and health coming from aggregates.

If the aggregate is used as a raw material for other building products (e.g. concrete), the effects on the environment and health during use must be considered in the EPD of the subsequent building product.

1.12 Reference service life (RSL)

In the EPD, the use stage is not declared (consideration "from cradle to gate" – A1-A3) or no information is given on the RSL due to the large number of different possible applications of the analysed aggregates.

1.13 Reuse stage

If the aggregate is used as a raw material for other building products (e.g. concrete, hydraulically bound material, asphalt), the possibilities of subsequent use depend on the applications of the building products. In principle, concretes, hydraulically bound materials and asphalts can be processed in such a way that they are returned to material production as secondary raw materials. This also applies to recycled unbound layers and railway ballast.

In addition, concrete granulates, asphalt granulates, mixed granulates and also recycled unbound materials/railway ballast are reused as unbound layers (e.g. in road construction).

1.14 Disposal

In principle, attempts are made to return aggregates and also recycled aggregates made of concrete, hydraulically bound materials and asphalts to the material production process.

If aggregates or building products with aggregates as raw materials cannot be recycled in a practicable way, they are disposed of at an inert waste or construction waste landfill.

The VeVA code (Ordinance on the Transport of Waste [21]) and the EWC waste code number [22] for "gravel and quarry waste" is 010408. The waste code number for concrete is 170101, for "mixtures of concrete, bricks, tiles and ceramics" 170107 and for "bituminous mixtures" 170302.

In the course of the production of the aggregates, elutriable fines are washed out. In accordance with Article 19c of the VVEA (Ordinance on the Prevention and Disposal of Waste [23]), the sludge produced in the plant is recycled for refilling material removal points and is therefore not considered as material requiring disposal.

1.15 Further information

In order to support and promote the conservation of flora and fauna, temporary ecological measures are already taken by many gravel plants during the rock excavation period. These include spawning sites for rare amphibians, breeding sites for rare bird species and insects and also barren soils for rare primary plants, etc., which are actively maintained professionally and, to some extent, integrated into educational trails for schools or the like.

2 LCA: Calculation rules

2.1 Declared unit/functional unit

The declared unit is 1 t of poured aggregate including moisture content.

Table 13: Declared unit of natural aggregate 0/4 mm, round

Description	Value	Unit
Declared unit	1	t
Average bulk density (moisture content = 4%)	1.52	t/m^3

Table 14: Declared unit of natural aggregate 0/4 mm, crushed

Description	Value	Unit
Declared unit	1	t
Average bulk density (moisture content = 4%)	1.50	t/m^3

Table 15: Declared unit of natural aggregate 4/x mm, round

Description	Value	Unit
Declared unit	1	t
Average bulk density (moisture content = 2%)	1.63	t/m^3

Table 16: Declared unit of natural aggregate 4/x mm, crushed

Description	Value	Unit
Declared unit	1	t
Average bulk density (moisture content = 2%)	1.39	t/m^3

Table 17: Declared unit of recycled aggregate 0/x mm

Description	Value	Unit
Declared unit	1	t
Average bulk density (moisture content = 4%)	1.53	t/m^3

The average for the individual aggregates is calculated weighted according to the production quantities of the individual plants.

2.2 System boundary

Due to the large number of possible uses for aggregates, this EPD considers "from cradle to gate" (product stage – A1-A3, **Fehler! Verweisquelle konnte nicht gefunden werden.**).

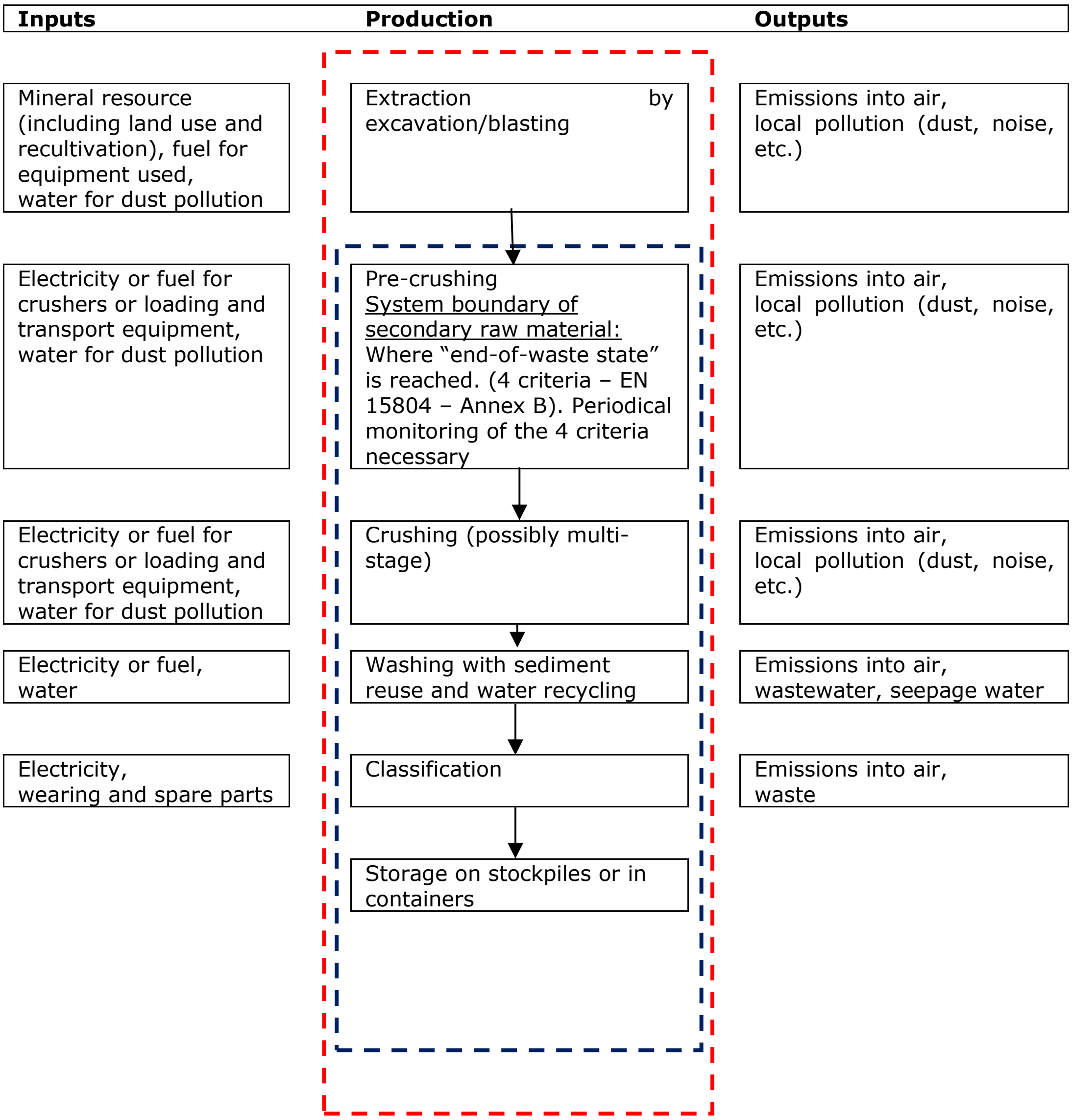

Figure 1: Flow chart of production processes

A1-A3:

The product stage generally comprises the production steps in the plants, including the provision of energy with the associated upstream chains, the manufacture of raw materials and auxiliary materials and their transportation to the plant, the plant infrastructure and administration (including drinking water and heating requirements) and the disposal of waste generated in production.

With regard to the provision of energy, for the electricity requirement electricity at the medium-voltage level (transmission of 1 kWh of electricity at medium voltage) and for internal transport the consumption of diesel in the transport equipment were calculated.

During the production of the aggregates, material losses occur, which can be broken down into elutriable material and other material losses.

Most of the process water used in plants is taken from nature (groundwater, river, rainwater, etc.) and reused as often as possible with the help of treatment measures. In some plants, drinking water is also fed into the process water cycle to some extent. Most of the process water that is no longer returned to the process cycle seeps away in the plant and some of it is discharged as moisture content with the aggregate.

The water for administrative buildings (toilets, etc.) is provided either with drinking water or with water from nature.

The wastewater generated in the plants is partly attributable to the disposal of water for administrative buildings and, to a lesser extent, to process water requiring disposal.

None of the examined plants was able to provide data on dust formation (fine dust). In general, however, attempts are made to keep dust formation as low as possible by means of corresponding humidification measures. A sensitivity analysis showed that fine dust emissions do not cause any loads with regard to the parameters applied in the EPD.

2.3 Estimations and assumptions

The service life of the gravel pits, quarries and sludge tanks was assumed to be 50 years [24]. In addition, it was assumed that over this period 50 times the annual production volume in 2016 will be produced in order to be able to allocate the used areas to the total production in these 50 years.

A service life of 25 years was assumed for machinery and conveyor belts and 50 years for buildings, roads and outdoor facilities [24]. Over these periods, too, the annual production volume for 2016 is used to allocate the infrastructure to the total production volume.

2.4 Cut-off rules

The material losses in the plants (consisting of elutriable material and other losses – e.g. during internal transport) exceed the limit of 1% and are therefore taken into account in the life cycle inventory analysis.

2.5 Background data

As the background database, ecoinvent 3.4 with the system model "cut-off by classification" was used. SimaPro 8.5.0 from the company Pré was used as software.

The current average Swiss consumer electricity mix (including electricity imports, electricity grid and transmission losses) was used for the electricity requirement.

2.6 Data quality

All essential data such as energy and raw material consumption, auxiliary materials, waste and infrastructure within the system boundary was provided by the analysed plants. A questionnaire coordinated with the client was used for this purpose. The collected data was scrutinised and discussed with the individual manufacturers and subsequently evaluated.

The data is up-to-date (annual average over the production year 2016). The criteria of the SÜGB-EPD programme (see Managementsystem-Handbuch (Management System Manual) [25]) and the National Annex of SN EN 15804 [3] for data collection, generic data and the cutting off of material and energy flows were met. The data is plausible.

While updating the ecoinvent database to version 3.4 in 2017, data sets were added and contained data sets were updated or their current applicability was checked, i.e. data sets with an older collection date (relevant for EPD >10 years) were checked to see if they were up-to-date and adapted accordingly. All applied background data sets thus fulfil the criteria of the SÜGB-EPD programme (see Managementsystem-Handbuch) and SN EN 15804 [3].

For the representativeness of the EPD results, see chapter 6.

2.7 Reporting period

The used data corresponds with the yearly average of the production year 2016.

2.8 Allocation

An economic co-product allocation within the individual plants (i.e. a distribution of the loads based on the respective shares of the individual aggregates in the operating income) was not possible due to a lack of information. Some plants process the produced aggregates in affiliated plants (often even directly adjacent to aggregate production) into other building products (e.g. concrete), which is why no direct operating income can be attributed to these aggregates.

A further difficulty was posed by the fact that for their applications aggregates are always combined from many different particle size classes to form a desired grading curve. A distribution of the operating income among the aggregates analysed in this study was therefore simply not possible for many plants.

Some plants were unable or unwilling to disclose data on their operating income for reasons of confidentiality (trade secrets).

The allocation for the aggregates produced within a plant is therefore based on the production tonnages. Since the manufacturers cannot provide detailed information on whether individual aggregates are subject to increased or decreased input or output consumption (e.g. diesel consumption), the total consumption in the plant is distributed linearly over the total production volume. Further, the allocation within the individual examined aggregates is then based on the production tonnages of those plants that produce the specific aggregate.

For secondary raw materials, the system boundary was set with the arrival of the (pre-crushed) material in the analysed plant because the 4 criteria according to SN EN 15804 [3] for reaching the end-of-waste state are fulfilled as of this point in time.

2.9 Comparability

In principle, a comparison or evaluation of EPD data is only possible if all data sets to be compared have been created in accordance with SN EN 15804 [3], the same programme-specific PCR/any additional rules and the same background database have been used, and the building context/product-specific performance characteristics are also taken into account. EPD of construction products of the same product group from different Pro-gramme Operators may not be comparable

3 LCA: Scenarios and further technical information

3.1 A1-A3 Product stage

According to SN EN 15804 [3], no technical scenario information is required for modules A1-A3 because the assessment of these modules is the responsibility of the manufacturer and may not be changed by the user of the life cycle assessment.

3.2 A4-A5 Construction stage

Modules not declared.

3.3 B1-B7 Use stage

Modules not declared.

3.4 C1-C4 End-of-life stage

Modules not declared.

3.5 Potential for reuse, recovery and recycling

Modules not declared.

3.6 Flow chart of the processes in the life cycle

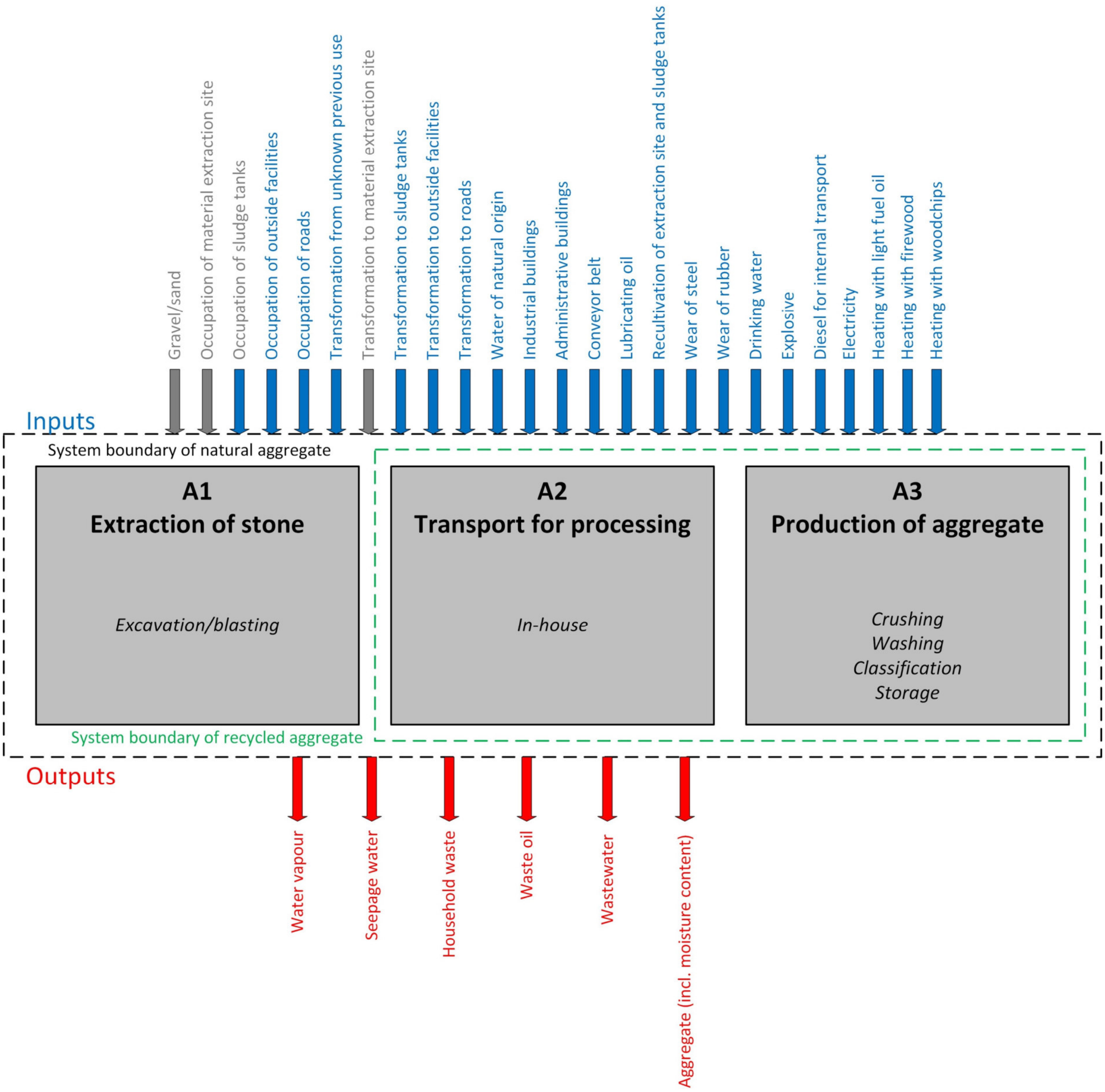

Figure 2: Flow chart with detailed inputs and outputs

A detailed allocation of the individual inputs and outputs to the modules A1, A2 and A3 is not possible because, to a large extent, the manufacturers cannot assign these to specific processes (e.g. electricity for conveyor belt – A2, crushing – A3, classification – A3, etc.) and can only give an overall indication.

4 LCA: Results

Table 18: Declared life cycle stages

PRODUCT STAGE			CON-STRUC-TION STAGE		USE STAGE							END-OF-LIFE STAGE				ADVANTAGES AND LOADS
A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
Raw material supply	Transport	Manufacture	Transport	Construction/installation	Use	Maintenance	Repair	Replacement	Conversion, renovation	Energy use for operations	Water use for operations	Demolition	Transport	Waste management	Disposal	Potential for reuse, recovery and recycling
X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

X = included in life cycle assessment; MND = module not declared; MNR = module not relevant

4.1 LCA: Results (per t poured incl. moisture content) – Natural aggregate 0/4 mm, round

Table 19: Natural aggregate 0/4 mm, round – results of the life cycle assessment environmental impacts

Parameter	Unit	A1-A3
GWP (global warming potential)	kg CO_2 equivalent / t	1.71E+00
ODP (depletion potential of the stratospheric ozone layer)	kg CFC-11 equivalent / t	4.51E-07
AP (acidification potential of soil and water)	kg SO_2 equivalent / t	1.23E-02
EP (eutrophication potential)	kg PO_4^{3-} equivalent / t	3.59E-03
POCP (formation potential of tropospheric ozone)	kg C_2H_4 equivalent / t	3.97E-04
ADPE (abiotic depletion potential for non-fossil resources)	kg Sb equivalent / t	7.38E-06
ADPF (abiotic depletion potential for fossil resources)	MJ H_u / t	2.41E+01

Table 20: Natural aggregate 0/4 mm, round – results of the life cycle assessment resource use

Parameter	Unit	A1-A3
PERE (renewable primary energy as energy carrier)	MJ H_u / t	6.98E+00
PERM (renewable primary energy resources as material utilisation)	MJ H_u / t	0
PERT (total use of renewable primary energy resources)	MJ H_u / t	6.98E+00
PENRE (non-renewable primary energy as energy carrier)	MJ H_u / t	4.90E+01
PENRM (non-renewable primary energy as material utilisation)	MJ H_u / t	0
PENRT (total use of non-renewable primary energy resources)	MJ H_u / t	4.90E+01
SM (use of secondary material)	kg / t	0
RSF (use of renewable secondary fuels)	MJ H_u / t	0
NRSF (use of non-renewable secondary fuels)	MJ H_u / t	0
FW (use of fresh water)	m^3 / t	INA*

* INA: Indicator Not Assessed: the ecoinvent data sets do not allow complete determination of the water flows

Table 21: Natural aggregate 0/4 mm, round – results of the life cycle assessment output flows

Parameter	Unit	A1-A3
HWD (hazardous waste disposed)	kg / t	3.15E-05
NHWD (non-hazardous waste disposed)	kg / t	2.34E-01
RWD (radioactive waste disposed)	kg / t	9.98E-04
CRU (components for re-use)	kg / t	0
MFR (materials for recycling)	kg / t	0
MER (materials for energy recovery)	kg / t	0
EEE (exported electric energy)	MJ / t	0
EET (exported thermal energy)	MJ / t	0

4.2 LCA: Results (per t poured incl. moisture content) – Natural aggregate 0/4 mm, crushed

Table 22: Natural aggregate 0/4 mm, crushed – results of the life cycle assessment environmental impacts

Parameter	Unit	A1-A3
GWP (global warming potential)	kg CO_2 equivalent / t	1.81E+00
ODP (depletion potential of the stratospheric ozone layer)	kg CFC-11 equivalent / t	4.63E-07
AP (acidification potential of soil and water)	kg SO_2 equivalent / t	1.33E-02
EP (eutrophication potential)	kg PO_4^{3-} equivalent / t	3.93E-03
POCP (formation potential of tropospheric ozone)	kg C_2H_4 equivalent / t	4.35E-04
ADPE (abiotic depletion potential for non-fossil resources)	kg Sb equivalent / t	8.26E-06
ADPF (abiotic depletion potential for fossil resources)	MJ H_u / t	2.52E+01

Table 23: Natural aggregate 0/4 mm, crushed – results of the life cycle assessment resource use

Parameter	Unit	A1-A3
PERE (renewable primary energy as energy carrier)	MJ H_u / t	7.07E+00
PERM (renewable primary energy resources as material utilisation)	MJ H_u / t	0
PERT (total use of renewable primary energy resources)	MJ H_u / t	7.07E+00
PENRE (non-renewable primary energy as energy carrier)	MJ H_u / t	5.03E+01
PENRM (non-renewable primary energy as material utilisation)	MJ H_u / t	0
PENRT (total use of non-renewable primary energy resources)	MJ H_u / t	5.03E+01
SM (use of secondary material)	kg / t	0
RSF (use of renewable secondary fuels)	MJ H_u / t	0
NRSF (use of non-renewable secondary fuels)	MJ H_u / t	0
FW (use of fresh water)	m^3 / t	INA*

* INA: Indicator Not Assessed: the ecoinvent data sets do not allow complete determination of the water flows

Table 24: Natural aggregate 0/4 mm, crushed – results of the life cycle assessment output flows

Parameter	Unit	A1-A3
HWD (hazardous waste disposed)	kg / t	3.53E-05
NHWD (non-hazardous waste disposed)	kg / t	2.56E-01
RWD (radioactive waste disposed)	kg / t	1.02E-03
CRU (components for re-use)	kg / t	0
MFR (materials for recycling)	kg / t	0
MER (materials for energy recovery)	kg / t	0
EEE (exported electric energy)	MJ / t	0
EET (exported thermal energy)	MJ / t	0

4.3 LCA: Results (per t poured incl. moisture content) – Natural aggregate 4/x mm, round

Table 25: Natural aggregate 4/x mm, round – results of the life cycle assessment environmental impacts

Parameter	Unit	A1-A3
GWP (global warming potential)	kg CO_2 equivalent / t	1.60E+00
ODP (depletion potential of the stratospheric ozone layer)	kg CFC-11 equivalent / t	4.29E-07
AP (acidification potential of soil and water)	kg SO_2 equivalent / t	1.17E-02
EP (eutrophication potential)	kg PO_4^{3-} equivalent / t	3.46E-03
POCP (formation potential of tropospheric ozone)	kg C_2H_4 equivalent / t	3.75E-04
ADPE (abiotic depletion potential for non-fossil resources)	kg Sb equivalent / t	6.86E-06
ADPF (abiotic depletion potential for fossil resources)	MJ H_u / t	2.24E+01

Table 26: Natural aggregate 4/x mm, round – results of the life cycle assessment resource use

Parameter	Unit	A1-A3
PERE (renewable primary energy as energy carrier)	MJ H_u / t	6.86E+00
PERM (renewable primary energy resources as material utilisation)	MJ H_u / t	0
PERT (total use of renewable primary energy resources)	MJ H_u / t	6.86E+00
PENRE (non-renewable primary energy as energy carrier)	MJ H_u / t	4.71E+01
PENRM (non-renewable primary energy as material utilisation)	MJ H_u / t	0
PENRT (total use of non-renewable primary energy resources)	MJ H_u / t	4.71E+01
SM (use of secondary material)	kg / t	0
RSF (use of renewable secondary fuels)	MJ H_u / t	0
NRSF (use of non-renewable secondary fuels)	MJ H_u / t	0
FW (use of fresh water)	m^3 / t	INA*

* INA: Indicator Not Assessed: the ecoinvent data sets do not allow complete determination of the water flows

Table 27: Natural aggregate 4/x mm, round – results of the life cycle assessment output flows

Parameter	Unit	A1-A3
HWD (hazardous waste disposed)	kg / t	3.04E-05
NHWD (non-hazardous waste disposed)	kg / t	2.23E-01
RWD (radioactive waste disposed)	kg / t	9.69E-04
CRU (components for re-use)	kg / t	0
MFR (materials for recycling)	kg / t	0
MER (materials for energy recovery)	kg / t	0
EEE (exported electric energy)	MJ / t	0
EET (exported thermal energy)	MJ / t	0

4.4 LCA: Results (per t poured incl. moisture content) – Natural aggregate 4/x mm, crushed

Table 28: Natural aggregate 4/x mm, crushed – results of the life cycle assessment environmental impacts

Parameter	Unit	A1-A3
GWP (global warming potential)	kg CO_2 equivalent / t	2.38E+00
ODP (depletion potential of the stratospheric ozone layer)	kg CFC-11 equivalent / t	5.55E-07
AP (acidification potential of soil and water)	kg SO_2 equivalent / t	1.78E-02
EP (eutrophication potential)	kg PO_4^{3-} equivalent / t	5.25E-03
POCP (formation potential of tropospheric ozone)	kg C_2H_4 equivalent / t	6.05E-04
ADPE (abiotic depletion potential for non-fossil resources)	kg Sb equivalent / t	1.15E-05
ADPF (abiotic depletion potential for fossil resources)	MJ H_u / t	3.31E+01

Table 29: Natural aggregate 4/x mm, crushed – results of the life cycle assessment resource use

Parameter	Unit	A1-A3
PERE (renewable primary energy as energy carrier)	MJ H_u / t	8.32E+00
PERM (renewable primary energy resources as material utilisation)	MJ H_u / t	0
PERT (total use of renewable primary energy resources)	MJ H_u / t	8.32E+00
PENRE (non-renewable primary energy as energy carrier)	MJ H_u / t	5.89E+01
PENRM (non-renewable primary energy as material utilisation)	MJ H_u / t	0
PENRT (total use of non-renewable primary energy resources)	MJ H_u / t	5.89E+01
SM (use of secondary material)	kg / t	0
RSF (use of renewable secondary fuels)	MJ H_u / t	0
NRSF (use of non-renewable secondary fuels)	MJ H_u / t	0
FW (use of fresh water)	m^3 / t	INA*

* INA: Indicator Not Assessed: the ecoinvent data sets do not allow complete determination of the water flows

Table 30: Natural aggregate 4/x mm, crushed – results of the life cycle assessment output flows

Parameter	Unit	A1-A3
HWD (hazardous waste disposed)	kg / t	4.61E-05
NHWD (non-hazardous waste disposed)	kg / t	3.36E-01
RWD (radioactive waste disposed)	kg / t	1.14E-03
CRU (components for re-use)	kg / t	0
MFR (materials for recycling)	kg / t	0
MER (materials for energy recovery)	kg / t	0
EEE (exported electric energy)	MJ / t	0
EET (exported thermal energy)	MJ / t	0

4.5 LCA: Results (per t poured incl. moisture content) – Recycled aggregate 0/x mm

Table 31: Recycled aggregate 0/x mm – results of the life cycle assessment environmental impacts

Parameter	Unit	A1-A3
GWP (global warming potential)	kg CO_2 equivalent / t	2.20E+00
ODP (depletion potential of the stratospheric ozone layer)	kg CFC-11 equivalent / t	5.79E-07
AP (acidification potential of soil and water)	kg SO_2 equivalent / t	1.62E-02
EP (eutrophication potential)	kg PO_4^{3-} equivalent / t	4.35E-03
POCP (formation potential of tropospheric ozone)	kg C_2H_4 equivalent / t	4.74E-04
ADPE (abiotic depletion potential for non-fossil resources)	kg Sb equivalent / t	7.27E-06
ADPF (abiotic depletion potential for fossil resources)	MJ H_u / t	3.19E+01

Table 32: Recycled aggregate 0/x mm – results of the life cycle assessment resource use

Parameter	Unit	A1-A3
PERE (renewable primary energy as energy carrier)	MJ H_u / t	7.67E+00
PERM (renewable primary energy resources as material utilisation)	MJ H_u / t	0
PERT (total use of renewable primary energy resources)	MJ H_u / t	7.67E+00
PENRE (non-renewable primary energy as energy carrier)	MJ H_u / t	6.13E+01
PENRM (non-renewable primary energy as material utilisation)	MJ H_u / t	0
PENRT (total use of non-renewable primary energy resources)	MJ H_u / t	6.13E+01
SM (use of secondary material)	kg / t	0
RSF (use of renewable secondary fuels)	MJ H_u / t	0
NRSF (use of non-renewable secondary fuels)	MJ H_u / t	0
FW (use of fresh water)	m^3 / t	INA*

* INA: Indicator Not Assessed: the ecoinvent data sets do not allow complete determination of the water flows

Table 33: Recycled aggregate 0/x mm – results of the life cycle assessment output flows

Parameter	**Unit**	**A1-A3**
HWD (hazardous waste disposed)	kg / t	3.62E-05
NHWD (non-hazardous waste disposed)	kg / t	2.40E-01
RWD (radioactive waste disposed)	kg / t	1.24E-03
CRU (components for re-use)	kg / t	0
MFR (materials for recycling)	kg / t	0
MER (materials for energy recovery)	kg / t	0
EEE (exported electric energy)	MJ / t	0
EET (exported thermal energy)	MJ / t	0

5 LCA: Interpretation

Fehler! Verweisquelle konnte nicht gefunden werden. to **Fehler! Verweisquelle konnte nicht gefunden werden.** show dominance analyses for the results of the analysed aggregates.

Inputs and outputs that have no influence on the results are not shown in the legend of the result interpretations. The resource inputs "gravel/sand" and "water of natural origin", the land use inputs "occupation xxx" and "transformation from/to xxx" as well as the emissions "water vapour" and "seepage water" have no influence on the results of the indicators examined here according to SN EN 15804 [3].

For the "Natural aggregate 4/x mm, round" the dominance analyses in **Fehler! Verweisquelle konnte nicht gefunden werden.** show the very strong influence which the diesel requirement for internal transport and the electricity requirement have on the results of most parameters.

One exception is the parameter *abiotic depletion potential for non-fossil resources (ADPE)*, where infrastructure inputs have the greatest influence on the results. This can be because of the fact that the consumption of the resource "gravel/sand" is not included in this parameter and that the demand for diesel and electricity is reflected in the parameter *abiotic depletion potential for fossil resources (ADPF)*. This is why infrastructure is more of a focus here.

Another exception is the parameter *non-hazardous waste disposed (NHWD)*, where, in particular, diesel consumption has less influence and infrastructure is more important.

The large influence of diesel consumption and electricity demand on the other parameters can be explained, on the one hand, by the fossil origin of diesel and, on the other hand, by the specific influences of the various types of electricity production in the Swiss electricity mix.

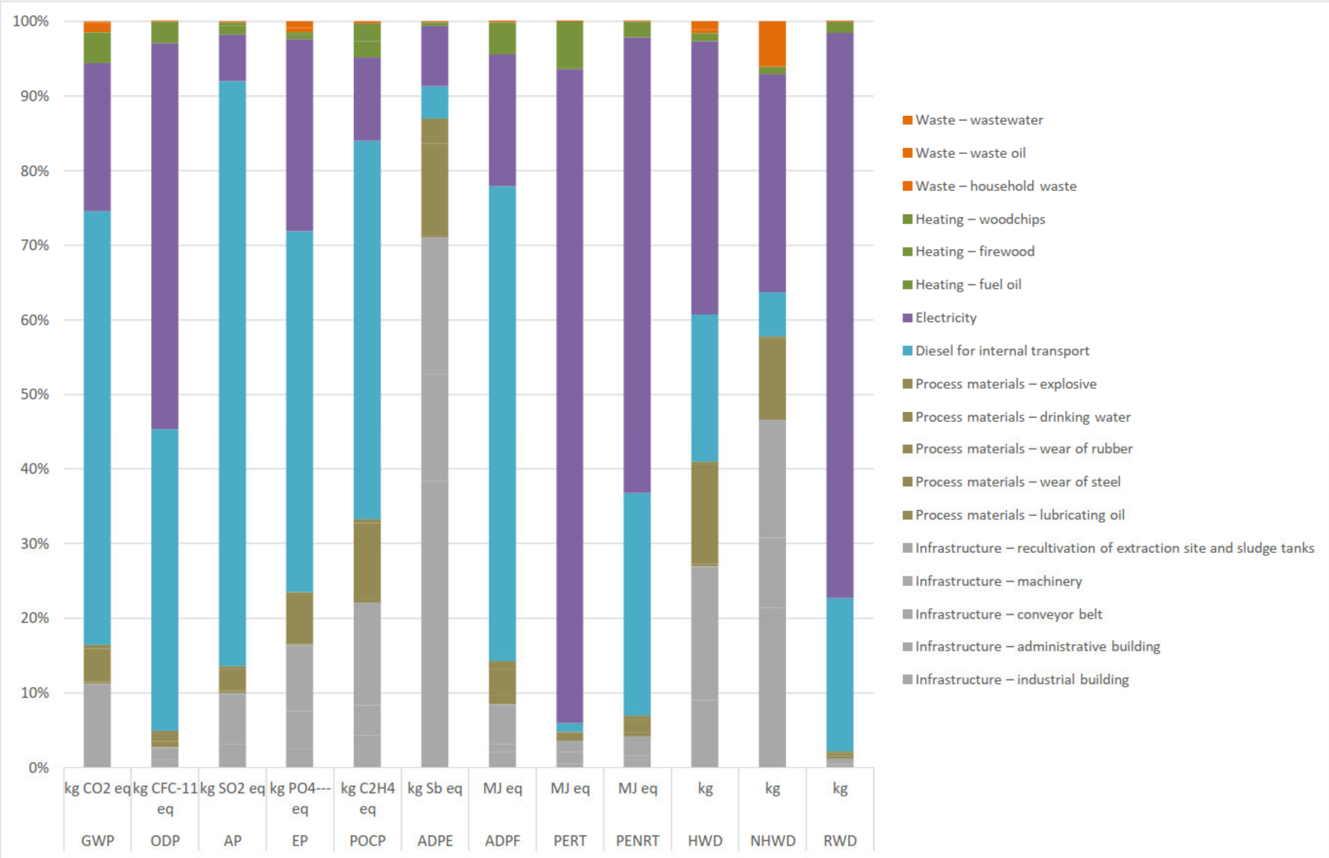

Figure 3: Natural aggregate 0/4 mm, round – shares of loads of modules A1-A3

Fehler! Verweisquelle konnte nicht gefunden werden. to **Fehler! Verweisquelle konnte nicht gefunden werden.** show that the results for the examined aggregates correlate very strongly, which can be attributed to similar up to congruent influences of the respective inputs and outputs. For this reason, the further dominance analyses are no longer discussed in detail.

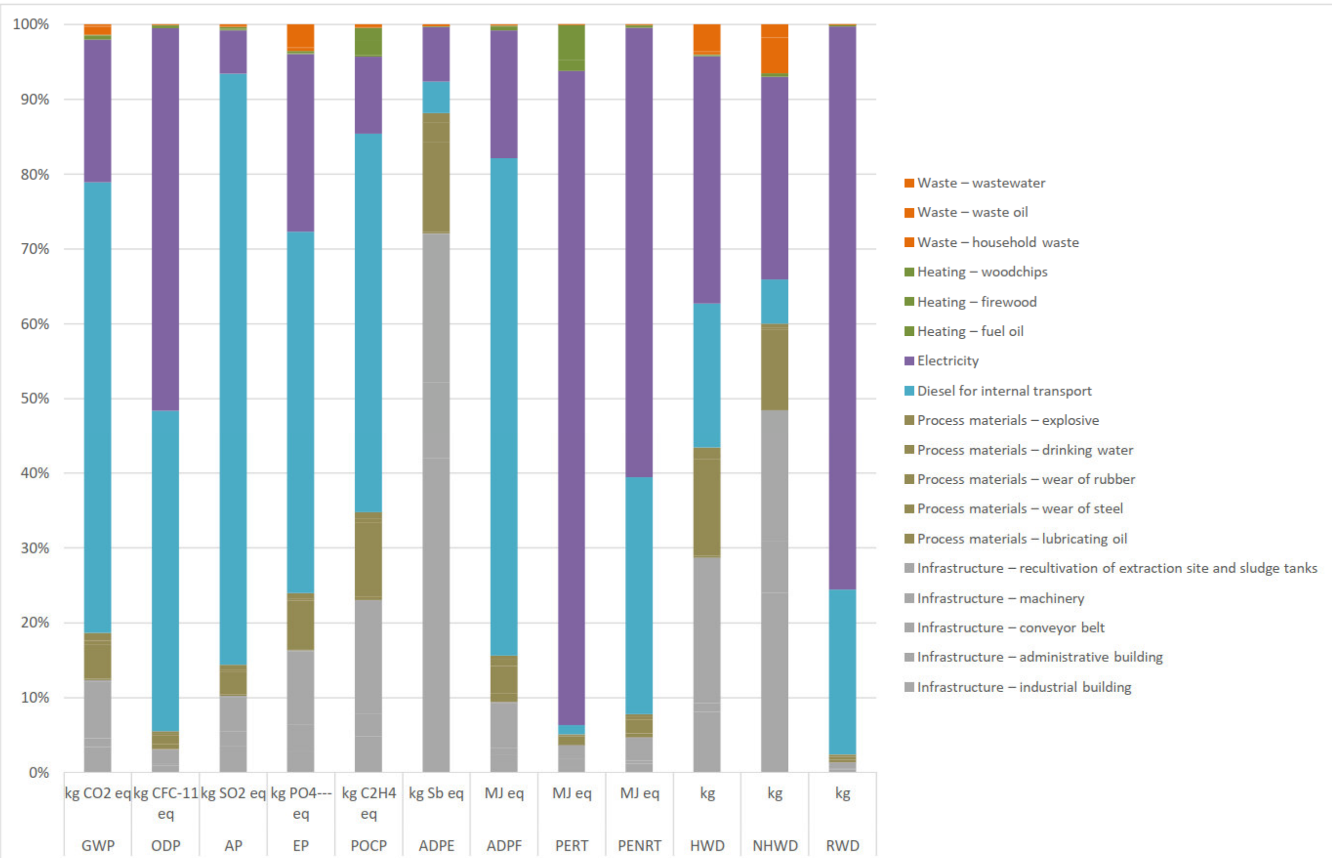

Figure 4: Natural aggregate 0/4 mm, crushed – shares of loads of modules A1-A3

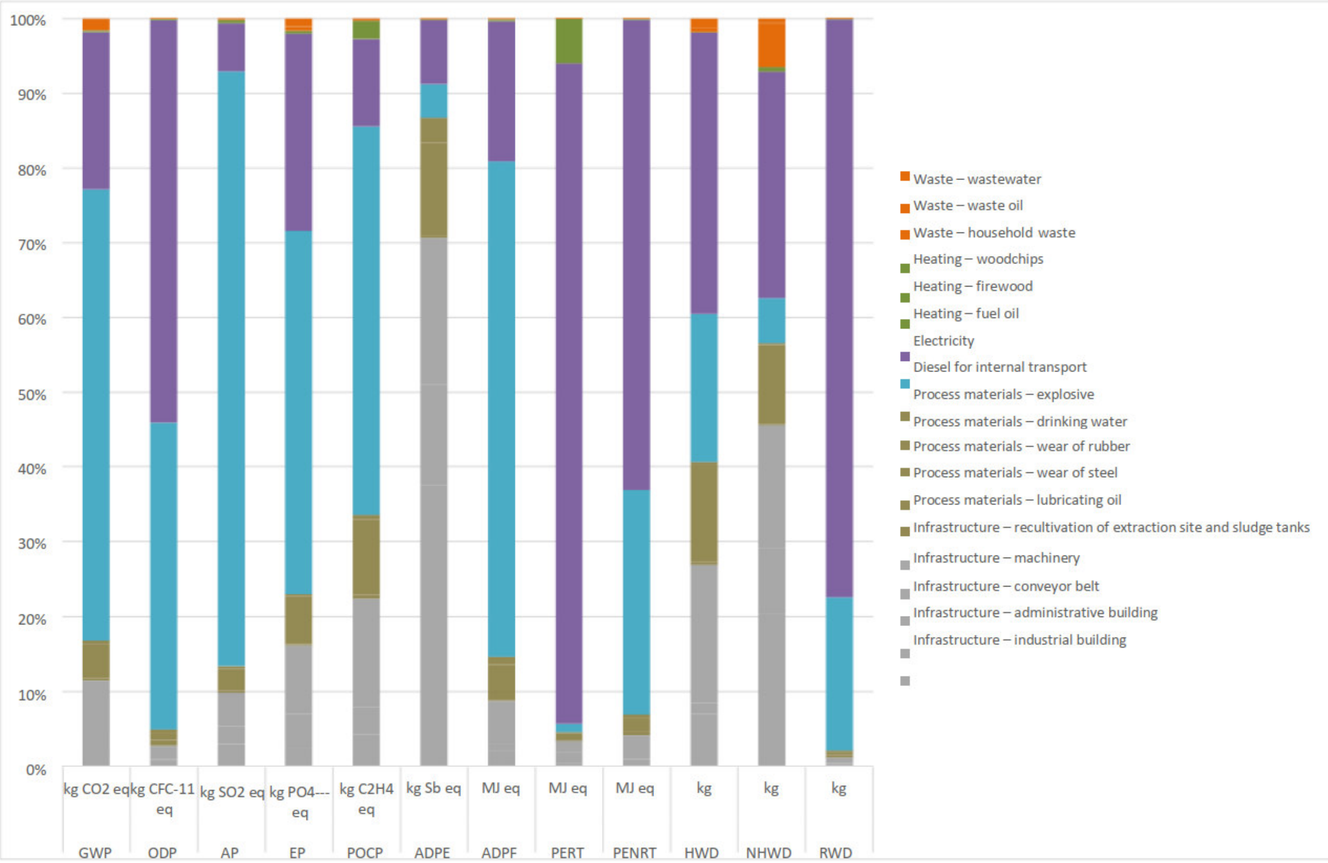

Figure 5: Natural aggregate 4/x mm, round – shares of loads of modules A1-A3

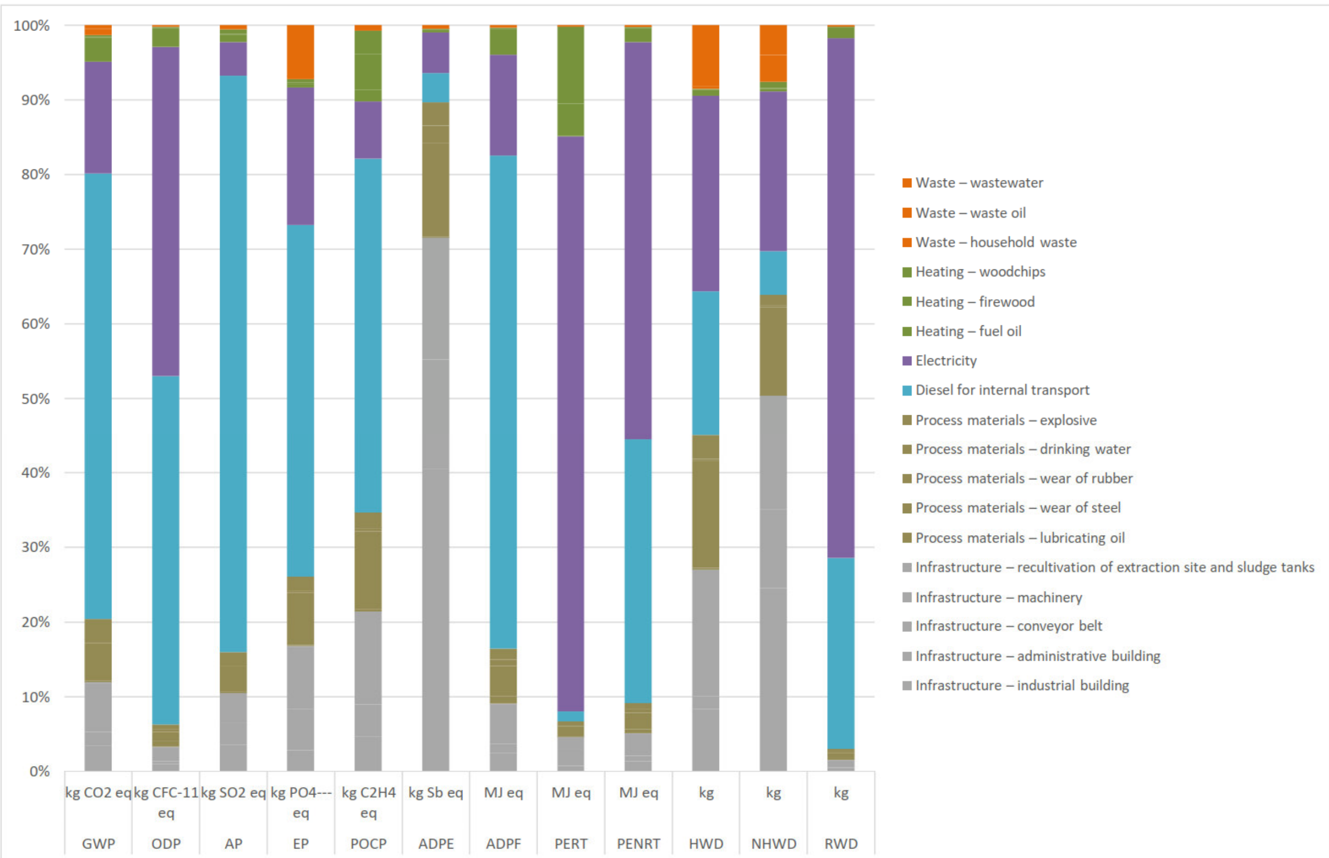

Figure 6: Natural aggregate 4/x mm, crushed – shares of loads of modules A1-A3

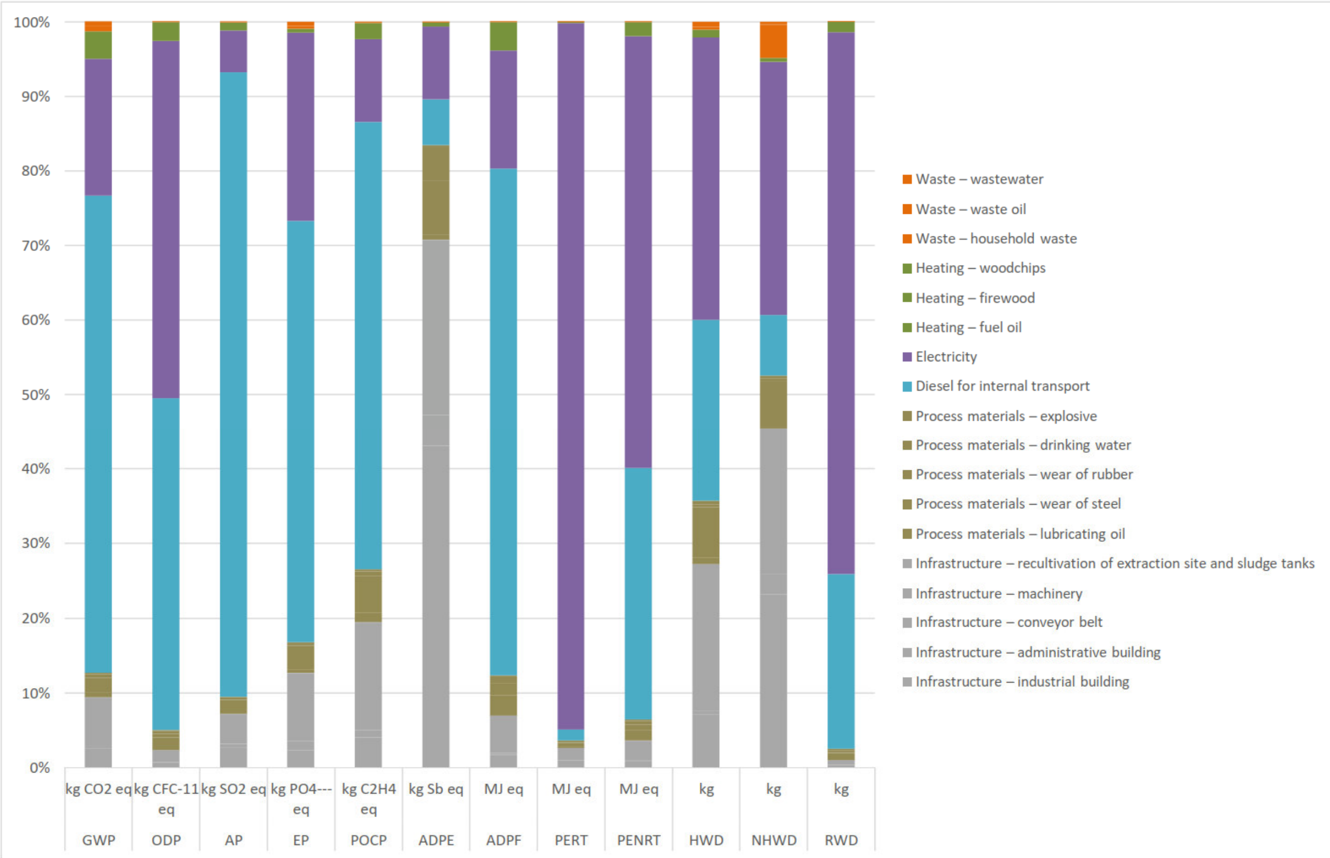

Figure 7: Recycled aggregate 0/x mm – shares of loads of modules A1-A3

6 Presentation of the representativeness of average EPD

6.1 Market

The EPD refers to the plants of the ASAC members that produce the analysed aggregates. According to the website, approx. 500 gravel plants are members of ASAC. This is well over 95% of Swiss gravel plants.

6.2 List of all plants and products

Table 34: Production quantities of the analysed plants (anonymised)

Plant #	Round particles 0/4 [t]	Angular particles 0/4 [t]	Round particles 4/x [t]	Angular particles 4/x [t]	Rec. aggregate 0/x [t]	Total per plant [t]	Total per plant without rec. aggregate [t]
1	28,297	-	68,379	1,405	3,113	101,194	98,081
2	90,000	40,000	150,000	60,000	15,000	355,000	340,000
3	47,000	-	102,100	-	-	149,100	149,100
4	83,000	5,000	140,000	10,500	19,000	267,500	248,500
5	12,000	250	23,900	3,800	24,336	64,286	39,950
6	441,000	246,000	947,000	101,000	-	1,735,000	1,735,000
7	-	32,332	-	97,559	-	129,891	129,891
8	-	29,462	-	28,534	-	57,996	57,996
9	45,357	-	104,720	-	-	150,077	150,077
10	58,832	18,481	116,258	42,908	-	236,479	236,479
11	45,940	-	32,186	-	-	78,126	78,126
12	121,215	19,374	121,215	38,120	-	299,924	299,924
13	50,970	6,455	96,216	8,302	-	161,943	161,943
14	103,660	26,948	250,591	39,081	-	420,280	420,280
15	275,901	149,776	764,934	86,733	-	1,277,344	1,277,344
16	97,262	43,609	280,875	38,408	-	460,154	460,154
Total [t]	**1,500,434**	**627,687**	**3,198,374**	**556,350**	**61,449**	**5,944,294**	**5,882,845**

6.3 Information about plants that were not considered

ASAC is unable to determine the number of plants producing the examined aggregates with the data it has available.
For the analysed plants, care was taken to ensure that large corporations, medium-sized companies and also small businesses were examined. Large corporations often also own medium-sized plants, some of which were also examined in this study.
The total output of aggregates in the 16 examined plants (in the overall study) amounts to 5.94 million tonnes (see **Fehler! Verweisquelle konnte nicht gefunden werden.Fehler! Verweisquelle konnte nicht gefunden werden.**). This represents 11.26% of the total output of aggregates in Switzerland in 2016 (52.75 million tonnes).
Based on the wide selection of plant and company sizes and the analysed production quantity, the EPD results and the associated studies can be described as representative.

6.4 Representativeness of the EPD results

The EPD results are representative of all plants of the ASAC members that produce the analysed aggregates. For this reason, an attempt was made to analyse a wide range of plants (small, medium-sized and large enterprises) which, geographically, are evenly distributed throughout Switzerland and use state-of-the-art technologies for aggregate production.
The vast majority of the Swiss gravel extraction areas lie in loose material above the groundwater level. In Switzerland, there are only 2 companies that are (still) allowed to extract gravel below the groundwater level. Today, no extraction permit is issued any more in Switzerland for this purpose. In addition, there are approx. <5 companies that extract material from lakebeds using gravel ships. Classic quarries are very much in the minority. These aspects were taken into account when selecting the plants to be analysed in terms of representativeness.

6.5 Additional references to required information in the EPD document:

a) Technical and functional characteristics – ranges AND average values including averaging

See chapter **Fehler! Verweisquelle konnte nicht gefunden werden.**/**Fehler! Verweisquelle konnte nicht gefunden werden.** *to* **Fehler! Verweisquelle konnte nicht gefunden werden.**.

b) Composition, base materials – ranges AND average values including averaging

See **Fehler! Verweisquelle konnte nicht gefunden werden.** *to* **Fehler! Verweisquelle konnte nicht gefunden werden.**.

c) Field of application, intended use
See **Fehler! Verweisquelle konnte nicht gefunden werden.**.

7 References

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[3] SN EN 15804+A1: 2013 Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products

[4] SN 640 743a: 1998 Use of demolished concrete

[5] SN EN 12620+A1: 2008 Aggregates for concrete

[6] SN 670102b-NA: 2008 Aggregates for concrete – National Annex

[7] SN EN 13139+AC: 2004 Aggregates for mortar

[8] SN 670101-NA: 2004 Aggregates for mortar – National Annex

[9] SN EN 13043: 2006 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas

[10] SN 670103b-NA: 2006 Aggregates for bituminous mixtures and surface treatments for roads, airfields and other trafficked areas – National Annex

[11] SN EN 13242+A1: 2007 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction

[12] SN 670119a-NA: 2007 Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction – National Annex

[13] SN EN 13285: 2010 Unbound mixtures – specifications

[14] SN EN 670119-NA: 2010 Unbound mixtures – specifications – National Annex

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[23] Swiss Federal Council, VVAE Ordinance on the Prevention and Disposal of Waste, as of 01.01.2018

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[26] SN EN ISO 14040: 2006 Environmental management – Life cycle assessment – Principles and framework

[27] SN EN ISO 14044: 2006 Environmental management – Life cycle assessment – Requirements and guidelines

[28] Evaluation of data collection in the participating plants (confidential)

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