# ENVIRONMENTAL PRODUCT DECLARATION

according to ISO 14025/ and EN 15804/

<table>
<thead>
<tr>
<th>Owner of the Declaration</th>
<th>TONALITY GmbH</th>
</tr>
</thead>
<tbody>
<tr>
<td>Publisher</td>
<td>Institut Bauen und Umwelt e.V. (IBU)</td>
</tr>
<tr>
<td>Program Holder</td>
<td>Institut Bauen und Umwelt e.V. (IBU)</td>
</tr>
<tr>
<td>Declaration number</td>
<td>EPD-TON-20190011-IBA1-DE</td>
</tr>
<tr>
<td>Date issued</td>
<td>06.03.2019</td>
</tr>
<tr>
<td>Valid until</td>
<td>05.03.2024</td>
</tr>
</tbody>
</table>

**TONALITY®**  
Ceramic Facade Elements  
TONALITY GmbH  

[www.ibu-epd.com](http://www.ibu-epd.com) / [https://epd-online.com](https://epd-online.com)
1. General Details

**TONALITY GmbH**
Owner of the Program
IBU - Institut Bauen und Umwelt e.V.
Panoramastr. 1
10178 Berlin
Deutschland

Declaration Number
EPD-TON-20190011-IBA1-DE

This declaration is based upon
Product Category Regulations:
Ceramic Cladding, 07.2014
(PCR tested and approved by the German independent Council of Experts (SVR))

Date of issue
06.03.2019

Valid until
05.03.2024

Prof. Dr.-Ing. Horst J. Bossenmayer
(Chairman, Institut Bauen und Umwelt e.V.)

Dr. Alexander Röder
(Chairman of the Board IBU)

2. Product

2.1 Product description/Product definition
The declared product concerns flat, level ceramic façade panels made of clay. The panels are made of different clay solids and receive their surface finish or their color through agreed fire curves. They are single skin panels as well as also panels with hollow cavities for suspended, back-ventilated rainscreen facades. The cladding panels are affixed using system-oriented aluminum sub-structures on primary façade support systems.

The respective national regulations apply for their use, in Germany the national technical approval with No. Z-10.3-796 of the German Institute for Building technology dated 15/11/2018 and the national technical approval with No. Z-10.3-798 German Institute for Building technology dated 16/05/2018.

2.2 Application
TONALITY® is used as a cladding material for suspended, back-ventilated rainscreen cladding as well as for decorative internal designs. The façade panels are also used for suspended ceilings, reveals and coverings.

2.3 Technische Data

**Technical Data**

<table>
<thead>
<tr>
<th>Classification</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw density</td>
<td>2000 - 2200</td>
<td>kg/m³</td>
</tr>
<tr>
<td>Thermal conductivity according to EN 60672-2</td>
<td>1,17</td>
<td>W/(mK)</td>
</tr>
<tr>
<td>Breaking strain dependent on thickness and height</td>
<td>0.5 – 6.67</td>
<td>kN</td>
</tr>
<tr>
<td>Water take-up according to EN 539-2</td>
<td>2 - 5</td>
<td>%</td>
</tr>
</tbody>
</table>

The degree of sound absorption is not relevant for application cases of ceramic façade panels.

2.4 Delivered Condition
Dimensions and tolerances of TONALITY® façade panels in accordance with the national technical approvals named in Point 2.1:
Thickness 22 mm:
Grid height 150, 175, 200, 225, 250, 300 mm
2.5 Basic Materials/Ancillary Materials

TONALITY® ceramic façade panels are comprised of ceramic façade panels and a system-relevant aluminum sub-structure. The ceramic façade tiles are comprised of the following basic materials and ancillary materials:

<table>
<thead>
<tr>
<th>Classification</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Clay</td>
<td>40 – 70</td>
<td>Mass %</td>
</tr>
<tr>
<td>Chamotte (fire clay)</td>
<td>20 – 35</td>
<td>Mass %</td>
</tr>
<tr>
<td>Color pigments</td>
<td>1 - 3</td>
<td>Mass %</td>
</tr>
<tr>
<td>Engobe/Glaze</td>
<td>0 - 3</td>
<td>Mass %</td>
</tr>
</tbody>
</table>

During production another 20% water or so is still required during the shaping process. Clays and chamottes (fire clays) originate from regional occurrences in near to our factory (in Germany’s Westerwald). color pigments and surface coatings are bought in, purchased from renown manufacturers of these materials.

According to the manufacturer, the aluminum sub-structure is comprised 35% of alloy AlMg3 H22/24 and 65% of alloy AlMg 4.5MnH24. Apart from this, the manufacturer confirms that 20% of the aluminum is secondary aluminum and 80% is primary aluminum.

The product/ at least a part of the product contains materials on the list of substances of very high concern (27.08.2016) above 0.1 mass by%: no.

The product/ at least a part of the product contains further CMR materials in category 1A or 1B, which are not on the list of substances of very high concern, above 0.1 mass by % in at least a part of the product.

The construction product on hand had biocidal products added to it or was treated with biocidal products (we are concerned here with a processed good in the spirit of the Biocide Product Regulation (EU) Nr. 528/2012): no.

2.6 Manufacture

The manufacture of the ceramic cladding panels is divided into eight process steps:

During raw material preparation doses of components required are measured out, they are homogenized and mixed into aplastic workable solid mass through adding water.

Shaping gives the plastic solid mass its desired shape through extrusion (pulltrusion).

During the drying process step, the water contained in the extruded blank is expelled from the product in a preservative manner.

The dried tiles are engobed or glazed during surface finishing. The façade elements receive their technical characteristics through firing in a rolling oven, and their special appearance.

Façade elements are cut exactly to the length desired during cutting.

These are inspected visually by random sampling during the Quality Control step, and dimensions are measured and checked.

In the final production step packaging, the façade elements are packaged securely for transport in accordance with the customer’s wishes.

2.7 Health and the Environment during Production

Efforts are made during the entire production process, to keep the effects on the environment as small as possible.

Strict limiting values force TONALITY GmbH to take technical precautions and should it be necessary to use specially agreed Personal Protective Equipment (P.P.E).

Emissions are measured annually internally and every two years externally in accordance with production approval.

Waste from the production process is either recycled internally and fed back into this again or are disposed of externally in an expert and correct manner, with evidence being recorded.

Noise loadings for neighbors and for employees are regularly monitored by TONALITY GmbH and these are followed corresponding to statutory boundary values. Appropriate P.P.E. is also provided for employees here.

2.8 Product Processing /Installation

Installation takes place via a system-oriented sub-structure. Information on installing in the national technical approvals must be followed. When drilling and cutting the ceramic material, appropriate Personal Protective Equipment must be worn (respiratory protection P2/FFP2, protective eyeglasses and ear defenders).

Sufficient ventilation must be guaranteed in the place of work.

Tools with low dust exposure (e.g. wet cutting equipment) must be used.

For re-­use, normal tools customary in trade can be used for working on the system-specific aluminum sub-structures. When doing this, likewise the Health & Safety at work regulations must be followed.

The ceramic façade panels are fixed in place by hanging the support lobes on the reverse onto hooks in the substructure. Additional security against unauthorized removal is possible.

2.9 Packaging

Packaging for the products is carried out on re-usable Euro palettes, in part with cardboard intermediate layers of cardboard or wood a using polyethylene shrink wrap film.

The re-usable palettes can be returned against repayment of a deposit. All other packaging materials are returned through the building materials trade and are directed to the recycling process.

2.10 Condition for Use

Following the production process, ceramic façade elements no longer change. The façade elements are resistant to weathering according to /EN 10545/ and are resistant to frost and acids as well as lye according to /EN 1304/.
2.11 Health & the Environment during Use
The façade elements do not emit any materials which are harmful to the environments and health. The natural ionizing radiation is extremely low and is comparable with other construction products.

2.12 Reference Working Life
Ceramic façade elements no longer change after the end of the production process. These are extremely long-lasting with use according to regulations.

2.13 Extraordinary Influences
Fire
Ceramic façade elements fulfill the requirements according to /EN 13501/. In case of fire, no toxic gases and steam, or ones obstructing vision arise.

<table>
<thead>
<tr>
<th>Fire Protection</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Building material class</td>
<td>A1</td>
</tr>
<tr>
<td>Falling burning drops</td>
<td>No</td>
</tr>
<tr>
<td>Smoke gas development</td>
<td>No</td>
</tr>
</tbody>
</table>

Wasser

2.14 After-Use Phase
With the correctly directed demolition of buildings, it may be possible to reuse ceramic façades. Homogenous ceramic elements from a single source may be re-worked into chamotte (dead clay) and in this way may be fed back into the production process. Ceramic elements obtained from demolitions can also be used for road building and civil engineering. Use as a floor covering for tennis courts is likewise possible. With correctly directed demolition, the sub-structure can also be re-used. It is also possible to submit the aluminum material to the recycling process.

2.15 Disposal
Where no recycling opportunities exist, cladding panels can be disposed of in the customary manner and sent for waste disposal (Waste Key 31409 - Construction Waste according to /LAGA-Waste Catalogue/, Waste Key 170102 – Tiles according to /European Waste Catalogue/, Disposal Class I according to TA-Municipal Solid Waste).

2.16 Further Information
You can receive further information at www.tonality-facades.de

3. LCA: Rules for Calculations

3.1 Declared Unit
This declaration refers to 1 m² of ceramic façade tiles including system-oriented aluminum sub-structure. The average weight per unit area (ceramic façade panel) is 40.8 kg/m², for the sub-structure it is 0.52 kg/m².

The raw density of the declared product is 2000-2200 kg/m³.

The re-calculation factor to 1 kg (incl. sub-structure) is 1/41.32=0.0242.

<table>
<thead>
<tr>
<th>Declared Unit</th>
<th>Wert</th>
<th>Einheit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Declared Unit</td>
<td>1</td>
<td>m²</td>
</tr>
<tr>
<td>Weight per unit area (including sub-structure 0.52kg/m²)</td>
<td>41.32</td>
<td>kg/m²</td>
</tr>
<tr>
<td>Raw density</td>
<td>2200</td>
<td>kg/m³</td>
</tr>
<tr>
<td>Re-calculation factor for 1 kg (incl. sub-structure)</td>
<td>0.0242</td>
<td>-</td>
</tr>
</tbody>
</table>

Based on secure ceramic compounds, no material contents which are dangerous to the water supply are washed out.

Mechanical Destruction
Ceramic cladding tiles can be destroyed mechanically. No negative effects on the environment should occur when this is carried out.

3.2 System Limit
This declaration corresponds to an EPD of the type "Weigh up to the factory gates - with options".

The Life Cycle Assessment takes the extraction and supply of raw materials into consideration, transporting raw materials and the actual product manufacture as well as packaging materials (Modules A1-A3), the treatment of packaging materials in waste incineration plants following installation of the product (Module A5), as well as transport following demolition (Module C2) and End-of-Life of materials (Disposing of the façade panels at an inert materials waste site (Module C4) and recycling the aluminum sub-structure (Module D). The credit notes for electricity and thermal energy from the disposal of packaging materials were likewise considered (Module D).

Module C3 merely displays the MFR indicator (Materials for Recycling). The quantity of aluminum is shown here, leading to the credits in Module D.

The user phase (Module B) is not taken into consideration in this study.

3.3 Estimates and Assumptions
The data for specifying the sub-structure were supplied directly by the supplier. According to the manufacturer, the aluminum sub-structure is composed 35% of alloy AlMg3 H22/24 and 65% of alloy AlMg 4.5MnH24. Apart from this, the customer confirmed, that 20% of the aluminum is secondary aluminum and 80% is primary aluminum. As no exact datasets for the concrete alloys of the secondary aluminum are available in the in database /GaBi 8.7/, the dataset „DE: Aluminium ingot (AlMg9) sec.“ was used as an estimate.
3.4 Cut-off regulations
All data recorded by the company i.e. of all the staring materials used in accordance to formulations, the thermal energy used as well as electricity requirements and co-products were considered in the assessment. The transport needs were taken into consideration for all the inputs examined. In accordance with /PCR Part A/ material and energy streams with a proportion of less than 1 percent of the total of with reference to the overall mass of the product. were also considered at this time.

The manufacture of machinery, equipment and other infrastructure, die required for manufacturing the articles under consideration, was not considered in the Life Cycle Assessment.

3.5 Background Data
The software system developed by thinkstep AG for comprehensive assessment /GaBi 8.7/ was used for modelling for the ceramic cladding panels (incl. sub-structure). The consistent datasets contained in the GaBi database are recorded in online GaBi documentation. The basic data in the GaBi database were used for energy, forms of transport, and ancillary materials.

The Life Cycle Assessment was drawn up for the reference region of Germany. Therefore, the relevant pre-stages in Germany such as the electricity utility supply or power supply for the production process were also used under these background conditions. The Electricity-Mix in Germany for reference year 2014 was used. All further background data sets were taken from the year 2018.

Some of the emissions from the combustion process were recorded as primary data by means of measurements by TONALITY GmbH. As the emissions measurements were not complete, an adjustment was made according to the actual emissions and a Worst-Case approach was selected for missing data.

3.6 Data Quality
Data recorded by TONALITY GmbH during the 2017 production year were used for the production phase modelling for the ceramic cladding panels (incl. sub-structure). All other relevant background datasets were taken from the database for the software /GaBi 8.7/. These are no more than 10 years old according to the specifications.

3.7 Period under Consideration
The data basis for the Life Cycle Assessment is based on data recorded in the year 2017. The period under consideration was 12 months.

3.8 Allocation
Spoilt waste (‘spillage’) from the ceramic cladding panels can be re-used. The firing waste is sent to a reprocessing plant free of charge. This firing waste can be used in different fields; for example, for building roads, as clay ashes for tennis courts, as chamotte (refractory clay) for producing stoneware goods etc.

The unfired solid is returned to the clay suppliers and is mixed in with secondary quality clay (Recycling). Die TONALITY GmbH receives no monetary payment for this.

As TONALITY GmbH supplies both co-products free of charge, no Co-Product-Allocation Rules are used. Both material streams depart the system boundaries without any implications on value or loads.

The Life Cycle Assessment considers the recycling potential of aluminum. Of the aluminum wastes occurring during manufacturing and End-of-Life of the sub-structure, first of all the required amount of secondary aluminum for manufacturing is fed back in or is saturated (‘closed loop’), after this a credit is granted for the remaining net quantity of scrap.

3.9 Comparability
Fundamentally, a comparison or assessment of EPD data is only possible, if all the datasets which must be compared have been drawn up according to /EN 15804/ and the context of the building, or the specific product performance characteristics were taken into consideration.

The background database used was /GaBi 8.7/.

4. LCA: Scenarios and further technical information
The following technical data forms the basis for the declared modules or may be used for developing specific scenarios in the context of a building assessment, if modules have not been declared (MND).

<table>
<thead>
<tr>
<th>Classification</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wooden palettes</td>
<td>0.93</td>
<td>kg/m²</td>
</tr>
<tr>
<td>Carboard</td>
<td>0.13</td>
<td>kg/m²</td>
</tr>
<tr>
<td>(Plastic) films</td>
<td>0.12</td>
<td>kg/m²</td>
</tr>
</tbody>
</table>

End-of-Life (C1-C4)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Value</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waste types - separately (Metal &amp; inert builders' waste)</td>
<td>41.32</td>
<td>Kg</td>
</tr>
</tbody>
</table>

As mixed construction waste collectively 0 kg
For re-use 0 kg
For Recycling (sub-structure without collective losses) 0.52 kg
To energy recovery 0 kg
To waste disposal (façade panel with no sub-structure) 40.8 kg
Transport for façade panels to End-of-life (Euro 6 truck) 50 km
Transport for the sub-structure to End-of-Life (rail + Euro 6 truck) 200 + 50 km
Loading 85 %
Volume loading factor 100 %

Potential for re-use, Energy Retrieval and
Recycling potential (D), relevant scenario details
End-of-Life of the declared products following the end of the user phase are included in the assessment.

A credit is awarded in Module D (without overall and re-melting conversion losses of a total of 10%. /EMPA 2008/) for the aluminum scraps arising from the sub-structures. We assume, that the aluminum sub-structure has reached the end of its waste characteristics immediately after the end of the user phase.

Module D also contains the credits for electricity and thermal energy because of thermal further processing of the packaging materials from Module A5.
The calorific value in this Life Cycle Assessment is based exclusively on the raw materials used for the packaging; plastic film (calorific value 43 MJ/kg), paper (calorific value 15 MJ/kg) and wooden palette (calorific value 13 MJ/kg). The façade panel itself including the sub-structure is non-flammable.

<table>
<thead>
<tr>
<th>Production stage</th>
<th>Stage of construction of the structure</th>
<th>Stage of use</th>
<th>Waste disposal stage</th>
<th>Credits and loads outside the system boundary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raw Materials</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manufacturing</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport from manufacturer to place of use</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Installation</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Use / Application</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maintenance</td>
<td></td>
<td></td>
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<tr>
<td>Repair</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Replacement</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Removal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy used for construction of building</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water used for operation of the building</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Removal / Demolition</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Waste treatment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposal</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potential for re-use, Recovery or Recycling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESULTS OF LIFE CYCLE ASSESSMENT OF ENVIRONMENTAL IMPACTS: 1 m² ceramic façade panels including system-oriented aluminum sub-structure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>A5</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Global Warming potential</td>
<td>[kg CO₂ eq.]</td>
<td>4,17E+1</td>
<td>2,24E+0</td>
<td>9,66E-2</td>
<td>0,00E+0</td>
<td>6,59E-1</td>
<td>-4,58E+0</td>
</tr>
<tr>
<td>Depletion potential of the stratospheric ozone layer</td>
<td>[kg CFC11 eq.]</td>
<td>2,23E-11</td>
<td>2,22E-14</td>
<td>2,03E-15</td>
<td>0,00E+0</td>
<td>1,74E-13</td>
<td>-7,28E-13</td>
</tr>
<tr>
<td>Acidification potential to the ground and water</td>
<td>[kg SO₂ eq.]</td>
<td>7,09E-2</td>
<td>2,73E-4</td>
<td>9,38E-5</td>
<td>0,00E+0</td>
<td>1,34E-3</td>
<td>-1,48E-2</td>
</tr>
<tr>
<td>Eutrophication potential</td>
<td>[kg PO₄ eq.]</td>
<td>7,79E-3</td>
<td>5,99E-5</td>
<td>2,29E-5</td>
<td>0,00E+0</td>
<td>5,31E-4</td>
<td>-1,83E-3</td>
</tr>
<tr>
<td>Potential for forming tropospheric ozone</td>
<td>[kg Ethr eq.]</td>
<td>6,18E-3</td>
<td>1,82E-5</td>
<td>3,78E-6</td>
<td>0,00E+0</td>
<td>2,99E-4</td>
<td>-8,68E-4</td>
</tr>
<tr>
<td>Potential for restricting abiotic resources – non-fossil fossil resources</td>
<td>[kg Sb eq.]</td>
<td>2,47E-4</td>
<td>3,19E-8</td>
<td>1,00E+0</td>
<td>0,00E+0</td>
<td>2,50E-7</td>
<td>-1,66E-6</td>
</tr>
</tbody>
</table>

RESULTS OF LIFE CYCLE ASSESSMENT OF USE OF RESOURCES: 1 m² ceramic façade panels including system-oriented aluminum sub-structure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>A1-A3</th>
<th>A5</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>renewable primary energy as the energy source</td>
<td>[MJ]</td>
<td>7,77E+1</td>
<td>1,41E+1</td>
<td>6,72E-2</td>
<td>0,00E+0</td>
<td>1,08E+0</td>
<td>-1,88E+1</td>
</tr>
<tr>
<td>renewable primary energy for material use</td>
<td>[MJ]</td>
<td>1,41E+1</td>
<td>-1,41E+1</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Total renewable primary energy</td>
<td>[MJ]</td>
<td>9,18E+1</td>
<td>9,21E-2</td>
<td>6,72E-2</td>
<td>0,00E+0</td>
<td>1,08E+0</td>
<td>-1,88E+1</td>
</tr>
<tr>
<td>non-renewable primary energy as the energy source</td>
<td>[MJ]</td>
<td>6,33E+2</td>
<td>5,50E+0</td>
<td>1,30E+0</td>
<td>0,00E+0</td>
<td>8,71E+0</td>
<td>-6,36E+1</td>
</tr>
<tr>
<td>non-renewable primary energy for material use</td>
<td>[MJ]</td>
<td>5,09E+0</td>
<td>-5,09E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Total non-renewable primary energy</td>
<td>[MJ]</td>
<td>6,83E+2</td>
<td>5,10E-1</td>
<td>1,30E+0</td>
<td>0,00E+0</td>
<td>8,71E+0</td>
<td>-6,36E+1</td>
</tr>
<tr>
<td>Use of secondary materials</td>
<td>[kg]</td>
<td>1,02E+1</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Renewable secondary fuels</td>
<td>[MJ]</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Non-renewable secondary fuels</td>
<td>[MJ]</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Use of freshwater resources</td>
<td>[m³]</td>
<td>1,09E+2</td>
<td>5,40E+0</td>
<td>1,01E+1</td>
<td>0,00E+0</td>
<td>1,66E+0</td>
<td>-3,48E+1</td>
</tr>
</tbody>
</table>

RESULTS OF LIFE CYCLE ASSESSMENT OF OUTPUT STREAMS AND WASTE CATEGORIES: 1 m² ceramic façade panels including system-oriented aluminum sub-structure

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Einheit</th>
<th>A1-A3</th>
<th>A5</th>
<th>C2</th>
<th>C3</th>
<th>C4</th>
<th>D</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dangerous waste sent for disposal</td>
<td>[kg]</td>
<td>6,20E-7</td>
<td>4,76E-10</td>
<td>6,31E-8</td>
<td>0,00E+0</td>
<td>1,50E-7</td>
<td>2,55E-8</td>
</tr>
<tr>
<td>Non-dangerous waste disposed of</td>
<td>[kg]</td>
<td>1,92E+0</td>
<td>6,86E-3</td>
<td>9,66E-5</td>
<td>0,00E+0</td>
<td>4,09E+1</td>
<td>-8,27E-1</td>
</tr>
<tr>
<td>Radio-active waste disposed of</td>
<td>[kg]</td>
<td>1,82E-2</td>
<td>1,34E-5</td>
<td>1,50E-6</td>
<td>0,00E+0</td>
<td>1,25E-4</td>
<td>-4,82E-3</td>
</tr>
<tr>
<td>Components for recycling</td>
<td>[kg]</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Materials to recycling</td>
<td>[kg]</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>4,42E-1</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Materials for energy recovery</td>
<td>[kg]</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Electrical energy exported</td>
<td>[MJ]</td>
<td>0,00E+0</td>
<td>2,98E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
<tr>
<td>Thermal energy exported</td>
<td>[MJ]</td>
<td>0,00E+0</td>
<td>6,92E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
<td>0,00E+0</td>
</tr>
</tbody>
</table>
6. LCA: Interpretation

In general, consumption of thermal energy and electricity has the greatest influence on all impact categories during the manufacturing of ceramic façade panels, apart from with abiotic consumption of non-fossil resources (ADPe).

The manufacture of the sub-structure contributes to all impact categories apart from with ADPe, at a rate of about 10-30%. This must be ascribed to the energy demands during the electrolysis process during the manufacture of aluminum. Of all the raw materials used, the color pigments contribute towards the most widely considered impact categories in a relevant manner. The Global Warming Potential (GWP), Acidification Potential (AP), Eutrophication Potential (EP), Petrochemical Ozone Creation Potential (POCP) and Abiotic Depletion of Fossil Resources (ADPF) are influenced by up to 10% to 25% by this preliminary product. This result is caused by the requirement for electricity during the production of „Ferrochrome“ in the initial supply chains.

In ADPe a different environmental profile is exhibited, compared to the other impact categories. In this case, about 80% of the abiotic consumption of resources is caused by the manufacture of the color pigments and ca. 15% is caused by the color coating of the surface. This results from the energy requirements during the manufacture of aluminum oxide (aluminum oxide is a component of the glaze formula).

Other raw material such as clay and chamotte (refractory clay) contribute towards 2% to 8% of all impact categories, apart from with ADPe. This is principally the result of the energy requirement of the two manufacturing processes.

Transport and energy needs for packaging are less significant in comparison to the other sub-systems defined.

7. Proofs

7.1 Radioactivity
Radioactivity is not relevant for the ceramic façade elements.

7.2 Exudation of Lye

Protocol: Chemical Investigations in accordance with /LAGA Directive No.20/ (Status: 05.11.2004), Table II 1.4-5 and Table II 1.4-6 and in accordance with Waste Disposal Ordinance (DepV) (Status: 16.07.2009)

Date: Test report 1082-11-2 of 29.02.12.
Outcome: The concentrations measures in the eluate are significantly below the boundary values.

8. Literary References

National technical approval:
National technical approval No. Z-10.3-796 of the Deutsches Institut für Bautechnik (DIBt) dated 15.11.2018

National technical Approval:
National technical approval No. Z-10.3-796 of the Deutsches Institut für Bautechnik (DIBt) dated 16.05.2018

/EN 1304/:
DIN EN 1304:2013-08, Clay roofing tiles and fitting – Product definitions and specifications; German version EN 1304:2013

/EN 13501/:

/EN 10545/:

Institut Bauen und Umwelt e.V. (publ.):
Product Category Rules for Construction Products Part B: requirement of the EPD for ceramic cladding, v1.6, 2017


/EMPA/


LAGA (German Federal and State Waste Working Group) Directive No. 20: (Status 05.11.2004), Table II 1.4-5 and Table II 1.4-6 and in accordance with Depositing Regulation (DepV) Status 16.07.2009


/IBU 2016/

/ISO 14025/
DIN EN ISO 14025:2011-10/, Environmental characteristics and declarations - Type III Environmental Declarations – principles and procedures.

/EN 15804/
<table>
<thead>
<tr>
<th>Section</th>
<th>Text</th>
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</table>
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