



Environmental Product Declaration

according to ISO 14025



**TECU[®] - Copper Strips and
Copper Alloys**

KME Germany AG & Co. KG

Declaration Number
EPD-KME-2011313-E

Institut Bauen und Umwelt e.V.
www.bau-umwelt.com



Institut Bauen
und Umwelt e.V.

	<p style="text-align: right;">Summary</p> <p style="text-align: center;"><i>Environmental Product-Declaration</i></p>
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<p>Institut Bauen und Umwelt e.V. www.bau-umwelt.com</p> 	<p style="text-align: right;">Program holder</p>
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<p>KME Germany AG & Co. KG Klosterstrasse 29 49074 Osnabrück</p>	 <p style="text-align: right;">Declaration holder</p>
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<p>EPD-KME-2011313-E</p>	<p style="text-align: right;">Declaration number</p>
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<p>TECU[®] Copper Strips and Copper Alloys</p> <p>This declaration is an environmental product declaration according to ISO 14025 and describes the environmental performance of the building products mentioned. It is intended to promote the development of environmental and health compatible construction.</p> <p>All relevant environmental data is disclosed in this validated declaration.</p> <p>The declaration is based on the PCR Document ,Construction Metals: 2004-11'.</p>	<p style="text-align: right;">Declared building products</p>
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<p>This validated declaration authorises the holder to bear the official stamp of the Association. It only applies to the above mentioned products for one year from date of issue. The declaration holder is liable for the information and evidence on which the declaration is based.</p>	<p style="text-align: right;">Validity</p>
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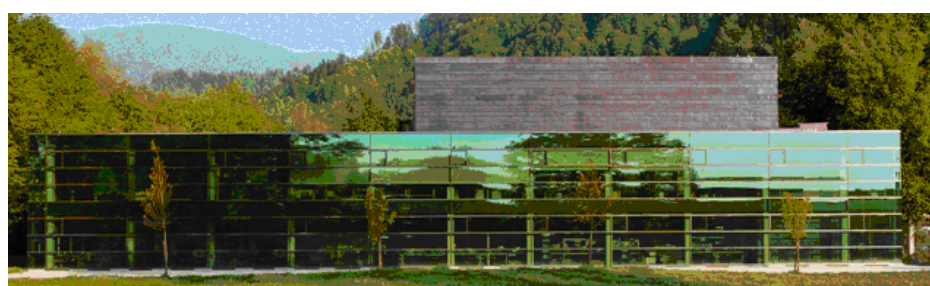
<p>The declaration is complete and contains in detail:</p> <ul style="list-style-type: none"> - Product definition and physical data - Information about raw materials and origin - Specifications on manufacturing the product - References for product processing - Information on product in use, singular effects and end of life - LCA results - Evidence and verifications 	<p style="text-align: right;">Content of the declaration</p>
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<p>1th August 2011</p>	<p style="text-align: right;">Date of issue</p>
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 <p>Prof. Dr.-Ing. Horst J. Bossenmayer (Chairman of the IBU)</p>	<p style="text-align: right;">Signatures</p>
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<p>This declaration, and the rules which it is based on, have been verified by the Independent Advisory Board (SVA) according to ISO 14025.</p>	<p style="text-align: right;">Verification of the declaration</p>
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 <p>Prof. Dr.-Ing. Hans-Wolf Reinhardt (Chairman of the SVA)</p>	 <p>Dr. Eva Schmincke (Verifier appointed by the SVA)</p>	<p style="text-align: right;">Signatures</p>
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Summary Environmental Product- Declaration

The material TECU® is copper Cu-DHP manufactured according to DIN EN 1172. The declaration also includes the surface qualities TECU® Oxide, pre-oxidised brown on both sides, TECU® Patina, green on one side pre-coated with patina, along with the Cu-Sn-alloy TECU® Bronze and the Cu-Al-alloy TECU® Gold.

Product Description

The fields of application of the TECU® copper sheets and strips and TECU® copper alloys are roof cladding, façade designs, and roof drainage systems.

Range of Application

The **Life Cycle Assessment (LCA)** was carried out according to DIN ISO 14040 et sqq. corresponding to the requirements of the IBU-Guidelines for Type III Declarations. Specific data from the company KME, the German Copper Institute (DKI) and data from the data base "GaBi 4" were used. The LCA includes raw material recovery and energy generation, raw material transportation, the actual manufacturing phase of the products, use phase and recycling of the copper strips.

Scope of the Life Cycle Assessment

The use phase of the copper strips is divided into various areas of application. This involves applications for roofs, roof drainage and façades. In the End of Life phase, the material treatment of copper scraps was modelled, implying that copper scraps are thought to be a direct replacement for the primary copper cathode. Fusing the scraps is not necessary. The resulting credit in copper yielded, is calculated as a substitute for the primary copper production.

TECU® Copper strip /-sheet (bright rolled / surface treated)				
Parameter *	TECU® Classic Production	TECU® Oxide Production	TECU® Patina Production	Recycling-** potential
Primary energy, non-renewable	12.08	19.22	18.23	-2.30
Primary energy, renewable	1.27	1.41	1.59	-0.15
Global Warming Potential GWP100	0.81	1.35	1.20	-0.18
Ozone Depletion Potential ODP	$0.09 \cdot 10^{-6}$	$0.12 \cdot 10^{-6}$	$0.15 \cdot 10^{-6}$	$-0.03 \cdot 10^{-6}$
Acidification Potential AP	$2.82 \cdot 10^{-3}$	$6.60 \cdot 10^{-3}$	$3.53 \cdot 10^{-3}$	$-1.38 \cdot 10^{-3}$
Eutrophication Potential EP	$0.27 \cdot 10^{-3}$	$0.32 \cdot 10^{-3}$	$0.32 \cdot 10^{-3}$	$-0.14 \cdot 10^{-3}$
Summer smog Potential(POCP)	$0.22 \cdot 10^{-3}$	$0.28 \cdot 10^{-3}$	$0.27 \cdot 10^{-3}$	$-0.11 \cdot 10^{-3}$

Results of the Life Cycle Assessment

)* units of the individual impact categories analogue to table 2

)** Recycling potential applies respectively for all TECU® products listed in table 1

TECU® Copper strip (alloyed)					
Parameter	Unit per kg	TECU® Gold Production	TECU® Bronze Production	Recycling potential	
				Gold	Bronze
Primary energy, non-renewable	[MJ]	23.26	13.53	0.05	0.30
Primary energy, renewable	[MJ]	2.65	1.99	0.003	0.02
Global Warming Potential GWP100	[kg CO2-eqv.]	1.54	0.78	$3.5 \cdot 10^{-3}$	0.02
Ozone Depletion Potential ODP	[kg R11-eqv.]	$0.17 \cdot 10^{-6}$	$0.11 \cdot 10^{-6}$	$0.5 \cdot 10^{-9}$	$3.4 \cdot 10^{-9}$
Acidification Potential AP	[kg SO2-eqv.]	$3.79 \cdot 10^{-3}$	$1.54 \cdot 10^{-3}$	$28 \cdot 10^{-6}$	$1.8 \cdot 10^{-3}$
Eutrophication Potential EP	[kg PO4-eqv.]	$0.23 \cdot 10^{-3}$	$0.13 \cdot 10^{-3}$	$2.7 \cdot 10^{-6}$	$18 \cdot 10^{-6}$
Summer smog Potential(POCP)	[kg ethylene -eqv.]	$0.32 \cdot 10^{-3}$	$0.12 \cdot 10^{-3}$	$2.1 \cdot 10^{-6}$	$14 \cdot 10^{-6}$

Produced by: PE INTERNATIONAL, Leinfelden-Echterdingen



In addition, the following **evidence and verifications** are also described in the Environmental Product Declaration:

- Atmospheric corrosion and surface loss (washing away), measurement of the rates of corrosion and the washing away of copper ions due to precipitation over a test period of 5 years (1995 – 2000)
- Calculation model to predict copper washing away rates based on European environmental data (Period under observation 1980 – 2000)

Evidence and verifications



Product group: Construction Metals
 Declaration holder: KME Germany AG & Co. KG
 Declaration number: EPD-KME-2011313-E

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Scope of validity This Environmental Product Declaration applies to the building products of TECU® copper strip (bright rolled, surface-treated) and TECU® copper alloys from the KME Osnabrück Plant.

0 Product definition

Product definition The material TECU® copper consists in 100 mass-% of Cu-DHP according to DIN EN 1172, i.e. oxygen-free phosphorus de-oxidised copper with limited residual phosphorus. The degree of purity according to DIN EN 1976 "semi-finished product" is at least 99.90 % copper. The material is obtainable in 3 surface qualities: TECU® Classic sheets and strips, bright rolled metallic shiny; TECU® Patina sheets, green patina-coated on one side; TECU® Oxide sheets and strips, industrially pre-oxidised brown on both sides. In addition, TECU® Bronze sheets and strips are available with a copper and zinc alloy (TECU® Zinc (CuSn4)), along with TECU® Gold sheets and strips with an aluminium alloy (TECU® GOLD (CuAl5Sn5Fe)).

Range of application

- TECU® copper sheets and strips for roofing and wall cladding
- Roof drainage systems (roof gutters, pipes and equipment)

Product standard / approval DIN EN 1976, DIN EN 17933-16, DIN EN 1172, DIN EN 1652, DIN EN 612, DIN EN 1462, DIN EN 504, DIN EN 506

Quality control Control by the manufacturer, Total Quality Management (TQM), system approval in Lloyd's Register Quality Assurance according to DIN EN ISO 9001. Environmental Management according to DIN ISO 14001-2001.

Presentation, properties Table 1: **Material thickness and weight of different copper strips using TECU® Classic as an example**

TECU® sheets und TECU® strips	
material thickness	weight
0.6 mm	5.34 kg/m ²
0.7 mm	6.23 kg/m ²
1.0 mm	8.9 kg/m ²
1.2 mm	10.68 kg/m ²
1.5 mm	13.35 kg/m ²
2.0 mm	17.8 kg/m ²

TECU® copper strips (surface-treated) are available in the colours: bright rolled (metallic shiny) classic, matt brown typical-copper oxide-layer and as sheets with matt green typical copper patina.



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Presentation, properties

Table 4: Product Data: TECU® Oxide

Product data for material thicknesses 0.60 mm – 0.70 mm	
Standards of Width	Roof Cladding Quality TECU® Oxide ≤ 670 mm
Thickness tolerance	± 0.02 mm
Edge bow - measuring length 1m - measuring length 5m	< 0.2 mm/m < 1.0 mm
Surface evenness (wave height) - measuring length 1m	< 0.2 % of the wavelength
Technological values	DIN EN 1172 (R240 = medium hard) tensile strength (R _m): 255 - 285 N/mm ² yield point (R _{p0,2}): 180 - 235 N/mm ² fracture strain (A50): min. 8 %
Ring - inside - Ø	370 / 500 mm
Delivery format	strips
Mark	Acc. to EN 1172

Table 5: Product Data: TECU® Patina

Product Data for Material Thicknesses 0.60 mm – 1.50 mm		
Standards of Width	Roof Cladding Quality TECU® Patina	
	≤ 800 mm	> 800 mm to 1000 mm
Thickness tolerance	± 0.02 mm	
Edge bow - measuring length 1m - measuring length 5m	< 0.2 mm/m < 1.0 mm	< 0.3 mm/m < 2.0 mm
Surface evenness (wave height) - measuring length 1m	< 0.2 % of the wavelength	
Technological values	DIN EN 1172 (R240 = medium hard) tensile strength (R _m): 255-285 N/mm ² yield point (R _{p0,2}): 180-235 N/mm ² fracture strain (A50): min. 8 %	
Delivery format	sheets	
Mark	Acc. to EN 1172	



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Presentation, properties

Table 6: Product Data: TECU® Gold

Product data for material thicknesses 0.70 mm – 1.00 mm		
Standards of Width	Roof Cladding Quality TECU® Gold ≤ 670 mm	
Thickness tolerance	± 0.06 mm	± 0.07 mm
Edge bow - measuring length 1m - measuring length 5m	< 0.2 mm/m < 1.0 mm	
Surface evenness (wave height) - measuring length 1m	< 0.2 % of the wavelength	
Technological values	DIN EN 1652 R480 (spring hard) tensile strength (R _m): 450-560 N/mm ² yield point (R _{p0,2}): max. 300 N/mm ² fracture strain (A50): ≥ 40 % hardness (HV) 100 - 130	
Delivery format	Strips and sheets	
Mark	Acc. to DIN EN 1652	

Table 7: Product Data: TECU® Bronze

Product data for material thicknesses 0.60 mm – 1.50 mm		
Standards of Width	Roof Cladding Quality TECU® Bronze ≤ 670 mm	
Thickness tolerance	± 0.02 mm	
Edge bow - measuring length 1m - measuring length 5m	< 0.2 mm/m < 1.0 mm	
Surface evenness (wave height) - measuring length 1m	< 0.2 % of the wavelength	
Technological values	DIN EN 1652 (R290 = hard) tensile strength (R _m): 290 - 390 N/mm ² yield point (R _{p0,2}): max. 190 N/mm ² fracture strain (A50): ≥ 40 %	
Ring - inside - Ø	500 mm	
Delivery format	Strips and sheets	
Mark	Acc. to DIN EN 1652	



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1 Raw materials

Raw materials prime products The material TECU® copper consists in 100 mass-% of Cu-DHP according to DIN EN 1172, i.e. oxygen-free phosphorus de-oxidised copper with limited residual phosphorus. The degree of purity according to EN 1652 is 99.90 % copper.

Auxiliary substances / additives Substances (additives) that come into direct contact with the raw materials used or the building products to be manufactured during the entire production process, but which do not influence them.

- **Rolling oil-emulsion:** 0.544 g/kg Cu
highly refined mineral oil, organic esters, polyhydrocarbons, antioxidants which are used for cooling or lubrication during the rolling process. The rolling oil emulsion is biodegradable.
- **Benzotriazole:** 0.000642 mg/kg Cu
is used to temporarily protect the metal. It does not enter the wastewater during production.

Material explanation

- for the "Patinating" process of TECU® Patina:
In a mechanical-chemical-thermal process, a green Patina is created directly from the bright rolled copper surface. This process involves the use of an oxidising solution that creates basic copper salts and copper oxides within 6 – 8 weeks at defined climatic conditions in the plant.

- for the "Oxidising" process of TECU® Oxide:

The copper strips are cleansed of rolling oil and emulsion in a de-greasing process. In the following stage, they are subjected to a two-phase oxidation process.

- TECU® Bronze is an alloy made from copper and zinc of CuSn4 quality.
- TECU® Gold is an alloy made from copper and aluminium of CuAl5 quality.

Raw material extraction and origin The copper ores are mainly mined in the following areas: Europe (Poland, Turkey), Asia (Indonesia), North America, South America (Argentina, Chile, and Peru). The copper mining from sulphured ores involves the following steps:

The copper content in the ore is usually reduced to a concentration of 25 – 30 % using flotation.

Smelting the concentrate to a sulphur smelter using the flash smelting technology, a state-of-the-art process: part of the sulphur and iron contained in the concentrate is oxidised through aeration and thereby a sulphur smelter is extracted with a copper content of 65–70%. The process air produced contains high levels of sulphur-dioxide.

This is cooled down and cleansed of any dust. The sulphur dioxide is reclaimed in the form of a sulphuric acid using a sulphuric acid facility.

Conversion / cleansing of the sulphur smelter and of the recycling copper to melted raw copper in the Pierce-Smith converter: here, the iron and sulphur are extracted from the smelter. The resulting raw copper shows copper levels of 99 %. Fire-refining of the raw copper in anode-ovens: by adding oxygen, the sulphur content is reduced to approx. 0.001 %, the resulting copper oxide is again reduced to metal with a very low oxygen content of 0.15 % using propane gas-reduction. Finally, the copper is poured into anodes.

Local and general availability of raw materials There is on average approx. 0.006 % copper in the earth's crust; all soils contain small amounts of copper – in its metallic form, as an element of minerals, or as a component of various chemical compounds. Copper occurs in pure metallic form in the Ural mountains and in the USA on the Upper Lake and in New Mexico. The most significant copper mining areas include this lake region in North America and the



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South West of the USA, Zambia, and the southern part of the African continent, the west coast of South America (mainly Chile and Peru) and Mexico. Furthermore, the copper mines of Kazakhstan and Uzbekistan. Australia, China, Indonesia, Papua New Guinea and the Philippines also have stocks worth mentioning.

In Europe, there remain only the copper deposits in Poland and Turkey that are of any economic importance. In Germany – for example in the Mansfelder countryside – there were only small quantities of copper, and these deposits have either been exhausted or can no longer be mined in terms of economic efficiency. Once source of copper as a raw material which is increasing in importance is the return of the metal using specific separation processes – basically a common practice for thousands of years, relatively easy to carry out based on the easy refundability of copper. The raw material copper is available anywhere, as copper is traded on the “London Metal Exchange”. The reserves that have been developed will suffice for several decades and there is still the potential to develop new resources. The raw materials used are limited in their availability. The copper reserves that can economically be mined using today’s technology are currently estimated to contain approx. 320 m tons worldwide. The reuse or recycling potential of copper is 100 % which helps conserve resources.



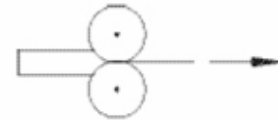
2 Manufacturing the building product

Manufacturing the building product

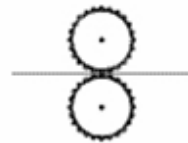
Structure of the manufacturing process:

The manufacturing process consists of 12 steps:

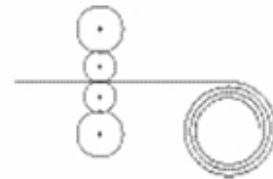
- Pouring: the highly pure Cu-DHP is poured into slabs, i.e. extruded blocks.
- Warming up: the slabs are heated in a furnace to a hot-roll temperature of approx. 900°C.
- Hot-rolling: on a roll stand with a top and bottom roller (reversing duo) the copper is roughed down in several passes i.e. the thickness is reduced by decreasing the gap between the rollers, e.g. to a thickness of approx. 13 mm.
- Milling: the thermal oxidation due to the high temperatures in warming up and hot-rolling causes a scale to form on the surface of the copper, which is removed by milling before the metal is subjected to any other surfaces. In this process, several tenths of millimetres are removed from each side.
- Cold roughing down: on a reverse quartet (four high stand), the copper band is then cold roughed down with more passes, thereby becoming more solid as it becomes reshaped.
- Intermediate annealing: therefore, before further processing, the copper is subjected to heat treatment involving intermediate annealing, causing a targeted loss of cohesion in the copper. This process is carried out in a protected atmosphere to prevent a renewed thermal oxidation of the surface.
- Finish rolling: the final thickness of the material, for TECU® copper strips and sheets mostly 0.6 or 0.7 mm and the desired stability, here usually R-240 (see page 3, "Mechanical properties of Cu-DHP") are achieved in the stability or condition rolling process.
- Stretcher levelling: on a stretch-levelling plant, the tolerances with regard to linearity and surface evenness are reduced even further.
- Separating: the resulting large coils can be split into narrower strips lengthwise. They can also be cut into smaller coils or sheets widthwise using squaring shears.
- "Patina-coating": TECU® Patina-sheets are industrially patina-coated green on one side with a specifically developed mechanical-chemical-thermal process. This process creates a layer of basic copper chlorides and copper oxides from the copper – a process comparable with the natural patina-formation resulting from atmospheric factors over a long period of



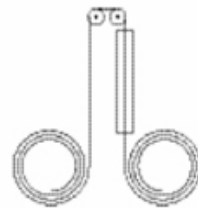
1. Hot rolling



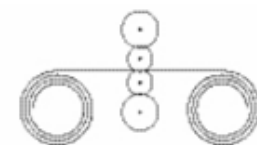
2. Milling



3. Cold roughing down



4. Intermediate annealing



5. Finish rolling





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time. TECU® Patina corresponds to the patina that naturally occurs on shiny copper under weathering in the atmosphere in terms of durability and behaviour. It is just as hazardous to health or the environment as copper itself. The surface of TECU® Patina consists of basic copper salts.

- Patina is sometimes wrongly referred to as “verdigris” in slang. However, verdigris is actually a reaction product of copper metal and acetic acid with the chemical formula $\text{Cu}(\text{OOC-CH}_3)_2$.
- “Oxidation”: TECU® Oxide sheets and strips are industrially oxidised brown on both sides in a thermal-chemical process. This process results in a layer of copper oxides from the copper. This is comparable to the natural brown oxide layer resulting from a reaction to atmospheric influences.

Health protection production Beyond the legally binding job safety regulations required for industrial plants, no additional protective devices for health protection are required for the manufacturing process.

Packaging Packaging materials used:

- Taut ribbon: PP/Polyester
- Disposable / reusable pallets, wood
- Cardboard boxes, cardboard / paper
- Plastic film (polyethylene foil (LDPE))

With regards to transport, packaging and storage, no special demands over and above the normal due care and attention are placed on TECU® Classic and TECU® Oxide.

The TECU® copper alloys are delivered with one side covered with foil.

Mechanical damage and scratches to the surface should be avoided. TECU® Patina-sheets must be transported in original packaging units and stored in a dry place. Once individual sheets have been removed from the packaging unit, it must be closed again immediately.

Detailed information on transport, packaging and storage can be found in the KME-information leaflets.

- Environmental protection production**
- **Air:** By means of adequate reduction of emissions (filter plants), the air is purified to below the limit values required by law (TA Luft).
 - **Water/soil:** No additional impact on water or soil occurs. The cooling of the casting process is based on a closed water circuit. The wastewater produced by the etching plant is cleaned in a neutralisation plant and discharged into the city sewage system after daily analysis and provision of retention samples.
 - **Noise:** Due to adequate acoustical absorption devices, measurements of sound levels have shown that all values inside and outside the production plant are far below the limits required by public law.



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3 Working with the building product

Processing recommendations

Basic principles:

- During transportation and storage, store (in the original packaging at room temperature) in a dry place.
- During temperatures below 0°, before opening the packaging units, first allow them to warm up to room temperature.
- Material can be processed tension-free.
- When installing and working with the building material, changes in length due to temperature conditions should be taken into account.
- Limiting processing temperatures: none (re-crystallisation level 180°C)
- Copper alloys can be used in all atmospheres apart from areas with a high ammonia concentration in the air.
- Detailed information on working with the material, such as mounting methods, deformation and joining techniques can be found in the corresponding information leaflets of KME Germany AG.

Combining copper and copper alloys with other metals:

Because of its position on the positive side of the electrochemical series, copper is not endangered by other metals. However, if it is wrongly combined with other metals, these could in turn be endangered by copper. Basically, any combination of copper and stainless steel (material numbers 1.4301, 1.4401 and 1.4571) or lead is safe.

A combination of copper and aluminium is safe if the aluminium has an electrically non-conductive surface achieved through coating or anodising, so that copper-containing water cannot form an electrochemical element with the aluminium. However, direct contact between the two metals should be avoided by installing a gap or an interim layer of non-conductive substances.

Installing copper construction parts above zinc or zinc-plated steel should be avoided, because if any copper ions enter running rainwater, this can lead to the formation of elements on the zinc and therefore to its more rapid destruction.

Combination of copper with other construction materials:

Copper has a good resistance to alkaline construction materials such as lime, cement, concrete etc. In the event of an unfavourable arrangement of constructional parts, some surface discolouring can occasionally occur. Draining unprotected bitumen surfaces above copper is a constructional error. The highly acidic bitumen degradation products that are caused by the effects of UV radiation, can attack copper.

Job safety

Means to protect health and maintain job safety:

When working with or installing TECU® products, no additional means to protect health are required beyond the job safety measures required by public law (e.g. protective gloves).

Environmental protection

Means to protect the environment:

No substantial environmental impacts occur when working with or installing these products. No special measures are necessary for the protection of the environment.

Residual material

Residual material and packaging:

Residual materials and packaging from TECU® products on the building site should be collected separately. When utilising these materials, the regulations of the local waste management authority and the information contained in Item 6 "Building product information" should be complied with.



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4 Building product in use

Constituents

TECU® copper is Cu-DHP, oxygen-free phosphorous-deoxidised copper with a limited quantity of residual phosphorous. The constituents correspond to the basic substances named in Item 1. The changes in colour of the surface are caused by:

Formation of an oxide layer: the effects of air constituents and moisture create an adherent, resistant protective layer on the originally smooth metallic surface. The initial copper (I) oxide tarnish that forms within a few hours is very thin (approx. 2 – 4 µm) and hardly visible, but it causes a marked stabilisation of the surface with regard to its resistance to the changing effects of the atmosphere (weathering).

Brown oxide layer: Further weathering causes the oxide layer to gradually grow; the thicker and denser it gets, the slower this growth becomes. The effects of air contamination and especially sulphuric dioxide (SO₂), cause a gradual conversion of the copper oxide layers into basic copper sulphate. This is accompanied by a gradual bathochromatic shift from brown-black to anthracite. At times, changes in colour can also adopt other typical copper colour tones.

Green Patina: depending on the building geometry, the effects of rainwater and the associated increase in the formation of basic copper compounds cause the formation of the green patina that is typical for copper.

If TECU® products with a pre-oxidised or pre-patinated surface (TECU® Oxide, TECU® Patina) are subjected to weathering; copper compounds also form in the above-described manner.

Long term durability

Durability: TECU® copper is UV-resistant and does not rot. It is resistant to defrost water (hot water corrosion), to a rust film and to most of the chemical substances used in building construction. As rain begins, copper can be washed away in soluble or insoluble form. The rates of copper elutriation under atmospheric weathering are between 0.7 g/m²*a and 1,3g/m²*a. This means the lifespan of copper roof cladding is > 250 years.

Environment - health effects

Health aspects:

There will be no affects to health if the TECU® products are used according to their designated function.

Environmental aspects:

When TECU® products are used as intended there is no hazard for water, air/ atmosphere or soil. Copper is a natural constituent of our soil and surface water and as such, is integrated into a large number of natural cycles depending on its bioavailability (natural copper concentration: soil: 3 - 120 mg/kg; plants: 0.01 - 70 mg/kg).

Corrosion and washing away rate in rain water flowing over TECU® products:

The surface of copper corrodes under the influence of the atmosphere. Some of the products of this corrosion are washed away by rainwater. The corrosion process is especially dependent on the SO₂-concentration in the air ("acid rain"). Due to the decrease in SO₂ concentration in the air over the last 10 years, a reduction in the rates of corrosion has been observed to less than a fifth of the previous values. This reduction is likely to continue. Consequently, copper washing away rates will also fall even further in the future (Wallinder 2007).

Injection of zinc into running waters:

Besides the naturally occurring, geologically-related copper content in water, widely-distributed anthropogenic sources add their share too. There is no evidence to suggest that precipitation water running off TECU® copper roofs into flowing waters poses any violation of the general quality requirements for flowing waters.

In bodies of water, copper gets embedded in the sediment. The water in natural bodies of water only releases as much copper as is required by the water organisms, provided there is enough copper present. A natural balance is created. The deciding factor is the bonding form of the copper which determines its bioavailability.



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Seepage into soil:

Due to the drainage of rainwater from TECU® copper roofs, there may at localised points, be slightly high levels of copper in technical drainage facilities (troughs, infiltration ditches, and soakaways). However, any excess supply of copper from these facilities does not pose any danger to soil / plants / animals or for the groundwater. The deciding factor is the bonding form of the copper which determines its bioavailability.

5 Singular effects

Fire

Fire performance:

The TECU® products comply with DIN 4102, Part 1 the Requirements of Building Material Class A1 “non-combustible”.

Smoke production/smoke concentration:

No smoke develops. A small amount of smoke can only develop with TECU® Patina products if the temperature exceeds approx. 400°C.

Toxicity of the fumes:

When patina decomposes, from approx. 440°C water vapour and small quantities of HCl are released. The resulting Cu(I)Cl melts at approx. 400°C.

Change of state (burning drip down/drop-out):

The melting point is + 1083 °C.

Water

Water impact:

See indications given under item 4 “Building product in use” as well as under item 7.1. “Evidence: metal inputs via seepage”.

Mechanical corrosion

Not environmentally relevant for metal sheets.

6 End of life phase

General

The process and new scrap materials that occur in the manufacture and processing of TECU® products are entirely fed back into the production process.

Disassembly

When renovating or disassembling a building, TECU® products can easily be collected, unmixed.

Circulation

The process and new scrap materials that occur in the manufacture and processing of TECU® products are entirely fed back into the production process. Separated waste occurring on the construction site and old scrap is collected and sold to secondary smelting companies either directly or via scrap metal dealers. The return rate of this construction waste is almost 100 %. As opposed to many other recycling materials, copper scrap is characterised by its very high value. The scrap can be processed into new building products with relatively little expenditure and energy. Energy savings as a result of copper extraction from recycled material is 80 - 92 % compared to primary metal production.

Disposal

Due to the effective recycling process, no copper from roof cladding or roof drainage systems has to be disposed of.

The packaging materials that are used – paper / cardboard, polyethylene (PE film), polypropylene (PP film) and steel can be recycled. If collected separately, they can be returned via INTERSEROH (INTERSEROH- Certificate Contract no. 25945); packaging is collected from its point of origin in returnable containers, taking statutory regulations into account. The returnable wooden and steel pallets are returned and re-funded (deposit system).



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7 Life cycle assessment

7.1 Production of copper strips

Declared unit	The declared unit is the production and recycling of one kg copper sheet (bright rolled).
System boundaries	<p>The life cycle analysis for the production of the copper strips comprises the life cycle phases from “cradle to gate”. It begins with the consideration of the ore mining and the processing to copper. The manufacture of the other raw and auxiliary materials is also included. The production of the sheets is included in the analysis.</p> <p>The use phase exclusively refers to the copper washing away for use in roofing and wall claddings, and in roof drainage systems.</p> <p>The system boundaries for the end of life phase refer to the life cycle phase material recycling, i.e. the processing of copper scraps. It is assumed that copper scraps are a direct replacement for the primary copper cathode. Fusing the scraps is not necessary.</p>
Cut-off criteria	<p>All material flows that enter the system and are over 1 % of their entire mass or contribute more than 1 % to the primary energy consumption, were taken into consideration on the input page.</p> <p>All material flows that exit the system and whose environmental impact makes up more than 1 % of the total impact in an impact category considered, are covered on the output page.</p>
Transports	Transportation in the prechain will be taken into account, if relevant. Transportation to the building site will not be considered.
Period under consideration	The base data for this Life Cycle Assessment (LCA) are based on the data acquisitions from 2005.
Background data	In order to model the life cycle for the production and recycling of the copper strips, the GaBi 4 software system developed by PE International was used /GaBi 4/. All relevant background data necessary for the production of copper strips were taken from the software GaBi 4 or were made available by the German Copper Institute (DKI).
Data quality	All data used are less than five years old.
Allocation	<p>In this product system, the following allocation is made:</p> <p>The allocation of sulphuric acids is carried out based on the price of the products created, copper cathodes and sulphuric acids.</p> <p>The recycling potential was calculated according to the requirement of the IBU PCR document “Construction Metals”.</p> <p>It describes the ecological value of a material’s “accumulation” in the “technosphere”. It states how many environmental burdens may be avoided in relation to a new production of the material (here, the avoidance of primary copper production). For this purpose, a collection rate of 99% is assumed. This value is taken from KME sources. Taking into account this collection rate and today’s technologies in metal recycling, one kilogram of copper strip is calculated to contain 8 % primary copper. Since the recycling potential represents a saving in the manufacturing of the product, it is composed of a complete dataset with several variables. If the complete recycling potential is exploited, the values for production are reduced by the values for the recycling potential. This demonstrates the life cycle view and is shown in the result tables as “Sum of production and recycling potential”.</p>
Indication to use phase	The lifetime of building products depends on the respective construction, use, service and maintenance.



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For the calculation of the copper washing away of a typical use phase, the application areas have to be considered separately (roof drainage, roofing, wall claddings); for cuttings, wetted surface and service lives, typical assumptions have to be made.

Table 8: Washing away of copper in specific applications of copper strips

	Roof drainage	Roofing	Wall claddings
Average sheet thickness (mm)	0.65	0.63	0.767
Gross density copper (g/cm ³)	8.9	8.9	8.9
Wetted surfaces (%)	50	75	10
max. weathering factor (g/m ² x a)	1.3	1.3	1.3
min. weathering factor (g/m ² x a)	0.7	0.7	0.7
max. Cu- washing away (g/kg x a)	0.112	0.174	0.019
min. Cu- washing away (g/kg x a)	0.060	0.094	0.010

Only the material-specific part of the use phase (washing away of copper) is described in this declaration.

7.2 Treatment (Recycling / re-melting / landfilling) of copper strips

Choice of treatment method

In addition to the manufacturing, the collection of the copper strips was also modelled. A collection rate of 99% was assumed. The amount of copper scrap that is available for the end-of-life recycling after the scrap required for production has been subtracted is credited.

Credits

The credit for the copper left-over is calculated with the dataset of the primary copper-cathode production.

7.3 Description of the balances and analyses

Life Cycle Inventory (LCI)

In the following chapters, the life cycle inventory analysis is interpreted in terms of primary energy consumption and waste.

Primary energy use

The following figures 1 and 2 depict the energy consumption for the production of 1 kg of copper strip.

With bright rolled and surface-treated sheets, the consumption of non-renewable energy for the manufacturing of sheets is between 12 MJ and 20 MJ per kg. 67 – 77 % of this comes from the production. The raw materials consume 20 – 30 % of the non-renewable energy used. The non-renewable energy used up by packaging is marginal. In addition, between 1.2 MJ and 1.5 MJ of renewable energy is used up for the production of 1 kg of copper strip. The largest part of this is required to manufacture the copper cathodes.



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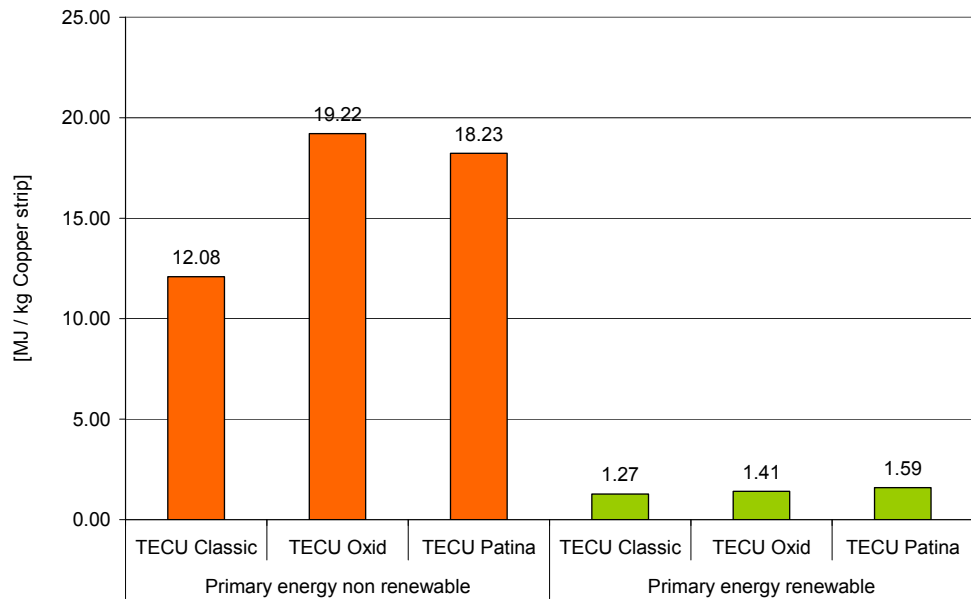


Figure 1: Use of primary energy sources in MJ/kg copper strip (bright rolled / surface-treated)

With alloyed sheets, the non-renewable energy consumption for the sheet production is between 13 MJ and 24 MJ per kg. Between 71 % and 89 % of this comes from production. The raw materials consume 11 – 29 % of the non-renewable energy used. The non-renewable energy used up by packaging is marginal.

In addition, approx. 2 MJ of renewable energy is used up for the production of 1 kg of copper strip.

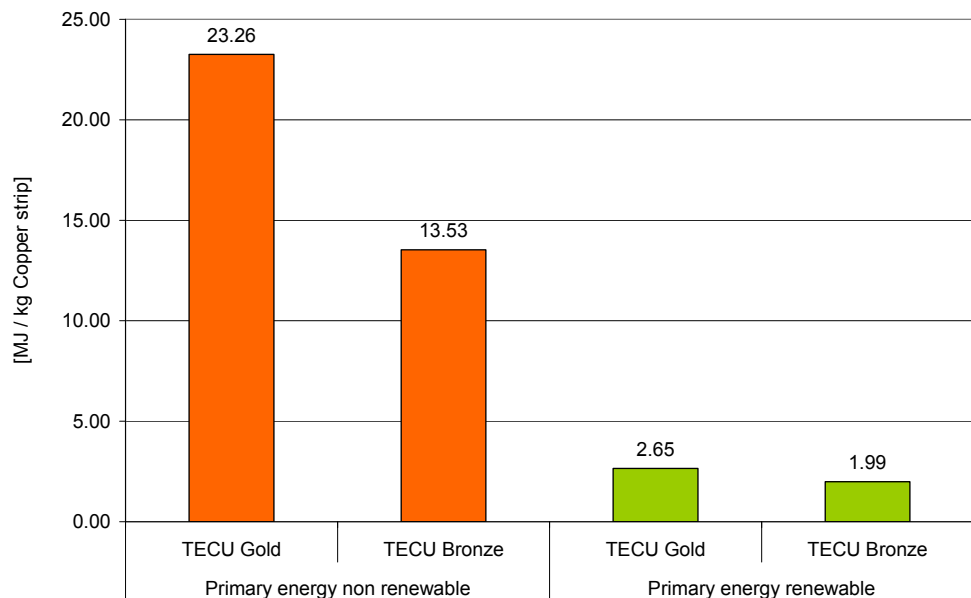


Figure 2: Use of primary energy sources in MJ/kg copper strip (alloyed)

Closer examination of the energy required to produce 1 kg of copper strip, as shown in figure 3, shows that natural gas is used as a significant primary energy source. The relatively high uranium part of the primary energy consumption is mainly due to the



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electricity used to produce copper strip, which is obtained from a mix of electricity, including atomic energy.

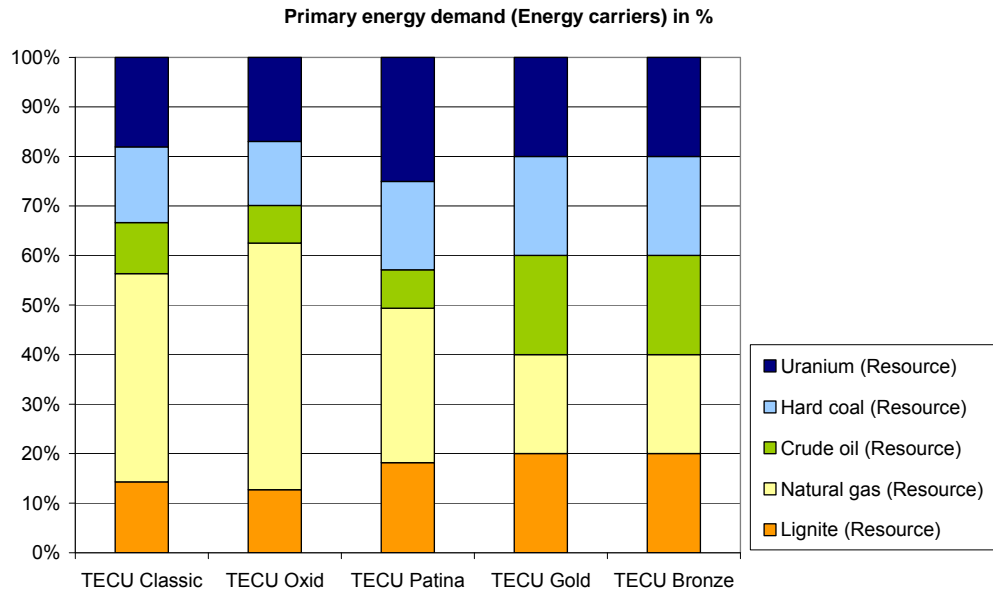


Figure 3: Breakdown of the use of renewable and non-renewable primary energy for the production of 1 kg copper strip

The recycling potential of primary copper is 2.5 MJ of primary energy for all 3 surface-treated copper strips. Figure 4 illustrates the breakdown of the renewable and non-renewable part of the recycling potential in comparison to the expenditure for the production of the bright rolled / surface-treated copper strips.

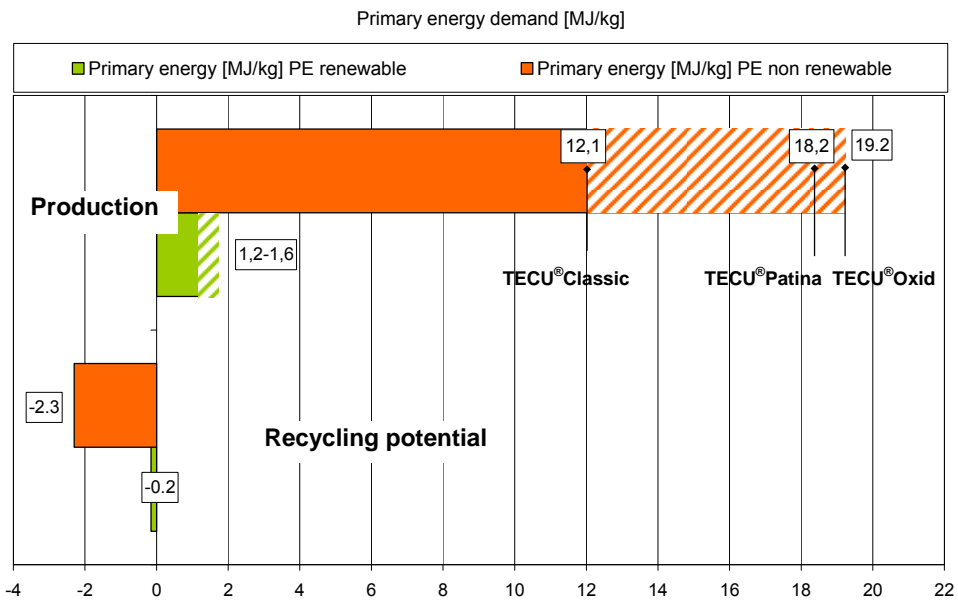


Figure 4: Balance for the primary energy consumption of 1 kg copper strip (production and recycling potential)

There is no recycling potential for alloyed copper strip. The quantity of scrap copper accumulated for collection once the use phase is over is not enough to produce the sheets.



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Waste

The assessment of the waste produced is presented separately for the three fractions: overburden/stockpile dump (containing ore processing residues), municipal waste (containing household rubbish and commercial waste), and hazardous waste including radioactive waste (see Table 9 to Table 13).

The stockpile dump represents the largest amount of the **overburden**. The stockpile dump is mainly attributed to the electricity generation (extraction of coal). Ore processing residues accrue from the extraction and processing of the ore concentrates.

The most important influencing parameter for the **municipal waste** (domestic and commercial waste) is the emulsion waste from the rolling processes. All the other parameters are of minor importance.

Hazardous waste consists mainly of waste from preliminary processes, above all from the production of copper cathodes and from the prechains for power production. The radioactive waste is purely a result of the consumption of electricity (nuclear power).

The following table shows the waste quantities for 1 kg of copper strip throughout the entire life cycle (production and resulting credit from the use of scrap copper). In the column "sum of production and recycling potential", the recycling potential is calculated from the sum of the production and credit.

Table 9: Waste quantities throughout the entire life cycle for 1 kg of copper strip TECU® Classic

Copper strip TECU® Classic			
Parameter	Production and Recycling potential [kg / kg Cu-sheet]	Waste from production [kg / kg copper strip]	credit [kg / kg copper strip]
overburden/stockpile dump	3.21	14.01	-10.80
municipal waste	0.05	$51.7 \cdot 10^{-3}$	$-0.3 \cdot 10^{-3}$
hazardous waste	$1.9 \cdot 10^{-3}$	$3.1 \cdot 10^{-3}$	$-1.2 \cdot 10^{-3}$

Table 10: Waste quantities throughout the entire life cycle for 1 kg of copper strip TECU® Oxide

Copper strip TECU® Oxid			
Parameter	Production and Recycling potential [kg / kg Cu-sheet]	Waste from production [kg / kg copper strip]	credit [kg / kg copper strip]
overburden/stockpile dump	4.14	14.86	-10.72
municipal waste	0.05	$51.5 \cdot 10^{-3}$	$-0.3 \cdot 10^{-3}$
hazardous waste	$2.8 \cdot 10^{-3}$	$4.1 \cdot 10^{-3}$	$-1.2 \cdot 10^{-3}$



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Wastes

Table 11: Waste quantities throughout the entire life cycle for 1 kg of copper sheet TECU® Patina

Copper sheet TECU® Patina			
Parameter	Production and Recycling potential [kg / kg Cu-sheet]	Waste from production [kg / kg copper strip]	credit [kg / kg copper strip]
overburden/stockpile dump	5.67	16.47	-10.80
municipal waste	0.05	$51.8 \cdot 10^{-3}$	$-0.3 \cdot 10^{-3}$
hazardous waste	$6.5 \cdot 10^{-3}$	$7.7 \cdot 10^{-3}$	$-1.2 \cdot 10^{-3}$

Table 12: Waste quantities throughout the entire life cycle for 1 kg of copper strip TECU® Gold

Copper strip TECU® Gold			
Parameter	Production and Recycling potential [kg / kg Cu-sheet]	Waste from production [kg / kg copper strip]	Credit)* [kg / kg copper strip]
overburden/stockpile dump	8.10	6.67	1.43
municipal waste	$52.6 \cdot 10^{-3}$	$52.6 \cdot 10^{-3}$	$38.3 \cdot 10^{-6}$
hazardous waste	$6.1 \cdot 10^{-3}$	$5.96 \cdot 10^{-3}$	$0.2 \cdot 10^{-3}$

)* since the use of primary copper cathodes was necessary, there is no reduction in the burden for either of the alloy products.

Table 13: Waste quantities throughout the entire life cycle for 1 kg of copper strip TECU® Bronze

Copper strip TECU® Bronze			
Parameter	Production and Recycling potential [kg / kg Cu-sheet]	Waste from production [kg / kg copper strip]	Credit)* [kg / kg copper strip]
overburden/stockpile dump	5.02	3.88	1.14
municipal waste	0.05	0.05	$30.4 \cdot 10^{-6}$
hazardous waste	$6.1 \cdot 10^{-3}$	$6.0 \cdot 10^{-3}$	$0.1 \cdot 10^{-3}$

)* since the use of primary copper cathodes was necessary, there is no reduction in the burden for either of the alloy products.



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Impact Assessment

Table 14 to Table 16 show the contributions of the production and treatment of bright rolled / surface-treated copper strips to the impact categories global warming potential, ozone depletion potential, acidification potential, eutrophication potential and photochemical ozone creation potential

Table 14: Results of the impact assessment for production and end of life for 1 kg of copper strip TECU® Classic

Copper strip TECU® Classic				
Parameter	Unit per kg	Sum of production and recycling	Production	Recycling potential
Global warming potential	[kg CO ₂ -eqv.]	0.66	0.85	-0.21
Ozone depletion potential	[kg R11-eqv.]	0.06 · 10⁻⁶	0.09 · 10 ⁻⁶	-0.03 · 10 ⁻⁶
Acidification potential	[kg SO ₂ -eqv.]	1.18 · 10⁻³	2.82 · 10 ⁻³	-1.64 · 10 ⁻³
Eutrophication potential	[kg PO ₄ -eqv.]	0.10 · 10⁻³	0.27 · 10 ⁻³	-0.17 · 10 ⁻³
Photochemical Ozone Creation Potential	[kg Ethene-eqv.]	0.09 · 10⁻³	0.22 · 10 ⁻³	-0.13 · 10 ⁻³

Table 15: Results of the impact assessment for production and end of life for 1 kg of copper strip TECU® Oxide

Copper strip TECU® Oxide				
Parameter	Unit per kg	Sum of production and recycling	Production	Recycling potential
Global warming potential	[kg CO ₂ -eqv.]	1.19	1.35	-0.21
Ozone depletion potential	[kg R11-eqv.]	0.08 · 10⁻⁶	0.12 · 10 ⁻⁶	-0.03 · 10 ⁻⁶
Acidification potential	[kg SO ₂ -eqv.]	4.97 · 10⁻³	6.60 · 10 ⁻³	-1.64 · 10 ⁻³
Eutrophication potential	[kg PO ₄ -eqv.]	0.15 · 10⁻³	0.32 · 10 ⁻³	-0.17 · 10 ⁻³
Photochemical Ozone Creation Potential	[kg Ethene-eqv.]	0.15 · 10⁻³	0.28 · 10 ⁻³	-0.13 · 10 ⁻³

Table 16: Results of the impact assessment for production and end of life for 1 kg of copper sheet TECU® Patina

Copper sheet TECU® Patina				
Parameter	Unit per kg	Sum of production and recycling	Production	Recycling potential
Global warming potential	[kg CO ₂ -eqv.]	1.03	1.20	-0.21
Ozone depletion potential	[kg R11-eqv.]	0.12 · 10⁻⁶	0.15 · 10 ⁻⁶	-0.03 · 10 ⁻⁶
Acidification potential	[kg SO ₂ -eqv.]	1.89 · 10⁻³	3.53 · 10 ⁻³	-1.64 · 10 ⁻³
Eutrophication potential	[kg PO ₄ -eqv.]	0.15 · 10⁻³	0.32 · 10 ⁻³	-0.17 · 10 ⁻³
Photochemical Ozone Creation Potential	[kg Ethene-eqv.]	0.14 · 10⁻³	0.27 · 10 ⁻³	-0.13 · 10 ⁻³



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Impact Assessment

Altogether, if the credit is included, there is a GWP of 0.64 kg CO₂-eqv. for the entire life cycle of one kg of TECU® Classic copper strip, 1.9 kg CO₂-ev. for TECU® Oxide, and 1.03 kg CO₂-eqv. for the entire life cycle of one kg of TECU® Patina. The emission of greenhouse gases is mainly a result of the generation of electricity and thermal energy.

The GWP is reduced by the bond of CO₂ in the charcoal to cover up the casting implements and in the wooden palettes.

Electricity generation and the manufacture of copper cathodes contribute the most to the ozone depletion potential. The manufacture of copper cathodes also makes the production phase's biggest contribution towards the eutrophication potential.

Both the manufacture of copper cathodes and the generation of electricity and thermal energy contribute to the acidification potential and photochemical ozone creation potential

A dataset from the German Copper Institute was used for the primary copper cathodes to obtain the credit. The proportion of recycling potential does not lead to a total credit for the complete life cycle in any of the impact categories assessed.

Table 17 and Table 18 show the contributions of the production and treatment phases to the impact categories.

Table 17: Results of the impact assessment for production and end of life for 1 kg of copper strip TECU® Gold

Copper strip TECU® Gold				
Parameter	Unit per kg	Sum of production and recycling	Production	Recycling potential
Global Warming potential	[kg CO ₂ -eqv.]	1.54	1.54	3.5 · 10 ⁻³
Ozone depletion potential	[kg R11-eqv.]	0.17 · 10⁻⁶	0.17 · 10 ⁻⁶	0.5 · 10 ⁻⁹
Acidification potential	[kg SO ₂ -eqv.]	3.82 · 10⁻³	3.79 · 10 ⁻³	28 · 10 ⁻⁶
Eutrophication potential	[kg PO ₄ -eqv.]	0.23 · 10⁻³	0.23 · 10 ⁻³	2.7 · 10 ⁻⁶
Photochemical Ozone Creation Potential	[kg Ethene-eqv.]	0.32 · 10⁻³	0.32 · 10 ⁻³	2.1 · 10 ⁻⁶

Table 18: Results of the impact assessment for production and end of life for 1 kg of copper strip TECU® Bronze

Copper strip TECU® Bronze				
Parameter	Unit per kg	Sum of production and recycling	Production	Recycling potential
Global Warming potential	[kg CO ₂ -eqv.]	0.80	0.78	23 · 10 ⁻³
Ozone depletion potential	[kg R11-eqv.]	0.11 · 10⁻⁶	0.11 · 10 ⁻⁶	3.4 · 10 ⁻⁹
Acidification potential	[kg SO ₂ -eqv.]	3.34 · 10⁻³	1.54 · 10 ⁻³	1.8 · 10 ⁻³
Eutrophication potential	[kg PO ₄ -eqv.]	0.15 · 10⁻³	0.13 · 10 ⁻³	18 · 10 ⁻⁶
Photochemical Ozone Creation Potential	[kg Ethene-eqv.]	0.13 · 10⁻³	0.12 · 10 ⁻³	14 · 10 ⁻⁶



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Electricity generation makes a significant contribution to the environmental impact in all impact categories and for both products. Thermal energy from natural gas and zinc production also make small contributions to the acidification, eutrophication and photochemical ozone creation potentials. The reason behind the almost doubled environmental impact of TECU® Gold compared to TECU® Bronze is the environmental burdens caused by aluminium production. Their contribution to the impact categories acidification potential and photochemical ozone potential is approx. 45 %.

8 Evidence

8.1 Washing away rates

Test set-up: testing period 1995 – 2000, test location Dübendorf, Switzerland, TECU® Classic and TECU® Patina, sheet thickness 0.7mm, surface 0.5m², roof inclination 45°, facing south.

Test Laboratory: EMPA, Swiss Federal Corrosion / Surface Protection dept., Dr. Faller

Results: over a testing period of 5 years, a washing away rate of 1.3 g/m² a was determined for TECU® Classic. The copper sheets pre-coated with patina proved to have the same values. As the patina forms, the corrosion rates regress continuously and stagnate at a low level. With some rains, an increased initial concentration in the first flush was identified.

Publication: see chapter 10 References

Calculation model for Copper Washing Away Rates:

Based on open air and laboratory data on the washing away of copper, a formula has been developed with which the washing away rate can be calculated for a 50 km² grid in Europe. The significant parameters for this formula comprise the SO₂-concentration, the pH-value of the rain, the amount of rainfall and the inclination of the roof altogether. For further information on the calculation model please see reference /Faller 2001/.

The washing away rate decreased by 57 % for the period of observation from 1980 – 2000.

Pulication: see chapter 10 References

9 PCR document and verification

This Declaration is based on the PCR-document “Construction Metals 2004-11”.

Review of the PCR document by the independent Advisory Board (SVA). Chair of the SVA: Prof. Dr.-Ing. Hans-Wolf-Reinhardt (University Stuttgart, IWB).
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Independent verification of the declaration according to ISO 14025:

<input type="checkbox"/> internal <input checked="" type="checkbox"/> external
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Validation of the declaration: Dr. Eva Schmincke
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