www.bre.co.uk

BRE Client Report

Life Cycle Assessment of Lapitec Sintered Stone Slab

Prepared for: Beatrice Giunta, Lapitec SpA

Date: 25 10 2018

Report Number: Q100042-1000 Issue: 1

BRE
Watford, Herts
WD25 9XX

Customer Services 0333 321 8811

From outside the UK:
T + 44 (0) 1923 664000
F + 44 (0) 1923 664010
E enquiries@bre.co.uk
www.bre.co.uk

Prepared for:
Beatrice Giunta
Lapitec SpA
Via Bassanese 6
31050 Vedelago TV
Italy

Prepared by

Name Fei Zhang

Position Consultant

Date 16th October 2018

Signature

Authorised by

Name Kim Allbury

Position Technical Manager

Date 25.10.2018

Signature K. Allbury

Executive Summary

Lapitec SpA commissioned BRE to undertake a Life Cycle Assessment (LCA) study of their sintered stone slabs and to produce a BRE Global EN type III environmental product declaration (EPD) according to the requirements of EN 15804. The EPD generated is to be verified under the BRE Global EN 15804 verified EPD scheme.

The requirements of this project were outlined in the BRE Proposal Ref.: QUO-01479-S0Q4X9

This is a cradle to gate LCA study for Lapitec sintered stone slabs covering the following information modules: A1 to A3 modules for the production stage, and this background report contains the data, assumptions, calculations, LCA results and interpretation of results.

The findings from the study show that the upstream production of the Italian grid electricity mix used at the Lapitec SpA site is by far the highest contributor across the impact categories analysed in Section 6 of this report.

In terms of raw materials, the iron oxide pigments and the frit obtain the highest values in the impact categories.

After electricity from the Italian grid, transport of raw materials and packaging to site is the next highest non-material contributor in each impact category.

Table of Contents

Abbreviations in Report

ADPE	Abiotic Depletion Potential – Elements
ADPF	Abiotic Depletion Potential – Fossil Fuels
AP	Acidification Potential for Soil and Water
CRU	Components for reuse
EE	Export energy
EP	Eutrophication Potential
EPD	Environmental Product Declaration
FW	Net use of fresh water
GWP	Global Warming Potential (Climate Change)
HWD	Hazardous waste disposed
LCA	Life Cycle Assessment
LCI	Life Cycle Inventory
LCIA	Life Cycle Impact Assessment
MER	Materials for energy recovery
MFR	Materials for recycling
MND	Module Not Declared
NHWD	Non-hazardous waste disposed
NMVOC	Non-methane volatile organic compounds
NRSF	Use of non-renewable secondary fuels
ODP	Ozone Depletion Potential
PCR	Product Category Rules
PENRE	Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials
PENRM	Use of non-renewable primary energy resources used as raw materials
PENRT	Total use of non-renewable primary energy resources
PERE	Use of renewable primary energy excluding renewable primary energy resources used as raw materials
PERM	Use of renewable primary energy resources used as raw materials
PERT	Total use of renewable primary energy resources

POCP	Photochemical Ozone Creation
RSF	Use of renewable secondary fuels
SM	Use of secondary material
RWD	Radioactive waste disposed (total)

Glossary of parameters used in EN 15804:2012+A1:2013

Parameter	Unit	What is it?
Global Warming Potential (Climate Change), GWP	kg CO_2 eq.	The earth's atmosphere absorbs some of the heat (infrared radiation) emitted from the sun, which causes the earth to heat up. This effect occurs naturally but has increased over the past few centuries. This is why the issue was called 'Global Warming'. The increased warming is due to the effects of a group of gases ('greenhouse gases') that sit in the earth's atmosphere and prevent the earth losing heat gained from the sun ("radiative forcing"). It has been realised that increases in temperature can result in weather extremes, e.g. droughts and floods, so the issue has become Climate Change. Climate Change can be measured over different time periods, typically the 100-year time period is used to reflect atmospheric changes.
Ozone Depletion Potential, ODP	kg CFC 11 eq.	The ozone layer is part of Earth's upper atmosphere (stratosphere). Loss of ozone in this layer creates the 'ozone hole' and increases the intensity of the ultra violet (UV) part of sunlight. Ozone is lost by its reaction with certain gases. The Montreal Protocol was signed in 1987 to address the production of man-made ozone depleting gases. CFC manufacture has been banned since 2000 and HCFCs will be phased out by 2015. The time table is: • 1 Jan 2004 banned from new plant • 2010 banned as virgin refrigerant for maintenance use • 2015 banned as recycled refrigerant for maintenance use
Acidification Potential for Soil and Water, AP	kg SO_2 eq.	An acid is a chemical that can produce hydrogen ions (H+, also called a 'proton') when it meets water. Hydrogen ions are highly reactive and can cause other substances to change their composition and their physical properties. Acid Deposition occurs when acidic gases react with rain ('acid rain') or water in the soil.
Eutrophication Potential, EP	kg $(PO_4)^{3-}$ eq.	Plants need nitrates and phosphates to grow. But some ecosystems are very sensitive to the amount of these nutrients (many plants need a low-nutrient environment). If the amount of nutrients becomes too high, eutrophication (over 'nutrification') occurs, and the ecosystem collapses.
Photochemical Ozone	kg C_2H_4 eq.	When ozone is created in the Earth's lower atmosphere (troposphere),

Parameter	Unit	What is it?
Creation, POCP		it can create smog. The creation of ozone happens when volatile organic compounds (VOCs) react to sunlight (photo-oxidation). VOCs include solvents, diesel and petrol. The speed at which low level ozone creation happens is affected by the presence of nitrogen oxides (NO_x).
Abiotic Depletion Potential – Elements, ADPE	kg Sb eq.	This impact category indicator is related to the extraction of virgin abiotic material e.g. extraction of aggregates, metal ores, minerals, earth etc. The extraction of such substances can mean that the natural carrying capacity of the earth is exceeded and make them unavailable for use by future generations. The category addresses the scarcity of the element.
Abiotic Depletion Potential – Fossil Fuels, ADPF	MJ eq.	This impact category indicator is related to the use of fossil fuels. Fossil fuels provide a valuable source of energy and feedstock for materials such as plastics. Although there are alternatives, these are only able to replace a small proportion of our current use. Fossil fuels are a finite resource and their continued consumption will make them unavailable for use by future generations.
Use of renewable primary energy excluding renewable primary energy resources used as raw materials, PERE	MJ	Primary energy from a renewable source used as a *fuel* not as a material. Note: Primary energy consumption refers to the direct use at the source, or supply to users without transformation, of crude energy, that is, energy that has not been subjected to any conversion or transformation process.
Use of renewable primary energy resources used as raw materials, PERM	MJ	Primary energy from a renewable source used as a *material* not as a fuel.
Total use of renewable primary energy resources, PERT	MJ	Total primary energy from a renewable source
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRE	MJ	Primary energy from a non-renewable source used as a *fuel* not as a material.
Use of non-renewable primary energy resources used as raw	MJ	Primary energy from a non-renewable source used as a *material* not as a fuel.

Parameter	Unit	What is it?
materials, PENRM		
Total use of non-renewable primary energy resources, PENRT	MJ	Total primary energy from a non-renewable source
Use of secondary material, SM	kg	Material recovered from previous use or from waste that substitutes primary materials. For example, recycled scrap metal, crushed concrete, glass cullet, recycled wood chips, and recycled plastic.
Use of renewable secondary fuels, RSF	MJ	Fuel recovered from previous use or from waste which substitutes primary fuels. For example, wood, plant-based oil and animal fats.
Use of non-renewable secondary fuels, NRSF	MJ	Fuel recovered from previous use or from waste which substitutes primary fuels. For example, solvents, tyres, and fossil-origin oil.
Net use of fresh water, FW	m^3	The abstraction of water from rivers, reservoirs and aquifers can cause the depletion, and disruption or pollution of these water sources. The indicator is calculated as: [total fresh water input] – [total fresh water output]. Not all datasets include data on the release of fresh water.
Hazardous waste disposed, HWD	kg	Hazardous waste is that defined within existing applicable legislation, e.g. in the European Waste Framework Directive
Non-hazardous waste disposed, NHWD	kg	This parameter represents the loss of resource implied by the final disposal of waste. This parameter reflects the loss of resource resulting from waste disposal (in contrast to recycling or reuse); does not include any other impacts associated with landfill or incineration – emissions from decomposition, burning and associated transport and other machinery are included in the relevant categories.
Radioactive waste disposed, RWD	kg	Total radioactive waste – mainly from nuclear electric power plants.
Components for reuse, CRU	kg	Amount of material available for reuse.
Materials for recycling, MFR	kg	Amount of material for recycling.

Parameter	Unit	What is it?
Materials for energy recovery, MER	kg	Amount of material for energy recovery – requires that the material is used in a power station with a thermal energy efficiency rate of not less than 60% or 65% for installations after 31st of December 2008 according to EC requirements.
Exported energy, EE	MJ	Energy exported from waste incineration and landfill.

1 Introduction

Lapitec SpA commissioned BRE to undertake a life cycle assessment (LCA) study of their sintered stone slabs, the outputs of which will be used to produce a BRE Global type III environmental product declaration. The requirements of this project are outlined in the BRE Proposal Ref.: QUO-01479-S0Q4X9 dated 3rd May 2018. The output of this LCA study will be used to obtain one EPD, covering all three thicknesses of the Lapitec sintered stone slabs, by giving results per kg with the relevant conversion factors stated.

This LCA study has been conducted according to the requirements of EN 15804:2012+A1:2013 (1) and the BRE Environmental Profiles 2013: Product Category Rules for Type III environmental product declaration of construction products to EN 15804:2012+A1:2013 (2).

2 Goal of Study

The goal of this study was to produce a BRE Global EPD to cover Lapitec sintered stone slabs according to the requirements of EN 15804.

This was a cradle to gate LCA study covering the following information modules: A1 to A3 for the production stage, and this background report contains the data, assumptions, calculations, LCA results and interpretation of results for the Lapitec sintered stone slabs.

Lapitec SpA recognises the environmental implications of its activities and intends to use this EPD to better understand environmental impacts associated with its products and processes, and to communicate this information and LCA results to a wider audience.

The output of this LCA study will be used to obtain one EPD, covering all three thicknesses of Lapitec sintered stone slab by stating conversion factors to apply to the declared unit of 1 kg.

The BRE Global verified EPD which will be obtained from the BRE Global Verified EPD Scheme will be published on www.greenbooklive.com. It will be used in business-to-business communication.

3 Scope of Study

3.1 Product Description

Lapitec is a non-porous sintered stone slab made in three thicknesses of 12 mm, 20 mm, and 30 mm, with use in construction and interior design, as both internal and external cladding, paving and flooring, as well having uses as worktop surfaces and in swimming pools.

3.2 Production process

Raw materials are taken from the warehouse and silos in measured quantities to be mixed. Water is added to and a homogenous mixture created. The mixture is pressed into slab shapes, and slabs are then dried at 200°C prior to entry in the kiln where they are sintered at temperatures up to 1190°C. After cooling, slabs are then polished for finishing and are packaged for dispatch or storage.

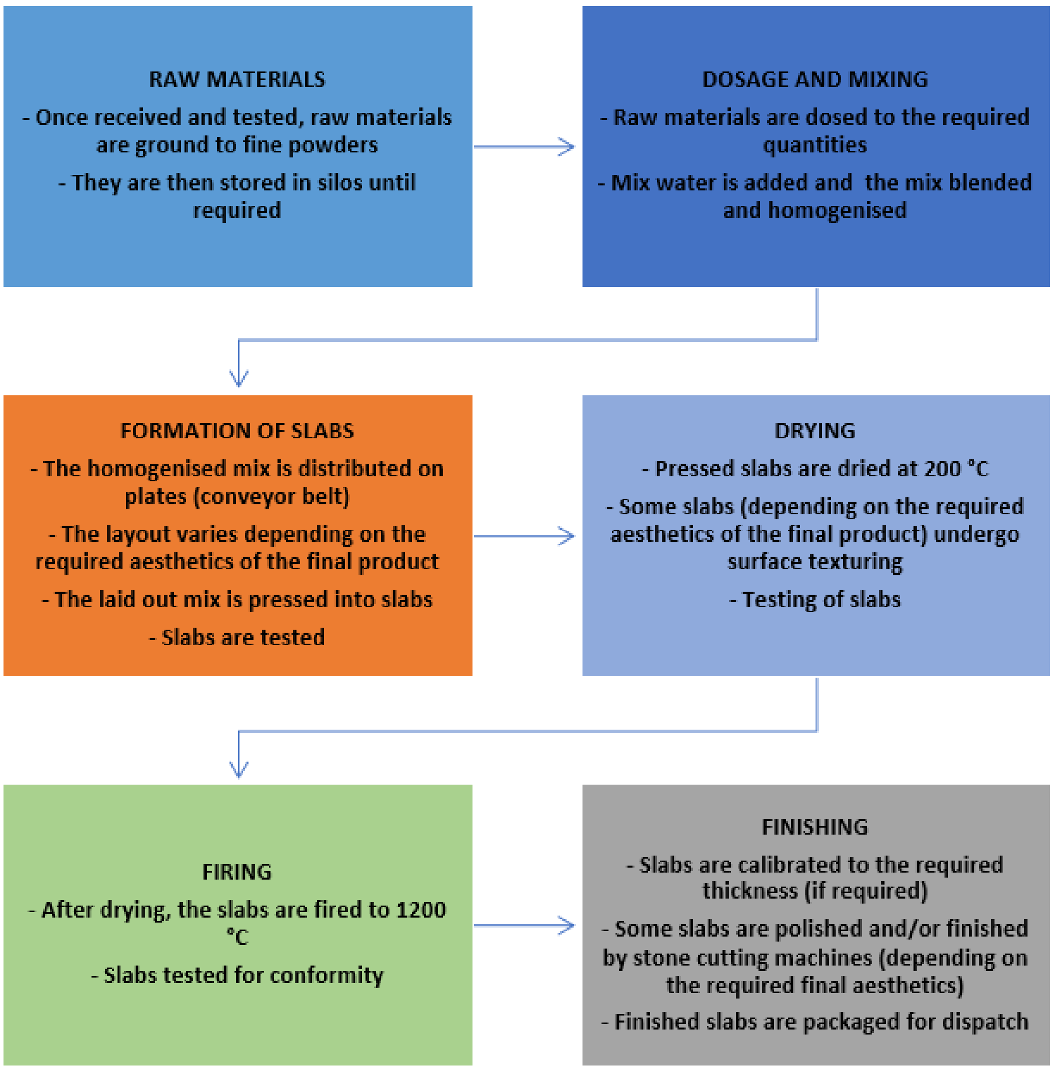


Figure 1: Typical process flow for the manufacture of Lapitec sintered stone slabs products, provided by Lapitec SpA.

3.3 Technical and Functional Characteristics

Lapitec sintered stone slabs are made in three thicknesses and a range of surface textures, although the composition of the slabs and the manufacturing process is the same.

Table 1: Characteristics of the Lapitec sintered stone slabs covered in this LCA

Characteristic	Sintered Stone Slab
Standard dimensions (length x breadth), EN 14617-16	3365 mm x 1500 mm
Thicknesses, EN 14617-16	12 mm, 20 mm, 30 mm
Density, EN 14617-1	2400 kg/m^3
Mass per m^2 (for 12 mm, 20 mm and 30 mm thicknesses)	28.8 kg/m^2, 48.0 kg/m^2, 72.0 kg/m^2
Flexural strength, EN 14617-2	53 N/mm^2
Compressive strength, ASTM C170	483 N/mm^2

Other technical characteristics of the Lapitec sintered stone slabs can be found in the product specification datasheets (https://www.lapitec.com/download/Certificates).

3.4 Area of intended application

Lapitec products are sintered stone slabs made at three different thicknesses. They can be used for external or internal cladding, paving and flooring and in swimming pools. They can also be used as worktop surfaces.

3.5 Declared / Functional Unit

The declared unit of the Lapitec sintered stone slabs is 1 kg. Conversion factors will be stated in the EPD which the user can apply to obtain results for 1m^2 of slab at each of the three manufactured thicknesses.

3.6 System Boundary

The system boundary of the EPD is according to the modular approach as defined in EN 15804. This cradle-to-gate EPD includes the product life cycle stages of A1 to A3. The included modules are shown in Figure 2 below, and outlined in more detail in the following sub-sections of the report.

Life cycle stages	Product			Construction		Use stage							End-of-life				Benefits and loads beyond the system boundary
						Related to the building fabric					Related to the building operation						
Modules	A1	A2	A3	A4	A5	B1	B2	B3	B4	B5	B6	B7	C1	C2	C3	C4	D
	Raw material supply	Transport	Manufacturing	Transport	Construction	Use	Maintenance	Repair	Replacement	Refurbishment	Operational energy use	Operational water use	Demolition	Transport	Waste processing	Disposal	Reuse / Recovery / Recycling potential
Cradle to Gate with options	X	X	X	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND	MND

X = declared module, MND = module not declared

Figure 2: Modules included in the Lapitec sintered stone slab LCA and EPD

3.6.1 Product stage: Information modules A1 – A3

This is the cradle-to-gate stage. The product stage includes the following information modules:

- A1: Raw material extraction and processing, and the processing of secondary material input (e.g. recycling processes).
- A2: Transport of raw materials and secondary material inputs to the manufacturer.
- A3: Manufacturing of the construction product, and packaging.

This stage includes the provision of all materials, products and energy, as well as waste processing up to the end-of-waste state (i.e. no longer considered a waste material), or disposal of final residues during the product stage.

Processes relating to resource extraction e.g. extraction of clay are included in the system. All energy used in factories and factory support offices is included but energy used in head offices and sales offices etc. are excluded. Maintenance of equipment is also not included.

Modules A1, A2 and A3 are declared as one aggregated module A1 – A3.

3.7 Cut-off Criteria / Criteria for the exclusion of inputs and outputs

Where there is insufficient data or data gaps for a unit process in the LCA study, the cut-off criteria is 1% of the total mass of input of that process. The total of neglected input flows per module is a maximum of 5% of energy usage and mass. The exception is if they have any of the following, in which case they have to be included:

- Significant effects of energy use in their extraction, use or disposal
- Are classed as hazardous waste

Data collected by Lapitec for the Vedelago manufacturing site in Italy was used. The inventory process in this LCA includes all data related to raw material, packaging material and consumable items, and the associated transport to the manufacturing site. Process energy and water use, direct production waste and non-production waste are included.

4 Life Cycle Inventory (LCI) Analysis – Data

4.1 Data collection

Data collection has followed the guidance provided in EN ISO 14044:2006, section 4.3.2 (3).

Data collection was by means of questionnaire. Manufacturing process data for the 12 month period 01/01/2017 to 31/12/2017 was provided by Lapitec SpA for the Vedelago manufacturing site.

Table 2: Address of the Lapitec SpA manufacturing site for which data was provided

Manufacturing site
Lapitec SpA, Breton SpA Vedelago, via Bassanese 6, 31050 Vedelago TV, Italy

4.1.1 Mass Balance

The resulting inventory from the production sites was checked for balance in mass. Mass balance checks were carried out by BRE to ensure that the inputs stated are sufficient to produce all the outputs, including waste arisings.

Lapitec does not record its material usage for production. Therefore, the bill of material formulation for the sintered slab material was multiplied by slab output to obtain an estimate of the raw material used for the year. The water added to the materials, the water content of the colloidal silica (60% mass), and the chemically bound water in the kaolin (~13% mass), were all discarded when considering the mass balance as they would not remain as solid in the final fired product. This gave a mass balance (inputs / outputs) of 110% when considering the production output. When the production wastes were taken into consideration as part of the output, the mass balance showed a deficiency of inputs. Therefore an uplift of 117% of the raw materials was required to account for the production waste.

The material input and output, the water use and the energy consumption data were checked for appropriateness compared to product-specific published data and internal BRE data.

4.1.2 Data Quality

In accordance with the requirements of EN 15804, the most current available data was used to calculate the LCA results. As outlined in Section 4.1 Data Collection above, the manufacturer-specific data for the Lapitec SpA site in Vedelago covers a production period of 1 year (01/01/2017 to 31/12/2017).

Data sets used for calculations have been updated within the last 10 years for generic data, and within the last 5 years for producer specific data. They are based on 1 year averaged data; the time period over which inputs to and outputs from the system are accounted for is 100 years; the technological coverage reflects the physical reality for the declared product; and generic data has been checked for plausibility.

4.2 Developing product level scenarios

Where the product stage modules (A1-A3) are calculated using actual data in line with the requirements of EN 15804, realistic and representative scenarios based on relevant technical information are used as the basis for assumptions used in the other information modules.

4.3 Selection of data / Background data

As outlined in Section 4.1 Data Collection, specific foreground data derived from Lapitec SpA production processes is used in the production LCA for modules A1-A3. Generic data is used for all other upstream and downstream processes that are beyond the control of the manufacturer (i.e. raw material production, and end-of-life).

As far as we are aware, all data sets are complete and conform to the system boundary and the criteria for the exclusion of inputs and outputs according to the requirements specified in EN 15804.

Modelling of the life cycle of the Lapitec sintered stone slabs is performed using SimaPro 8 LCA software from PRé (4). All relevant background LCI datasets are taken from the ecoinvent database v3.2 (5) unless indicated otherwise. Where the creation of BRE background datasets was required, these have been created from ecoinvent datasets, and have been noted as being BRE created. All data sets used in the modelling are listed in Table 3.

Table 3: Background datasets used in Lapitec sintered stone slabs LCA study.

Dataset	Comment
Feldspar {RER}| production | Alloc Def, U	Proxy for nepheline
Flat glass, uncoated {RER}| production | Alloc Def, U	Proxy for frit
Kaolin {RER}| production | Alloc Def, U	
Feldspar {RER}| production | Alloc Def, U	
Silica sand {GLO}| cryolite production, from fluosilicic acid | Alloc Def, U	Proxy for colloidal silica
Iron Oxide pigments - 100% powder (from Laux process) EN BRE 15804	BRE created
Tap water {Europe without Switzerland}| market for | Alloc Def, U	
BRE 15804 converted EUR-flat pallet {RER}| production | Alloc Def, U into mass	ecovinent dataset with unit converted from piece to mass
BRE 15804 Polyester yarn	BRE created
Corrugated board box {RER}| production | Alloc Def, U	
Packaging film, low density polyethylene {RER}| production | Alloc Def, U U	Proxy for celluloid film
Printed paper, offset {CH}| offset printing, per kg printed paper | Alloc Def, U	
Electricity, medium voltage {IT}| market for | Alloc Def, U	
Electricity, low voltage {IT}| electricity production, photovoltaic, 3kWp slanted-roof installation, multi-Si, panel, mounted | Alloc Def, U	
Heat, district or industrial, natural gas {GLO}| market group for | Alloc Def, U	

Dataset	Comment
Transport, freight, lorry 16-32 metric ton, EURO5 {GLO}| market for | Alloc Def, U	
Transport, freight train {Europe without Switzerland}| market for | Alloc Def, U	
Transport, freight, sea, transoceanic ship {GLO}| market for | Alloc Def, U	
Decarbonising waste {CH}| treatment of, residual material landfill | Alloc Def, U	Proxy for exhausted lime
BRE Materials leaving system (recycled) No Impacts	BRE created for reporting only
Municipal solid waste {CH}| treatment of, sanitary landfill | Alloc Def, U	
Wastewater, average {CH}| treatment of, capacity 5E9l/year | Alloc Def, U	

4.4 Allocation

No data allocation was required for this LCA, as all sintered stone slabs made at the Lapitec site for the stated production period are included.

4.5 Description of the unit processes

The production process for the Lapitec sintered stone slabs is represented schematically in Figure 1 on page 13. The inputs and outputs relating to 1 kg of Lapitec sintered stone slab from the Vedelago production site are given in Table 4. Note that the 17% uplift, which was applied in the modelling, has not been added in this table.

Table 4: Lapitec sintered stone slab input and output data

Process data	Unit	Quantities
Total site (sintered stone slab) production	kg kg/m^3	3,845,295 2,400
Nepheline	kg km	569,592 Road: 202
Frit	kg km	460,626 Road: 199
Kaolin (13% loss on ignition)	kg km	1,089,652 (947,997 after firing process) Road: 1,161
Feldspar	kg km	2,005,952 Road: 341
Colloidal silica (60% water content)	kg km	323,853 (146,608 after drying process) Road: 2,068

Process data	Unit	Quantities
Iron oxide pigments	kg km	99,058 Road: 1,514
Mix water	kg km	361,567 n/a
Wood pallet (supplier 1) Wood pallet (supplier 2)	kg km kg km	11,733 Road: 182 3,850 Road: 7
Polyester rope	kg km	41,600 Road: 7
Cardboard	kg km	8,333 22
Plastic film (supplier 1) Plastic film (supplier 2)	kg km kg km	2,600 Road: 22 9,515 Road: 157
Paper labels	kg km	68 Road: 423
Mains electricity, Italy	kWh	7,514,650
Solar PV electricity, on site roofing	kWh	814,650
Natural gas	MJ	6,747,755
Non-process mains water	m^3	604.520
Water to sewer	m^3	574.294 (= 604.520 * 95%)
Production waste (excess material recycled off-site)	kg	1,107,680
Non-production waste (exhausted lime)	kg	4,200
Non-production waste (mixed to recycling)	kg	1,597,838
Non-production waste (municipal waste to landfill)	kg	6,600
Mixed recyclables (plastic, card, paper)	kg	71,709
Total dry raw materials in (13% kaolin LOI subtracted)	kg	4,229,833 (4,952,975 with 17% uplift)
Total mass out (production + waste)	kg	4,952,975
Mass balance (input/output)	%	**85 (100 with 17% uplift)**

4.6 Data Modelling

All of the above input/output processes were combined into a single dataset to represent the A1 to A3 (production stage) of the Lapitec sintered stone slab manufacturing, and to obtain results per mass of slab.

No allocation of data was required as all Lapitec sintered stone slabs made over the 12 month period and their raw materials were included, so total site water, energy, waste and wastewater values were used. Although Lapitec measures emissions from its oven and machinery, the source of these emissions is the natural gas combusted on site. Therefore these measured emissions were not included as they are already included in the ecoinvent dataset used to represent the natural gas.

See Appendix A for SimaPro screenshots demonstrating the contributions to product impacts by production output.

4.7 Product composition

According to Lapitec SpA, the products contain no substances that are listed in the 'Candidate List of Substances of very high concern for authorisation'. The composition shown in Table 5 below represents the Lapitec sintered stone slab.

Table 5: Composition of the Lapitec sintered stone slabs in terms of solid input content prior to firing

Material / chemical input	% mass per declared unit
Feldspar	46
Kaolin	25
Nepheline	13
Frit	11
Silica (from colloidal silica, 60% water not included)	3
Iron oxide pigment	2

bre

5 Life Cycle Impact Assessment (LCIA) – Results

The results of the Lapitec sintered stone slab LCA for modules A1- A3 are given below.

5.1 Declaration of parameters derived from LCA

As specified in EN 15804, the environmental impacts are declared and reported using the parameters and units shown in the Table below. Baseline characterisation factors are from CML – IA version as required. Results are reported to 3 significant figures.

Table 6: Parameters for describing environmental impacts

Impact Category	Parameter	Unit
Global Warming (Climate Change)	Global warming potential, GWP	kg CO_2 equiv., 100 years
Ozone Depletion	Depletion potential of the stratospheric	kg CFC 11 equiv.
Acidification for Soil and Water	Acidification potential of soil and water,	kg SO_2 equiv.
Eutrophication	Eutrophication potential, EP	kg $(PO_4)^{3-}$equiv.
Photochemical Ozone Creation	Formation potential of tropospheric	kg C_2H_4 equiv.
Depletion of Abiotic Resources – elements	Abiotic depletion potential for non-fossil resources, ADP-elements	kg Sb equiv.
Depletion of Abiotic Resources – Fossil Fuels	Abiotic depletion potential for fossil resources, ADP-fossil fuels	MJ, net calorific value.

5.2 Other parameters

The following environmental information describing resource use, waste and other output flows (also derived from the LCI, but not assigned to the impact categories listed in Table 6 above) are also reported as shown in Table 7 below.

Table 7: Other parameters (combined for ease of presentation)

Parameter	Unit
Resource use	
Use of renewable primary energy excluding renewable primary energy resources used as raw materials, PERE	MJ, net calorific value
Use of renewable primary energy resources used as raw materials, PERM	MJ, net calorific value
Total use of renewable primary energy resources, PERT	MJ, net calorific value
Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials, PENRE	MJ, net calorific value
Use of non-renewable primary energy resources used as raw materials, PENRM	MJ, net calorific value
Total use of non-renewable primary energy resources, PENRT	MJ, net calorific value

Parameter	Unit
Use of secondary material, SM	kg
Use of renewable secondary fuels, RSF	MJ, net calorific value
Use of non-renewable secondary fuels, NRSF	MJ, net calorific value
Net use of fresh water, FW	m^3
Waste to disposal	
Hazardous waste, HWD	kg
Non-hazardous waste, NHWD	kg
Radioactive waste disposed (total low, intermediate and high level waste), RWD	kg
Other output flows	
Components for reuse, CRU	kg
Materials for recycling, MFR	kg
Materials for energy recovery, MER	kg
Export energy, EE	MJ per energy carrier

In the LCA results table, indicators (parameters) that have not been determined are typically reported as INA (indicator not assessed).

5.3 LCA Results

For clarity of presentation, the results table only show stages declared. However, any resulting EPD will include all stages appropriately labelled as either MND for module not declared or MNR for module not relevant. To obtain results for each of the three thickness of slab made by Lapitec SpA, multiply results in Table 9 by the following mass per slab in Table 8:

Table 8: Mass of $1m^2$ for each slab thickness

Slab thickness (mm)	Mass per m^2 (kg)
12	28.8
20	48
30	72

Table 9: LCA results for 1 kg of Lapitec sintered stone slab

(AGG = aggregated; INA = indicator not assessed)

Parameters describing environmental impacts										
			GWP	ODP	AP	EP	POCP	ADPE	ADPF
			Kg CO_2 equiv.	Kg CFC 11 equiv.	kg SO_2 equiv.	kg $(PO_4)^{3-}$ equiv.	kg C_2H_4 equiv.	kg Sb equiv.	MJ, net calorific value.
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-A3	1.63	2.24e-7	7.96e-3	1.93e-3	7.70e-4	5.24e-6	25.4
GWP = Global Warming Potential; ODP = Ozone Depletion Potential; AP = Acidification Potential for Soil and Water; EP = Eutrophication Potential; POCP = Formation potential of tropospheric Ozone; ADPE = Abiotic Depletion Potential – Elements; Abiotic Depletion Potential – Fossil Fuels										

Parameters describing resource use, primary energy								
			PERE	PERM	PERT	PENRE	PENRM	PENRT
			MJ	MJ	MJ	MJ	MJ	MJ
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-A3	3.72	5.58e-6	3.72	27.6	0	27.6
PERE = Use of renewable primary energy excluding renewable primary energy used as raw materials; PERM = Use of renewable primary energy resources used as raw materials; PERT = Total use of renewable primary energy resources; PENRE = Use of non-renewable primary energy excluding non-renewable primary energy resources used as raw materials; PENRM = Use of non-renewable primary energy resources used as raw materials; PENRT = Total use of non-renewable primary energy resources								

Parameters describing resource use, secondary materials and fuels, use of water						
			SM	RSF	NRSF	FW
			kg	MJ net calorific value	MJ net calorific value	m^3
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-A3	0	0	0	0.0233

SM = Use of secondary material; RSF = Use of renewable secondary fuels; NRSF = Use of non-renewable secondary fuels; FW = Net use of fresh water

Other environmental information describing waste categories					
			HWD	NHWD	RWD
			kg	kg	kg
Product stage	Raw material supply	A1	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG
	Total (of product stage)	A1-A3	0.0614	0.167	8.55e-5

HWD = Hazardous waste disposed; NHWD = Non-hazardous waste disposed; RWD = Radioactive waste disposed

Other environmental information describing output flows – at end of life						
			CRU	MFR	MER	EE
			kg	kg	kg	MJ per energy carrier
Product stage	Raw material supply	A1	AGG	AGG	AGG	AGG
	Transport	A2	AGG	AGG	AGG	AGG
	Manufacturing	A3	AGG	AGG	AGG	AGG
	Total (of product stage)	A1-A3	0	0.704	0	0

CRU = Components for re-use; MFR = Materials for recycling; MER = Materials for energy recovery; EE = Exported Energy

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

6 Interpretation

The following section of the report contains the interpretation of the Lapitec sintered stone slab from Section 5. All interpretation has been performed in accordance with the requirements of the scheme and the BRE Global PCR, and all data assumptions and limitations as stated in the report have been considered throughout the interpretation.

6.1 Global Warming Potential (Climate Change) (GWP)

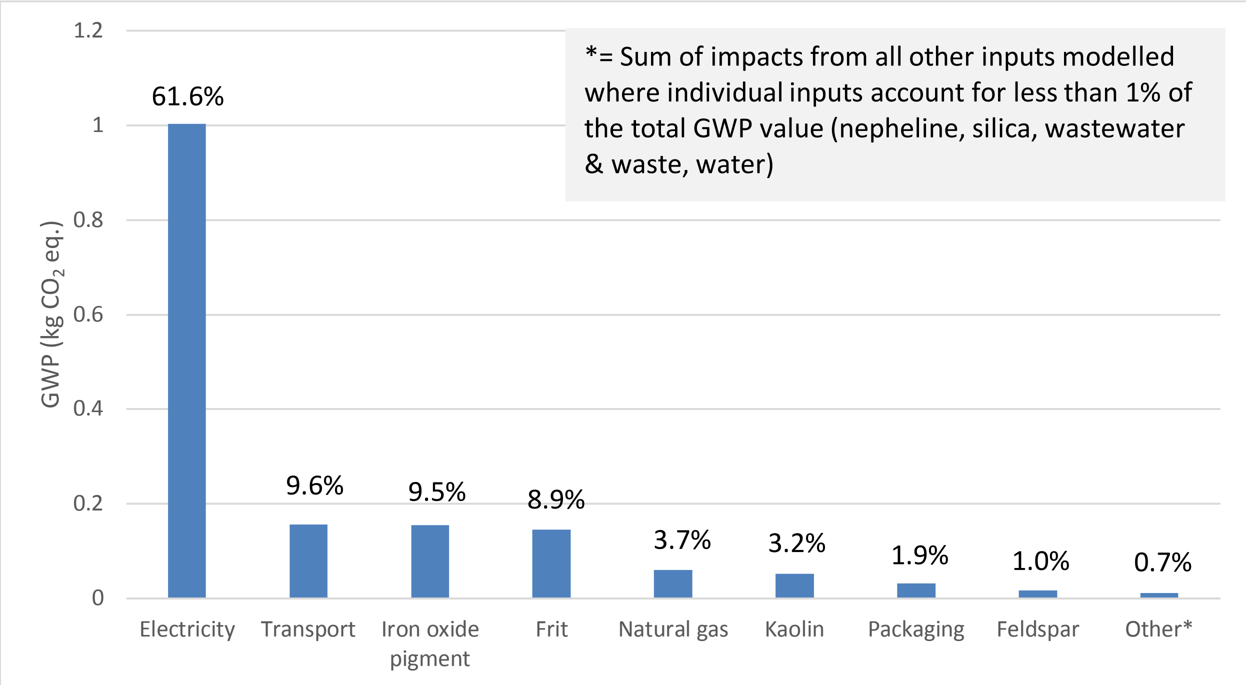


Figure 3: GWP (kg CO_2 eq.) per kg of Lapitec sintered stone slab production

As shown in Figure 3, the total GWP value for the production stage of 1kg of Lapitec sintered stone slab is 1.63 kg CO_2 eq. ~62% of this value arises from the electricity usage on site, mainly from the upstream combustion of coal linked to a component of the Italian mains electricity mix.

At 9.6%, the combustion of fuels required for the transport of raw materials and packaging to site is the second highest contributor to the GWP value. This is closely followed at 9.5% by the upstream production of the iron oxide pigments, mainly associated with the smelting of iron ore.

Cumulatively the raw materials are responsible for 23% of the total GWP value with the frit being the highest contributing raw material after the iron oxide pigments.

6.2 Ozone Depletion Potential (ODP)

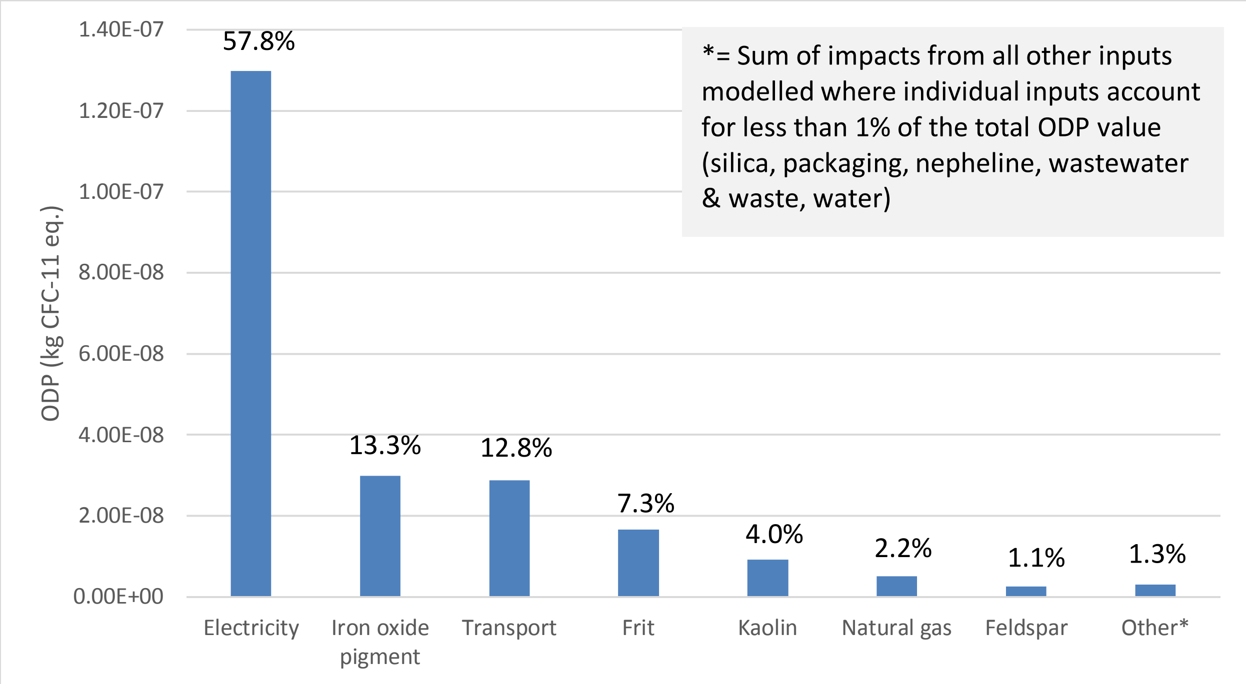


Figure 4: ODP (kg CFC-11 eq.) per kg of Lapitec sintered stone slab production

As shown in Figure 4, the total ODP value for the production stage of 1kg of Lapitec sintered stone slab is 2.24e-7 kg CFC-11 eq. ~58% of this value arises from the electricity usage on site, mainly from the gases released by the upstream combustion of natural gas linked to a component of the Italian mains electricity mix.

At 13.3%, the iron oxide pigments are the second highest contributor to the ODP value, largely due to emissions from the electricity required for upstream iron oxide production. Responsible for 12. 8%, transport of raw materials and packaging to site is the third largest contributor to the total ODP value due to emissions from diesel combustion.

Cumulatively the raw materials are responsible for just under 23% of the total ODP value, with the frit being the highest contributing raw material after the iron oxide pigments.

6.3 Acidification Potential (for Soil and Water) (AP)

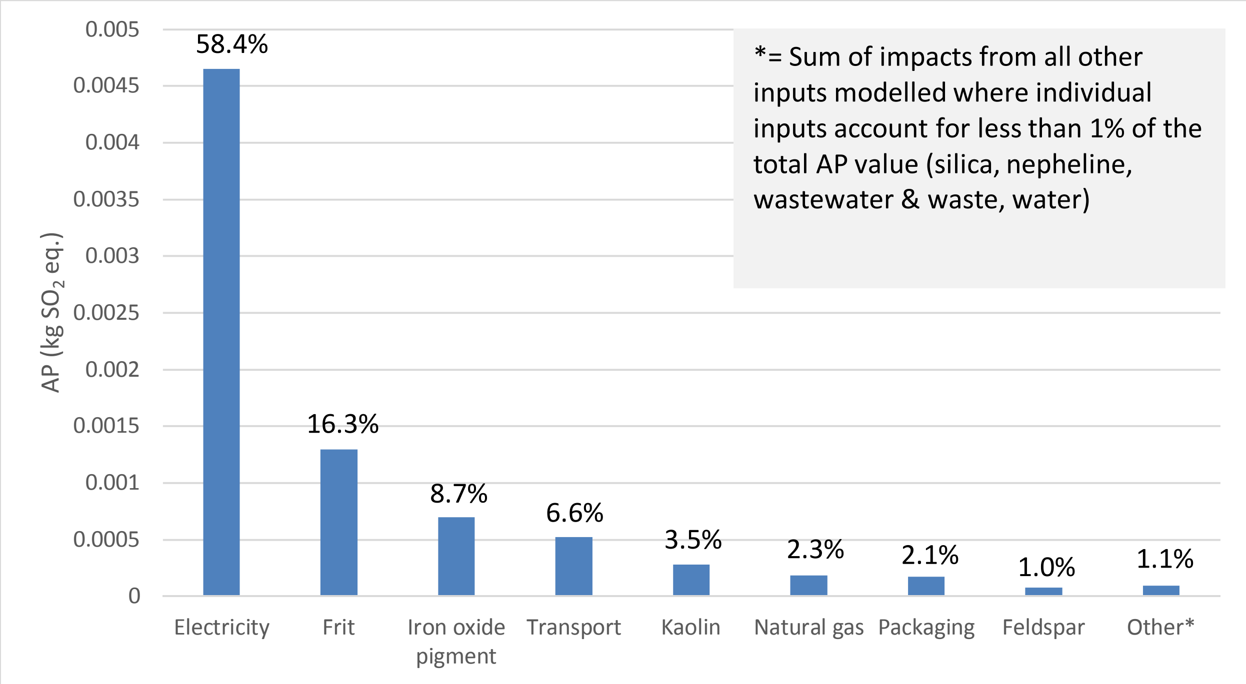


Figure 5: AP (kg SO_2 eq.) per kg of Lapitec sintered stone slab production

As seen in Figure 5, the total AP value for the production stage of 1kg of Lapitec sintered stone slab is 0.00796 kg SO_2 eq. ~58% of this value arises from the electricity usage on site, mainly from the gases released by the upstream combustion of coal linked to a component of the Italian mains electricity mix.

At 16.3%, the frit is the second highest contributor to the AP value, linked to upstream processing of some of its raw materials. Responsible for 8.7%, upstream production of the iron oxide pigments is the third largest contributor to the total AP value due to SO_2 related emissions from upstream natural gas combustion.

Cumulatively the raw materials are responsible for just under 31% of the total ODP value. Emissions from fossil fuel combustion required for transport of raw materials and packaging are responsible for the fourth largest AP contributor.

6.4 Eutrophication Potential (EP)

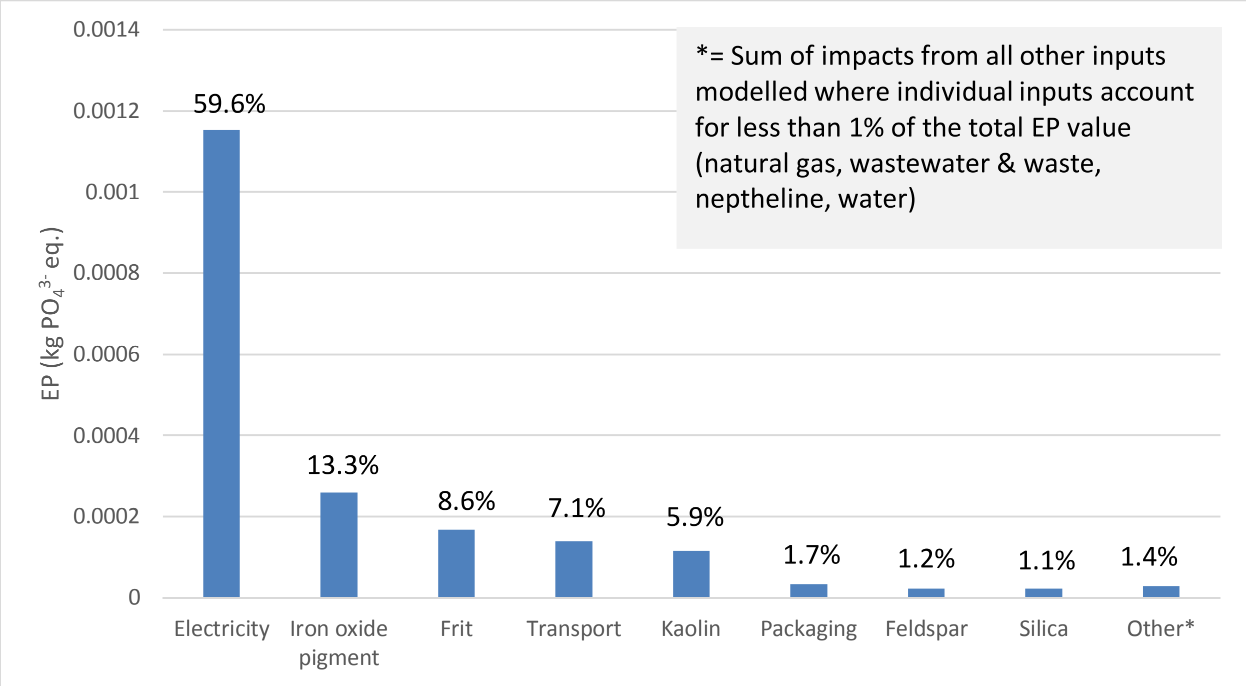


Figure 6: EP (kg PO_4^{3-} eq.) per kg of Lapitec sintered stone slab production

Figure 6 shows that the total EP value for the production stage of 1kg of Lapitec sintered stone slab is 0.00193 kg PO_4^{3-} eq. Just under 60% of this value arises from the electricity usage on site, mainly from upstream processing and wastes from coal linked to a component of the Italian mains electricity mix.

At 13.3%, the iron oxide pigments are the second highest contributor to the EP value, linked to upstream processing of some of its raw materials. With a contribution of 8.6%, upstream production of the frit is the third largest contributor to the total EP value due to raw materials used to make the frit and resulting wastes and sludges associated with their processing.

Cumulatively the raw materials are responsible for just under 31% of the total EP value.

6.5 Photochemical Ozone Creation Potential (POCP)

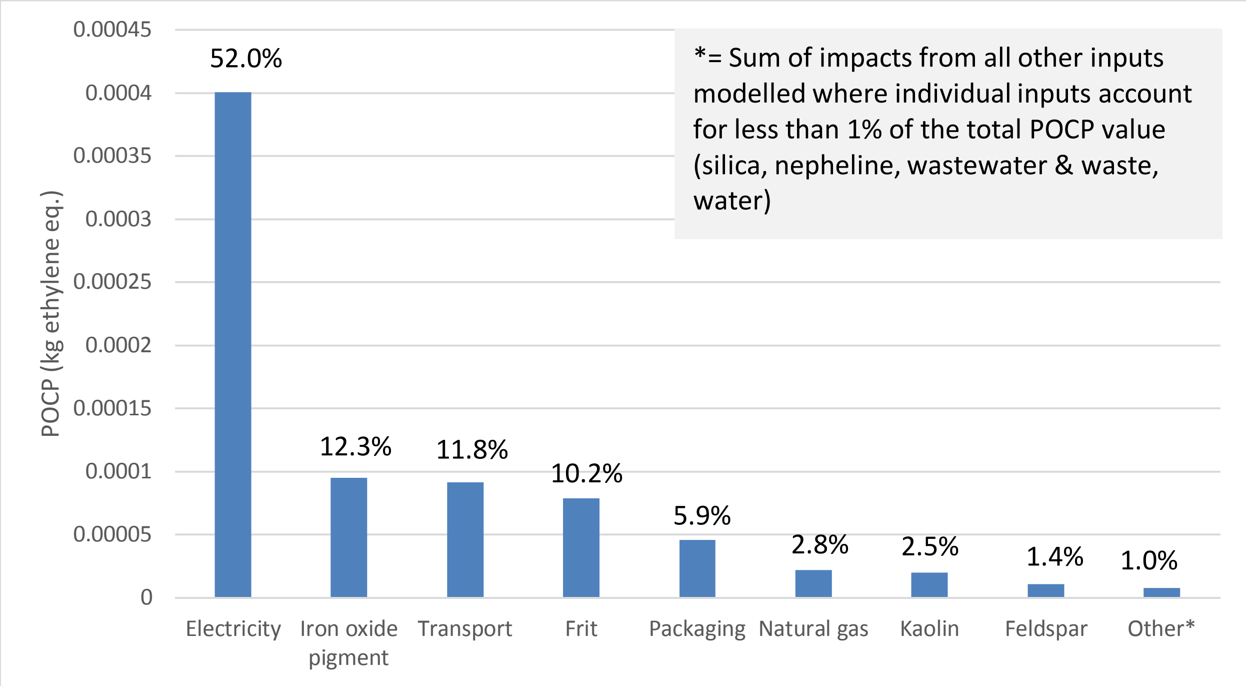


Figure 7: POCP (kg ethylene eq.) per kg of Lapitec sintered stone slab production

Certain emissions of carbon monoxide (CO), NOx, SOx, and NMVOCs to the atmosphere react to sunlight (photo-oxidation) to create ozone. Figure 7 shows that the total POCP value for the production stage of 1kg of Lapitec sintered stone slab is 0.000770 kg ethylene eq. 52% of this value arises from the electricity usage on site, mainly from emissions of combustion of various fossil fuels used in the Italian mains electricity mix.

At 12.3%, the iron oxide pigments are the second highest contributor to the POCP value, linked to upstream processing of some of its raw materials, for example coking processes. With a contribution of 11.8%, transport of raw materials and packaging to site (mainly the associated emissions related to diesel combustion) is the third largest contributor.

Cumulatively the raw materials are responsible for 27.4% of the total POCP value, with the frit being the highest contributing raw material after the iron oxide pigments. This is due to energy emissions associated with its upstream production.

6.6 Abiotic Depletion Potential (Elements) (ADPE)

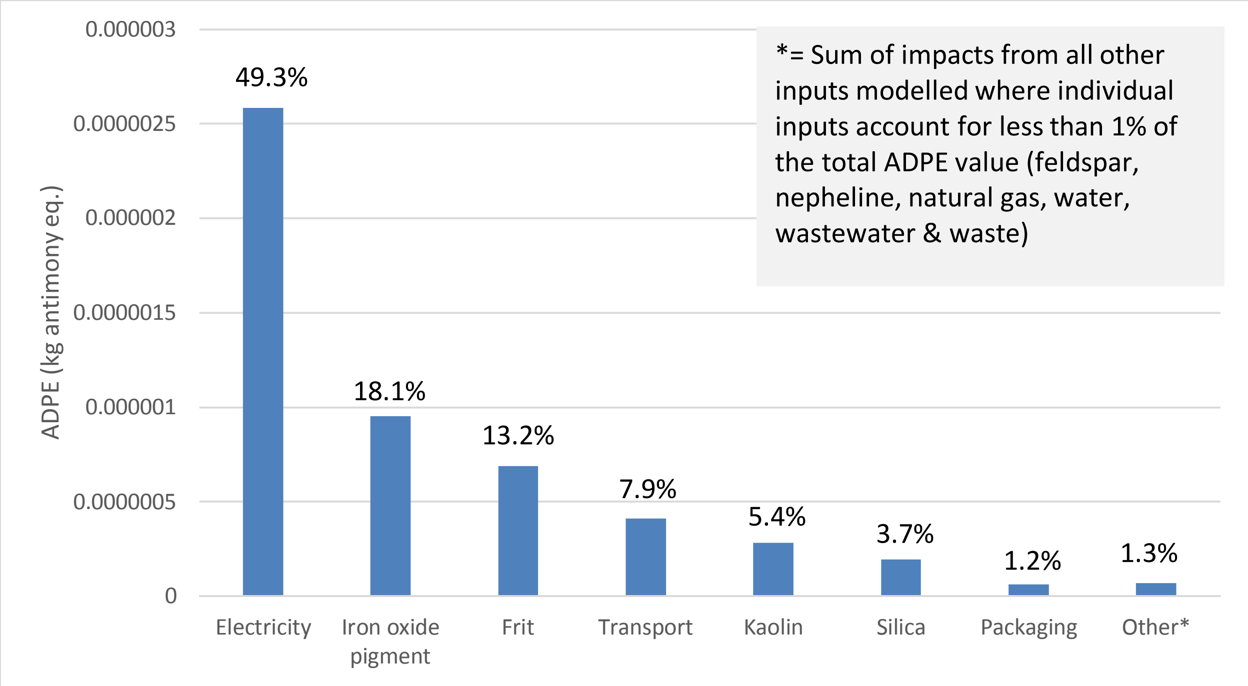


Figure 8: ADPE (kg antimony eq.) per kg of Lapitec sintered stone slab production

This impact category is related to extraction of virgin abiotic material elements from the environment, for example the extraction of aggregates, minerals, ores etc. Figure 8 shows that the total ADPE value for the production stage of 1kg of Lapitec sintered stone slab is $5.24e^{-6}$ kg antimony eq. Approximately 49% of this value arises from the electricity usage on site. About 22% of this 29% is related to the extraction of raw materials used to produce the photovoltaic panels used on site. The remaining 78% of this 29% is mainly from extraction of raw materials used in transmission of the Italian mains electricity mix.

At 18.1%, the iron oxide pigments are the second highest contributor to the ADPE value, linked to upstream extraction of the iron ore source. With a contribution of 13.2%, frit, or rather the extraction of the minerals used to produce it, is the third largest contributor.

Cumulatively the raw materials are responsible for 41.5% of the total ADPE value. Transport of raw materials and packaging, or rather materials extracted upstream to make the transport vehicles, is the fourth highest contributor to this impact category.

6.7 Abiotic Depletion Potential (Fossil fuels) (ADPF)

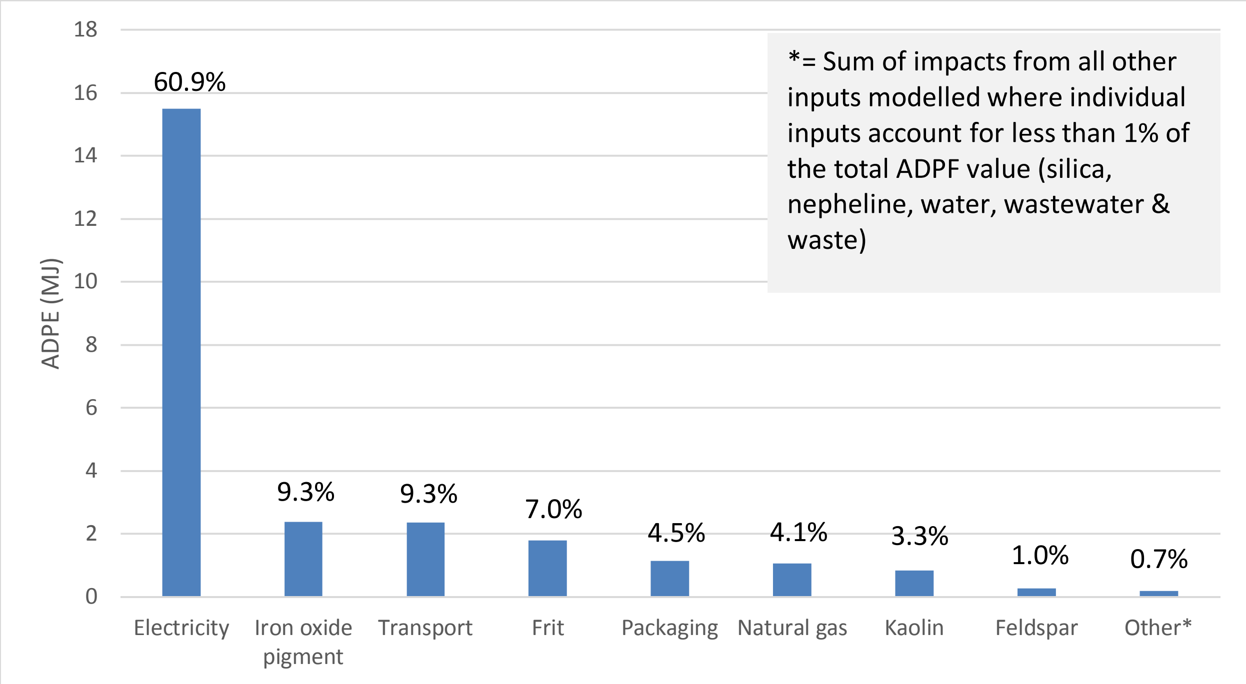


Figure 9: ADPF (MJ) per kg of Lapitec sintered stone slab production

This impact category is related to extraction of abiotic fossil fuel materials from the environment. Figure 9 shows that the total ADPF value for the production stage of 1kg of Lapitec sintered stone slab is 25.4 MJ. 60.9% of this value is related to the electricity, mainly the extraction of the various fossil fuels (for example coal and natural gas) used to make up various components of the Italian grid electricity mix.

At 9.3% each, the iron oxide pigments and the transport of raw materials and packaging to site are the joint second highest contributors to the ADPF value.

The ADPF value associated with the iron oxide pigment is due to the fossil fuels used in the upstream manufacture of the pigments, whilst that resulting from the transport to site input is related mainly to the extraction of the required fossil fuels used to power the transportation vehicles.

Cumulatively the raw materials are responsible for 21.2% of the total ADPF value. Frit is the highest contributing raw material after the iron oxide pigments due to fossil fuels extracted to provide the energy needed for its upstream production.

See Appendix A for network flows for the Lapitec sintered stone slab product stage (A1-A3) for each of the seven impact categories displayed in the above graphs.

6.8 Sensitivity Analysis

A sensitivity analysis has been performed to understand the relationships between input and output variables in the study. Where analysis revealed ‘hot spots’ within the models, the data and results were compared to existing Environmental Product Declarations and further LCA studies on similar processes.

6.9 Conclusions

The findings from the LCA analysis show that overwhelmingly, the electricity (mostly from Italian grid electricity mix) and quantities used, is responsible for the highest impact on the environment in all of the seven impact categories assessed, with the electricity from onsite photovoltaic panels having minor impacts, except in the ADPE category.

The raw materials of iron oxide pigments and frit (due to the natural resources and energy used in their upstream processing), and the transport of the raw materials and packaging to site (due to fuel usage in most categories), are the second, third and fourth highest contributors in all seven categories after the electricity. The hierarchy of these three contributors varies between impact categories.

7 References

(1) BSI. Sustainability of construction works – Environmental product declarations – Core rules for the product category of construction products, BS EN 15804:2012+A1:2013. London, UK, BSI Standards Limited, 2014

(2) BRE. BRE Global product category Rules for Type III environmental product declaration of construction products to EN 15804:2012+A1:2013, PN514. Watford, UK, BRE Global Limited, 2014

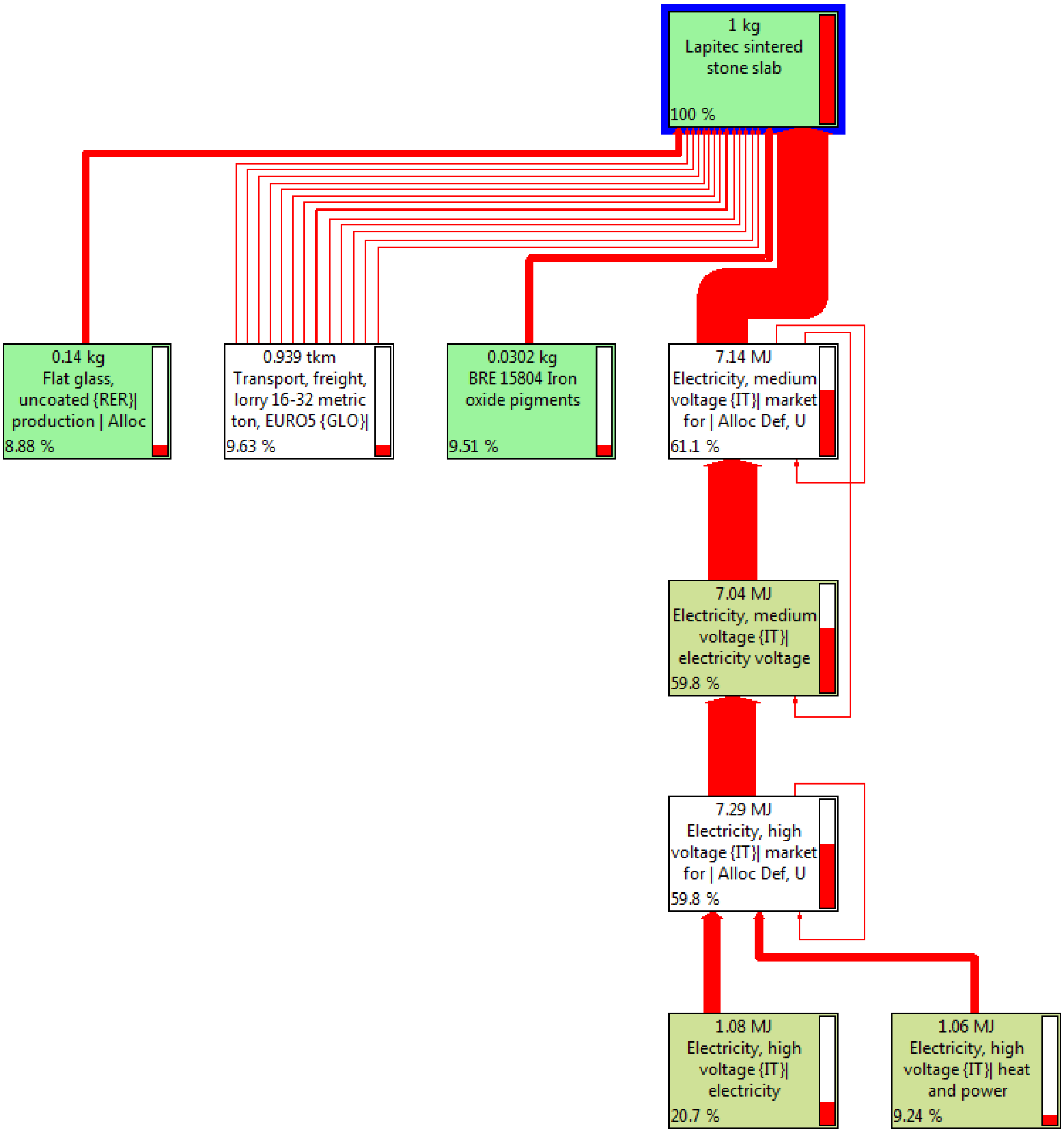
(3) BSI. Environmental management – Life cycle assessment – Requirements and guidelines, BS EN ISO 14044:2006. London, UK, BSI Standards Limited, 2006

(4) PRé Consultants bv SimaPro 8 LCA Software 2013. http://www.pre-sustainability.com

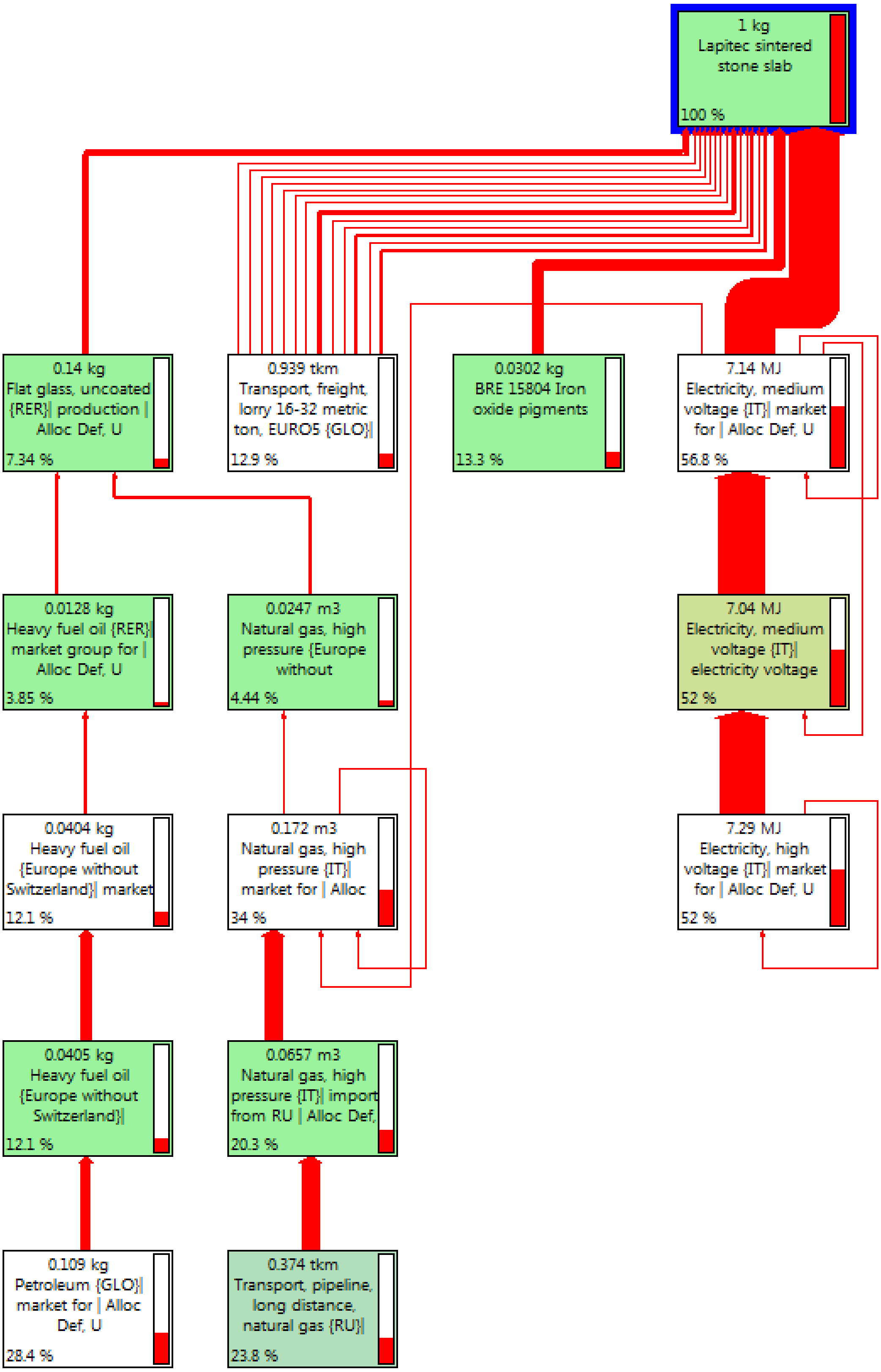
(5) ecoinvent Centre. Swiss Centre for life Cycle Inventories. http://www.ecoinvent.org

Appendix A Network flows for the production stage of Lapitec sintered stone slab

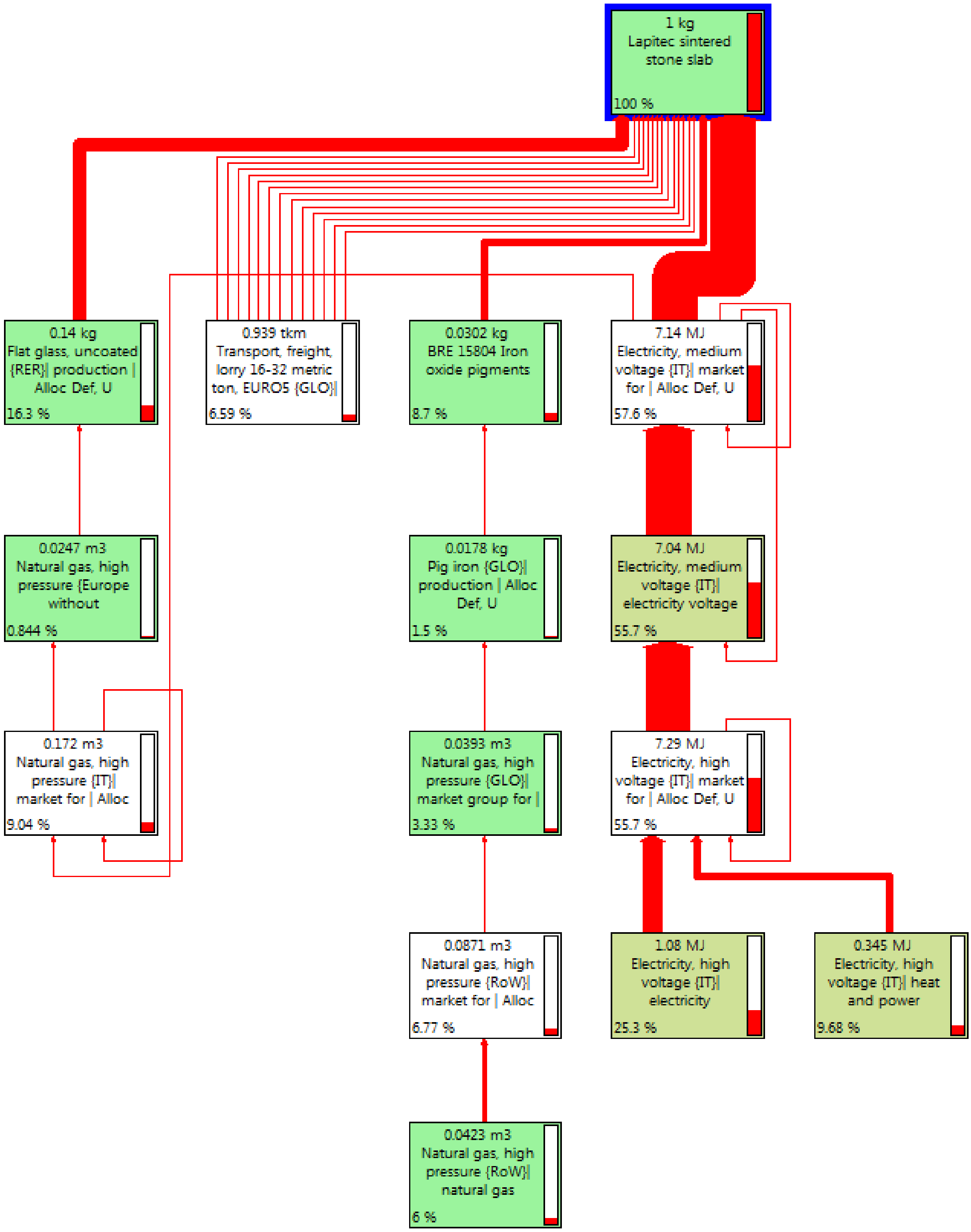
GWP



ODP

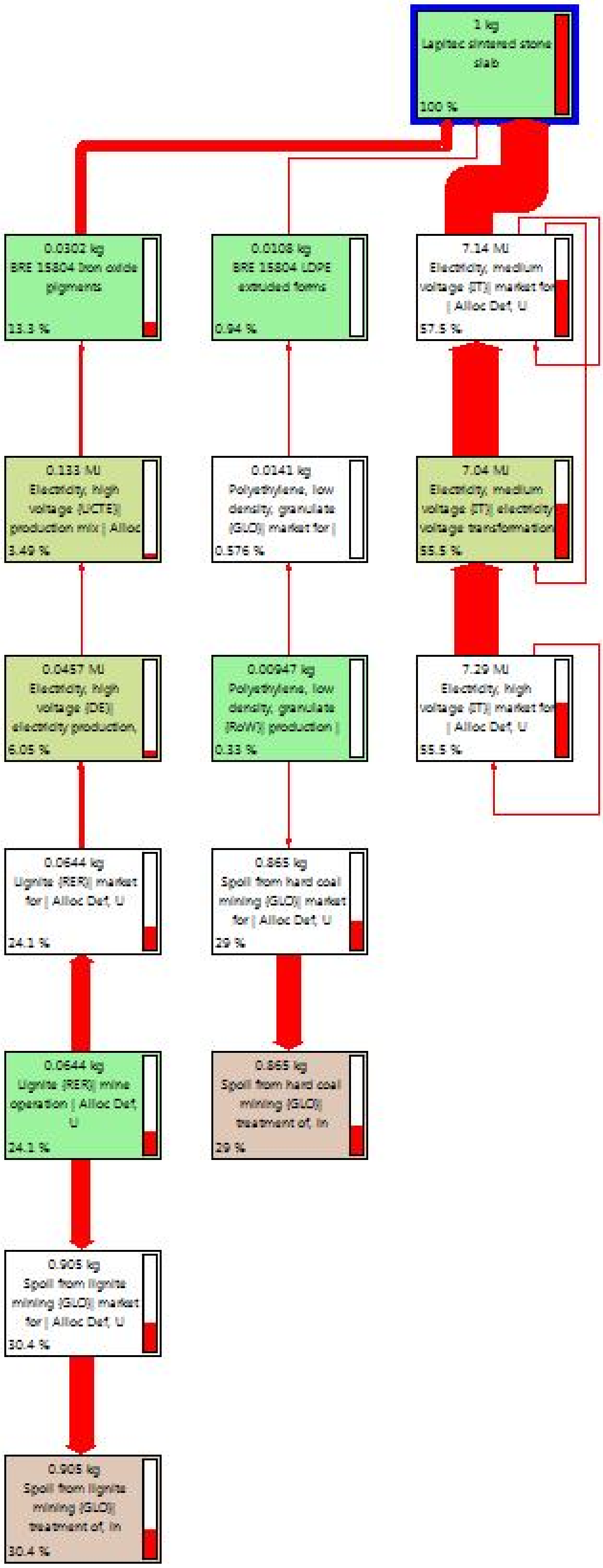

1 kg
Lapitec sintered stone slab
100 %
0.14 kg
Flat glass, uncoated {RER}| production | Alloc Def, U
7.34 %
0.939 tkm
Transport, freight, lorry 16-32 metric ton, EURO5 {GLO}|
12.9 %
0.0302 kg
BRE 15804 Iron oxide pigments
13.3 %
7.14 MJ
Electricity, medium voltage {IT}| market for | Alloc Def, U
56.8 %
0.0128 kg
Heavy fuel oil {RER}| market group for | Alloc Def, U
3.85 %
0.0247 m3
Natural gas, high pressure {Europe without
4.44 %
7.04 MJ
Electricity, medium voltage {IT}| electricity voltage
52 %
0.0404 kg
Heavy fuel oil {Europe without Switzerland}| market
12.1 %
0.172 m3
Natural gas, high pressure {IT}| market for | Alloc
34 %
7.29 MJ
Electricity, high voltage {IT}| market for | Alloc Def, U
52 %
0.0405 kg
Heavy fuel oil {Europe without Switzerland}|
12.1 %
0.0657 m3
Natural gas, high pressure {IT}| import from RU | Alloc Def,
20.3 %
0.109 kg
Petroleum {GLO}| market for | Alloc Def, U
28.4 %
0.374 tkm
Transport, pipeline, long distance, natural gas {RU}|
23.8 %

AP

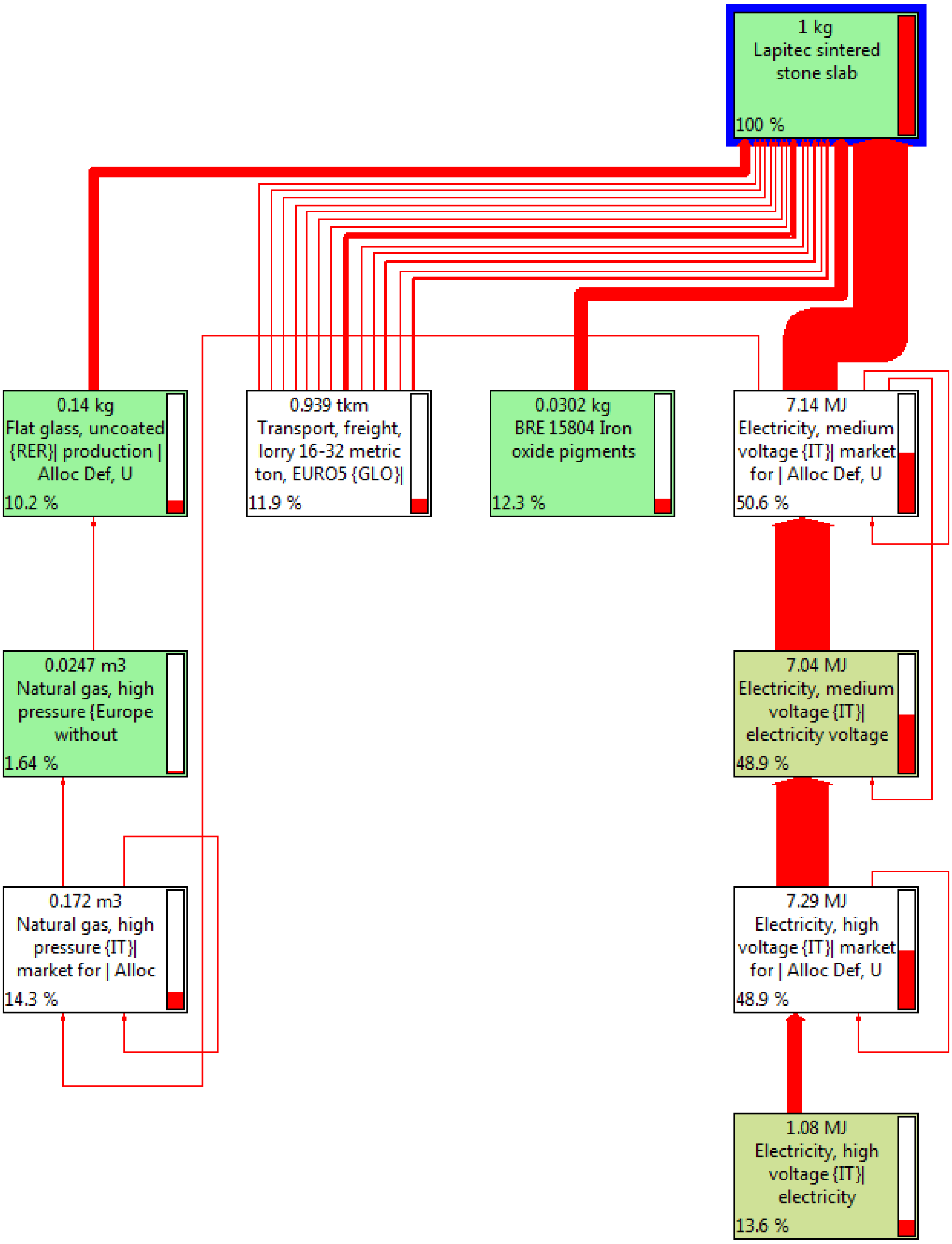


1 kg
Lapitec sintered stone slab
100 %
0.14 kg
Flat glass, uncoated {RER}| production | Alloc Def, U
16.3 %
0.939 tkm
Transport, freight, lorry 16-32 metric ton, EURO5 {GLO}|
6.59 %
0.0302 kg
BRE 15804 Iron oxide pigments
8.7 %
7.14 MJ
Electricity, medium voltage {IT}| market for | Alloc Def, U
57.6 %
0.0247 m3
Natural gas, high pressure {Europe without
0.844 %
0.0178 kg
Pig iron {GLO}| production | Alloc Def, U
1.5 %
7.04 MJ
Electricity, medium voltage {IT}| electricity voltage
55.7 %
0.172 m3
Natural gas, high pressure {IT}| market for | Alloc
9.04 %
0.0393 m3
Natural gas, high pressure {GLO}| market group for |
3.33 %
7.29 MJ
Electricity, high voltage {IT}| market for | Alloc Def, U
55.7 %
0.0871 m3
Natural gas, high pressure {RoW}| market for | Alloc
6.77 %
1.08 MJ
Electricity, high voltage {IT}| electricity
25.3 %
0.345 MJ
Electricity, high voltage {IT}| heat and power
9.68 %
0.0423 m3
Natural gas, high pressure {RoW}| natural gas
6 %

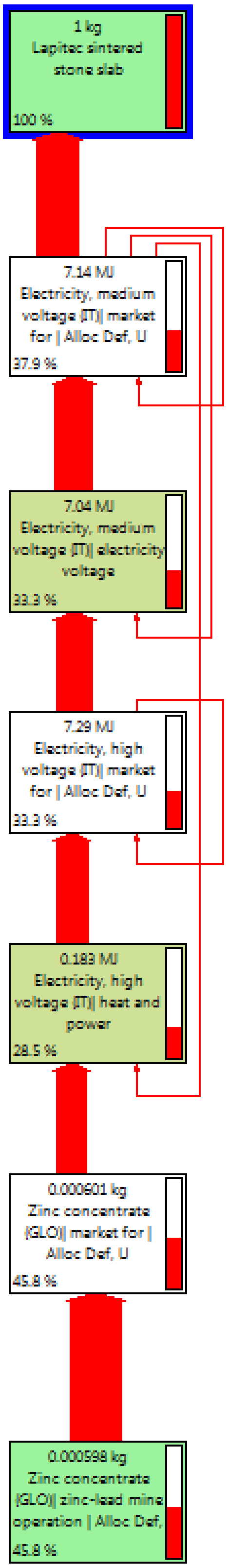
EP


1 kg
Lapitec sintered stone slab
100 %
0.0302 kg
BRE 15804 Iron oxide pigments
13.3 %
0.0108 kg
BRE 15804 LDPE extruded forms
0.94 %
7.14 MJ
Electricity, medium voltage {IT}| market for | Alloc Def, U
57.5 %
0.133 MJ
Electricity, high voltage {UCTE}| production mix | Alloc
3.49 %
0.0141 kg
Polyethylene, low density, granulate {GLO}| market for |
0.576 %
7.04 MJ
Electricity, medium voltage {IT}| electricity voltage transformation
55.5 %
0.0457 MJ
Electricity, high voltage {DE}| electricity production,
6.05 %
0.00947 kg
Polyethylene, low density, granulate {RoW}| production |
0.33 %
7.29 MJ
Electricity, high voltage {IT}| market for | Alloc Def, U
55.5 %
0.0644 kg
Lignite {RER}| market for | Alloc Def, U
24.1 %
0.865 kg
Spoil from hard coal mining {GLO}| market for | Alloc Def, U
29 %
0.0644 kg
Lignite {RER}| mine operation | Alloc Def, U
24.1 %
0.865 kg
Spoil from hard coal mining {GLO}| treatment of, in
29 %
0.905 kg
Spoil from lignite mining {GLO}| market for | Alloc Def, U
30.4 %
0.905 kg
Spoil from lignite mining {GLO}| treatment of, in
30.4 %

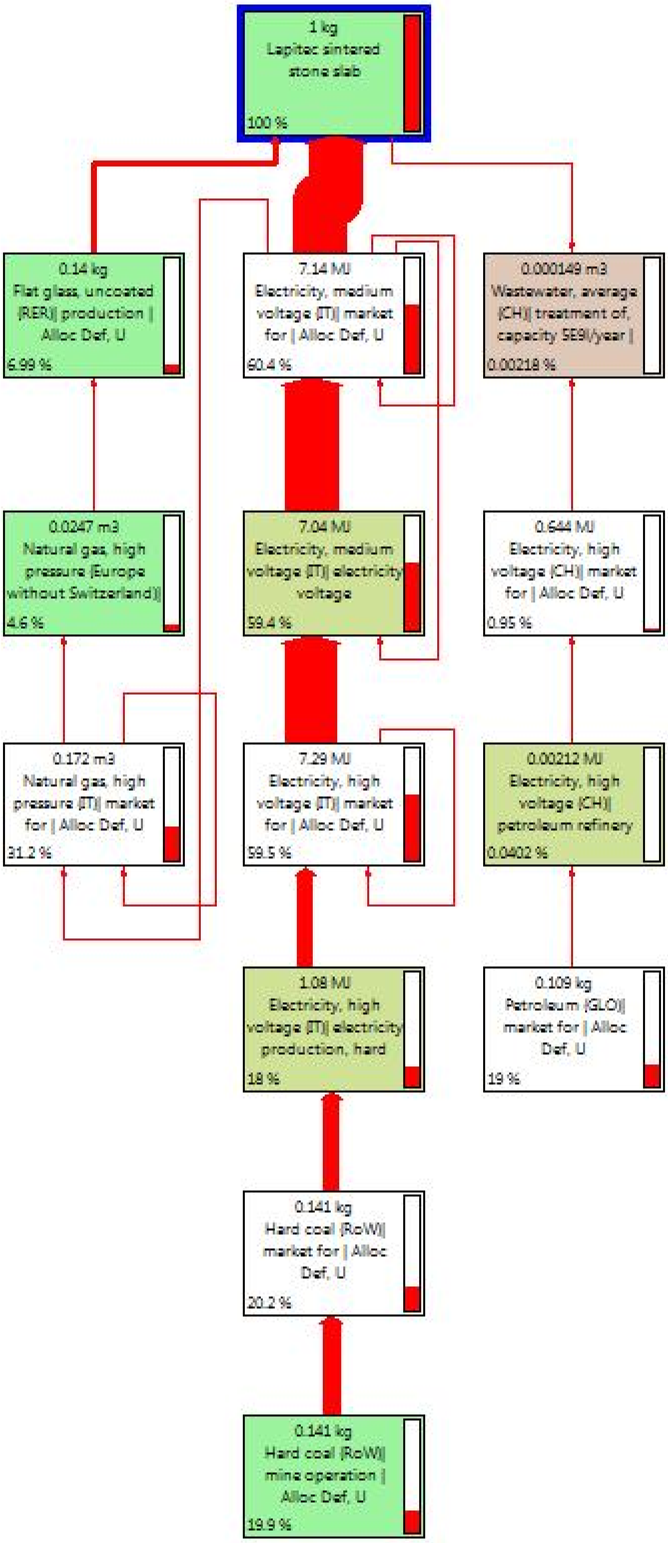
POCP


1 kg
Lapitec sintered stone slab
100 %
0.14 kg
Flat glass, uncoated {RER}| production | Alloc Def, U
10.2 %
0.939 tkm
Transport, freight, lorry 16-32 metric ton, EURO5 {GLO}|
11.9 %
0.0302 kg
BRE 15804 Iron oxide pigments
12.3 %
7.14 MJ
Electricity, medium voltage {IT}| market for | Alloc Def, U
50.6 %
0.0247 m3
Natural gas, high pressure {Europe without
1.64 %
7.04 MJ
Electricity, medium voltage {IT}| electricity voltage
48.9 %
0.172 m3
Natural gas, high pressure {IT}| market for | Alloc
14.3 %
7.29 MJ
Electricity, high voltage {IT}| market for | Alloc Def, U
48.9 %
1.08 MJ
Electricity, high voltage {IT}| electricity
13.6 %

ADPE


1 kg
Lapitec sintered stone slab
100 %
7.14 MJ
Electricity, medium voltage {IT}| market for | Alloc Def, U
37.9 %
7.04 MJ
Electricity, medium voltage {IT}| electricity voltage
33.3 %
7.29 MJ
Electricity, high voltage {IT}| market for | Alloc Def, U
33.3 %
0.183 MJ
Electricity, high voltage {IT}| heat and power
28.5 %
0.000601 kg
Zinc concentrate {GLO}| market for | Alloc Def, U
45.8 %
0.000598 kg
Zinc concentrate {GLO}| zinc-lead mine operation | Alloc Def,
45.8 %

ADPF



Report Ends