Environmental Product Declaration

according to ISO 14025

Fibre-Cement Building Material Product

UAC Berhad

Declaration number
EPD-UAC-2010111-E

Institute Construction and Environment
www.bau-umwelt.com

Institut Bauen
und Umwelt e.V.

	Summary ***Environmental Product Declaration***

Institute Construction and Environment **www.bau-umwelt.com** Institut Bauen und Umwelt e.V.	**Programme holder**
UAC Berhad 36, Jalan Portland, Tasek Industrial Estate, 31400 Ipoh, Perak Darul Ridzuan, Malaysia	**Declaration holder**
EPD-UAC-2010111-E	**Declaration number**
Fibre cement building material products by UAC This declaration is an environmental product declaration according to ISO 14025 and describes the specific environmental impacts of the mentioned construction materials. It is supposed to advance the development of environmentally and health friendly construction. All relevant environmental data is revealed in this validated declaration. The declaration is based on the PCR document „fibre cement": 2007-02".	**Declared building products**
This validated declaration entitles the usage of the label of the Institute Construction and Environment. This exclusively applies to the mentioned products, three years from the date of issue. The declaration holder is liable for the basic information and verifications.	**Validity**
The **declaration** is complete and contains in detailed form: - Product definition and information about building physics - Information about basic material and the material's origin - Description of the product's manufacture - Indication of product processing - Information about the in-use conditions, extraordinary impacts and subsequent usage phase - Life cycle assessment results - Testings and verifications	**Content of the Declaration**

1st February 2010		**Date of issue**
Prof. Dr.-Ing. Horst J. Bossenmayer (President of the Institute Construction and Environment)		**Signatures**

This declaration, and the rules which it is based on, have been verified by the Independent Advisory Board (SVA) according to ISO 14025.		**Verification of the declaration**
Prof. Dr.-Ing. Hans-Wolf Reinhardt (Chairman of the SVA)	Dr. Birgit Grahl (Reviewer appointed by the SVA)	**Signatures**

Summary

Environmental Product-Declaration

Product description

The declared products are building sheets/panels made of fibre cement. "UCO" is a prefix registered trademark for UAC range of fibre cement products. All products are asbestos-free.

Range of application

The products are applied as follows:

UCO Superflex: ceiling and wall portioning, both internally and externally. Also used for gable end, façade, eave lining, permanent formwork and substrate flooring.

UCO Decoceil/ UCO Ceil: ceiling

UCO Vistabord/Flexabord/Multiflex: internal drywall applications, external soffits, internal ceiling, fire doors

UCO Lattices: gable ends, room divider, pergola roofs, fencing, veranda, patio and window, privacy screens, wind breaker and feature panels.

UCO Sedartex Woodgrain/Smooth Planks: siding, gable end and fascia application

UCO Supertex Woodgrain Panel: wall partition, gable end and fascia application

UCO Duravent: ceiling, eave

UCO Shingles: roofing

UCO Bargeboard: gable end, facia

Based on the annual production data an average metric tonne fibre cement product is calculated. This averaged metric tonne fibre cement product represents all UAC flat sheet products mentioned above.

Scope of the Life Cycle Assessment

The LCA was performed according to DIN ISO 14040/44 corresponding to the requirements of the guide lines concerning Type III declarations of the Institute Construction and Environment. Specific industrial data provided by UAC for the production plant in Ipoh, Malaysia, as well as data from the data base „GaBi 4" was applied as data basis. The LCA comprises raw material extraction, pre-product and energy production, raw material and pre-product transports and the actual manufacturing phase of the fibre cement products. The production of packaging materials and its end of life phase are included as well. The declared unit used for this study is the average production of 1 metric tonne fibre-cement. The average bulk density of the products is about 1,350 kg/m^3.

LCA results

UAC fibre cement products			
Assessment parameter in unit per t	**Manufacturing**	**Use phase Transportation**	**Total**
Primary energy, non renewable [MJ]	9385.6	727.5	10113.1
Primary energy, renewable [MJ]	2668.1	0.69	2668.8
Secondary fuels [MJ]	70.1	0	70.1
Global Warming Potential (GWP 100) [kg CO2-equ.]	833.8	56.4	890.2
Acidification Potential (AP) [kg SO2- equ.]	3.94	1.43	5.37
Eutrophication Potential (EP) [kg PO4- equ.]	0.445	0.14	0.585
Ozone Depletion Potential (ODP) [kg R11- equ]	8.95E-06	5.84E-08	9.01E-06
Photochemical Ozone Creation Potential (POCP) [kg C2H4- equ.]	0.281	0.08	0.361

Created by: PE INTERNATIONAL, Leinfelden-Echterdingen

Testing and verifications

In addition, the following **testing and verifications** are presented in the Environmental Product Declaration:

- Leaching behaviour

Scope of validity

This environmental product declaration refers to fibre cement sheets and panels of the mentioned average composition produced by UAC Berhad at the production plant located in Ipoh, Malaysia. The considered averaged metric tonne fibre cement product represents all UAC flat sheet products mentioned within this declaration.

0 Product definition

Product definition

The declared products are building sheets/panels made of fibre cement.

These products include UCO Superflex, UCO Vistabord, UCO Flexabord, UCO Multiflex, UCO Decoceil, UCO Ceil, UCO Sedartex Woodgrain Plank, UCO Smooth Plank, Supertex Woodgrain Panel, UCO Lattices, UCO Duravent, UCO Shingles and UCO Bargeboard.

"UCO" is a prefix registered trademark for UAC range of fibre cement products. All products are asbestos-free.

Application

1. UCO Superflex: ceiling and wall portioning, both internally and externally. Also used for gable end, façade, eave lining, permanent formwork and substrate flooring.
2. UCO Decoceil/ UCO Ceil: ceiling
3. UCO Vistabord/Flexabord/Multiflex: internal drywall applications, external soffits, internal ceiling, fire doors
4. UCO Lattices: gable ends, room divider, pergola roofs, fencing, veranda, patio and window, privacy screens, wind breaker and feature panels.
5. UCO Sedartex Woodgrain/Smooth Planks: siding, gable end and fascia application
6. UCO Supertex Woodgrain Panel: wall partition, gable end and fascia application
7. UCO Duravent: ceiling, eave
8. UCO Shingles: roofing
9. UCO Bargeboard: gable end, facia

Product standard / approval

Malaysian Standard MS1296:1992 Fibre cement flat sheets

European Standard EN12467:2004 Fibre cement flat sheets – Product specification and test methods

Quality control

Product conforms and certifies to (a) MS1296:1992 for UCO Superflex and (b) EN12467:2004 for 7.5mm UCO Sedartex Woodgrain Plank.

Quality Management System in accordance to ISO 9001:2008 for design and manufacture of fibre cement products.

Other products: in accordance to internal quality assurance & control system.

Geometrical data

UCO Superflex:

Nominal Thickness, mm	Nominal weight of board (kg) for standard size products				
	2440 x 1220 mm	1220 x 1220 mm	1220 x 610 mm	603 x 603 mm	595 x 595 mm
3.2	13.8	6.9	3.5	1.7	1.6
3.5	15.5	7.8	3.9	1.9	1.8
4.5	19.6	9.8	4.9	-	-

6.0	26.6	13.3	6.7	-	-
9.0	41.3	20.6	10.3	-	-
12.0	55.4	27.7	13.8	-	-

Other sizes and thickness can be manufactured on request.

UCO Ceil:

Standard size, mm	595x595	603x603
Nominal thickness, mm	3.2	
Approx. Weight/board, kg	1.7	

UCO Decoceil: Angkasa/Chemerah/Chemerah Plus/Tika/Forra Plus

Standard size, mm	1220x1220	1220x610
Nominal thickness, mm	3.2	
Approx. weight/board, kg	7.2	3.6

UCO Vistabord/Flexabord/Multiflex:

Standard size, mm	2440 x 1220	2745 x 1220	3050 x 1220
Nominal thickness, mm	6.0, 7.5, 9.0, 12.0		

UCO Lattices:

Standard size, mm	2440 x 1220	2745 x 1220	3050 x 1220
Nominal thickness, mm	6.0		

UCO Sedartex Woodgrain Plank:

Nominal thickness, mm	6.5	7.5
Nominal width, mm	210 or 230	
Nominal length, mm	3660	

UCO Sedartex Smooth Plank :

Nominal width, mm	230			210		225	150
Nominal length, mm	3660						
Nominal thickness, mm	7.5	9.0	12.0	7.5	9.0	12.0	12.0
Approx. weight/plank, kg	9.4	11.0	15.6	8.6	10.0	15.2	10.2

UCO Supertex Woodgrain Panel:

Nominal thickness, mm	6.0
Nominal width, mm	1216
Nominal length, mm	2440
Approx. weight/panel, kg	28

UCO Duravent:

Standard size, mm	1220 x 1220		1220 x 915		1220 x 610	
Nominal thickness, mm	3.2	4.5	3.2	4.5	3.2	4.5
Approx. weight/board, kg	6.4	9.0	4.9	6.7	3.3	4.5
Slot width, mm	7		7		7	
Slot length, mm	150		220		150	

UCO Shingles:

Nominal width, mm	1220
Nominal thickness, mm	4.5
Nominal Depth, mm	610
Coverage	325 shingles per 100m^2

UCO Bargeboard:

Nominal Length, mm	2720
Nominal thickness, mm	5.0

Building physical data

UCO Superflex / UCO Duravent / UCO Shingles / UCO Lattices / UCO Decoceil / UCO Ceil:

Physical Properties	Value
Ave Oven dry density [kg/m^3]	1,360
Flexural Strength Ave oven dry flexural strength [MPa] Ave saturated flexural strength [MPa]	 20 13
Thermal conductivity	0.30W/m.K (estimated at 20°C)

UCO Vistabord / Flexabord / Multiflex :

Physical Properties	Value
Ave Oven dry density [kg/m^3]	1,380
Flexural Strength Ave oven dry flexural strength [MPa] Ave saturated flexural strength [MPa]	 17 12
Thermal conductivity	0.47W/m.K (estimated at 20°C)

UCO Sedartex WoodGrain Plank :

Physical Properties	Value
Ave Oven dry density [kg/m^3]	1,380
Strength acc. to MS1296:1992 : Ave oven dried flexural strength [MPa]	 19

Ave saturated flexural strength [MPa]	13
Thermal conductivity	no value available

UCO Sedartex Smooth Plank :

Physical Properties	Value
Ave Oven dry density [kg/m^3]	1,380
Flexural Strength Ave oven dry flexural strength [MPa] Ave saturated flexural strength [MPa]	 20 13
Thermal conductivity	no value available-

UCO Supertex WoodGrain Panel :

Physical Properties	Value
Ave Oven dry density [kg/m^3]	1,380
Flexural Strength Ave oven dry flexural strength [MPa] Ave saturated flexural strength [MPa]	 18 13
Thermal conductivity	no value available

For all considered products the following building physical data apply:
according to DIN EN 12467 and MS 1296:

- Compression strength < 15 N/mm²
- Tensile strength 0.5-1.0 N/mm²
- E-module 5500 N/mm²
- Linear extension coefficient α_t 10^{-5} mm/mK
- Equilibrium moisture content at 23°C, 80% humidity: 6-8%
- Moisture expansion (air-dried to drenched) in 0.16-0.18%
- Water vapour diffusion pressure loss coefficient μ according to DIN 4108-4 not tested

Sound-proofing

With a 6mm fibre cement sheet (1190mmx1190mm) installed in the opening between two adjacent but acoustically isolated reverberation rooms, 17-33 dB sound transmission loss at frequency from 125-5000Hz. Airborne noise insulation is determined as STC30. (tested in accordance to ASTM E90-90)

The difference between the sound absorption of the room with and without the 6mm fibre cement sheet is determine to obtain the total sound loss by using the reverberation time values. Noise reduction coefficient is determined as NRC0.10. (ASTM E423-90a)

Sound transmission loss(UCO Vistabord): Estimated 25dB (6mm), 28dB (9mm)

Fire Protection Requirements

Fire propagation index: range from 9 – 4.6, according to BS 476-6:1989

Surface spread of flame test: Class 1 surface spread of flame (actual result 0 mm at 1.5 m), according to BS 476-7:1997

1 Basic materials

pre-products	Fibre cement: (pre-products composition in % by dry mass) • Cement 30 - 40% • Silica 50 - 60% • Pulp / cellulose fibre 6 - 9%
Coatings	None
Auxiliary substances/ additives	• Alumina/Aluminium Trihydrate 0 - 5% • Silica fume 0 - 5% • Red pigment 0 - 1%
Comment on pre-products	• Portland Cement: Produced according to MS 522: 2007 & BS EN 197-1: 2000. It is a hydraulic cement produced by pulverizing clinker consisting essentially of hydraulic calcium silicates, usually containing one or more of the forms of calcium sulfate as an interground addition. • Pulp: Unbleached softwood kraft pulp which has Kappa number between 20 and 30. Cellulose fibre is the main reinforcement aid to bind the matrix together for forming the sheet. During the manufacturing process, it acts as filtering aid to retain cementitious matrix from being washed away by the excessive water. • Silica: Sand from Ground that have min 85% SiO2. Ground silica that reaches minimum 300m2/kg is extracted, elutriated and sieved. It will be mixed together with cement in order to react during autoclave. • Aluminium trihydrate: Hydrated alumina, also known as alumina trihydrate (ATH), or simply hydrate, is more accurately chemically designated as aluminium trihydroxide, Al(OH)3. It is used in fibre cement board to improve product ductility and durability. • Silica fume: Silica fume is a by-product resulting from the reduction of high purity quartz with coal in an electric arc furnace in the manufacture of ferro silicon and silicon metal. Silica fume, which has a high content of amorphous (non-crystallized) silicon dioxide and consists of very fine spherical particles (in the order of 1/100th the size of a cement particle), is collected by filtering gases escaping from the electric arc furnaces. Silica fume helps to improve the fibre cement interlaminar bonding strength. • Red pigment: Iron oxide with min 80% active ingredients is blend together with fibre cement mix to tint red colour to the flat sheets.
Raw Materials origin and pre-product production	• Cement is obtained and purchased locally from two sources with a distance of 0.5km and 16km from the cement production plants to UAC factory respectively. • Sand is obtained and purchased locally from a sand mine. Average transport distance between the location of sand mine and the factory is 95 km • Pulp is imported mainly from New Zealand and Chile. • Alumina is imported from India and Australia. • Silica fume is imported from Norway and China. • Red pigment is imported from China.
Availability of Raw Materials	Fibre cement consists of materials (lime & sand) for which there is no resource shortage according to current knowledge. Pulp source comes from forest plantation.

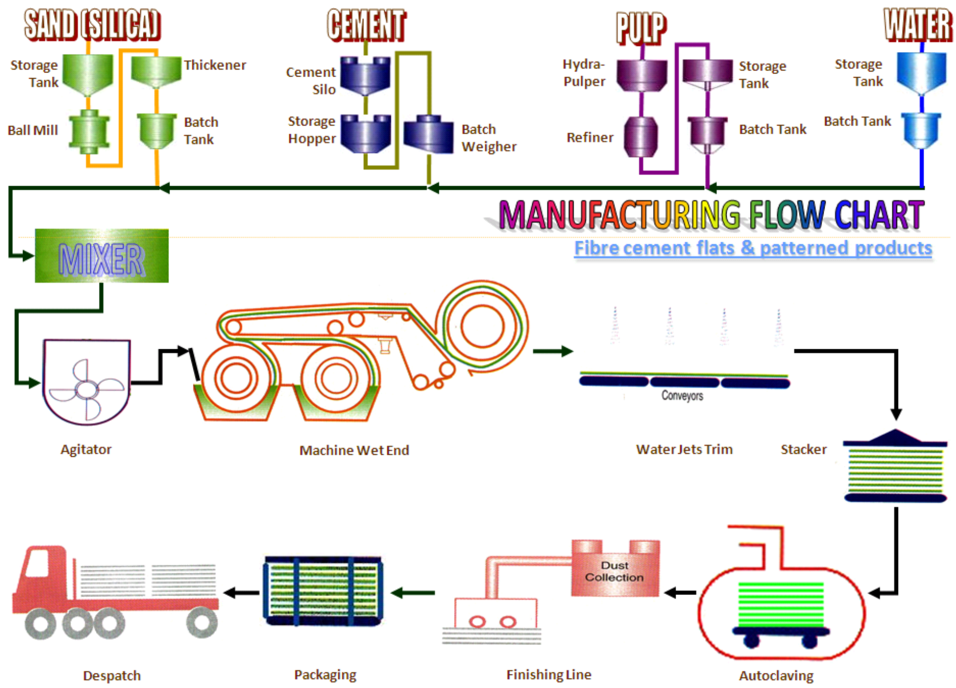
2 Product manufacture

Product Manufacture

Fibre cement flat sheets are produced with Hatschek process or wet process.

- The pre-products are mixed homogeneously and pumped to the tubs at controlled rate so that tubs are filled and overflow.
- A uniform film is formed onto the sieves and the film will be picked up by felt which will then be transferred to a size roller to be rolled in layers for the manufacturing of 'green sheet' (sheet formed immediate in the production process not yet entered the autoclaving process) according to the desired thicknesses. The speed of the felt is controlled in order to achieve consistent sheet thickness at a specified production rate.
- Individual size roller determines the length of sheet being produced. If patterned sheet is to be produced, a patterned sleeve will be placed on the size roller to create the desired patterns.
- Once the desired thickness is achieved, it will then be separated and taken off from size roller by a cut-off wire.
- The green sheet will then be trimmed into size by high pressure water jet while the remaining scraps will return to scrap agitator which will then transferred back to feed agitator for reuse in order to minimise waste generated.
- The trimmed green sheets are stacked in tiers on steel base pallet.
- The stacked green sheets will then be air-cured for minimum 6-8 hours before curing in autoclave for total process duration of 10-12 hours.

The autoclaved sheets will undergo further cutting or trimming into the final dimension at sheet finishing with either guillotine knife or rotating saw. Sanding, edge recessing and slotting are also being done at sheet finishing.



Health protection production

During the entire manufacturing process, no health protection measures extending beyond mandatory occupational safety measures for commercial operations are required.

Dust mask, safety shoes, ear plug/protection and glove are used.

Environmental protection production	Air: Dust is collected through dust collector and filter before release to air. Dust emission is below the Permissible Level under Regulation 25 of the Environmental Quality (Clean Air) Regulations 1978 /Act 127/ Water: The process water is meant for reuse in the manufacturing process. However, excess water accumulated during manufacturing and systems cleaning are diverted to wastewater treatment plant in the factory before discharge to the drain. Noise: Sheet finishing 1 – Above LEQ 90dBA, max 115dBA and peak 140dB Sheet finishing 2 – Above LEQ 90dBA, max 115dBA and peak 140dB Despatch & crating – Above max 115dBA and peak 140dB Sheet machine 1 – Above max 115dBA and peak 140dB Sheet machine 3 – Above LEQ 90dBA and max 115dBA Sheet machine 4 – Above LEQ 90dBA, max 115dBA and peak 140dB Sheet machine 5 – Above LEQ 90dBA, max 115dBA and peak 140dB Engineering services – Above max 115dBA and peak 140dB Maintenance – Above max 115dBA and peak 140dB Electrical – Above max 115dBA Store – Below LEQ 90dBA, max115 dBA and peak 140dB QC - Below LEQ 90dBA, max115 dBA and peak 140dB Personal protective equipment (ear plug & ear muff) is sufficient to - reduce the highest LEQ experienced in the plant to less than 85dBA - reduce the highest max level to less than 115dBA - reduce the highest peak level below 140dB
Packaging	Stretch wrap, wooden pallets, PET strap, hardboard edge/corner protectors

3 Product processing

Processing Recommendations	Special low dust equipment such as slow-running, hard-metal-fitted separating saws and milling cutters as well as manual tools such as busters, punch pliers are available for processing. Drilling is normally carried out with normal HSS drills. Structurally required ancillary products for installation are timber/steel framing including the required anchoring, connecting means (nails, screws, fasteners, metal angles, PVC jointer, plastic/metal casing bead, angle trim) and jointing means such as perforated paper tape, jointing compound, foam tape flashing and foam backing tape. For wet areas, flashing strip should extend into shower tray. Metal eternal angles or paper tape should not be used. Where shower bases or pre-formed trays are used, an additional nogging should be provided.
Labour protection Environmental protection	The usual occupational safety measures must be complied with accordance to the manufacturer's information as follows: • Wear safety glasses when cutting and nailing Fibre Cement Sheet (FCS). • Use ear protection when cutting siding with a circular saw. • Cutting FCS with a circular saw creates a large amount of dust which can

lead to the incurable lung disease silicosis. Always cut siding outside and use a dust collecting saw hooked to a HEPA-equipped vacuum system if possible.

- Wear a NIOSH approved N-95 dust mask or respirator when cutting FCS.

Contractors should follow UAC ceiling installation guide and fixing manual for fixing, cutting and forming holes of the said fibre cement board.

Based on current knowledge, hazards to water, air and soil will not arise from installing fibre cement board.

Residual material/ Packaging	Sheet sections and packaging must be collected separately. For disposal, the regulations of the local disposal authority and notes in /Act 127/ and chapter 'End of life' phase must be observed. Packaging: If they are collected in the pure form, it can be recycled into resin form and use for packing in other applications. Within the LCA model, packaging materials are assumed to be incinerated in the End-of-life stage. Pallets: Can be accepted by pallet maker for rebuilding & reuse purpose or recycle to use in composite pallet. It can also ground up for use as landscape mulch, animal bedding, and composting and soil amendment. If no such pallet supplier will accept the used pallets, then it can be safely dispose in landfill (manufacturer's recommendation)

4 In-use conditions

Contents	Fibre cement green sheets will undergo the hydrothermal reaction during the autoclaving process to form calcium silicate hydrate phases with the predominant of tobermorite, the resultant of cement (lime)-silica reaction. During the aging process while in use, at the right condition with the presence of carbon dioxide and moisture in the atmosphere, the calcium silicate hydrate phases will be carbonated through a carbonation process. Fibre cement flat sheets contained about 8% moisture content at equilibrium condition.
Impact relations Environment-health	Environmental aspects: Hazards to water, soil and air cannot arise from fibre cement flat sheets based on current knowledge. Health aspects: During normal use according to construction materials' purpose and fixing and installation guides are being observed, no health impairment is known due to basic materials employed and their behaviour according to current knowledge.
Durability / Utilisation condition	Fibre cement products can be used with almost no limits after the settling of the cement binding agent if used according to the regulations.

5 Extraordinary impacts

Fire	• Toxicity of the fumes: No known of toxic fume released during fire (see test results regarding the toxicity of the combustion in Chapter 8: Evidence). • Flame spread: Fibre cement flat sheets will not ignite and no flame spread. • Fire propagation: Fire propagation index is less than 3.
Water	No hazardous contents to be formed in water while being washed. The pH value of the board is alkaline (pH ≅12 when moist)

6 End of Life

Disassembly
The façade and flat sheets can be removed through unscrewing or drilling the rivets, depending on the fastening system. If large quantities are assembled by plastering, it will be broken and removed. For floorings with tiles on the top, disassembly will be done through destruction.

Reutilisation
In their undamaged form, the dismantled form can be reused according to their original purpose or as foundation wall protection.

For damaged form, it may be used as infill material for SolidWall System (Materials recycling).

Recycling
Possible uses as part of the constituent

1. for SolidWall System infill material
2. to make into a non commercial value 'timber blocks' made of cementitious waste material for in house applications to reduce the use of actual timber block

Reclamation
Disassembled fibre cement products are also suitable for reclamation as padding and filling material in cement production.

Disposal
Fibre cement:

Fibre cement flat sheets. According to Malaysia solid waste regulations, remains of fibre waste cement products from construction site or from demolition can be disposed as solid waste. According to European Waste Catalogue, waste key: 170101 (Concrete), remains of fibre cement products from construction site or from demolition can be stored without problem due to their mostly mineral content in garbage landfills of landfill class I.

7 Life cycle assessment

7.1 General

This LCA report is conducted by PE International GmbH according to the requirements of the International Standards /ISO 14040/ and /ISO 14044/ and the requirements given in the PCR document /PCR 2007/ and the general guideline by the Institute Construction and Environment e.V.

The LCA model was calculated with the GaBi software and database /GaBi 4/. The Life Cycle assessment declaration refers to the production of one metric tonne fibre cement sheets and panels manufactured by UAC at the plant in Ipoh, Malaysia. Whith the help of questionnaires annual production data were collected for all produced flat sheet products made of fibre cement. The production data are based on plant data measured during the year 2008. The LCA is representative for fibre cement sheets and panels manufactured by UAC Malaysia.

Declared Unit
All products show similar recipes with some differences in dosage of pre-products for certain products. The mentioned products show different densities, but the production procedure is the same for each. Based on the annual production data one average metric tonne fibre cement product is calculated. The averaged bulk density of the products is 1,350 kg/m3.

System boundaries
Our system boundary includes the production of fibre-cement products from extraction of raw material to the production of finished packaged product at the factory gate (cradle to gate). GaBi database was used for producing energy and transport. The frame work of observations specifically includes:

- Manufacture of all pre-products employed
- Transport of raw materials and pre-products

- packaging of the final product
- Product manufacturing cost (energy, resources, waste, emissions), including precursor products and energy preparation from resources.
- Production of packaging materials and its end-of-life (incineration)

All examined fibre cement products were manufactured at the UAC Ipoh plant in Malaysia. The products are assumed as maintenance free products. No cleaning or other maintenance activities are considered with regard to the products examined for the use phase. In this declaration, a consideration of end-of-life scenarios was waived.

7.2 Manufacturing the ceramic cladding elements

Cut-off Criteria

In the assessment, all data from the production data acquisition have been considered, i.e. all raw material and pre-products used as per formulation, utilised thermal energy, internal fuel consumption and electric power consumption, direct production waste, and all emission measurements available. For all considered inputs and outputs assumptions have been made on the expenditures for transports. Thus also material and energy flows with a proportion of less than 1% have been considered.

It can be assumed that the total sum of neglected processes would have contributed less than 5% to the considered impact categories.

Machines and facilities required during production will be neglected.

Transportation

The transportation of the raw and auxiliary materials and pre-products used has been included.

Observation period

Primary data was collected from UAC to represent their 2008 calendar year activities. Additional data necessary to model base material production and energy use obtained from the GaBi 4 database have a time range of approximately 2002 to present, depending on energy and material profiles.

Background data

The GaBi 4 software was used for modelling the life cycle for the manufacturing of UAC fibre-cement products.

Electricity grid mix for Malaysia boundary condition was used in modelling the system. Dataset which are not available under Malaysia boundary condition are represented by the best possible dataset and boundary condition whenever possible at the point when this study was conducted.

Data quality

All relevant flows are calculated in this study. As a measure of data quality, it is reported whether the data were measured, calculated, or estimated. The age of the data employed in this study is 2008. Wherever possible, directly measured data from UAC plant is utilized. Most data for the precursor chain is derived from industrial sources that were collected under consistent chronological and methodological framework conditions. The process data and the used background data are consistent. In addition, the origin of the data is documented. Additional information is gathered regarding the age of the data and geographical and technology coverage. The input and output data of the whole process plant was strongly emphasized. The supplied data (processes) were supplied by UAC and checked for plausibility. Therefore, the data quality can be described as good.

Allocation

No allocation rules were applied in the life cycle assessment for the foreground data of the examined products. Packaging materials are incinerated in waste-to-energy-plants. Incorporated CO2 is released totally when incinerated. Incineration emissions are calculated, credits are not gained, neither for power grid mix nor for thermal energy.

Note on use stage

The life cycle of building products depends on the according construction, usage situation, the user, maintenance and service. The products are assumed as maintenance free products. No cleaning or other maintenance activities are considered with regard to the products examined for the use phase.

A use phase scenario, considering the transportation from Malaysia to Germany is investigated with the following assumptions:

- Ipoh to Klang, 205 km via truck train
- Klang to Hamburg, 15450 km via ship.

7.3 Demonstrating the balances and analysis

Life cycle inventory analysis

The life cycle inventory analysis regarding the primary energy consumption, water consumption and waste is presented in the following chapters.

Primary energy consumption

The following table shows the primary energy consumption (renewable and non-renewable) according to the different stages of manufacturing which are pre-product production (including transportation processes to the manufacturing plant), material preparation, manufacturing process, autoclave, finishing & dust collector and packaging of one metric tonne of UAC fibre-cement production.
Table 1: Total primary energy input for manufacturing 1 metric tonne of UAC fibre-cement products

UAC fibre cement products [MJ/t]							
Parameter	Pre-products including transportation	Material preparation	Manufacturing process	Autoclave	Finishing & Dust collector	Packaging	Total
Non renewable energy resources [MJ]	3674.4	1440.2	1987.2	1512.7	681.64	89.64	9385.6
Renewable energy resources [MJ]	2157.6	47.28	62.88	0.68	22.26	377.41	2668.1

Non renewable primary energy consumption:

39% of the non-renewable energy demand is contributed by the pre-product production (incl. transportation), which is mainly caused by energy intensive processes in the pre-production of cement and pulp. The contribution of cement and pulp in the pre-product stage is 53% and 30% individually making up to 83% contribution to the overall non-renewable primary energy demand in the pre-product stage.

The contributions from other stages of manufacturing are material preparation (16%), manufacturing process (21%), autoclave (16%), finishing and dust collector (7%), and packaging (1%).

Figure 1 below shows a detailed analysis of the individual contribution of non-renewable primary energy demand according to the different source of energy such as natural gas (36%), crude oil (21%), hard coal (17%), lignite (1%), uranium (3%) and renewable energy resources (22%) in manufacturing 1 metric tonne of fibre-cement.

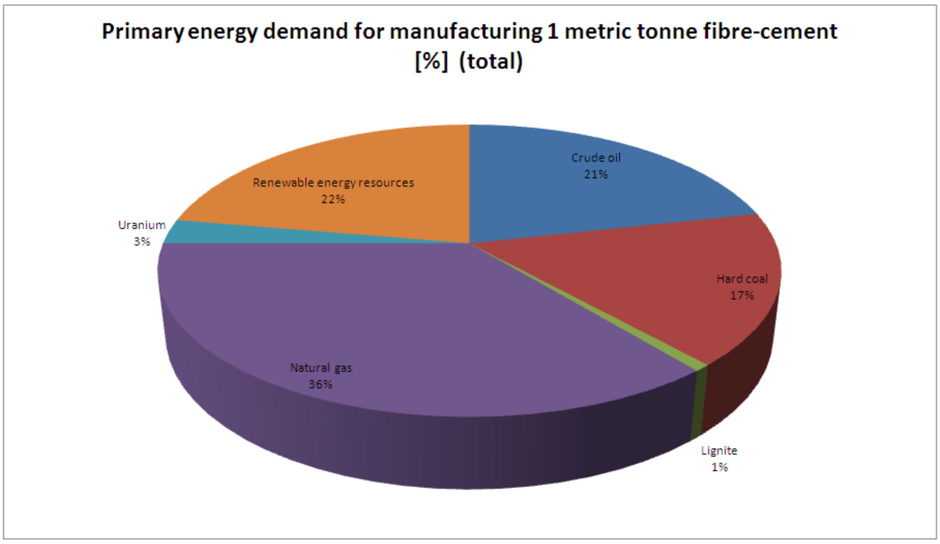


Figure 1: Distribution of total primary energy demand for manufacturing 1 metric tonne of UAC fibre-cement.

Renewable primary energy consumption:

From the overall renewable energy demand, 95% is used in the raw material acquisition stage, mainly for the biomass based materials like wood and cellulose. 81% from this amount is due to cellulose production and 14% is contributed by the production of wooden pallets. This is the amount of solar energy stored in the wood necessary to grow biomass / trees.

The following figure displays the split of different renewable energy resources in the manufacturing of 1 metric tonne fibre cement. Solar energy is the most important renewable energy. It is used in photosynthesis and calculated as cost in the balanced system. This feedstock energy is included in products like pulp and wooden pallets.

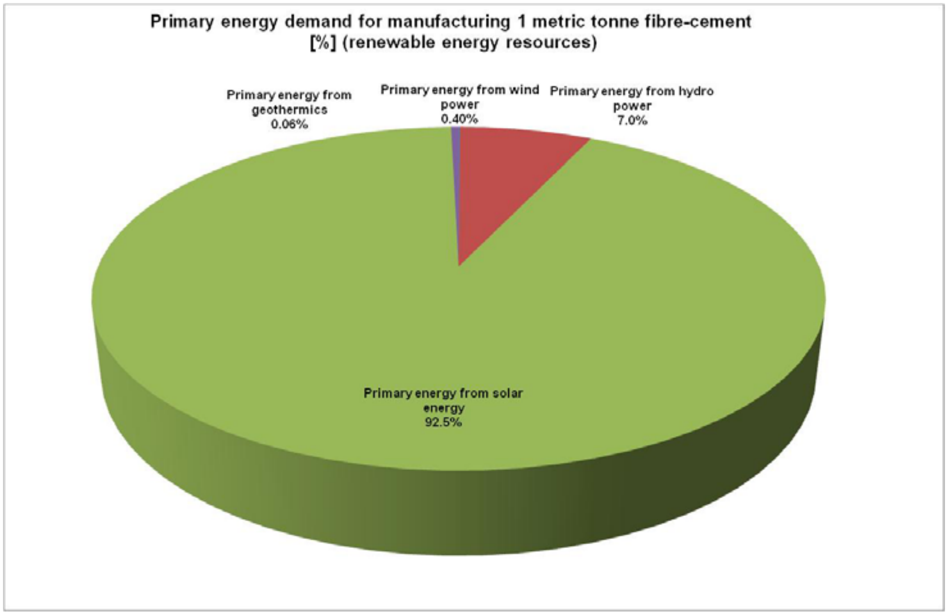


Figure 2: Distribution of renewable primary energy demand for manufacturing 1 metric tonne of UAC fibre-cement.

Secondary fuels

For the production of one metric tonne fibre cement sheets and panels about 70.1 MJ renewable secondary fuels are applied. This is due to the use of palm kern shell within the cement kiln. Other secondary fuels are not applied in the Malaysian cement production.

Water use

During the production of 1 tonne fibre cement products and upstream processes, 11 m³ of water are required.

About 72 % of the 11 m³ water results from upstream processes within the pre-products production and preparation, mainly from the pulp processing. Another 15% are due to upstream processes of the power consumption at plant.

Material resources

Used non renewable material resources mainly represent inert rock, lime stone, sand and soil (Table 7-1).

Table 7-1: Use of non renewable material resources during the production of one metric tonne fibre cement product

UAC fibre-cement products	
Parameter	Manufacture [kg / t]
Soil	247.4
Inert Rock	1136.7
Lime stone	639.7
Sand	632.1
Clay	22.6
Gypsum (natural)	19.0
Sodium chloride	7.03
Chrome ore	0.020
Copper ore	0.059
Manganese ore	0.069
Iron Ore	12.4
Bauxit	23.5
Basalt	2.24

Limestone is the main material resource needed for cement production.

The rate of non-exploitable rock and soil is primarily ascribed to the raw material extraction and the extraction of energy sources for the power generation.

Waste

The analysis of the waste accumulation is demonstrated in three separate fractions: rubble/dump commodities (including residues from the ore processing), municipal waste (household garbage and industrial waste are included here) and hazardous waste including radioactive waste (Table 7-2).

Rubble is represents the greatest amount of the dump flows. Rubble mainly accumulates during the raw material extraction, mainly in the course of the lime stone and sand extraction.

Consumer waste amounts are due to upstream processes in the pre-product production, especially sludge within the pulp production.

Hazardous wastes are mainly sludge wastes from upstream processes in the pre-product production.

The following table shows the waste accumulation during the manufacturing of one metric tonne fibre cement product.

Table 7-2: Waste accumulation during the production of one metric tonne fibre cement product

UAC fibre-cement products	
Parameter	Manufacture [kg / t]
Rubble / Spoil	1,537
Commercial waste similar domestic garbage	3.11
Toxic waste (including radioactive waste)	1.89

Impact assessment

The following figure shows the relative contribution of the production of 1 metric tonne UAC fibre cement to the considered impact categories. The contributions are distinguished in different subsystems: pre-product production, material preparation, manufacturing process, autoclave, finishing and dust collector and packaging (incl. its incineration).

The considered impact categories include global warming potential (GWP), acidification potential (AP), eutrophication potential (EP), ozone depletion potential (ODP) and Photochemical Ozone Creation Potential (POCP).

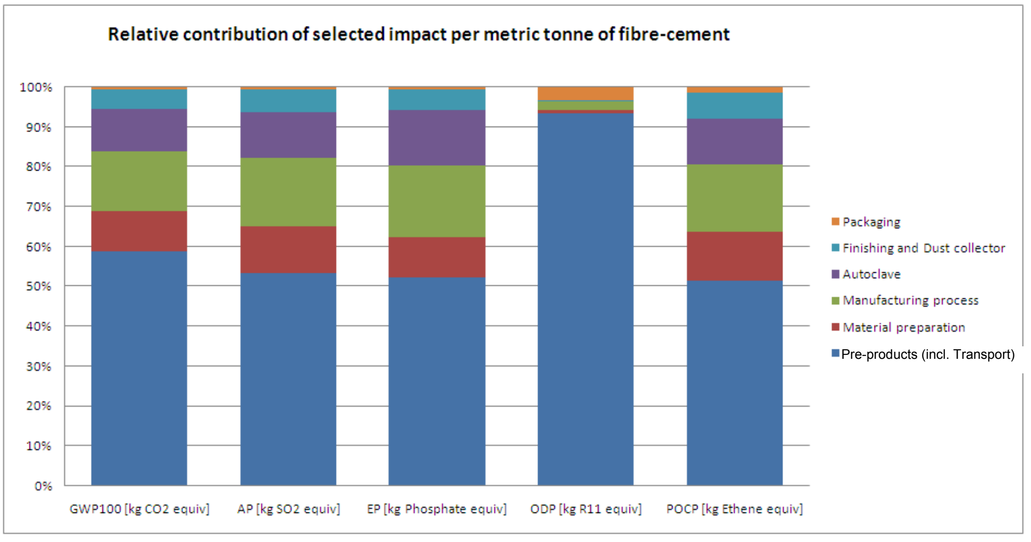


Figure 3: Relative contribution of individual impact categories for manufacturing 1 metric tonne of UAC fibre-cement.

Thus, the pre-products production has visibly the most important influence on the considered impact categories.

Table 2 shows the absolute contribution of manufacturing 1 metric tonne of UAC fibre-cement according to individual environmental effects, divided into different stages of manufacturing.

Table 2: Absolute results of manufacturing 1 metric tonne of UAC fibre-cement according to individual environmental effects

	Unit	Pre-products including transportation	Material preparation	Manufacturing process	Autoclave	Finishing and Dust collector	Packaging
Global Warming Potential (GWP 100 years)	kg CO_2-Equiv.	381.08	104.65	161.68	113.02	49.50	23.88
Acidification Potential (AP)	kg SO_2-Equiv.	2.09	0.46	0.68	0.45	0.23	0.03
Eutrophication Potential (EP)	kg Phosphate-Equiv.	0.23	0.04	0.08	0.06	0.02	5.90E-03
Ozone Depletion Potential (ODP)	kg R11-Equiv.	8.36E-06	6.54E-08	2.03E-07	5.66E-09	2.03E-08	2.96E-07
Photochemical Ozone Creation Potential (POCP)	kg Ethene-Equiv.	0.14	0.03	0.05	0.03	0.02	4.77E-03

The main contributor of GWP which accounts to 46% during the production phase of one metric tonne fibre cement is the pre-product production (including transportation). The cement and pulp production are both energy intensive processes. At the same time, these components are the main materials used to produce fibre cement. In the case of pulp an overcompensation of GWP takes place, due to carbon storage.

The acidification potential is dominated by the pre-product production with 53%. Other contributors are the material preparation with 12%, the manufacturing process with 17%, autoclave with 11%, finishing and dust collector (6%) and packaging (1%).

The eutrophication potential is mainly caused by the pre-products with almost 52%. It is followed by the manufacturing process (18%), autoclave (14%), material preparation (10%), finishing and dust collector (5%) and packaging (1%).

The ozone depletion potential is 94% determined by the pre-products used, what is mainly due to upstream processes within the pulp production.

Finally, the contribution of pre-product production accounts with 51% to the overall POCP potential. While most of the POCP values are caused by combustion to generate electricity, the share of POCP value in finishing & dust collector stage is mainly caused by the combustion of LPG and diesel as a fuel for the forklift.

Use phase

A simple scenario was done for the use phase in this study. The fibre-cement products are assumed as maintenance free products. No cleaning or other maintenance activities are required once the products are assembled.

However, in the model the distribution of the product (to Germany as a scenario) based on 1 metric tonne of fibre-cement is included.

The following table shows the environmental impacts only resulting from the transportation from Malaysia (Ipoh) to Germany (Hamburg) for 1 metric tonne UAC fibre cement. Within the scenario it is assumed to transport the fibre cement product 205 km via lorry and 15 450 km via ship.

Table 3: Environmental impact from distribution to Germany

Transportation and landfill site	Unit	Transportation 15655 tkm
Primary energy, non-renewable	MJ	727.5
Primary energy, renewable	MJ	0.69
Global Warming Potential	kg CO_2-Equiv.	56.38
Acidification Potential	kg SO_2-Equiv.	1.43
Eutrophication Potential	kg Phosphate-Equiv.	0.14
Ozone Depletion Potential (ODP)	kg R11-Equiv.	5.84E-08
Photochemical Ozone Creation Potential	kg Ethene-Equiv.	0.08

8 Testing and verifications

8.1 Leaching behaviour

Measuring institution: Hygiene-Institut des Ruhrgebiets, Gelsenkirchen, control reports from 27th November 2009.

Procedure: Determination of the eluate values according to DIN 38414 for fibre cement panels “UCO Superflex”

Results:

In accordance with waste code "170101" (description: "concrete", restriction: "only selected waste from construction or demolition measures") of the "Abfallverzeichnis Verordnung" (Ordinance on the European Waste Catalogue, remnants of fibre cement panel that cannot be reused may be disposed of harmlessly in landfill sites that have the water-relevant characteristics of landfill class 1, as defined by the "Verordnung zur Vereinfachung des Deponierechts" (Ordinance on the Simplification of Waste Disposal Regulations).

9 PCR-Document and Verification

This declaration is compliant to the PCR Document Fibre cement 2007-02.

Review of the PCR Document through the Independent Advisory Board (SVA). Chairman of the SVA: Prof. Dr.-Ing. Hans-Wolf Reinhardt (University Stuttgart, IWB)
Independent verification of the declaration according to ISO 14025: ☐ internal ☒ external
Validation of the declaration: Dr. Birgit Grahl

Literature

/Act 127/ Laws of Malaysia Act 127 – Environmental Quality Act 1974 - Environmental Quality, Regulations, 2009

/ASTM E C423-90a/ ASTM E C423-90a - Sound absorption and sound absorption coefficient by the reverberation room method

/ASTM E90/ ASTM E90 : 1990 - Laboratory measurement of Airborne Transmission Loss of Building Partition

/BS 476-6/ BS 476: Part 6 : 1989 (UDC 614.841.332 : 620.1 : 69.01:536.463:001.4) - Fire tests on building materials and structures Part 6. Method of test for fire propagation for products, 1989

/BS 476-7/ BS 476: Part 7 : 1997 - Fire tests on building materials and structures Part 7. Method of test to determine the classification of the surface spread of flame of products, 1997

/BS EN 197-1/ BS EN 197-1: Cement - Part 1: Composition, specifications and conformity criteria for common cements; German version prEN 197-1:2009

/DIN 38414/ DIN 38414:1984: German standard methods for the examination of water, waste water and sludge; sludge and sediments (group S); determination of leachability by water (S 4); German version DIN 38414:1984

/DIN 4108-4/ DIN 4108-4:2007: Thermal insulation and energy economy buildings – Part 4: Hygrothermal design values

/DIN EN ISO 9001/ DIN EN ISO 9001:2008: Quality management systems - Requirements (ISO 9001:2008); Trilingual version EN ISO 9001:2008

/EN 12467/ EN 12467: Fibre cement flat sheets - Product specification and test methods; German version EN 12467:2004 + A1:2005 + A2:2006

/Eyerer 2000/ Eyerer, P. und Reinhardt, H.W. (Hrsg.): Ökologische Bilanzierung von Baustoffen und Gebäuden - Wege zu einer ganzheitlichen Betrachtung. Birkhäuser Verlag Zürich, 2000

/GaBi 4/ GaBi 4: Software and data base for holistic balancing. LBP, University Stuttgart and PE International GmbH, 2001-2009.

/Hy 2009/ Hygiene-Institut des Ruhrgebiets, Institut für Umwelthygiene und Umweltmedizin, Eluate analysis of UAC fibre cement panels, Prüfzeichen A-184229-09-WR, Gelsenkirchen, 27/11/2009

/IBU 2006/ Leitfaden (Ausgabe 20.01.2006) für die Formulierung der produktgruppen-spezifischen Anforderungen der Umwelt-Produktdeklarationen (Typ III) für Bauprodukte, Institut Bauen und Umwelt e.V., www.bau-umwelt.com

/ISO 14020/ DIN EN ISO 14020:2002-02, Environmental labels and declarations – General principles (ISO 14020:2000)

/ISO 14025/ DIN EN ISO 14025:2007-10, Environmental labels and declarations – Principles and procedures (ISO 14025:2006)

/ISO 14040/ DIN EN ISO 14040:2006-10, Environmental management - Life cycle assessment - Principles and framework (ISO 14040:2006)

/ISO 14044/ DIN EN ISO 14044:2006-10, Environmental management - Life cycle assessment - Requirements and guidelines (ISO 14040:2006)

/ISO 8990/ ISO 8990:1996-09,: Thermal insulation - Determination of steady-state thermal transmission properties - Calibrated and guarded hot box (ISO 8990:1994); German version EN ISO 8990:1996

/MS 1296/ MS 1296 : 1992 (UDC 666.916) - Specification for Fibre-Cement Flat Sheets, 1992

/MS 133/ MS 133: Pt. G6 : 1978 - Method of test for paints : Resistance to fungal growth, 1978

/MS 522/ MS 522: Pt 1-4: 1989: Specification for portland cement (ordinary and rapid hardening), 2007

/MS 858/ MS 858 : 1993, clause 3.4 - Specification for glazed ceramic tiles for internal walls, 1993

/PCR 2007/ PCR Fibre Cement, Product Category Rules Fibre Cement, 2007-02, Institute Construction and Environment

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